ANALYSIS OF RELATIONSHIPS BETWEEN WATER QUALITY AND PLANKTON OF RESERVOIRS IN THAILAND

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A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in Environmental Biology

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การวิเคราะห์ความสัมพันธ์ระหว่างคุณภาพน้ำกับแพลงก์ตอน
ในอ่างเก็บน้ำของประเทศไทย

นายภูริภัท ว่องพิพัฒนานนท์

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรดุษฎีบัณฑิต
สาขาวิชาชีววิทยาสิ่งแวดล้อม
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Suranaree University of Technology has approved this thesis submitted in partial fulfillment of the requirements for the Degree of Doctor of Philosophy.

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การศึกษาวิจัยนี้เน้นวิเคราะห์ความสัมพันธ์ระหว่างคุณภาพน้ำกับแพลงก์ตอนในแหล่งน้ำนิ่งของประเทศไทย จากการรวบรวมข้อมูลคุณภาพน้ำและแพลงก์ตอนในแหล่งน้ำนิ่งจากรายงานการประเมินผลกระทบสิ่งแวดล้อมและรายงานต่าง ๆ ที่เกี่ยวข้อง จำนวน 109 ชุดข้อมูล เมื่อนำมาศึกษาความสัมพันธ์และสัมประสิทธิ์สหสัมพันธ์ของข้อมูลด้านคุณภาพน้ำและแพลงก์ตอนที่ระดับความเชื่อมั่น 95% พบว่าความสัมพันธ์และสัมประสิทธิ์สหสัมพันธ์ของข้อมูลด้านคุณภาพน้ำกับชนิดและปริมาณของแพลงก์ตอนในแต่ละไฟลัมมีความแตกต่างกันออกไปตามปัจจัยด้านคุณภาพน้ำและแพลงก์ตอน ส่วนการวิเคราะห์หาสมการที่เหมาะสมที่สุดระหว่างข้อมูลด้านคุณภาพน้ำและปริมาณแพลงก์ตอน พบว่ามีตัวแบบที่เหมาะสม 13 ตัวแบบ โดยมีค่าสัมประสิทธิ์การกำหนด (Coefficient of determination, R^2) อยู่ในช่วง 0.65-0.90

เมื่อเปรียบเทียบความถูกต้องของตัวแบบที่เหมาะสม 13 ตัวแบบ พบว่าตัวแบบของไฟลัม Chlorophyta, Chrysophyta, Rotifera, Arthropoda, Chordata, total phytoplankton และ total zooplankton เพียง 7 ตัวแบบเท่านั้นที่สามารถนำมาคาดการณ์ปริมาณแพลงก์ตอนในแหล่งน้ำนิ่งได้ โดยมีปัจจัยคุณภาพน้ำที่เกี่ยวข้องทั้งหมด 14 ปัจจัย ได้แก่ บีโอดี ของแข็งแขวนลอย คลอโรฟิลล์ เอ ของแข็งละลายน้ำทั้งหมด ค่าการนำไฟฟ้า ไนโตรเจนทั้งหมด อุณหภูมิของน้ำ ความโปร่งแสง ความลึกของแหล่งน้ำ ความเป็นกรดเป็นด่าง โซเดียม ไนเตรท โพแทสเซียม และปริมาณออกซิเจนที่ละลายน้ำ สำหรับการสร้างฐานข้อมูลของคุณภาพน้ำและแพลงก์ตอนในแหล่งน้ำนิ่งของประเทศไทยสามารถจัดทำระบบฐานข้อมูลและเริ่มดำเนินการเก็บรวบรวมข้อมูลด้านคุณภาพน้ำและแพลงก์ตอนของแหล่งน้ำนิ่งเริ่มต้นเป็นจำนวน 113 ข้อมูล

สาขาวิชาชีววิทยา

ปีการศึกษา 2547

ลายมือชื่อนักศึกษา..

ลายมือชื่ออาจารย์ที่ปรึกษา..

ลายมือชื่ออาจารย์ที่ปรึกษาร่วม..

ลายมือชื่ออาจารย์ที่ปรึกษาร่วม..

PURIPAT WONGPIPATTANANON : ANALYSIS OF RELATIONSHIPS BETWEEN WATER QUALITY AND PLANKTON OF RESERVOIRS IN THAILAND. THESIS ADVISOR : ASSOC. PROF. SOMPONG THAMMATHAWORN, Ph.D. 369 PP. ISBN 974-533-354-9

RELATIONSHIPS/ WATER QUALITY/ PLANKTON/ RESERVOIRS/ THAILAND

This research focuses on analysis of relationships between water quality and plankton in stagnant water of Thailand. One hundred and nine data on water quality and plankton of stagnant water were selected from environmental impact assessment reports and related reports. The relationships have been analyzed with confidential level of 95%. The relationships and correlations between water quality and abundance of plankton as well as the relationships and correlations between water quality and number of plankton species in each phylum vary depending on water quality parameter and plankton. There are 13 fittest models between water quality and abundance of plankton. The coefficient of determination (R^2) of each model ranges between 0.65-90.0.

The 7 fittest models are phyla Chlorophyta, Chrysophyta, Rotifera, Arthropoda, Chordata, total phytoplankton, and total zooplankton. These 7 parameters can be used to estimate abundance of plankton organism in stagnant water. Totally 14 water quality parameters which relate to abundance of plankton comprise biochemical oxygen demand, suspended solid, chlorophyll a, total dissolved solid, conductivity, total nitrogen, water temperature, transparency, depth of water, pH, sodium, nitrate, potassium, and dissolved oxygen. Data of water quality and plankton from reservoirs of Thailand have been constructed in database system. Initially, the database system can compile 113 data on water quality and plankton in reservoirs of Thailand.

School of Biology

Academic Year 2004

Student's Signature..

Advisor's Signature..

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List of Abbreviations

^oC	=	Degree Celsius
cm	=	centimeter
m	=	meter
TS	=	Total solids
TDS	=	Total dissolved solids
SS	=	Suspended solids
DO	=	Dissolved oxygen
mg/l	=	milligram/liter
ng	=	nanogram
BOD	=	Biochemical oxygen demand
COD	=	Chemical oxygen demand
NO_3-N	=	Nitrate-nitrogen
NO_2-N	=	Nitrite-nitrogen
NH_3-N	=	Ammonia-nitrogen
Organic-N	=	Organic-nitrogen
Mg	=	Magnesium
RNA	=	Ribonucleic acid
DNA	=	Deoxyribonucleic acid
ANSI	=	American National Standards Institute
CPU	=	Control Processing Unit

List of Abbreviations (continued)

RAM	=	Random Memory Access
DBMS	=	Database Management System
DBA	=	Database Administrator
DFD	=	Data Flow Diagram
GUI	=	Graphic User Interface
EIA	=	Environmental Impact Assessment
ONEP	=	Office of Natural Resources and Environmental Planning and Policy
VIF	=	Variance Inflation Factor
APHA	=	American Public Health Association
AWWA	=	American Water Works Association
WEF	=	Water Environment Federation
R	=	Correlation coefficient
R^2	=	Coefficient of determination

Chapter I

Introduction

1.1 Significance of the Study

Development projects generate growth in agriculture, industry, business, commercial sectors, and strengthen national economic condition. However, the development activities often relate to exploitation of natural resources resulting in current and future impacts on environmental resources especially water resources which is very important. All of development projects always have water resource as a main component and the water resource would also be directly and indirectly affected by the project. The impact on water resource is not only changes in characteristics of water but also effects on living organisms in water.

Fresh water resource could be categorized into 2 types as running water and stagnant water. Both types of water resource could be with different abundance and species composition of plankton. These differences might indicate specific characteristic, some environmental condition of water source i.e. type of water and capacity of water source, season, physical and chemical properties of water and other population in water source. Benthic algae and diatom can be found in running water i.e. river and stream with high flow in rainy season. Plankton in phylum Euglenophyta would be mostly found in ditch and fish pond while green algae in phylum Chlorophyta especially desmid can be mostly found in large stagnant water such as reservoir, lake, and flooded area (จันทร์พิมพ์ แสนอุดม, 2536).

In addition, Davis (1955) reported that fresh water had to be either lentic (standing water) or lotic (running water). Lentic waters include, in addition to ground water, (which need not concern us here in as much as its plankton content was almost always negligible), lakes, ponds, and swamps. A lake could be defined as a body of standing water isolated from sea. It was of sufficient depth so that there was a large area of open water devoid of rooted vegetation. A pond was simply a shallow lake with rooted submerged vegetation, and a swamp was a pond so shallow that its whole expanse was occupied by emergent vegetation, rooted in the bottom.

Maryland Department of Natural Resources (2004) reported that the plankton represented one of the most direct and profound responded to pollution entering the Chesapeake Bay. The degree of eutrophication or nutrient enrichment is often gauged by the amount of plankton growth in an aquatic environment. Because of plankton's fundamental importance to the eutrophication process, limitation of their growth, or production, is often one of the direct targets of management actions. These actions are typically directed at reducing nutrient inputs as a means of limiting plankton growth. The limitation of plankton growth is in turn expected to improve some of the impacts that result from excessive growth. Thus, an assessment of water quality to guide and evaluate management action logically includes the measurement of plankton communities and their growth rates.

In Thailand, most of aquatic ecology research relates to water resource development project, environmental and ecology research works. The aquatic ecology and water qualities are mostly studied together in parallel with each other. However, many research organizations mainly focus in results of the study on an individual, specific aspect as water quality or aquatic ecology. The relations between water quality and aquatic ecology results have been scarcely mentioned. It can be concluded that the relationships between the 2 things have not been clearly identified in Thailand and there are no researches, which focus and present relationships between water quality and aquatic ecology in water resources. Therefore, this study will concentrate on maximizing the use of water quality and aquatic ecology data of stagnant water resources especially reservoir, pond, swamp, etc. This is the study on relationship between water quality and aquatic ecology especially plankton by analyzing the relationships in terms of model. In addition, database system of water quality and plankton in reservoirs of Thailand is to be set up. The expectation of this study is to conduct a pilot study on compilation of baseline data for further study on relationships between water quality and aquatic ecology in other reservoirs in Thailand.

1.2 Research Objectives

1) To study relationships between water quality and plankton in reservoirs of Thailand.

2) To study appropriate model for reservoirs in Thailand.

3) To set up database system of water quality and plankton in reservoirs of Thailand.

1.3 Scope and Limitations of the Study

This study focused on stagnant water in reservoir, pond, etc. Data on the water quality sampling and aquatic ecology sampling collected at the same time in reservoirs will be compiled. The water quality and aquatic ecology parameters concerned are water temperature, pH, transparency, depth of water, turbidity, conductivity, dissolved oxygen, total solid, total dissolved solid, suspended solid, total hardness, chloride, acidity, alkalinity, nitrate-nitrogen, nitrite-nitrogen, organic-nitrogen, total nitrogen, ammonia-nitrogen, sulfate, phosphate, biochemical oxygen demand, chemical oxygen demand, oil & grease, calcium, sodium, potassium and chlorophyll a, phytoplankton, zooplankton, etc. The study areas are the reservoirs in northern, northeastern, central and southern regions of Thailand such as Kew Lom reservoir in Lampang province, Nong Han reservoir in Sakon Nakhon province, water supply reservoir of Krabi power plant in Krabi province, etc.

1.4 Expected Results

1) Knowledge about relationships between water quality and plankton of reservoirs in Thailand.

2) Water quality and plankton database model of reservoirs in Thailand.

3) System for water quality and plankton data collection is set up.

Chapter II

Literature Reviews

2.1 Plankton

Lenz (1972) reported that the word ‘plankton’, which originated from the Greek (literally: that which wanders about), was a collective term for all the organisms of which floated in the water and did not execute individual movements any importance.

Wimpenny (1966) reported that plankton was named by Victor Hensen who was German scientist. He used the word “Plankton” from Greek word and, meaning something that floated passively hither and thither. ธิดาพร หรบรรพ์ (2540) reported that “Plankton” came from Greek word which Victor Hensen, German Oceanologist publicized in 1887. It means small plants and animals in aquatic ecology that can be floated by wind and wave current (Strickland, 1960 and ลัดดา วงศ์รัตน์, 2538a).

Davis (1955) stressed that “plankton was the community of organisms that drifted passively in the water in which they floated”. Plankton consisted of phytoplankton and zooplankton. Phytoplankton was the plants of the plankton and zooplankton was animal plankton. The plants were the basic producers, in the plankton as elsewhere, it was felt that it would be desirable to consider first the phytoplankton, and subsequently the zooplankton. The organisms of plankton would, therefore, be considered in the following orders:

1) Cyanophyta	11) Rotifera
2) Chrysophyta: bacillariaceae	12) Bryozoa
3) Chlorophyta	13) Brachiopoda
4) Protozoa	14) Phoronidea
5) Porifera	15) Chaetognatha
6) Coelenterata	16) Annelida
7) Ctenophora	17) Arthropoda
8) Platyhelminthes	18) Mollusca
9) Nemertea	19) Echinodermata
10) Nemathelminthes	20) Chordata

Davis (1955) reported that planktonic plants were called phytoplankton. The phytoplankton proper consisted of chlorophyll-bearing plants, which were therefore capable of performing photosynthesis, while the saproplankton consisted of nonphytosynthesic plants, including the bacteria and fungi.

กุสุมา สุภัทรากุล (2540) said that plankton was a small life in water and was very important for aquatic life especially phytoplankton because it was primary producer in water source. Phytoplankton had chlorophyll to absorb energy for exchanging inorganic matter into organic matter. Then, phytoplankton was the most important primary product in form of single cell, colony or filament.

Palmer (2001) reported that phytoplankton (microscopic free-floating plants) were the foundation of the aquatic biota in the receiving water as the food supply for zooplankton. Without nutrients, aquatic organisms could not exist; however, an excess of phytoplankton biomass could cause receiving water quality to degrade, primarily in the oxygen demands for the decay of expired phytoplankton biomass.

Phytoplankton was photosynthesis plankton group. It was classified in plant kingdom. Phytoplanktons had chlorophyll but did not have leaves, stem and true roots. They were single cell size (which could not be viewed with eyes and have to be viewed by microscope) to large cell size (comprised many cell and could be viewed with eyes). Prescott (1962) and Round (1973) reported that phytoplankton was lower plant and algae in 7 phyla namely Cyanophyta (blue-green algae), Chlorophyta (green algae), Bacillariophyta (diatom), Chrysophyta (yellow-brown algae), Pyrrophyta (dinoflagellate), Euglenophyta (euglenoids), and Cryptophyta (cryptomonad) (ธิดาพร หรบรรพ์, 2540).

Davis (1955) reported that the zooplankton consisted of those plankters with a holozoic nutrition, and thus it included all of the planktonic animals. Zooplankton comprised 16 phyla such as Protozoa (protozoans), Coelenterata (cnidaria), Ctenophora (comb-jellies), Platyhelminthes (flat worms), Nemertinea (ribbon worms), Rotifera (rotifers), Chaetognatha (arrow worms), Annelida (segmented worms), Arthropoda (arthropods), Phoronida (phoronids), Ectoprocta (moss animals), Brachiopoda (lamp shell), Mollusca (mollusks), Echinodermata (spiny-skinned animals), Hemichordata (hemichordates), and Chordata (chordates) (ลัดดา วงศ์รัตน์, 2538b).

Raymont (1963) reported that usefulness of plankton was being natural food for aquatic life from larva period to adult period. Though, some of aquatic life feed from smaller aquatic life, but the study tracing consumption chain revealed that all of aquatic life initially consumed plankton (กุสุมา สุภัทรากุล, 2540).

2.2 Correlation between Water Quality, Species and Abundance of Plankton

2.2.1 Temperature

Palmer (2001) said that temperature was an important factor in the chemical reactions and biological activity in the receiving water. พิศมัย เฉลยศักดิ์ (2543) and ลัดดา วงศ์รัตน์ (2530) reported that temperature was important for aquatic life and aquatic environment. Temperature of natural water sources would vary according to sunlight, season, ambient air temperature, latitude and longitude, topographical condition, depth, turbidity, water volume, general environment of water courses including heat from biochemical reaction of microorganism and heat from human and animal activities especially heat from cooling water of industrial plant discharge into river (สิรินี ทิพพากร, 2527; ไมตรี ดวงสวัสดิ์ และจารุวรรณ สมศิริ, 2528; Reid, 1961; Environmental Protection Agency, 1973; Ruttner, 1963; Smith, 1992).

Temperature of fresh water highly varies during the year especially in stream. The temperature in small and shallow fresh water sources change according to light intensity and ambient air temperature (Shirota, 1966; Smith, 1992). Temperature is important factor for growth and distribution of phytoplankton and zooplankton in tropical area and sub-tropical area (Smith, 1950). As water temperature increased, metabolism rate of aquatic life would also increase but capacity of dissolve of oxygen would decrease, so, aquatic life would lack oxygen (ไมตรี ดวงสวัสดิ์ และจารุวรรณ สมศิริ, 2528; Sleigh, 1973). Therefore, water temperature had effect on type of aquatic life in water sources (Smith, 1992). Temperature also had effect on distribution of phytoplankton. Temperature would affect chemical processes, respiration process, and metabolism of phytoplankton, all of which were important for reproduction and growth of phytoplankton (สุนีย์ สุวภีพันธ์, 2527; Raymont, 1963; Valiela, 1995). The phytoplankton growth related with appropriate temperature and sunlight in each season, many diatom could be found at temperature 15-25^{o}C or in spring with plenty of light and low temperature and many green algae could be found in summer at temperature 30-35^{o}C with high intensity of light. There would be no plankton growth in winter with low temperature and low intensity of light, (Smith, 1950; Welch, 1980). Green algae number decreased at temperature >35^{o}C but blue green algae increased (ไมตรี ดวงสวัสดิ์ และจารุวรรณ สมศิริ, 2528). The maximum number of blue-green algae could be found at temperature 35-45^{o}C (Welch, 1980). The plankton abundance is the highest during March to April in tropical zone (Sournia, 1969). โสภณา บุญญภิวัฒน์ (2521) reported that microplankton increased during April to July at the Chao Phraya river mouth. The water temperature is generally in the range of 23.06-31.4^{o}C in rivers of Thailand (อนันตศักดิ์ ส่องพราย, 2523). The appropriate temperatures and condition for various phytoplankton growths are 20-29^{o}C with pH 6.0-7.5 (Smith, 1950; Fogg, 1975).

ณฐกร ประดิษฐ์สรรพ์ (2543) reported that water temperature would have different effects on phytoplankton depending on types. When temperature changed the aquatic environment would also change such as dissolved oxygen value would decrease when temperature increased. Thus, water temperature had high impact on abundance and number of phytoplankton in water (ลัดดา วงศ์รัตน์, 2530). Perkins (1974) said that temperature affected metabolism rate of plankton. The temperature was higher at water surface; the metabolism rate of plankton at water surface was also higher than that in lower layer of water for about 50%. ธิดาพร หรบรรพ์ (2540) said that water temperature affected growth of phytoplankton. The temperature of water source would vary according to climate condition, season, light, depth and other factors (ลัดดา วงศ์รัตน์, 2530). The diatom group would increase significantly, and it would become a dominant group when water temperature increased from 20^{o}C to 30^{o}C. Blue-green algae would be the dominant group when water temperature increased from 30^{o}C to 35^{o}C, but the green algae and diatom groups would increase when water temperature decreased. It showed that the plankton would not die when temperature increased but there would be change on group of phytoplankton. Moreover, the increased water temperature would indirectly increase number of phytoplankton by increasing quantity of bacteria. The bacteria would decompose organic matter to be nutrient of plant causing increase in number of phytoplankton. The increment of dinoflagellate group in genus *Peridinium* sp. and increment in number of zooplankton especially larva of Naupalius of copepod occurred when water temperature increased for about

5.5°C from ambient water temperature in at The Pamlico river mouth (Carpenter, 1973). Welch (1952) reported that the highest number of plankton would be found at water temperature of 30-35°C.

สมชาย สุรวิทย์ (2539) reported that water temperature in fresh water resources would vary according to ambient air temperature. It would affect aquatic plant especially phytoplankton in terms of growth and increase in number in various degree. Thus, temperature was a limit factor of phytoplankton growth.

วราภรณ์ พรหมพจน์ (2526) studied type, number of plankton and characteristic of water in Bueng Boraphet lake, Nakhonsawan province. She found that phytoplankton was maximum in September during the middle of rainy season due to influence from the river. The other period with maximum phytoplankton was in early summer during March to May (March is the beginning of summer and May is mid-summer) due to continuous increase of temperature, high intensity of sunlight, clear water and no sediment in water. Then, light could shine into water body and phytoplankton could grow well. In the study on type and number of phytoplankton in the region with very low temperature of Johanna and Marchant (1991) at Grooked lake, Yestfold Hills, Antarctic area during summer, it was found that there were only 3 species of phytoplankton comprising *Chlamydomonas*, *Ochromonas* and *Peridinium* with 23.8×10^2 unit/liter. In addition, chlorophyll a was found in the range of only 0.29-1.8 microgram/liter.

2.2.2 pH

โสภณา บุญญภิวัฒน์ (2521) said that abundance of microplankton in many genus varied in water with different pH values. The pH was very important to variation of type and number of phytoplankton. There would be only a few species of blue-green algae such as *Scytonema ocellum*, *Hapalosiphon pumilus*, and *Chroococcus prescotti* with low density in water with acid condition. The filament of green algae mainly found was in *Microspora* and *Oedogonium* genus group. There were no blue-green algae in water sources with pH <4.5, but there were some survivor of desmids group (Prescott, 1962). These agree with Vymazal (1995) who reported that blue-green algae were not found in very acid environments; in those conditions, the only algae found were eukaryotic. Scagel, Bandoni, Roure, Schofield, Stein, and Taylor (1967) found that distribution of diatom had correlation with pH value of water. If water was in acid condition (pH = 4.0-6.5), there would be many genus of diatom with low density in each genus. On the opposite, if water was in alkaline condition (pH = 7.5-9.0), there would be only a few genus of diatom with high density in each genus. Blue-green algae would have the highest growth in high alkaline condition, pH 9-10 (Shirota, 1966). Most of desmids could grow well in medium pH condition but some species i.e. *Micrasterias denticulata* and *M. Thomasiana* would grow well at pH 7.65-8.1 and pH 7.7-7.75 respectively (Brook, 1981) while Euglena could tolerate pH of water in the range of 3-5 (Round, 1981). However, Vymazal (1995) emphasized the role of pH as a factor determining the composition of freshwater phytoplankton communities.

2.2.3 Transparency

ณฐกร ประดิษฐ์สรรพ์ (2543) reported that light was very important for photosynthesis process of phytoplankton. As light penetrated into water, water would absorb some radiation of light. Some of light would be used by phytoplankton in photosynthesis process (Shirota, 1966). The suspended particles in water i.e. soil sediment, organic matter, inorganic matter, plankton and small aquatic life caused light dispersion and absorb light. It would obstruct light from penetrating into the water. If intensity of light was suitable, density of phytoplankton would be high. Moreover, light would also help distribution of plankton in vertical direction. In case intensity of light was excess, plankton would move to depth zone and plankton would come to water surface in nighttime (Raymont, 1963). The intensity of light would vary according to site, season, time of day, and depth of water level due to light absorption of water and suspended matter including light reflection from plankton and suspended matter (ลัดดา วงศ์รัตน์, 2530). สมชาย สุรวิทย์ (2539) reported that photosynthesis rate would be highest at water surface and light had effect on abundance of phytoplankton. High growth of phytoplankton would cause increase in number of zooplankton species. Shirota (1966) reported that it would be difficult for protozoa i.e., Ciliate to respire and eat food in turbid water with high sediment.

เฉลิมศรี พละพล (2532) reported that transparency of a water source was the extent that secchi disc could be visible from water surface. ไมตรี ดวงสวัสดิ์ และจารุวรรณ สมศิริ (2528) reported that optimal transparency of water for aquatic life growth ranged between 30-60 cm. The low transparency of water (less than 30 cm.) might be due to high turbidity or high abundance of plankton resulting in lack of oxygen in water. For water with high transparency (more than 60 cm.), it meant that water source was in poor condition.

2.2.4 Depth of Water

Odum (1959) found that density of phytoplankton was the highest in range of light level beneath water surface and continuously decreases when depth increased such as case of Mendota lake at Wisconsin State, the density of plankton was more than 5,000 unit/liter at water surface. The euplankton group of phytoplankton was found on water surface while benthic forms were mostly found on waterbed. In addition, the water quality varied according to depth such as pH at water surface was higher than pH at water bed, dissolved oxygen at water surface and at mid-depth were also higher than at waterbed (เดชาพล รุกขมธุร์, 2528).

2.2.5 Turbidity, Total Solid (TS), Total Dissolved Solid (TDS) and Suspension Solid (SS)

Lenz (1972) reported that transparency or turbidity measurements offered another aid for the determination of plankton concentrations, and particularly for phytoplankton concentrations. Palmer (2001) reported that the turbidity measurement, which was a light transmittance measurement, was frequently used in receiving waters. The interpretation of secchi disc data was extremely difficult and probably should be avoided in quantitative interpretations. กุสุมา สุภัทรากุล (2540) reported that turbidity increased in water source while abundance of plankton and diversity of plankton decreased. Water was turbid because there was a lot of sediment in water, light could be less penetrate into water and it was not enough for photosynthesis process. In addition, small sediment particles could obstruct light more than large sediment particle. Suspended solids meant to the mass of organic and inorganic particles suspended in water (Palmer, 2001). Maryland Department of

Natural Resources (2004) reported that suspended solids concentration in the water column was an important water quality indicator because of its effected on water transparency. These suspended solids consisted of inorganic material such as clays and organic material such as living phytoplankton. Suspended solids reduced the depth to which sunlight could penetrate, thereby reducing the habitable zones for phytoplankton and submerged aquatic vegetation that depended upon light to grow. Water transparency, or turbidity, was considered the primary limiting factor to phytoplankton growth in some regions of the bay. Reduction in light penetration had also been implicated as a major cause of declines in submerged aquatic vegetation in recent decades.

2.2.6 Conductivity

พันทวี มาไพโรจน์ และศิริเพ็ญ ตรัยไชยาพร (2543) said that conductivity was capability for electricity transmission of water. This property depended on demand and type of ion in water including water temperature during measurement period. The inorganic compound i.e. inorganic acid, base, and salt e.g. HCl, Na_2CO_3 and NaCl were good conductivity carrier. In opposite, organic compounds could not be soluble in water, thus, they could not be conductivity carrier. The conductivity of water could not indicate type of matter in water but it could only indicate increase or decrease of matter in water (กรรณิการ์ สิริสิงห, 2525). Therefore, it could indicate quantity of soluble salt especially Total Dissolved Solids (TDS). The conductivity of water would positively vary to concentration of solutions, temperature and pH of water which depended on environmental factor of water source and watershed such as geology condition, rock and soil, topography, rainfall, evaporation, volume of water, biochemical process in water source, and human activities, etc. The high pH of water (more than 9) and low pH of water (less than 5) might highly affect conductivity of water especially in high temperature condition, many of matter would decompose well, resulting in high conductivity of water. In natural water with good condition, the conductivity of water ranged 150-300 microcement/centimeter. The high conductivity (more than 300 microcement/centimeter) of water indicated that water source had pollution and had impact on surviving of aquatic plant.

2.2.7 Dissolved Oxygen, DO

Palmer (2001) said that dissolved oxygen meant to the concentration of dissolved oxygen in the liquid expressed in mg/l. ไมตรี ดวงสวัสดิ์ และจารุวรรณ สมศิริ (2528) reported that oxygen is very important factor for life because all of living things needed to use oxygen in many processes with body for growth. ณฐกร ประดิษฐ์สรรพ์ (2543) said that dissolve oxygen demand is very important in chemical and biology reaction. Plant and animal needed oxygen in respiration process and other process for growth (สมใจ กาญจนวงศ์, 2532). Dissolve oxygen demand would depend on many factor such as flow rate of water current, water temperature, air pressure and respiration rate of aquatic life in water source, etc (Maitland, 1978). The capacity for dissolving oxygen in fresh water was in the range of 14.6 liter at $0^{o}C$ and 6.9 mg/liter at $35^{o}C$ with 1 atmospheric pressure (ไมตรี ดวงสวัสดิ์ และจารุวรรณ สมศิริ, 2528). Moreover, oxygen could be less dissolved in water when water temperature increased. High salinity water would also dissolve less oxygen (Warren, 1971). It dissolved oxygen demand was less than 1 mg/liter, the fish would die (Boyd, 1982). Dissolved oxygen demand would vary in each season with maximum value in winter, followed by rainy season and summer respectively. In general, dissolved oxygen demand suitable for living of aquatic life should not be less than 5 mg/liter. If dissolved oxygen demand was less than 3 mg/liter, it would be dangerous to aquatic life (นันทนา คชเสนี, 2536). ไพเราะ เคาศิริกุล (2522) said that dissolved oxygen was very important factor which had influence on abundance of plankton, and diatom *Achnanthes minutissima* needed oxygen for living (Patrick, 1977) but some species of diatom could grow in water with low dissolved oxygen such as *Navicula seminulum* and *Nitzschia amphibia.* Algae could not be found in water with very low or zero dissolved oxygen, the only species found was diatom in genus Nitzschia and Pleurosigma which produced mucus for cell coverage (Green, 1968).

กุสุมา สุภัทรากุล (2540) said that oxygen could be used in respiration process and phytoplankton can produce oxygen from photosynthesis process. Werner (1977) said that *Achnanthes minutissima* need high oxygen demand, *Navicula seminulum* and *Nitzschia amphibia* could highly grow in low oxygen demand, and *Nitzschia formalis* could live in water with lack of oxygen. Maitland (1978) reported that DO was very important factor for survival of aquatic life. DO demand depended on many factors such as temperature, atmosphere pressure, stream flow rate, photosynthesis rate, and respiration rate of aquatic life in water source. Palmer (2001) presented that DO was required for most aquatic life and was one of the most important receiving quality parameters. Typically, fish liked DO concentration of between 5 and 8 mg/liter.

2.2.8 Total Hardness

Smith (1950) said that calcium and magnesium were important to increase of number of plankton because they released bicarbonate to increase carbondioxide gas for photosynthesis process. Low hardness water with high alkalinity condition would have high pH problem during high growth of phytoplankton and algae due to lack of calcium for crytallation of carbonate, so, there was high increase of hydroxyl. The pH of water might be high (about 11) when water hardness was low (มั่นสิน ตัณฑุลเวศม์ และไพพรรณ พรประภา, 2538). Nevertheless, water hardness had high effect on bioproductivity because soft water would absorb less carbonmonoxide for photosynthesis of plant resulting in low productivity of the water source. Productivity of water would increase when hardness of water was higher than 30 mg/liter. If water had excess hardness, plant would not be able to absorb iron element in soil (ภานุ เทวรัตน์มณีกุล, สุจินต์ หนูขวัญ, กำชัย ลาวัณยวุฒิ, วีระ วัชรกรโยธิน และนวลมณี พงศ์ธนา, 2539). Water hardness had impact on type and number of phytoplankton. The green algae in order Volvocales such as *Valvox* sp. and *Pandorina* sp. could be found in high hardness water.

There were many yellow-green algae in-group of Coccolithophorids (Prescott, 1962) and *Microcystis*, *Chroococcus*, *Anabaena*, *Pediastrum*, *Staurastrum*, *Coscinodiscus*, and *Melosira*, etc. in high calcium water in tropical zone (Round, 1981). The large number of phytoplankton in desmids group, and some species of blue-green algae and green algae were found in low hardness water (Chapman, 1969). Nevertheless, กุสุมา สุภัทรากุล (2540) reported that desmids were found in water source with little hardness.

2.2.9 Acidity

กรรณิการ์ สิริสิงห (2525) said that water acidity was capability of water to release proton or hydrogen ion. The important acidity were carbon-dioxide acidity and mineral acidity. Scagel, Bondoni, Roure, Schofield, Stein, and Taylor (1967) studied relationship between distribution of diatom and pH of water and found that diatom would be in high number of families acidity of water (pH) ranging 4.0-6.5 but with low abundance of plankton in each family. พัชริดา เหมมัน (2543) also reported that high abundance of phytoplankton in water source would use carbondioxide gas for photosynthesis process until there would be shortage of free CO_2, plankton would use carbon dioxide from buffer system process causing of alkalinity compound from bicarbonate (HCO^-_3) to carbonate (CO^{2-}_3) and hydroxide (OH^-) respectively. It would result in increase of pH and change in abundance of plankton.

2.2.10 Alkalinity

The total alkalinity of seawater was the amount of hydrogen ion required to convert all the anions of weak acids to the unionized (Raymont, 1980). กุสุมา สุภัทรากุล (2540) said that diatom in genus *Achnanthes, Aaphora ovalis, Caloneis amphibaena, Navicula cryptocephala, N. gregaria, N. radiosa, Gyrisigma acuminatum, Nitzschia sigmoidea, Cymatopleura soleci* and *Cocconeis* were found in rather alkaline water.

2.2.11 Nutrient

ณฐกร ประดิษฐ์สรรพ์ (2543) reported that there were many essential nutrient but the most essential nutrient for growth of plant were nitrogen and phosphorus (ลัดดา วงศ์รัตน์, 2530). Phytoplankton would use nitrogen in form of nitrate, ammonia, urea and amino acids depending on type of plankton. Phosphorus was found in both organic form and inorganic form in natural water sources. The important component was orthophosphate in fresh and marine water (ลัดดา วงศ์รัตน์, 2530). Anderson (1997) reported that the ecology of the dominant freshwater planktonic diatom genera was well understood in terms of their responses to nutrients, light and temperature, and was derived from contemporary experimental and lake-survey data. Sommer (1989) studied about component of food in cell of various phytoplankton in fresh water and marine water. Results of the study can be summarized as follows:

1) Cyanophyta i.e. *Anabaena flosaquae* and *Chroococeus limneticus* consisted of more than 45% of phosphorus element component, about 9% more than nitrogen element.

2) Chlorophyceae especially *Sphaerocystic schroeteri*, *Ankyra judayi* and *Closterium acutum* consisted of 44% of nitrogen element component, the remaining were other element.

3) For Cryptophyceae i.e. *Rhodomonas minuta*, *Rhodomonas lens*, and *Cryptomonas ovata* about 57% of component was phosphorus.

4) For Prymnesiophyceae i.e. *Chrysochromulina parva*, major component was phosphorus element.

5) Dinophyceae: *Ceratium hirundinella* had nitrogen as main component, while *Peridium bipes*, *P. cinctum*, *P. umbonatum*, *P. inconspicuum* had phosphorus element as main component.

a) Nitrogen

Nitrogen is essential for photosynthesis and stability of protein structure. Protein, carbohydrate and fat are important components of life (ประมาณ พรหมสุทธิรักษ์, 2531). The nitrogen could be considered to exist in four components: phytoplankton nitrogen, organic nitrogen, ammonia, and nitrate (Palmer, 2001). The energy came from indirectly nitrogen absorption from photosynthesis process which would release hydrogen and carbon in the final stage of the process (Round, 1973). Nitrogen is a necessary nutrient for the growth of aquatic plants (Palmer, 2001). The protein production of plant was not only from photosynthesis but it also depended on carbohydrate and nitrate existence. Nitrogen had function in cell production. Many of organic matter had nitrogen component which could be found in plant especially high protein aquatic life such as algae which had amines, amino acids, nucleic acids and alkaloids. Phytoplankton would use many type of nitrogen compound such as nitrate, ammonia, urea, and amino acid. The forms nitrogen used depended on type of phytoplankton (Carpenter, Remsen, and Watson, 1972) but the most common forms of nitrogen used were nitrate and ammonia (Fogg, 1975). However, many algae were capable of using organically combined nitrogen, especially amino acids, urea, and purines, as their sole nitrogen source (Vymazal, 1995). The fixed-nitrogen would produce amino acid and protein. When microorganism was degraded, the protein would be changed to amino acid and then changed to ammonium ion. This ammonium would be directly used by plant or changed to nitrate because some plant could live together with microorganism which could fix nitrogen (Keeney, 1970). There was high quantity of phytoplankton in water source with high nitrogen. Many phytoplankton in blue-green algae group i.e. *Aphanizomenon flos-aquae* and *Microcystis aeroginasa*, green algae group in order Volvocales and group of Euglenoids i.e. genus *Phacus*, *Euglena* and *Trachelomonas* were found in fresh water with medium nitrogen. Some of diatom including *Molosira varians*, *Synedra ulna* and *Navicula viridula* could grow well in water with high nitrates (2-3 mg/liter). *Navicula cryptocephala* and *Nitzschia palea* also could grow well in water with high nitrate (Patrick, 1977). The result of study of Peter (1991) revealed that *Closterium aciculare* had specific relation with nitrogen compound in form of ammonia and could quickly grow in water source with high ammonia but it could not grow in other nitrogen compound sources. However, because much of the nitrogen was in an ammonia form, it exerted a high oxygen demand on the receiving water. Furthermore, high concentrations of ammonia were toxic to fish (Palmer, 2001). Moreover, some phytoplankton genus could fix nitrogen from atmosphere for usage such as *Oscillatoria*, *Trichodesmium*, and *Calothrix* (ลัดดา วงศ์รัตน์, 2530) and blue-green algae i.e. *Aphanizomenon* and *Anabaena* (Horne and Goldman, 1994). โสภณา บุญญภิวัฒน์ (2521) reported that nitrogen compound which was nutrient of microplankton such as ammonia had high effect on abundance of microplankton. Nitrate is another nitrogen compound that was nutrient of microplankton. It had low effect on abundance of microplankton. Some plankton, which used nitrate as nutrient, could grow better than that which used ammonia. The difference of nutrient need was compensation factor of phytoplankton. Most of phytoplankton would use nitrate and ammonia rather than other forms (Keeney, 1970). Palmer (2001) reported that domestic sewage (typically 25 to 30 mg/l of total organic nitrogen) and animal wastes contained high concentrations of organic nitrogen, which could cause eutrophication in the receiving water.

b) Phosphorus

Palmer (2001) reported that phosphorus was an aquatic plant nutrient. In natural freshwater receiving waters, phosphorus was frequently the nutrient that limits excessive aquatic plant growths. Domestic wastewaters were a source of phosphorus for the receiving water and could cause excessive aquatic plant growths, which would result in a degraded water quality. In most temperate fresh waters, phosphorus is the limiting nutrient for alga growth. (Rekolainen, Ekholm, Ulen, and Gustafson, 1997). Phosphorus is a macronutrient but its availability is often in the ng g^{-1} range. Phosphorus is an element which was often limiting for plant growth (Vymazal, 1995). Phosphorus had function in metabolism energy bond of P-O-P within polyphosphate molecule called energy rich phosphate. Polyphosphate would accumulate to be high-energy phosphate, which was energy source for synthesis nucleic acid, protein and cell division (Hammer, 1975). Phosphorus was in different forms of phosphate in natural water and wastewater such as orthophosphate, organic phosphate or condenses phosphate. These phosphate would be dissolved in the water or contained in plant and animal remains. Different phosphate forms could contaminate in natural water and wastewater such as phosphate from cloth washing wastewater, polyphosphate from fertilizer which was used in agriculture and contaminated in runoff in form of orthophosphate (กรรณิการ์ สิริสิงห, 2525). Vymazal (1995) reported that the principal form of phosphorus known to be directly available to plants was orthophosphate phosphorus. It was the only important inorganic phosphorus source for algae. Potentially available phosphorus forms included a large number of compounds that could be converted to orthophosphate and thus become available to algae. Phosphorus/ phosphate is element, which generate growth and produce protoplasm in plant and animal (ไมตรี ดวงสวัสดิ์ และจารุวรรณ สมศิริ, 2528). Phytoplankton cell could accumulate many phosphate when there was high organic matter in the water, these accumulated phosphate would be used when there was lack of phosphate in the water. When level of phosphate in water decreased, plant cell would produce alkaline phosphatase enzyme and would stop producing enzyme when normal phosphate condition was resumed. And, the lack of phosphate would affect growth rate of algae. Protein chlorophyll i.e. chlorophyll a, RNA and DNA would decrease but carbohydrate and starch would increase resulting in alteration of cell shape (ลัดดา วงศ์รัตน์, 2530). Round (1973) reported that the appropriate phosphorus quantities for growth of blue-green algae were 0.45 mg phosphate/liter for *Coccochloris peniocystis* and 0.002 mg phosphate/liter for *Asterionella formosa*. Otherwise, the growth of *Dinobryon* and *Uroglena* would decrease when quantity of phosphate was less than 0.005 mg/liter. Vymazal (1995) showed that as little as 1 μg/liter of phosphorus was sufficient to provide optimum growth of a diatom

Asterionella formosa in experiments. Sawyer and McCarty (1967) reported that there would be a few species of phytoplankton with high quantity in each species in water source with eutrophication condition such as blue-green algae i.e. *Microcystis aeruginosa*; *Oscillatoria rubescus*; *Anabaena spiroides*; *Aphamizomenom flos-aquae*, a few families of green algae, and dinoflagellates i.e. *Peridinium bipes*, and *Ceratium* sp. in highest quantity. โสภณา บุญญภิวัฒน์ (2521) reported that phosphate was very important nutrient element, which affected abundance of microplankton at water surface, and abundance of diatom and green algae.

Prescott (1962) reported that in water source with high phosphorus only a few phytoplankton species could be found but with high abundance in each species such as blue-green algae species i.e. *Microcystis, Oscillatoria, Anabaena,* few green algae species and high abundance of dinoflagellate species i.e. *Peridinium bipes, Ceratium* sp.

Hutchison (1957) reported that there was more organic phosphate compound than inorganic phosphate compound in fresh water. Increase of phosphate in water source would result in increase of abundance of algae growth in water source (นพรัตน์ ฤาชา, 2528). Gibson (1997) reported that the tendency for enrichment to increase the incidence of cyanobacterial blooms, sometimes toxic, provides a compelling third motive for the focus on phosphorus.

2.2.12 Sulfur

Vymazal (1995) reported that sulfur was an important bioelement. A large variety of sulfur-containing compounds were found in living cell. Sulfur was generally present in small quantity in all plant cells but was probably not a limiting factor for many algae under normal conditions. Sulfur was incorporated into numerous organic compounds and sulfates were present in the vacuoles. There was an evidence for the connection between divalent sulfur compounds and the assimilation of silica in diatoms. Sulfur was required by algae for both autotrophic and heterotrophic growth. Since most algae could supply all of their sulfur requirement by reduction of sulfate. Sulfite supported the growth of two blue-green algae and thiosulfate the growth of *Chlorella pyrenoidosa* at rates similar to sulfate. Both were good sources for *Porphyridium cruentum*. Among the amino acids, methionine and cysteine could act as a sole sulfur source for the growth of *Chlorella pyrenoidosa*. Methionine could also provide sulfur to several strains of *Chlorella*, *Anacystis nidulans* and *Anabaena variabilis*. *Chlorella vulgaris* was able to utilize either sulfate, D-methionine, or L-methionine as the only source of sulfur for growth. Uptake of sulfate by both *Chlorella pyrenoidosa* and *Scenedesmus* sp. was stimulated by light. Vymazal (1995) presented that *Chlorella pyrenoidosa* utilized thiosulfate for growth as effectively as sulfate, and more effectively than a variety of organic sulfur compounds containing sulfur in various oxidation states.

2.2.13 Biochemical Oxygen Demand, BOD

Palmer (2001) said that Biochemical Oxygen Demand (BOD) meant to the concentration of dissolved oxygen required to oxidize organic and inorganic substances expressed at a water temperature. พันทวี มาไพโรจน์ และศิริเพ็ญ ตรัยไชยาพร (2543) referred to the 5 day BOD was oxygen demand that bacteria used to degrade degradable organic matter at excess oxygen and temperature of 20 degree Celsius in 5 days. BOD indicated organic matter contamination in water that measured capability of water to dispose contamination under natural condition. Generally, BOD value came from DO concentration in initial day minus remaining of DO concentration after 5 days. Then, BOD was indicator value for water source pollution.

เปี่ยมศักดิ์ เมนะเศวต (2539) reported that BOD was oxygen measurement unit that microorganism used for degradation of organic suspension solid or dissolved in water. BOD was water quality indicator in water source. BOD was oxygen demand that bacteria used in organic matter degradation at excess oxygen condition but BOD showed degradation of organic matter, which was measured, from oxygen demand of bacteria. If there was excess organic matter in water source, it caused to lack of dissolved oxygen because oxygen demand of bacteria was needed to degrade organic matter (กรรณิการ์ สิริสิงห, 2525).

2.2.14 Oil and grease

Palmer (2001) reported that municipal wastewaters were a source of oils and grease. Most regulating agencies specify that surface grease and oils are undetectable by sight or smell (<0.1 mg/liter).

2.2.15 Calcium

Smith (1950) said that calcium and magnesium were important to increase in abundance of plankton because they produced bicarbonate, which would increase carbon dioxide gas for photosynthesis process. Water with low hardness and high alkalinity might have high pH problem. During high growth of phytoplankton and algae, if there was lack of calcium for carbonate crystallization, there would be high hydroxyl and high pH. The pH might be 11 in water with low hardness (มั่นสิน ตัณฑุลเวศม์ และไพพรรณ พรประภา, 2538).

Raymont (1980) reported that the reaction of CO_2 with water gave rise to protons, bicarbonate and carbonate ions. Most of the total carbon dioxide presented in the ocean, however, exists as bicarbonate and carbonate ions which had entered in river water, their charges being balanced mainly by the abundant cations Ca^{2+}, Na^{+}, Mg^{2+} and K^{+}. Bicarbonate and carbonate ions entering thus, were derived from continental weathering processes involving CO_2.

Vymazal (1995) reported that optimal concentration for algae was 0.03-0.5 mg/liter without chelate and 40 mg/liter with EDTA. In some algae, such as *Chara*, excess calcium was inhibitory; in *Chara* calcium level of 20 mg/liter greatly reduces the rate of photosynthesis. The calcium requirement of many species was considerably less than found in natural habitats. There seemed to be little evidence for the limitation of production from a direct lack of calcium, although relatively high concentrations seemed to be needed by some non-planktonic blue-green algae. Calcium ions undoubtedly played a part in the maintenance of cytoplasmic membranes and wall structures. It was also a major component of the walls of members of several algal classes. Some algal cells were able to utilize HCO_3^- directly in exchange for OH^-; and by this exchange process the pH of the bathing solution increased, ultimately causing the precipitation of $CaCO_3$. The nitrogen-fixing blue-green alga *Anabaena cylindrica* required macroquantities of calcium for growth regardless of whether the algae were given molecular nitrogen or nitrate nitrogen. However, Vymazal (1995) presented the evidence that calcium enhanced nitrogen fixation in the blue-green alga *Nostoc muscorum*. Calcium could partially substitute for magnesium in the growth of blue-green algae *Oscillatoria rubescens* and green algae *Ankistrodesmus falcatus*.

2.2.16 Magnesium

สถาบันวิจัยประมงน้ำจืด (2538) reported that magnesium was important nutrient element to growth of plant and algae because magnesium was a component of chlorophyll which had function as phosphate carrier, it helped in inflation of plasma and acceleration of enzyme relating to respiratory process. Moreover, magnesium would help produce lecithin, nucleoprotein, DNA and RNA.

Vymazal (1995) said that magnesium was a constituent of chlorophyll, was obviously an absolute requirement for pigmented algae of all groups and was also necessary for the formation of catalase. Magnesium is an essential cofactor or activator in many reactions, such as nitrate reduction, sulfate reduction, and phosphate transfers (except phosphorylases).

2.2.17 Sodium

Vymazal (1995) reported that sodium was required for photosynthesis, bicarbonate transport, urea and nitrate transport, silicate uptake, intracellular pH regulation, alkalotolerance and affect nitrate reduction in blue-green algae. However, Large amounts of sodium may be inhibitory, which may account for the lack of blue-green algae in marine environment. Sodium was not generally regarded as an absolute requirement for the majority of algae, but the blue-green algae are among the few plants that have an absolute sodium requirement. Sodium occurred in waters mostly as a simple cation Na^+. Photosynthesis in some blue-green algae has also been shown to be stimulated by elevated Na^+concentrations.

In addition, Vymazal (1995) reported that sodium ions increased the affinity of the diatom *Phaeodactylum* for HCO_3^- and even at high HCO_3^- concentrations sodium ions enhances HCO_3^- utilization. Since sodium and potassium had similar chemical properties, the early experiments dealing with sodium and algal growth were concerned with its possible replacement for potassium. Sodium might replace potassium, at least in part. The replacement of potassium by rubidium had been reported for a number of algal species.

2.2.18 Potassium

Vymazal (1995) reported that potassium was present in many algae in high concentrations relative to the external medium. Its functions included osmotic regulation and the maintenance of the electrochemical environment of the algal cells. It was also a cofactor for variety of enzymes. Potassium was known to be a highly mobile element, which got readily distributed during active growth. *Oscillatoria* sp. grew when potassium in the medium was replaced by sodium and presented very low requirements of blue-green algae for potassium. However, Vymazal (1995) said that very limited information was available on the transformation of potassium (as well as calcium and magnesium) under waterlogged situations.

2.2.19 Chlorophyll a

สมชาย สุรวิทย์ (2539) reported that all of species of phytoplankton had chlorophyll a, which was green chlorophyll with very great importance for photosynthesis. The property of chlorophyll a which had chemical formula of

$C_{55}H_{72}O_5N_4Mg$, was that it could not dissolve in water but it could dissolve in organic solvent (Fogg, 1975). In normal case, chlorophyll a would be about 0.5-1.5% of dry weight of phytoplankton and could be about 6% of weight of phytoplankton in soft light condition. Prescott (1962) reported that there was low quantity of chlorophyll a at water surface with very high transparency of water in Crystal lake, Wisconsin State and more quantity could be found near the waterbed. The found planktons were 15 species of benthic desmids.

The measurement of chlorophyll a could indicate approximate biomass of phytoplankton in water (ลัดดา วงศ์รัตน์, 2530). In general, amount of chlorophyll a would have correlation with phytoplankton quantity in direct variation. ลัดดา วงศ์รัตน์ (2530) reported that when abundance of phytoplankton increased in water source, chlorophyll a could increase too. Therefore, abundance of phytoplankton had positive relationship with chlorophyll a. Moreover, chlorophyll depended on physical, chemical and biological properties such as stratification of water, water temperature, light, nutrient (Pennock, 1985).

2.3 Related Plankton Research and Documents

The study of ธิดาพร หรบรรพ์ (2540) found that in Bang Pakong river, the quantity of total phytoplankton were positively related to water temperature, pH, transparency, total suspended solid, salinity, and nitrate while those of phylum Bacillariophyta were positively related to water temperature, pH, total suspended solid, salinity, and nitrate but those of phylum Chlorophyta were negatively related to total suspended solid, salinity, nitrate, and total phosphorus; those of phylum Pyrrophyta were positively related to transparency; and those of phylum Euglenophyta were positively related to orthophosphate. The amount of chlorophyll a, were positively related to water temperature, total suspended solid, ammonia and total phosphorus, as well as to the abundance of phytoplankton in phylum Bacillariophyta and the total phytoplankton.

ผุสดี เทียนถาวร (2540) reported that a total of 66 genera in 6 phyla of phytoplankton recorded comprised 25 genera of Bacillariophyta, 23 genera of Chlorophyta, 10 genera of Cyanophyta, 4 genera of Pyrrophyta, 3 genera of Euglenophyta and 1 genera in Chrysophyta. Phylum Cyanophyta was negatively related to temperature and positively related to nitrate, phylum Chlorophyta was positively related to ammonia and nitrate, phylum Bacillariophyta was negatively related to temperature and positively to ammonia, nitrate and chlorophyll a; while those phyla of Chrysophyta, Pyrrophyta and Euglenophyta had no significant relation with any parameters of water quality. The total phytoplankton were negatively related to temperature and positively to ammonia, nitrate and chlorophyll a.

The study on seasonal variation of type and density of plankton within Tha Chin river of พิศมัย เฉลยศักดิ์ (2543) found that two hundred and six species were identified; 156 species of phytoplankton and 50 species of zooplankton. Numbers of species of phytoplankton in each class are as follows: Cyanophyceae (19), Chlorophyceae (63), Euglenophyceae (27), Bacillariophyceae (37), Chrysophyceae (2), and Dinophyceae (6). Numbers of zooplankton species in each phylum are as follows: Protozoa (21), Rotifers (23), and Arthropoda (6). There were relationships between plankton abundance and water qualities. Positive relationships were temperature, pH, salinity, dissolved oxygen, nutrients, chlorophyll a, negative relationship was transparency. Zooplankton abundance had positive relationships with water qualities (pH, salinity, and dissolved oxygen) but negative relationships with temperature and transparency.

ณฐกร ประดิษฐ์สรรพ์ (2543) reported that a total of 130 genera 233 species in 3 division of phytoplankton recorded comprised 66 genera 82 species of Chromophyta, 49 genera 115 species of Chlorophyta, 15 genera 36 species of Cyanophyta and a total of 59 genera 88 species in 5 phyla of zooplankton recorded comprised of 33 genera 38 species and 2 unidentified of Protozoa, 16 genera 40 species of Rotifera, 10 genera 10 species and 7 unidentified of Arthropoda, Bivalve larvae and Gastropod larvae of Mollusca and Annelid larvae of annelida. Phylum Cyanophyta, Chlorophyta, Chromophyta and total phytoplankton were positively related to total suspended solid, salinity, pH, alkalinity, total hardness, dissolved oxygen, BOD, ammonia, nitrate, orthophosphate, total phosphorus and chlorophyll a. Phylum Protozoa, Rotifera, Annelida, Arthropoda, Mollusca and total zooplankton were positively related to salinity, alkalinity, total hardness, ammonia, nitrate, orthophosphate and chlorophyll a.

สมชาย สุรวิทย์ (2539) reported that phytoplankton found in Ratcha-Prabha reservoir were of 6 phyla or 105 genera. They comprised of 60 genera of phylum Chlorophyta, 22 genera of Bacillariophyta, 16 genera of Cyanophyta, 3 genera of Euglenophyta, 2 genera of Pyrrophyta and 2 genera of Chrysophyta. Phylum Chlorophyta was positively related to dissolved oxygen, alkalinity, nitrate, total phosphorus and orthophosphate. Phylum Bacillariophyta was positively related to free carbondioxide, total hardness, and calcium. Phylum Chlorophyta was positively related to total hardness and calcium. Phylum Euglenophyta were negatively related to dissolved oxygen and positively related to free carbondioxide, calcium, conductivity, and total nitrogen. Phylum Pyrrophyta was positively related to total hardness, calcium total nitrogen, ammonia, nitrate, total phosphorus and orthophosphate. The total phytoplankton was positively related to total hardness, calcium, total phosphorus, orthophosphate and chlorophyll a.

พัชริดา เหมมัน (2543) reported that the phytoplankton found in Black Tiger Shrimp culture ponds and water supply canal were of 5 phyla or 58 genera comprising 16 genera of phylum Cyanophyta, 22 genera of phylum Chlorophyta, 15 genera of phylum Bacillariophyta, 1 genus of phylum Chrysophyta and 4 genera of phylum Pyrrophyta. A relationship between water quality and number of phytoplankton was also studied. It was found that number of phytoplankton has a reversed relationship with salinity, transparency, BOD and phosphate, while it has a direct relationship with pH, dissolved oxygen, NO_2-N, NH_3-N and alkalinity.

Jarvinen (2002) reported that phytoplankton production could be limited by nitrogen (N) rather than phosphorus (P) in brown-water lakes.

2.4 Database and Database System

2.4.1 Data

Merriam-Webster, Incorporated (1993) defined data in Merriam-Webster's Collegiate Dictionary as follows:

1) Factual information (as measurements or statistics) used as a basis for reasoning, discussion, or calculation.

2) Information output by a sensing device or organ that includes both useful and irrelevant or redundant information and have to be processed to be meaningful.

3) Information in numerical form that could be digitally transmitted or processed.

Data are facts represented by values-numbers, character strings, or symbols which carry meaning in a certain context (Everest, 1986).

สุระ พัฒนเกียรติ (2546) reported that data were facts or occurred events. They were group of symbol representing quantity or other activities that had not been interpreted and analyzed. The data were numeric values (quantity), text letter, document, picture and sound and unassessed information.

Webster's Dictionary defined data as: "things known or assumed; facts or figures from which conclusions can be inferred." (Everest, 1986).

Everest (1986) said that the American National Standards Institute (ANSI) offered a dual definition for data:

1) A representation of facts, concepts, or instructions in a formalized manner suitable for communication, interpretation, or processing by humans or by automatic means.

2) Any representation such as characters or analog quantities to which meaning is or might be assigned. Generally, we perform operations on data or data items to supply some information about an entity.

2.4.2 Database

Merriam-Webster, Incorporated (1993) defined database in Merriam-Webster's Collegiate Dictionary that Database meant a usually large collection of data organized especially for rapid search and retrieval (as by a computer).

สุระ พัฒนเกียรติ (2546) reported that database was a group of data or data file that comprised table. Each table comes from Field which was collected in terms of relationship. It helped to reduce redundancy of data during data collection including help to find out data, and keep it in sequence. It facilitated use and regular updating of data.

Database is a mechanized, shared, formally defined, and centrally controlled collection of data used in an organization (Everest, 1986).

Database is a computer term for a collection of information concerning a certain topic or business application (Prague and Irwin, 1997).

2.4.3 Database System

สุระ พัฒนเกียรติ (2546) reported that system was set of components or units that interrelate in functions or activities to achieve the objective and database system was a system of collected data in form of database which had interrelation to support operation of organization.

Date (1995) reported that the advantages of a database system consisted of:

1) Compactness: No need for possibly voluminous paper files.

2) Speed: The machine could retrieve and change data far faster than a human could. In particular, ad hoc, spur-of-the-moment queries could be answered quickly without any need for time-consuming manual or visual searches.

3) Less drudgery: Much of the sheer tedium of maintaining files by hand was eliminated. Mechanical tasks were always better done by machines.

4) Currency: Accurate, up-to-date information was available on demand at any time.

2.5 Database System Component

สุระ พัฒนเกียรติ (2546) reported that generally, database system related with 4 major components as:

1) Data

2) Hardware such as Secondary Storage, CPU., Main RAM

3) Software i.e. Database Management System (DBMS)

4) Users which could be categorized in 3 groups as

- Application Programmer had a function for program application.
- End User was user of data from database system.
- Database Administrator (DBA) was a director who controlled and made decision to determine database structure, data type, data storage method, pattern for data using, data security and internal control data regulation.

A computer-based data processing system has four basic components: machines, programs, data, and people. Machines and programs are also called hardware and software (Everest, 1986).

2.6 Database Management System (DBMS)

A database management system (DBMS) is a computer-based system to mange a database, or a collection of databases or files (Everest, 1986).

สุระ พัฒนเกียรติ (2546) reported that DBMS meant program which function for interconnection between user and database for management and accuracy control, redundancy control, and relationship between data in database including inquiry and improvement of data. In connection with data in database command order was used. DBMS program would compile command order to operation for action with data in database.

2.6.1 Database Management System (DBMS) Component

1) Authorized User's Profiles mean component on control management such as to set up password for users or agencies.

2) Catalogued Queries/ Report/ Label Definition mean to control management section for requirement on data searching, summarized table reports.

3) Transaction and Screen Definition mean set of program which controls management in data presentation via monitor or to respond user request.

4) User's Application Programs mean specific program that was designed to be used in specific organization or to respond specific request of users in some level.

5) Data Definition and Stored Database mean total storage of data.

2.6.2 Function of Database Management System (DBMS)

DBMS Program has function as follows:

1) Compile management command order of data in database into the form, which database understands.

2) Bring compiled command orders to database work by order such as Retrieve data, Update data, Delete data, Add data, etc.

3) Damage protection for data in database, it will check work command order whether it would work or not.

4) Regularly keep correct relationship of data in database.

5) Keep description related to data in database in Data Dictionary. These description was called Matadata.

6) Control correctness and efficiency of database work.

2.7 Steps of System Development

สุระ พัฒนเกียรติ (2546) reported that the system development had to be planned and appropriate tools had to be chosen for efficient work system. The steps of system development are as follows:

2.7.1 Problem Definition

Problem Definition is preliminary study on work system to know problems from analysis as follows:

1) Existing Problem Analysis: In information system development, it is necessary to know responsible agency of existing information system, existing information system components, document or data of existing information system, existing methodology of information system and current problem in order that

development and improvement of system are compatible with existing information system.

2) Need from New Development System Analysis: It is analysis of need and pattern of information system that get information system to respond request of user and to be in accordance with existing information system.

3) Analysis of existing technology, personnel and resource of agency. It is analysis for checking technology, resource of agency such as personnel, materials and equipment, machines, data, program, budget and benefit of project implementation.

2.7.2 Feasibility Study

As known the problem from operation, there was feasibility study to solve the problem and to consider appropriate alternative with system from many factors such as feasibility in collection and existing data usage, feasibility of technology and resource, feasibility of operation, feasibility of time, feasibility of criteria and financial feasibility or feasibility of budget (สุระ พัฒนเกียรติ, 2546).

2.7.3 System Analysis

สุระ พัฒนเกียรติ (2546) reported that System Analysis was study on existing work system from interview, question, observation and literature review. It was to understand development work system in terms of characteristic of work system, description, user request, need from new work system, scope of work. The tools of analysis and design work system comprise:

1) Context Diagram. It is diagram that shows scope of work system. It shows some data that relate to system and it is overview of system.

2) Data Flow Diagram (DFD). It is diagram that shows source of data, end of data, storage of data, interpretation of data and total data flow diagram of system. It is to create understanding on way of data flow into system, process or steps and overall answer from system. It is written in graphical symbol.

3) Data Dictionary. It is reference, which explains total description of data in system. It is definition and pattern of data, which shows components of system comprising type of data, meaning of data and characteristic of data and limitation of data.

2.7.4 System Design

After development system has been analyzed from problem and feasibility study, the next step is system design for understanding and clearing (สุระ พัฒนเกียรติ, 2546). Description of system can be designed as follows:

1) Output Design: It is presentation design data of monitor in terms of user request report and data print from printer. This data will be sent to user.

2) Input Design: It is record form for filling data into system.

3) Database Design: The database design methodology could be summarized as follows:

- Request user data collection from system analysis.
- Database Design. It uses entity relationship diagram to show relationship of data that consisted of entity, attribute, relationship and degree of relation.
- Determine key such as primary key, candidate key and foreign key. It is used to refer to data from table.

- Set up pattern of interesting things and mapping into table and make table into normal form by normalization that is data analysis pattern to reduce redundancy, reduce error from addition, improvement and delete data in table.

Prague and Irwin (1997) reported that the seven-step method for database design consisted of:

1) Overall system design

2) Report design (Output)

3) Data design (Fields)

4) Table design (Relationship)

5) Field design (Validation)

6) Form design (Input)

7) Menu design (Automation)

2.7.5 System Development

สุระ พัฒนเกียรติ (2546) reported that when system was designed and constructed or was implemented to set up program, appropriate program had to be chosen. In former work system, program was minor database system that separated work in each topic and did not relate with each other. The edit of structure of data or program was difficult because it was necessary to edit related minor programs. There was software of Database Management System (DBMS) or Database Management Program. It had capability of data collection in same resource for correctness of data and decrease in redundancy of data. It could efficiently use retrieve data and search data in database and construct information system to be easy for storage, retrieval, inquiry and reporting. Microsoft Access program was a program that had database management system and had database management relationship. It was work on windows system and had user interface by Graphic User Interface (GUI) which was user friendly.

2.7.6 Testing

It is testing program to find out problem and bugs. It is to debug to correct before actual work. The testing system has to be carefully planned for completation and efficient testing (สุระ พัฒนเกียรติ, 2546).

2.7.7 Implementation

สุระ พัฒนเกียรติ (2546) reported that the complete work system was implemented including setting up training course for new system for related personnel, setting up system and installing new program into computer of organization, preparing document or manual of system to explain correct step of program uses and internal data management.

2.7.8 Maintenance

Generally, information system would be regularly changed. It would affect data file, document, system work and instructions. Then, it must be regularly maintained for efficiency of system (สุระ พัฒนเกียรติ, 2546).

2.8 Benefits of the Database Approach

Date (1995) reported that some of the specific advantages that accrued from the notion of centralized control of the data were as follows:

1) Redundancy could be reduced.

2) Inconsistency could be avoided (to some extent).

3) The data could be shared.

4) Standards could be enforced.

5) Security restrictions could be applied.

6) Integrity could be maintained.

7) Conflicting requirements could be balanced.

Chapter III

Research Procedure

3.1 Research Methodology

The research methodology comprises data collection, data analysis, field survey for data collection, data analysis, fittest model analysis, fittest model comparison, water quality and plankton database design and water quality and plankton database system preparation.

3.2 Data Collection and Data Analysis

3.2.1 Data Collection

1) Sources of Data

Data were collected from documents, papers, reports such as Fishery research reports, Environmental Impact Assessment (EIA) reports, Environmental monitoring reports, etc. With reference to Article 46 of the Enhancement and Conservation of National Environmental Quality Act, B.E. 2535. The Ministry of Science Technology and Environment issued Ministerial Decrees setting EIA requirement for sizes and types of projects. For projects that require construction permits from government agencies, the project proponents have to submit the EIA reports to the agencies concerned and Office of Natural Resources and Environmental Planning and Policy (ONEP). Construction permits can only be issued after the EIA reports are endorsed by ONEP. ONEP prepared guidelines for preparing EIA reports and operation manual for environmental monitoring and audit; the guidelines include manual for water quality and aquatic ecology study. The water quality and aquatic ecology studies are parts in EIA and environmental monitoring reports. Therefore, the water quality and aquatic ecology data can be selected from EIA and environmental monitoring reports. The selected data must be from samplings conducted in the same time from fresh, stagnant water such as reservoir, pond, swamp, etc. Data on water quality and plankton are of totally 28 water sources in four regions in Thailand. There are 109 water quality and plankton data. The detail of water source data, location and period of sampling are presented in Table 1.

2) Collection of Data on Water Quality and Aquatic Ecology

a) Collection of Data on Water Quality

Data on water quality were collected from EIA reports and related reports. The water quality data were investigated and analyzed to follow standard method of water quality analysis such as water temperature, pH, transparency, depth of water, turbidity, conductivity, dissolved oxygen, total solid, total dissolved solid, suspended solid, total hardness, chloride, acidity, alkalinity, nitrate-nitrogen, nitrite-nitrogen, organic-nitrogen, total nitrogen, ammonia-nitrogen, sulfate, phosphate, biochemical oxygen demand, chemical oxygen demand, oil&grease, calcium, sodium, potassium and chlorophyll a. Data on water quality parameter would be selected at the same time and the same station for plankton sampling.

Table 1. Water source of water quality and plankton data in Thailand.

Water Sources	Location	Sampling Period
Small reservoir		
1. Krok Mai Daeng Reservoir	Chakkarat district, Nakhon Ratchasima province.	September 17, 1993 and January 22, 1994.
2. Nong Song Hong reservoir	Chakkarat district, Nakhon Ratchasima province.	September 17, 1993 and January 22, 1994.
3. Bueng Tan Dieo (pond)	Kaeng Khoi district, Saraburi province.	July 14, 1996.
4. Bueng Bang Amphan (pond)	Bamnet Narong district, Chaiyaphum province.	February 15-16, 1996.
5. Bueng Thale (pond)	Bamnet Narong district, Chaiyaphum province.	February 15-16, 1996.
6. Sa Kaeo (pond)	Bamnet Narong district, Chaiyaphum province.	February 15-16, 1996.
7. Small reservoir of EGAT.	Nua Khlong Pre-district, Krabi province.	January 20, 1996 and March 13-14, 1996.
8. Major reservoir of EGAT	Nua Khlong Pre-district, Krabi province.	March 13-14, 1996.
9. Nong Na Tan (reservoir)	Kumphawapi district, Udon Thani province.	September 28, 1996.
10. Nong Lat (pond)	Thawat Buri district, Roi Et province	December 1, 1994.

Table 1. Water source of water quality and plankton data in Thailand. (continued)

Water Sources	Location	Sampling Period
11. Nong Hong (pond)	Thawat Buri district, Roi Et province.	December 1, 1994.
12. Bueng Kaeng Nam Ton (pond)	Muang district, Khon Kaen province.	January 11-12, 1991.
13. Nong Yai (pond)	Phatthana Nikhom district, Lop Buri province.	August 31-September 1, 1996.
14. Pond infront of Udon Thani airport	Muang district, Udon Thani province.	September 24, 2000.
15. Huai Nong Khem reservoir	Phonsawan district, Nakhon Phanom province.	September 29-30, 1997 and March 5-6, 1998.
16. Kud Pla Khao (pond)	Tha Uthen district, Nakhon Phanom province.	September 29-30, 1997 and March 5-6, 1998.
17. Small reservoir in Salaeng sub-district	Muang district, Chanthaburi province.	March 16-24, 1994 and August 11-14, 1994.
18. Upper Retention pond	Pak Chong and Sikhiu district, Nakhon Ratchasima province.	October 31, 2002.
19. Huai Phan Sadet reservoir	Sriracha district, Chonburi province.	March 8, 1995.

Table 1. Water source of water quality and plankton data in Thailand. (continued)

Water Sources	Location	Sampling Period
Large reservoir		
20. Nong Han Kumphawapi (reservoir)	Kumphawapi district, Udon Thani province	September 28, 1996 and January 21, 1991.
21. Thale Noi (lake)	Khwuan Khanun district, Patthalung province.	January 27- February 1, 1994.
22. Nong Leng Sai (pond)	Mae Chai district, Phayao province.	April 2, 1997.
23. Mae Kham reservoir	Mae Moh district, Lampang province.	November 19, 1993.
24. Mae Chang reservoir	Mae Moh district, Lampang province.	November 19, 1993.
25. Kew Lom reservoir	Chae Hom district, Lampang province.	November 6, 1995 December 26, 1995 March 7, 1996. May, August and November, 1989. February, 1990.
26. Nong Han (pond)	Muang district, Sa Kon Nakhon province.	December 24, 1993.

Table 1. Water source of water quality and plankton data in Thailand. (continued)

Water Sources	Location	Sampling Period
27. Lam Ta Khong reservoir	Pak Chong and Sikhiu district, Nakhon Ratchasima province.	July 22, 1994. September 15-16, 2000 December 21-22, 2000 February 24-25, 2001 May 8-9, 2001 August 12-13, 2002 October 23-24, 2002.
28. Khiritharn reservoir	Makham district, Chanthaburi province.	March 16-24, 1994 and August 11-14, 1994.

b) Collection of Data on Aquatic Ecology

Data on aquatic ecology is focused on plankton data especially phytoplankton and zooplankton. The data on plankton are collected from identified plankton results in EIA reports and related reports. Data on plankton are reported in terms of phylum, genus and species including abundance of plankton species. The abundance of plankton species are presented in unit cell per cubic meter of water. The data of plankton is presented in term of abundance and plankton species in each sampling station.

3.2.2 Data Analysis

The MINITAB program was used for statistical analysis of water quality and plankton data. The MINITAB program can be download from www.minitab.com.

The detail of MINITAB program was presented in manual guidebook of Meyer and Krueger (2001).

1) Analysis of Basic Statistics of Data

All of water quality and plankton data were initially analyzed with basic statistic. Each data parameter was analyzed for mean, standard deviation, maximum value, minimum value, etc. The results of analysis of basic statistics of data were presented in normal distribution curve.

2) Analysis of Relationships and Correlation of Data

The relationships of data were studied between 2 factors of linear correlation analysis, while the others factors were fixed constant because all of factors were quantitative factors. Then, the correlation coefficient (r) is quantitative and direction. The correlation coefficient values are between -1 to 1. If average correlation coefficient value is equal to -1, it means that it has perfect negative correlation. In contrast, if average correlation coefficient value is equal 1, it means that it has perfect positive correlation or direct relationships. In case of the average correlation coefficient value is equal to 0, it means that there is no correlation or there is no linear correlation between 2 factors.

3) Fittest Model Analysis

The fittest model analysis was analyzed by regression method. The regression analysis is a method to find out function and relationship patterns that are used to predict study factors such as abundance of plankton in each phylum, species of plankton in each phylum. The forecast of study factors will use knowledge on other related factors or more than 1 such as water quality parameters i.e. water temperature, DO, BOD, COD, etc. The regression analysis will use first factor selection in regression line. The stepwise method is mostly used for first factor selection. The step of stepwise consists of forward and backward steps. Therefore, selection criteria consist of 2 aspects such as selection criteria that a predictor is to be entered or removed from the equation. The F-statistic determines significant level at 0.05 or less than 0.05 for entered selection criteria and determines significant level at 0.1 or more than 0.1 for removed selection criteria. Generally, the F-statistic significant level of entered selection criteria must be lower than removed selection criteria. Therefore, if p-value is less than or equal to significant level, each first factor would pass into regression line and if p-value is more than or equal significant level, the predictor will not pass, it would be removed out from regression line.

The fittest model analysis for water quality and abundance of plankton in each phylum are detailed in Appendix A. However, steps of analysis can be summarized as below:

a) Relationships between water quality and abundance of plankton in each phylum was analyzed by stepwise. It analyzed data between 29 parameters of water quality (Independent Variable, X) and 1 phylum of abundance of plankton (Dependent Variable, Y).

b) Some of water quality data were rejected data because it had missing data in some parameter and some of water quality data had to be rejected which to reduce error and incorrect of equation. However, all of data had more than 30 number of data in order to acceptable event following to the Central Limit Theorem (คณาจารย์ภาควิชาคณิตศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย, 2537; พิศมัย หาญมงคลพิพัฒน์, 2545).

c) It was needed to consider coefficient of determination (R^2) value at more than 0.65 after finishing analysis between water quality parameter and abundance of plankton in each phylum. After that they would be analyzed together for fittest model with regression analysis.

d) The regression analysis results were considered on 4 parameters i.e. Durbin-Watson value, residual value, Variance Inflation Factor (VIF) and normal distribution curve.

- Durbin-Watson value is autocorrelation value test. The Durbin-Watson value is compared with D_U and D_L in Table of Durbin-Watson. The detail of Durbin-Watson value consideration is presented below:
  - Appropriate Durbin-Watson value ranges between D_U-(4-D_U). It shows that both of predictors are free.
  - If Durbin-Watson value is < D_L, it shows that both of predictors are positive correlation. If Durbin-Watson value is close to 0, it shows that both of predictors have high continuous positive correlation.
  - If Durbin-Watson value is >4-D_L, It shows that both of predictors are negative correlation. If Durbin-Watson value is more than 2.5, it shows that both of predictors have high negative correlation.
  - If Durbin-Watson value does not follow above criteria, data of Dependent Variable must be edit by take ln, take log, take square, take $\sqrt{\ }$ or 1/Y. After that, the edited data will be regression analysis again.

• Residual value is considered by graph and distribution of data. The data is normal distribution and all data have nearly even values, line of graph is in 45-degree linear characteristic. In case data scatter out of data group, it is called "Outlier" which must be removed from group of data before regression analysis again.

• Variance Inflation Factor (VIF) is used to check correlation between independent variance. Appropriate VIF must not close to 0.

• Normal distribution curve is used to check performance of data to be used in regression analysis. If data have normal distribution, graph is symmetry curve; it shows that the data is appropriate for regression analysis. In case normal distribution curve is on the left skew or on the right skew, some data must be edited and then analyze again.

e) In case the 4 regression analysis results are correct and appropriate following criteria, the analysis result can be presented in terms of equation between Independent Variable (X) or water quality parameters and Dependent Variable (Y) or plankton parameter.

3.3 Fittest Model Comparison

3.3.1 Field Survey for Data Collection

1) Location of Study Site

Lam Ta Khong reservoir was selected for field investigation because it is stagnant water source and located near the laboratory. Lam Ta Khong reservoir is a component of Lam Ta Khong dam that storage water for electric power production and water use purposes. It is located in Pak Chong district and Sikhiu district, Nakhon Ratchasima province. Lam Ta Khong reservoir has capacity of water about 324 million cubic meters. The 4 designated water quality and plankton sampling stations consist of (1) southern part of Lam Ta Khong reservoir (2) western part of Lam Ta Khong reservoir (3) northern part of Lam Ta Khong reservoir and (4) eastern part of Lam Ta Khong reservoir (Figure 1).

2) Water Quality Data Collection

Water quality sampling was conducted at water surface (0-30 cm from water surface). The water quality sampling investigation and analysis followed American Public Health Association, American Water Works Association, and Water Environment Federation (1995). The water quality samples were preserved by refrigerant at temperature 20 degree Celsius. The water quality samples were analyzed with 29 parameters as water temperature, pH, transparency, depth of water, turbidity, conductivity, dissolved oxygen, total solid, total dissolved solid, suspended solid, total hardness, chloride, acidity, alkalinity, nitrate-nitrogen, nitrite-nitrogen, organic-nitrogen, total nitrogen, ammonia-nitrogen, sulfate, phosphate, biochemical oxygen demand, chemical oxygen demand, oil & grease, calcium, sodium, potassium and chlorophyll a. The standard methods of water quality parameter analysis are presented in Table 2.

3) Plankton Data Collection

Plankton sampling was conducted at water surface (0-30 cm from water surface). Plankton samples were collected by plankton net size 59 micron and pouring 20 liters of water through plankton net. Plankton sample was collected and preserved by 4 % of formalin solution. Plankton samples were sent to identify abundance and plankton species at Aquaculture Department, Faculty of Fishery, Kasetsart University. The abundance of plankton unit is cell per cubic meter of water.

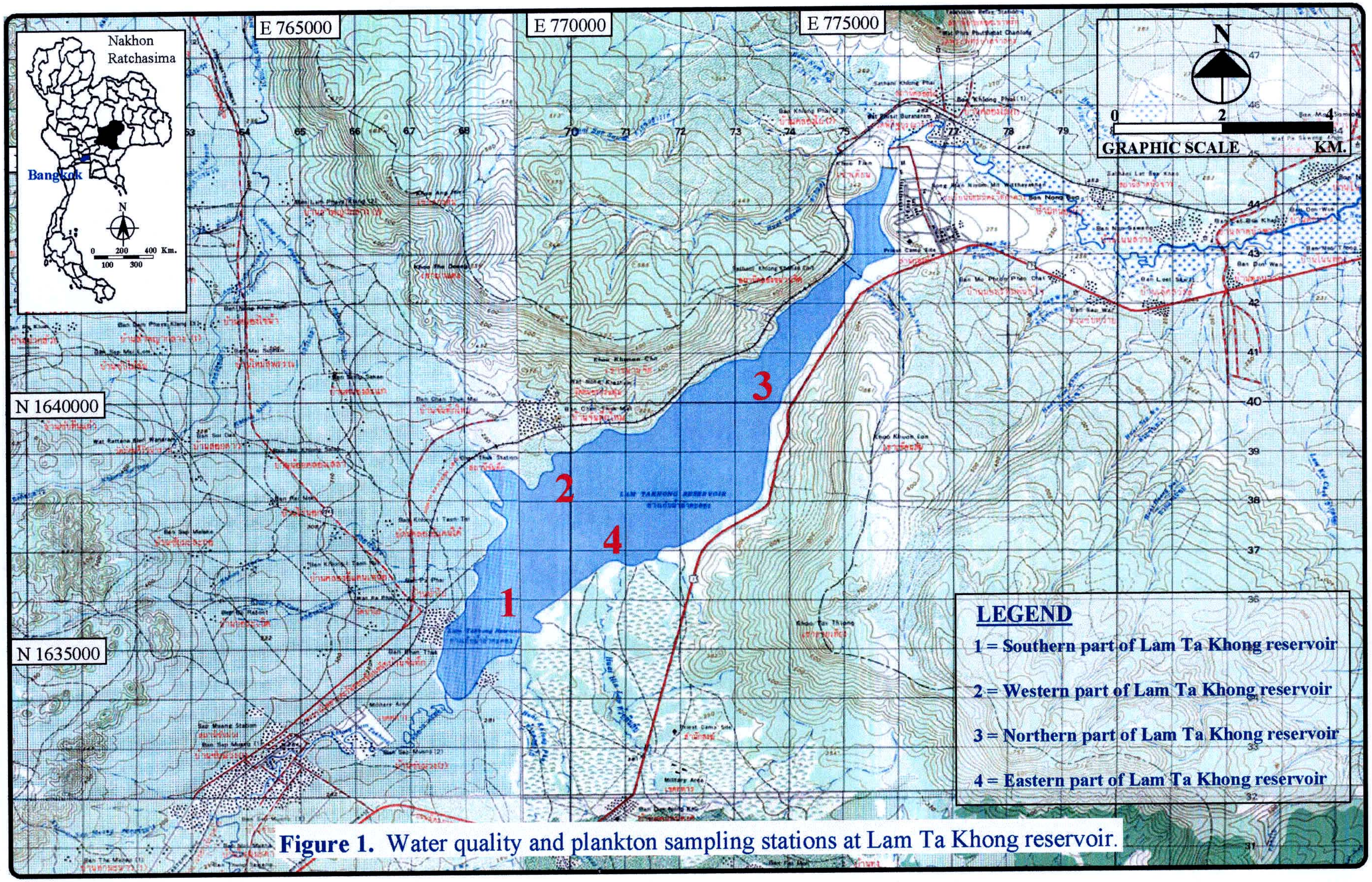

Figure 1. Water quality and plankton sampling stations at Lam Ta Khong reservoir.

Table 2. The standard methods of water quality parameter analysis.

Water Quality Parameter	Analysis Method
Temperature	Thermometer
Transparency	Secchi disc
Turbidity	Turbidimeter
pH	pH meter
Dissolved Oxygen (DO)	DO meter
Conductivity	Conductivity meter
Biochemical Oxygen Demand (BOD)	Azide modification; 20^{o}C, 5 days
Chemical Oxygen Demand (COD)	Open reflux method
Total Solids (TS)	Dried at 103-105^{o}C
Total Dissolved Solids (TDS)	Dried at 103-105^{o}C
Suspended Solid (SS)	Glass fibre filter disc.
Total hardness	EDTA titrimetric method
Total acidity	Titration method
Total alkalinity	Titration method
Total phosphate	Ascorbic acid method
Total nitrogen	Kjeldahl method
Nitrate-nitrogen (NO_3-N)	Cadmium reduction method

Table 2. The standard methods of water quality parameter analysis. (continued)

Water Quality Parameter	Analysis Method
Nitrite-nitrogen (NO_2-N)	Cadmium reduction method
Ammonia-nitrogen (NH_3-N)	Indophenol method
Organic-nitrogen (Organic-N)	Kjeldahl method
Sulfate	Turbidimetric method
Chloride	Mercuric nitrate method
Calcium	EDTA titrimetric method
Magnesium	Calculation method
Sodium	Flame emission photometric method
Oil & grease	Parpition-gravimetric method
Potassium	Atomic absorption method
Chlorophyll a	Algal biomass indicator

3.3.2 Comparison between fittest model analysis result and field survey data

After conducting water quality and plankton sampling at 4 stations in Lam Ta Khong reservoir, water quality and plankton samples will be analyzed in laboratory by American Public Health Association (APHA), American Water Works Association (AWWA), and Water Environment Federation (WEF) (1995) standard methods for water quality analysis (Table 2). The results of water quality investigation from field survey and laboratory analysis of each station will be substituted in fittest models from fittest model analysis result for projection abundance of plankton in each phylum.

The abundance of plankton in each phylum from substituted water quality values is expected value. The expected values will be compare with abundance of plankton in each phylum from field survey and directly count in laboratory (observed value). Then, expected values will be compared with observed values in terms of graph and table for consideration of abundance of plankton in each phylum from fittest model.

3.4 Design of Database System of Water Quality and Plankton of Reservoirs in Thailand

The steps of water quality and plankton database system design consist of:

1) To collect data on water quality and plankton from stagnant water. These data were analyzed for relationships and correlations between water quality and plankton.

2) To design system, the detail are as follows:

a) Output design: monitor of computer presents the output data. The output data comprise water quality report, abundance of plankton and plankton species report, sampling station, sources of data, photo of sampling station, photo of plankton species found and related data that user requires. All of output data can be print out by printer.

b) Input design: it is record pattern design to fill up water quality and plankton data of stagnant water that investigated in the same time. The related data i.e. sampling station, sources of data, photo of plankton species, etc. are added to system.

c) Water quality and plankton database design: the steps of database design can be summarized as follow:

- System analysis, determine criteria for data set up, retrieve of data, and data management procedures.
- Database design by using entity relationship diagram which presents water quality and plankton data relationship. The diagram consists of entity, attribute, relationship and degree of relation.
- Determine key such as primary key, candidate key and foreign key for data reference from tables.
- Design pattern of interested data and mapping into table and change table to normal form by normalization process which it is data analysis pattern to reduce redundancy of data and reduce error from adding, improving and deleting of data in table.

3) Use Microsoft Access to construct system or to develop water quality and plankton program. Microsoft Access program is a database management system, which can manage database and relationship of data. Microsoft Access is run on Window Operation and user friendly.

4) Program testing is a process to find out bugs and obstacles in system and debugs to correct before program implementation.

5) To prepare document and user manual. It can explain interested person and organization about correct steps of program implementation.

3.5 Instrumentation

3.5.1 Water Quality Sampling and Analysis Equipment

1) Polyethylene bottle size 5 liter and 1 liter
2) BOD bottle
3) Beaker size 2 liter
4) Separatory funnel
5) Buchner funnel
6) Cylinder
7) Erlenmeyer flask
8) Filter flask
9) Volumetric flask
10) Pipette and burette
11) Depth measurement equipment
12) Secchi disc
13) GPS of GARMIN model GPS12
14) Temperature meter
15) pH meter of HORIBA model D-24
16) Conductivity meter of HORIBA model D-24
17) DO meter of YSI model 51B
18) Chemicals for total hardness analysis
19) Chemicals for chloride analysis
20) Chemicals for acidity analysis
21) Chemicals for alkalinity analysis
22) Chemicals for nitrate-nitrogen analysis

23) Chemicals for nitrite-nitrogen analysis
24) Chemicals for sulfate analysis
25) Chemicals for phosphate analysis
26) Chemicals for BOD analysis
27) Chemicals for COD analysis
28) Chemicals for oil & grease analysis
29) Chemicals for calcium analysis
30) Chemicals for magnesium analysis
31) Total solid, total dissolved solid and suspended solid equipment
32) Vacuum pump and membrane filter funnel
33) Filter papers
34) Gooch crucible
35) Hot air oven
36) Hot plate
37) BOD incubator
38) Desiccator
39) Spectrophotometer
40) Turbidity meter
41) Water bath
42) Evaporating dish
43) Analytical balance
44) Magnetic bar and stirrer

3.5.2 Plankton Sampling Equipment

1) Plankton bottle size 250 millimeter
2) Plankton net size 59 micrometer, transect lines 30 cm
3) Formalin solution concentration 4%
4) Camera

3.5.3 Machine and Equipment for Data Analysis and Database Management System

1) Computer 1 set
2) Program MINITAB
3) Program Microsoft Access

Chapter IV

Analysis Results and Discussions

4.1 Data Collection Results

One-hundred and nine data on water quality and aquatic ecology of stagnant water resources such as pond, reservoir, lake, etc. were selected from EIA reports and related reports. The data on water quality and data on aquatic ecology were data of the same period. The data of water quality consisted of 29 parameters as water temperature, pH, transparency, depth of water, turbidity, conductivity, DO, total solid, total dissolved solid, suspended solid, total hardness, chloride, acidity, alkalinity, nitrate-nitrogen, nitrite-nitrogen, organic-nitrogen, total nitrogen, ammonia-nitrogen, sulfate, phosphate, BOD, COD, oil & grease, calcium, magnesium, sodium, potassium, and chlorophyll a.

The data on aquatic ecology comprised abundance of plankton and number of plankton species in each phylum. There were totally 14 phyla of plankton such as Cyanophyta (blue-green algae), Chlorophyta (green algae), Bacillariophyta (diatom), Chrysophyta (yellow-brown algae), Pyrrophyta (dinoflagellate), and Euglenophyta (euglenoids) in phytoplankon and Protozoa (protozoans), Rotifera (rotifers), Arthropoda (arthropods), Annelida (segmented worms), Nematoda (nematodes), Chordata (chordates), Mollusca (mollusks), and Coelenterata (cnidaria) in zooplankton including total phytoplankton, total zooplankton, and grand total plankton species and abundance. Six hundred and thirteen of plankton species were collected. They consisted of phytoplankton in phyla Cyanophyta (blue-green algae) 67 species, Chlorophyta (green algae) 179 species, Bacillariophyta (diatom) 97 species, Chrysophyta (yellow-brown algae) 8 species, Pyrrophyta (dinoflagellate) 10 species, and Euglenophyta (euglenoids) 27 species, and addition, zooplankton in phyla Protozoa (protozoans) 47 species, Rotifera (rotifers) 112 species, Arthropoda (arthropods) 57 species, Annelida (segmented worms) 2 species, Nematoda (nematodes) 1 species, Chordata (chordates) 2 species, Mollusca (mollusks) 3 species, and Coelenterata (cnidaria) 1 species. The 109 data were collected from water sources in Thailand. It was shown in Table 3.

Table 3. Water source of water quality and plankton data in Thailand.

No.	Water Sources	District	Province
1	Krok Mai Daeng reservoir	Chakkarat	Nakhon Ratchasima
2	Nong Song Hong reservoir	Chakkarat	Nakhon Ratchasima
3	Bueng Tan Dieo (pond)	Kaeng Khoi	Saraburi
4	Bueng Bang Amphan (pond)	Bamnet Narong	Chaiyaphum
5	Bueng Thale (pond)	Bamnet Narong	Chaiyaphum
6	Sa Kaeo (pond)	Bamnet Narong	Chaiyaphum
7	Small reservoir of EGAT.	Nua Khlong pre-district	Krabi
8	Major reservoir of EGAT	Nua Khlong pre-district	Krabi

Table 3. Water source of water quality and plankton data in Thailand. (continued)

No.	Water Sources	District	Province
9	Nong Han Kumphawapi (reservoir)	Kumphawapi	Udon Thani
10	Nong Na Tan (reservoir)	Kumphawapi	Udon Thani
11	Nong Lat (pond)	Thawat Buri	Roi Et
12	Nong Hong (pond)	Thawat Buri	Roi Et
13	Thale Noi (lake)	Khwuan Khanun	Patthalung
14	Bueng Kaeng Nam Ton (pond)	Muang	Khon Kaen
15	Nong Leng Sai (pond)	Mae Chai	Phayao
16	Mae Kham reservoir	Mae Moh	Lampang
17	Mae Chang reservoir	Mae Moh	Lampang
18	Kew Lom reservoir	Chae Hom	Lampang
19	Nong Han (pond)	Muang	Sa Kon Nakhon
20	Nong Yai (pond)	Phatthana Nikhom	Lop Buri
21	Pond infront of Udon Thani airport	Muang	Udon Thani
22	Huai Nong Khem reservoir	Phonsawan	Nakhon Phanom
23	Kud Pla Khao (pond)	Tha Uthen	Nakhon Phanom
24	Lam Ta Khong reservoir	Pak Chong and Sikhiu	Nakhon Ratchasima

Table 3. Water source of water quality and plankton data in Thailand. (continued)

No.	Water Sources	District	Province
25	Small reservoir in Salaeng sub-district	Muang	Chanthaburi
26	Khiritharn reservoir	Makham	Chanthaburi
27	Upper retention pond	Pak Chong and Sikhiu	Nakhon Ratchasima
28	Huai Phan Sadet reservoir	Sriracha	Chonburi

The data sources are detailed in Appendix B. The details of water quality and aquatic ecology data are presented in Appendix C.

4.2 Basic Statistics of Data and Characteristic of Water Quality and Plankton Community in Thai Reservoirs

Basic statistics of data can be categorized into 2 aspects such as data on water quality and data on aquatic ecology. The details are as follows:

4.2.1 Water Quality Data

Basic statistics of water quality data were studied and analyzed in 29 parameters as water temperature, pH, transparency, depth of water, turbidity, conductivity, DO, TS, TDS, SS, total hardness, chloride, acidity, alkalinity, nitrate-nitrogen, nitrite-nitrogen, organic-nitrogen, total nitrogen, ammonia-nitrogen, sulfate, phosphate, BOD, COD, oil & grease, calcium, magnesium, sodium, potassium and chlorophyll a. Basic statistics of water quality data can be categorized into 3 aspects as physical, biological and chemical properties. The details are as follows:

1) Physical Properties

There are 3 parameters comprising water temperature, transparency, depth of water. The water temperature data distribution is also in normal curve; the average value is about 28 degree Celsius. The transparency data distribution is on the left skew, showing that transparency data are of low values. The average transparency value is about 80 centimeter. The average depths of stagnant water are 5 meters. However, most of stagnant water depths are about 2 meters. The details of basic statistics result of physical properties are shown in Figure 2.

2) Biological Properties

Only 1 parameter in biological property is chlorophyll a. The chlorophyll a data distribution is mostly in normal curve, most of chlorophyll a values is about 12 mg/m^3 of water. The details of basic statistics result of biological properties are shown in Figure 3.

3) Chemical Properties

There are 25 parameters comprising pH, turbidity, conductivity, DO, total solid, total dissolved solid, suspended solid, total hardness, chloride, acidity, alkalinity, nitrate-nitrogen, nitrite-nitrogen, organic-nitrogen, total nitrogen, ammonia-nitrogen, sulfate, phosphate, BOD, COD, oil & grease, calcium, magnesium, sodium and potassium. The stagnant waters have pH value of about 8. The turbidity of water is about 25 mg/liter. The average of conductivity is about 500 microhos/cm. Average DO value is about 7 mg/l. The average total solid, total dissolved solid and suspended solid values are about 100, 180 and 25 mg/l respectively.

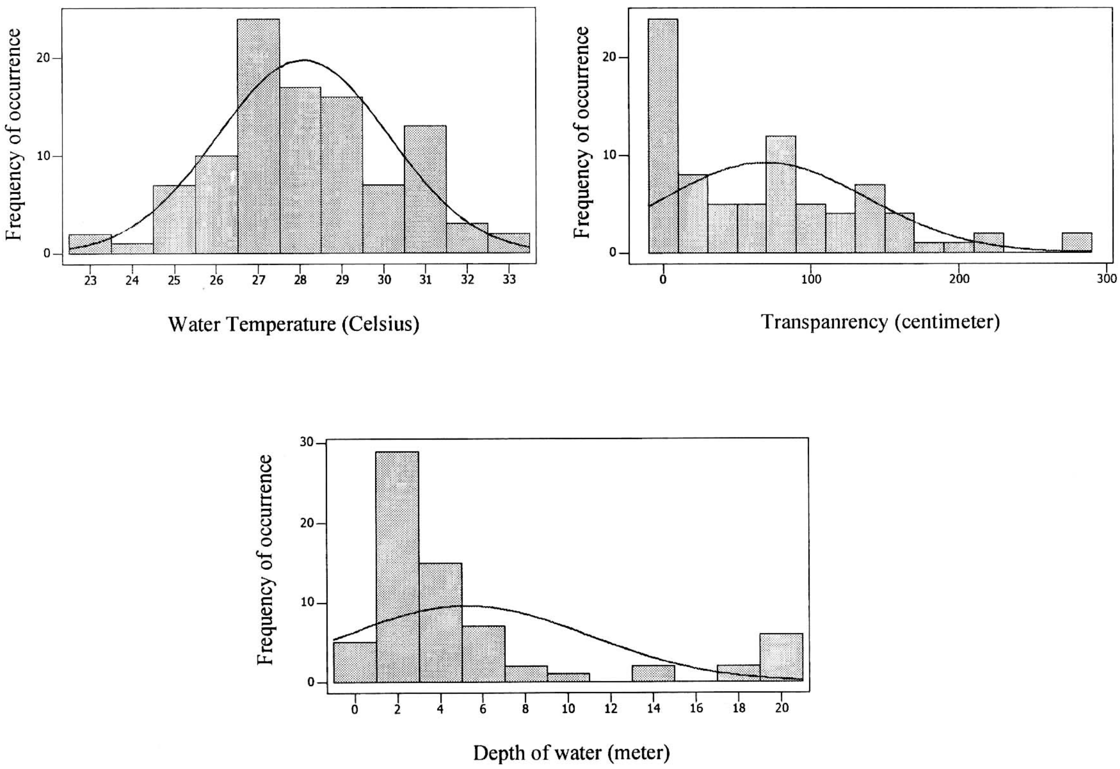

Figure 2. Basic statistical result of physical properties of water quality data.

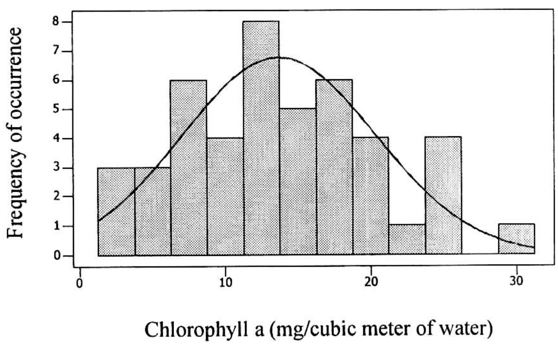

Figure 3. Basic statistical result of biological properties of water quality data.

The average total hardness is about 90 mg/l. The chloride values are low, average value is about 20 mg/l. The acidity values are low and with few records. The alkalinity data distribution is in normal curve; it is 90 mg/l on the average. Nitrogen in form nitrate-nitrogen, nitrite-nitrogen, organic-nitrogen, total nitrogen, ammonia-nitrogen are of quite low values. The sulfate and phosphate values are also low. The average BOD values are about 3 mg/l. The COD average values are about 20 mg/l. The average oil & grease values are about 2 mg/l. Calcium, magnesium, sodium, and potassium values are quite low. The details of basic statistics result of chemical properties are shown in Figure 4.

4.2.2 Plankton Data

Basic statistics of plankton organism data were studied and analyzed for abundance of plankton and number of plankton species in each phylum including total phytoplankton, total zooplankton and grand total plankton. The details are as follows:

1) Abundance of Plankton

a) Phytoplankton: There were totally 6 phyla of phytoplankton comprising Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta and Euglenophyta. All of phytoplankton abundance are in low values. The basis statistical results of abundance of phytoplankton phylum are presented in Figure 5.

b) Zooplankton: There were totally 8 phyla of zooplankton comprising Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca and Coelenterata. All of zooplankton abundance are in low values. The basis statistical results of abundance of zooplankton phylum are presented in Figure 6.

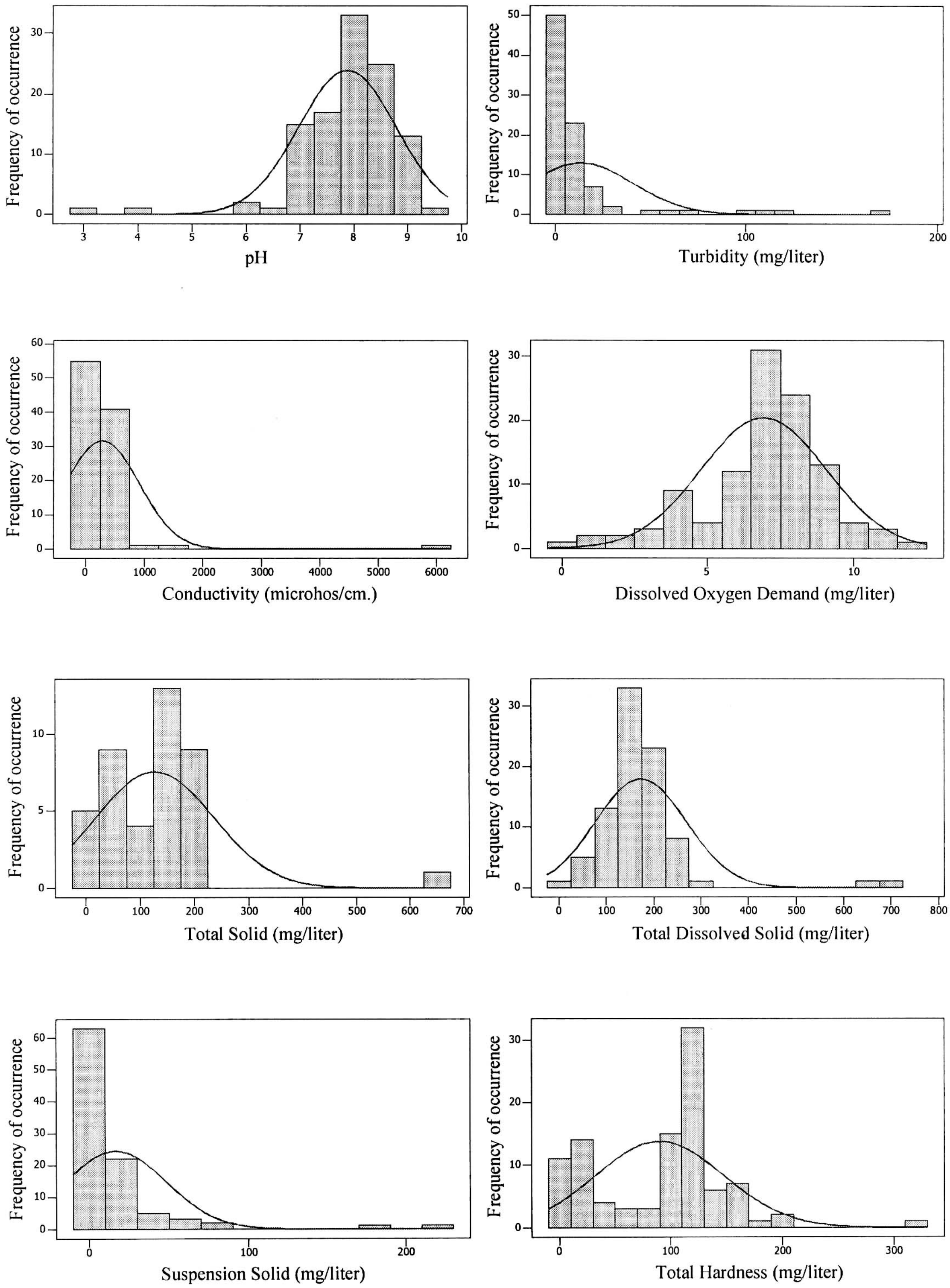

Figure 4. Basic statistical result of chemical properties of water quality data.

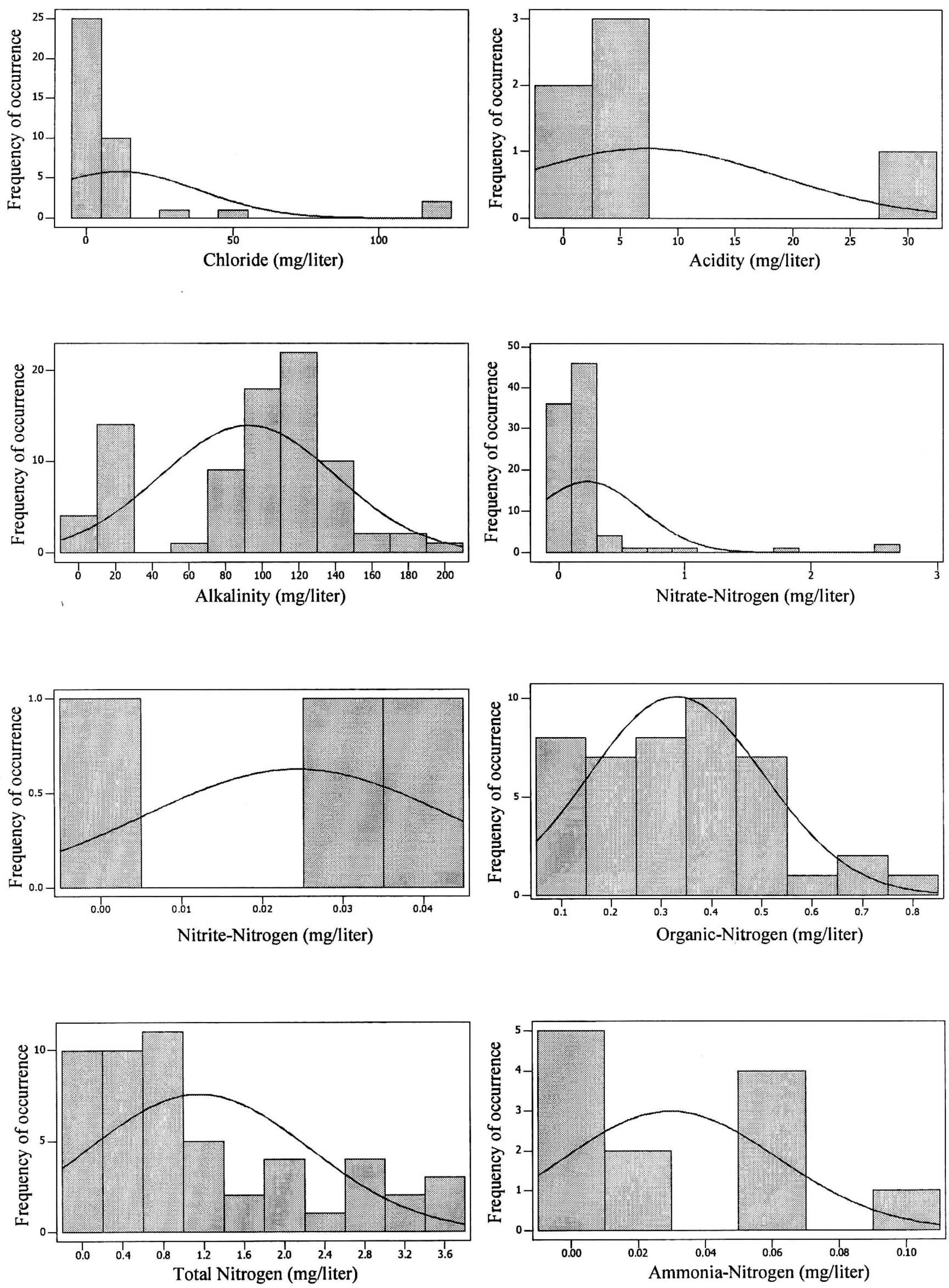

Figure 4. Basic statistical result of chemical properties of water quality data. (continued)

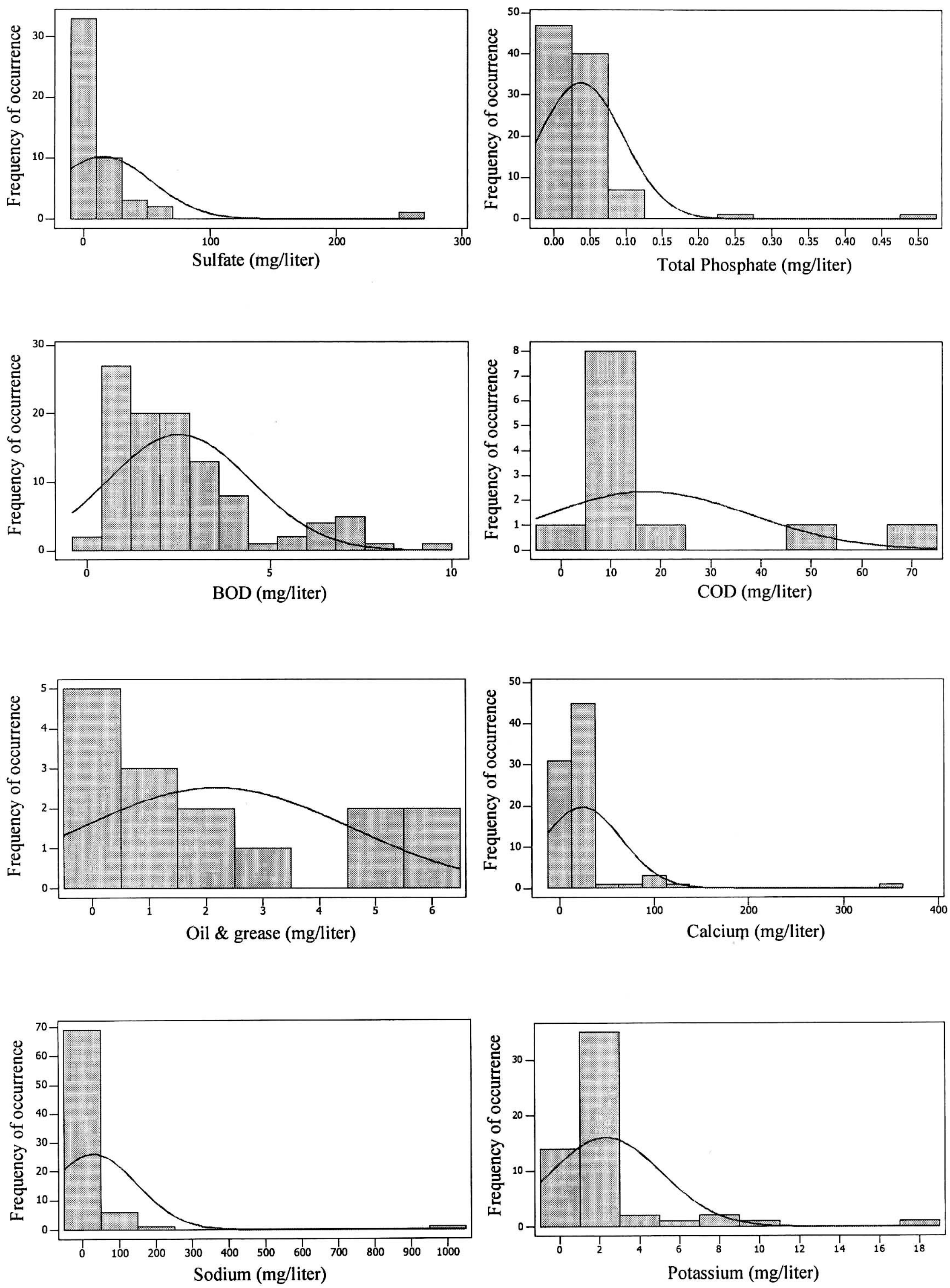

Figure 4. Basic statistical result of chemical properties of water quality data. (continued)

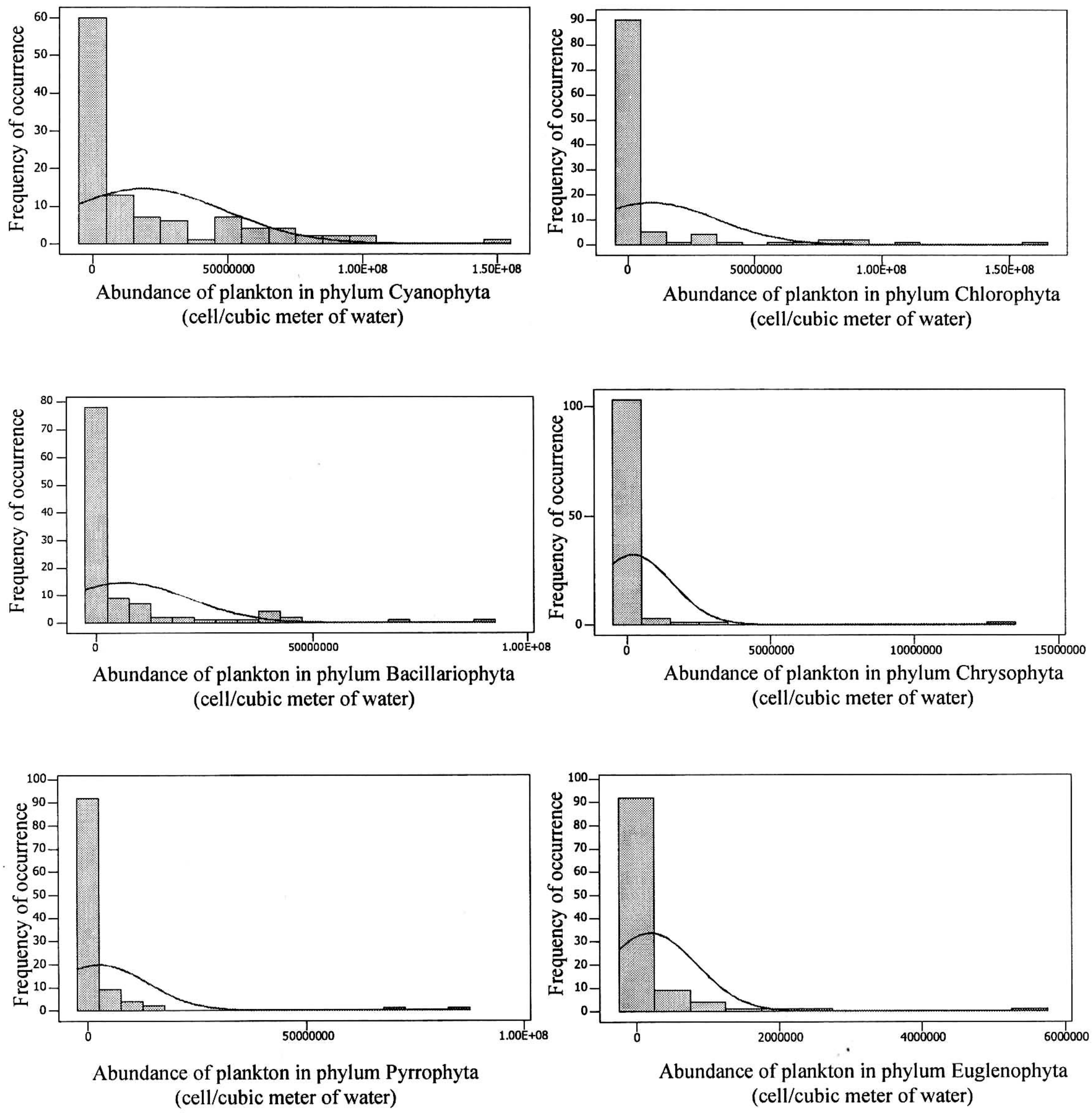

Figure 5. Basic statistical result of abundance of phytoplankton in each phylum.

c) Total plankton: There were totally 3 aspects of total plankton studying comprising total phytoplankton, total zooplankton and grand total plankton species. Abundance of total phytoplankton, total zooplankton and grand total plankton are of low values. The basis statistical results of abundance of total plankton are presented in Figure 7.

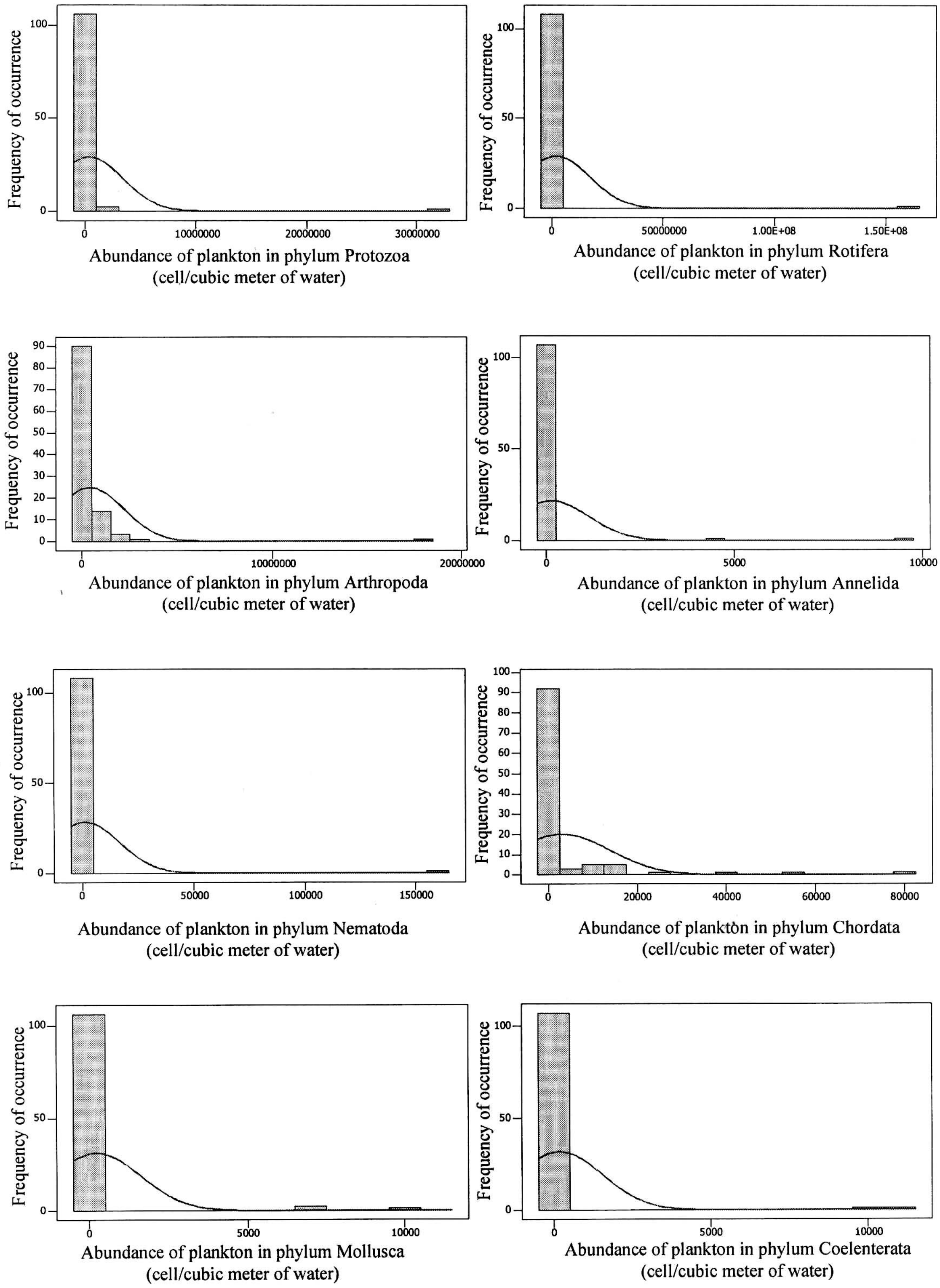

Figure 6. Basic statistical result of abundance of zooplankton in each phylum.

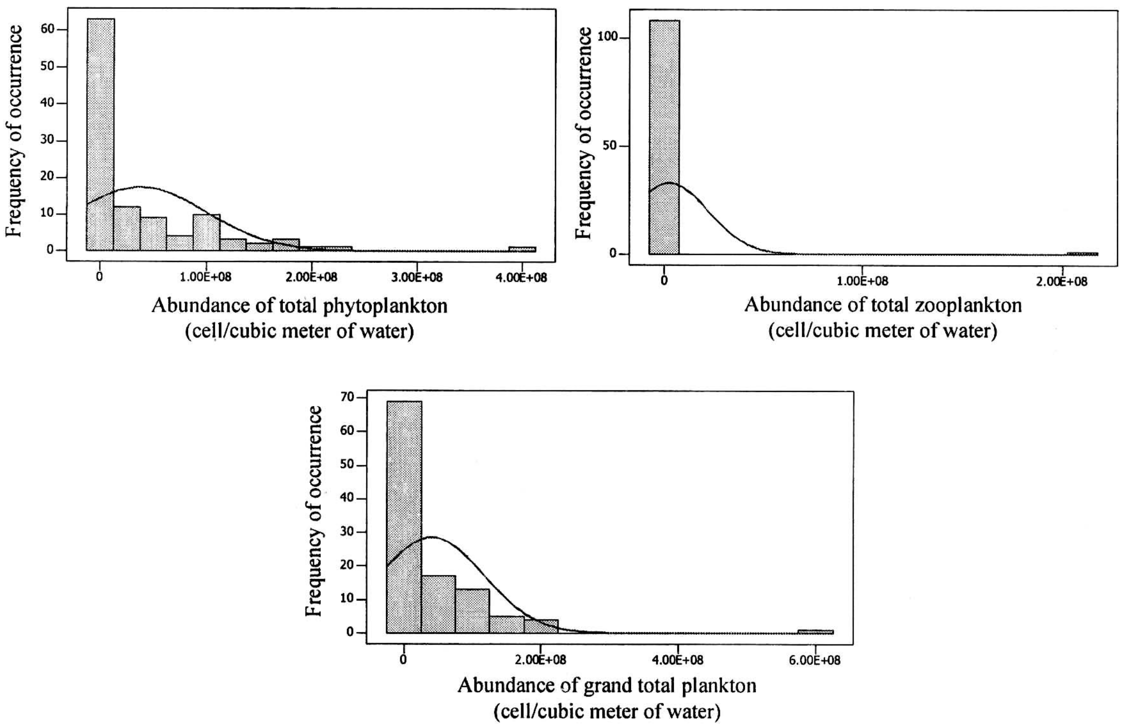

Figure 7. Basic statistical result of abundance of total phytoplankton, total zooplankton and grand total plankton.

2) Number of Plankton Species

a) Phytoplankton: There were totally 6 phyla of phytoplankton comprising Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, and Euglenophyta. All of number of phytoplankton species are in low values. The basis statistical results of number of phytoplankton species in each phylum are presented in Figure 8.

b) Zooplankton: There were totally 8 phyla of zooplankton comprising Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, and Coelenterata. All of number of zooplankton species are in low values. The basis statistical results of number of zooplankton species in each phylum are presented in Figure 9.

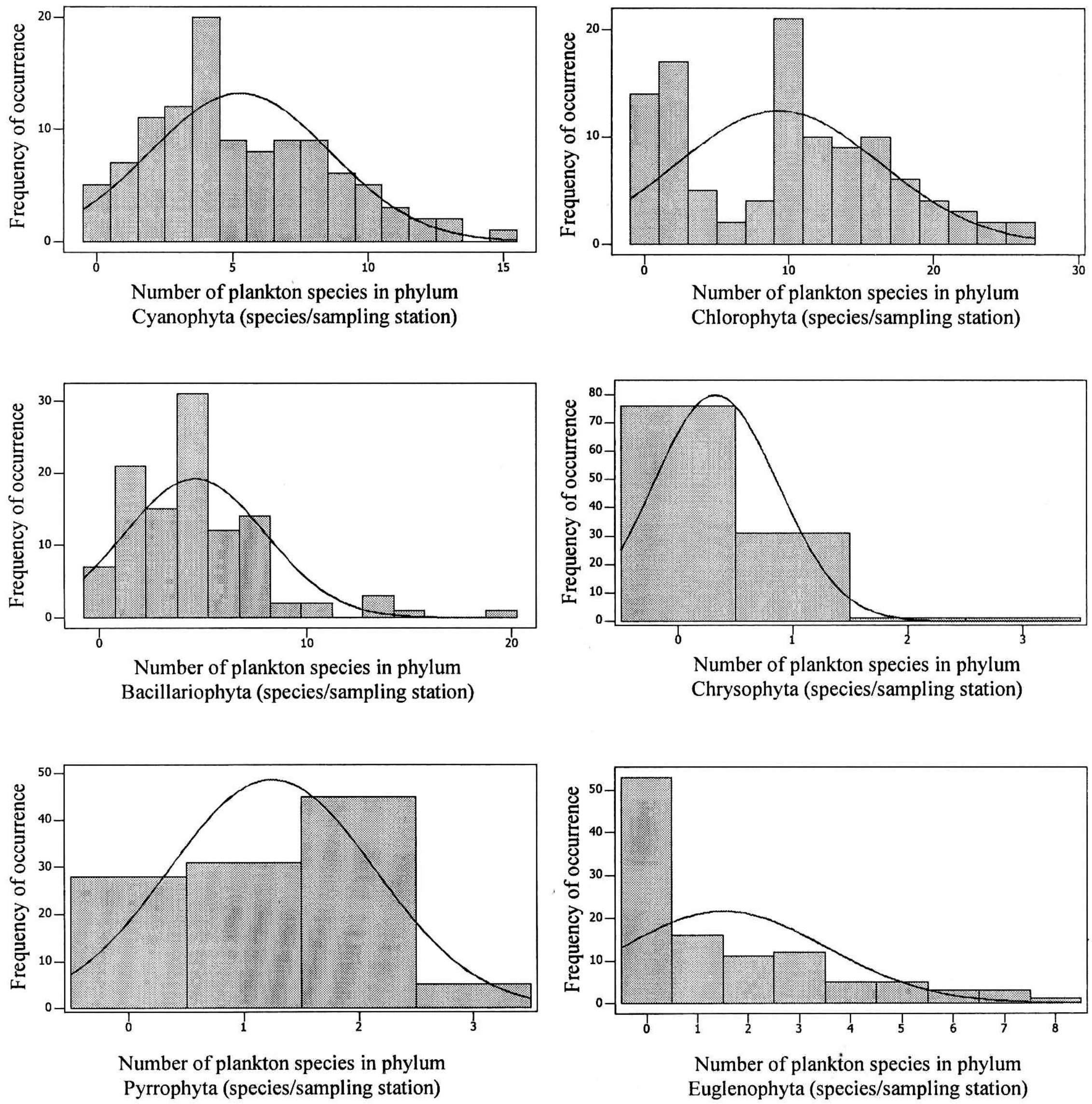

Figure 8. Basic statistical result of number of phytoplankton species in each phylum.

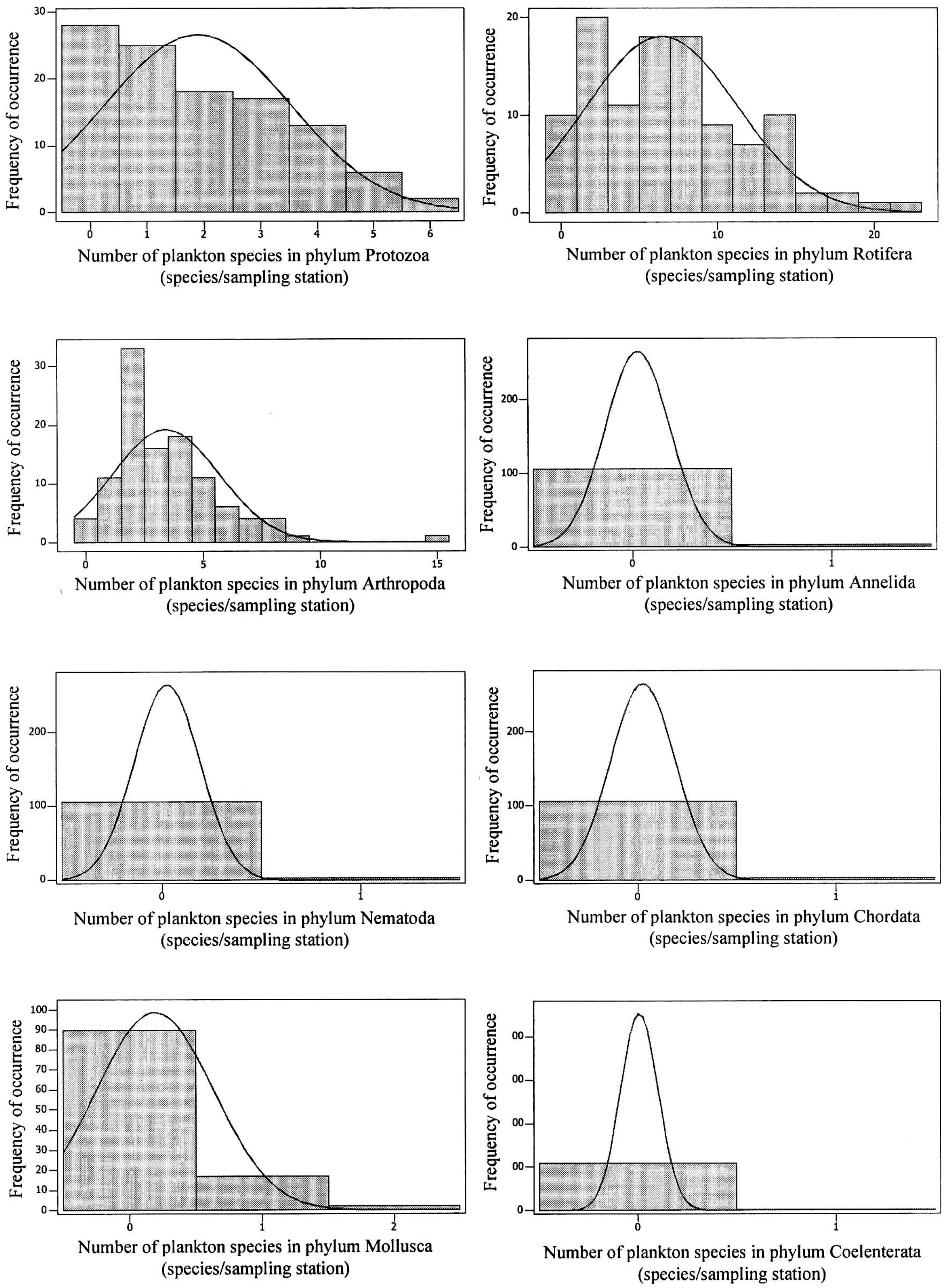

Figure 9. Basic statistical result of number of zooplankton species in each phylum.

c) Total plankton: There were totally 3 aspects of number of total plankton species comprising number of total phytoplankton species, number of total zooplankton species and number of grand total plankton species. Number of total phytoplankton, total zooplankton and grand total plankton species are in low values. The basis statistical results of number of total plankton species are presented in Figure 10.

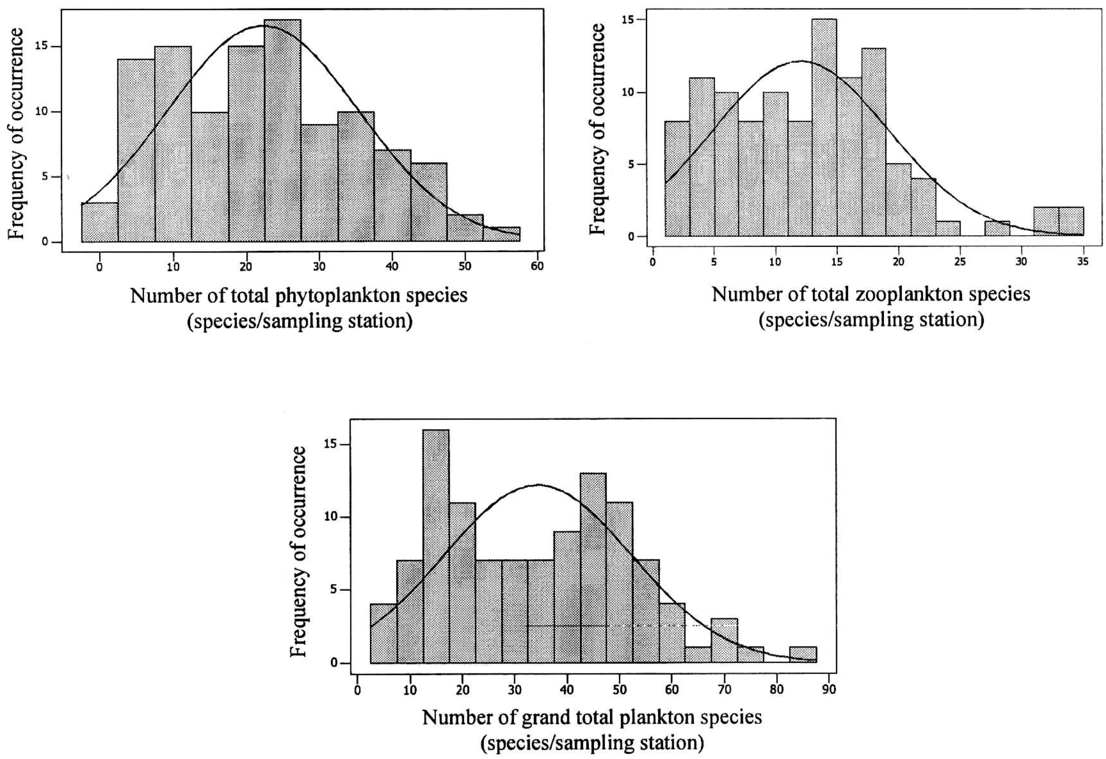

Figure 10. Basic statistical result of number of total phytoplankton species, total zooplankton species and grand total plankton species.

3) Plankton species

Basic statistics of plankton species data studied and analyzed comprise 613 plankton species in each phylum such as Cyanophyta (67 species), Chlorophyta (179 species), Bacillariophyta (97 species), Chrysophyta (8 species), Pyrrophyta (10 species), and Euglenophyta (27 species), Protozoa (47 species), Rotifera (112 species), Arthropoda (57 species), Annelida (2 species), Nematoda (1 species), Chordata (2 species), Mollusca (3 species), and Coelenterata (1 species). The dominant species of phytoplankton is phylum Chlorophyta with 179 species and dominant species of zooplankton is phylum Rotifera with 112 species. Total phytoplankton and zooplankton species are 388 and 225 species respectively (Table 4).

4.3 Relationships and Correlations of Water Quality and Plankton

The study on relationships and correlations of water quality and plankton study comprise 2 aspects as correlations between water quality and abundance of plankton and correlations between water quality and number of plankton species. There were 109 items of data for analysis of relationships between water quality and abundance of plankton in each phylum and analysis of relationships between water quality and number of plankton species in each phylum. The correlations between 29 parameters of water quality and abundance of plankton in each of 14 phyla including total phytoplankton, total zooplankton, and grand total plankton were studied. The relationships were analyzed with confidential level of 95% (Appendix D). The result of study can be concluded as follows:

Table 4. Species and phyla of phytoplankton and zooplankton found in Thai stagnant water.

Phylum	Number of species
Phytoplankton	
1. Cyanophyta	67
2. Chlorophyta	179
3. Bacillariophyta	97
4. Chrysophyta	8
5. Pyrrophyta	10
6. Euglenophyta	27
Sub-total phytoplankton species	**388**
Zooplankton	
7. Protozoa	47
8. Rotifera	112
9. Arthropoda	57
10. Annelida	2
11. Nematods	1
12. Chordata	2
13. Mollusca	3
14. Coelenterata	1
Sub-total zooplankton species	**225**
Grand total plankton species	**613**

4.3.1 Relationships between Water Temperature and Plankton

Totally 102 records of data on water temperature and plankton were analyzed. The water temperature data ranged between 23.0-33.0 degree Celsius. The correlation analysis results are concluded as follows:

1) Abundance of Plankton

Relationships between water temperature and abundance of phytoplankton in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton in terms of R are 0.065, 0.061, 0.053, 0.176, 0.161, -0.012, and 0.101 respectively (Table 5).

Relationships between water temperature and abundance of zooplankton in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton, and grand total plankton in terms of R are 0.002, -0.001, 0.009, -0.077, -0.125, -0.068, -0.115, 0.006, 0.000, and 0.083 respectively (Table 6).

All of analysis results reveal that water temperature and abundance of plankton do not correlate with each other.

2) Number of plankton species

Relationships between water temperature and number of phytoplankton species in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton species in terms of R are 0.023, -0.114, -0.223*, -0.047, -0.049, 0.057, and -0.108 respectively (Table 7).

Table 5. Correlation coefficient between water quality and abundance of phytoplankton in each phylum.

No.	Water Quality Parameters	Statistical Values	Phylum						Total Phytoplankton
			Cyanophyta	Chlorophyta	Bacillariophyta	Chrysophyta	Pyrrophyta	Euglenophyta	
1	Water Temperature	R	0.065	0.061	0.053	0.176	0.161	-0.012	0.101
		Sig.	0.514	0.539	0.599	0.078	0.107	0.905	0.312
		N	102	102	102	102	102	102	102
2	pH	R	0.329*	0.090	0.164	-0.140	0.086	0.087	0.246*
		Sig.	0.000	0.350	0.088	0.146	0.373	0.371	0.010
		N	109	109	109	109	109	109	109
3	Transparency	R	-0.094	-0.116	0.033	0.072	-0.046	-0.142	-0.093
		Sig.	0.405	0.307	0.770	0.528	0.683	0.209	0.413
		N	80	80	80	80	80	80	80
4	Depth of Water	R	0.303*	-0.029	0.235	-0.102	-0.030	-0.104	0.195
		Sig.	0.011	0.811	0.052	0.406	0.809	0.396	0.109
		N	69	69	69	69	69	69	69
5	Turbidity	R	-0.206	-0.092	-0.161	-0.023	-0.040	-0.075	-0.197
		Sig.	0.052	0.391	0.131	0.828	0.708	0.483	0.065
		N	89	89	89	89	89	89	89
6	Conductivity	R	-0.034	-0.066	-0.012	-0.062	0.009	0.022	-0.046
		Sig.	0.740	0.519	0.907	0.540	0.931	0.826	0.652
		N	99	99	99	99	99	99	99
7	Dissolved Oxygen	R	0.280*	0.154	0.089	-0.036	0.160	0.105	0.247*
		Sig.	0.003	0.109	0.357	0.711	0.096	0.278	0.010
		N	109	109	109	109	109	109	109
8	Total Solid	R	0.044	-0.289	-0.103	-0.098	0.059	-0.051	-0.010
		Sig.	0.785	0.067	0.521	0.543	0.713	0.752	0.949
		N	41	41	41	41	41	41	41
9	Total Dissolved Solid	R	0.057	-0.078	0.116	-0.155	0.179	0.141	0.053
		Sig.	0.600	0.478	0.289	0.154	0.100	0.195	0.629
		N	86	86	86	86	86	86	86
10	Suspended Solid	R	-0.158	-0.037	-0.120	0.008	-0.083	-0.075	-0.134
		Sig.	0.123	0.717	0.241	0.935	0.417	0.465	0.190
		N	97	97	97	97	97	97	97

Table 5. Correlation coefficient between water quality and abundance of phytoplankton in each phylum. (continued)

No.	Water Quality Parameters	Statistical Values	Phylum						Total
			Cyanophyta	Chlorophyta	Bacillariophyta	Chrysophyta	Pyrrophyta	Euglenophyta	Phytoplankton
11	Total Hardness	R	0.378*	-0.012	0.279*	-0.143	0.243*	0.311*	0.284*
		Sig.	0.000	0.905	0.005	0.158	0.015	0.002	0.004
		N	99	99	99	99	99	99	99
12	Chloride	R	-0.030	-0.003	-0.012	-0.029	-0.024	0.168	-0.015
		Sig.	0.858	0.985	0.944	0.862	0.887	0.308	0.927
		N	39	39	39	39	39	39	39
13	Acidity	R	-0.139	-0.194	0.094	-0.225	-0.188	-0.230	-0.196
		Sig.	0.793	0.713	0.860	0.668	0.721	0.661	0.710
		N	6	6	6	6	6	6	6
14	Alkalinity	R	0.530*	-0.021	0.473*	-0.185	0.300*	0.372*	0.452*
		Sig.	0.000	0.848	0.000	0.093	0.006	0.001	0.000
		N	83	83	83	83	83	83	83
15	Nitrate-Nitrogen	R	-0.111	-0.064	-0.132	0.045	-0.075	-0.076	-0.125
		Sig.	0.291	0.543	0.209	0.673	0.478	0.471	0.234
		N	92	92	92	92	92	92	92
16	Nitrite-Nitrogen	R	0.360	-0.972	-0.959	0.644	-0.965	-0.965	-0.828
		Sig.	0.765	0.151	0.183	0.554	0.168	0.168	0.379
		N	3	3	3	3	3	3	3
17	Organic-Nitrogen	R	-0.232	-0.041	-0.348*	0.177	-0.274	-0.023	-0.319*
		Sig.	0.130	0.794	0.020	0.251	0.072	0.882	0.035
		N	44	44	44	44	44	44	44
18	Total Nitrogen	R	-0.197	-0.011	-0.240	-0.096	-0.184	-0.023	-0.221
		Sig.	0.162	0.940	0.087	0.497	0.191	0.873	0.115
		N	52	52	52	52	52	52	52
19	Ammonia-Nitrogen	R	0.206	0.188	0.196	-0.276	0.250	-0.533	0.196
		Sig.	0.520	0.559	0.542	0.385	0.433	0.074	0.541
		N	12	12	12	12	12	12	12
20	Sulfate	R	0.041	-0.054	-0.032	-0.068	-0.004	-0.132	-0.052
		Sig.	0.781	0.712	0.827	0.642	0.978	0.365	0.721
		N	49	49	49	49	49	49	49

Table 5. Correlation coefficient between water quality and abundance of phytoplankton in each phylum. (continued)

No.	Water Quality Parameters	Statistical Values	Phylum						Total Phytoplankton
			Cyanophyta	Chlorophyta	Bacillariophyta	Chrysophyta	Pyrrophyta	Euglenophyta	
21	Total Phosphate	R	-0.186	-0.151	-0.135	-0.057	-0.044	-0.052	-0.193
		Sig.	0.069	0.142	0.189	0.584	0.668	0.613	0.059
		N	96	96	96	96	96	96	96
22	BOD	R	0.322*	0.279*	-0.012	-0.075	0.072	0.103	0.278*
		Sig.	0.001	0.004	0.901	0.452	0.466	0.297	0.004
		N	104	104	104	104	104	104	104
23	COD	R	-0.156	-0.334	-0.372	-0.270	-0.263	-0.330	-0.316
		Sig.	0.628	0.289	0.234	0.396	0.408	0.295	0.317
		N	12	12	12	12	12	12	12
24	Oil & Grease	R	-0.045	-0.214	-0.214	-0.171	-0.357	-0.157	-0.154
		Sig.	0.874	0.443	0.444	0.542	0.191	0.575	0.585
		N	15	15	15	15	15	15	15
25	Calcium	R	-0.076	-0.058	-0.046	-0.048	0.000	-0.018	-0.077
		Sig.	0.494	0.600	0.683	0.667	1.000	0.875	0.487
		N	83	83	83	83	83	83	83
26	Magnesium	R	-0.020	-0.095	0.109	-0.083	0.231*	0.044	0.025
		Sig.	0.854	0.389	0.321	0.450	0.033	0.691	0.817
		N	85	85	85	85	85	85	85
27	Sodium	R	-0.061	-0.046	-0.011	-0.036	0.041	-0.021	-0.046
		Sig.	0.601	0.694	0.924	0.757	0.721	0.856	0.691
		N	77	77	77	77	77	77	77
28	Potassium	R	-0.069	0.143	-0.038	0.036	0.054	-0.045	0.036
		Sig.	0.614	0.292	0.780	0.792	0.692	0.742	0.794
		N	56	56	56	56	56	56	56
29	Chlorophyll a	R	-0.029	0.209	-0.154	-0.298*	0.169	-0.176	0.085
		Sig.	0.851	0.169	0.313	0.046	0.266	0.247	0.577
		N	45	45	45	45	45	45	45

Notes R = Correlation coefficient
* = Correlation is significant at the 0.05 level

Table 6. Correlation coefficient between water quality and abundance of zooplankton in each phylum.

No.	Water Quality Parameters	Statistical Values	Phylum								Total Zooplankton	Grand Total Plankton
			Protozoa	Rotifera	Arthropoda	Annelida	Nematoda	Chordata	Mollusca	Coelenterata		
1	Water Temperature	R	0.002	-0.001	0.009	-0.077	-0.125	-0.068	-0.115	0.006	0.000	0.083
		Sig.	0.986	0.992	0.928	0.440	0.210	0.494	0.249	0.950	0.999	0.407
		N	102	102	102	102	102	102	102	102	102	102
2	pH	R	-0.074	-0.070	-0.024	-0.029	0.013	0.227*	0.060	0.047	-0.066	0.185
		Sig.	0.443	0.472	0.808	0.763	0.896	0.018	0.538	0.629	0.494	0.054
		N	109	109	109	109	109	109	109	109	109	109
3	Transparency	R	-0.140	-0.160	-0.267*	0.305*	0.241*	-0.048	-0.055	0.019	-0.216	-0.097
		Sig.	0.217	0.157	0.017	0.006	0.032	0.671	0.628	0.865	0.055	0.394
		N	80	80	80	80	80	80	80	80	80	80
4	Depth of Water	R	-0.107	-0.050	-0.203	-0.026	ND	0.075	0.173	-0.071	-0.123	0.189
		Sig.	0.383	0.683	0.094	0.830	ND	0.539	0.155	0.564	0.313	0.120
		N	69	69	69	69	69	69	69	69	69	69
5	Turbidity	R	-0.048	-0.012	0.094	-0.060	-0.047	-0.095	-0.006	-0.059	0.013	-0.193*
		Sig.	0.653	0.911	0.381	0.574	0.660	0.377	0.955	0.582	0.903	0.070
		N	89	89	89	89	89	89	89	89	89	89
6	Conductivity	R	-0.034	-0.033	-0.028	-0.014	-0.007	-0.018	-0.017	-0.004	-0.033	-0.046
		Sig.	0.736	0.749	0.782	0.890	0.942	0.858	0.871	0.969	0.749	0.650
		N	99	99	99	99	99	99	99	99	99	99
7	Dissolved Oxygen	R	-0.127	-0.125	-0.094	-0.039	0.039	0.331*	-0.041	0.074	-0.123	0.171
		Sig.	0.189	0.194	0.330	0.690	0.689	0.000	0.672	0.445	0.203	0.076
		N	109	109	109	109	109	109	109	109	109	109
8	Total Solid	R	0.161	-0.024	0.045	0.036	0.017	ND	ND	0.000	0.050	-0.005
		Sig.	0.315	0.882	0.782	0.825	0.918	ND	ND	1.000	0.758	0.973
		N	41	41	41	41	41	41	41	41	41	41
9	Total Dissolved Solid	R	-0.015	-0.025	-0.048	-0.044	-0.044	0.036	-0.009	-0.018	-0.026	0.036
		Sig.	0.888	0.820	0.659	0.690	0.687	0.739	0.935	0.872	0.815	0.742
		N	86	86	86	86	86	86	86	86	86	86
10	Suspended Solid	R	-0.010	-0.005	0.022	-0.066	-0.050	-0.077	0.024	-0.053	-0.003	-0.111
		Sig.	0.925	0.962	0.832	0.523	0.625	0.455	0.814	0.605	0.974	0.281
		N	97	97	97	97	97	97	97	97	97	97

Table 6. Correlation coefficient between water quality and abundance of zooplankton in each phylum. (continued)

No.	Water Quality Parameters	Statistical Values	Phylum								Total Zooplankton	Grand Total Plankton
			Protozoa	Rotifera	Arthropoda	Annelida	Nematoda	Chordata	Mollusca	Coelenterata		
11	Total Hardness	R	-0.083	-0.092	-0.082	0.015	0.030	0.159	0.053	0.056	-0.090	0.209
		Sig.	0.416	0.364	0.421	0.880	0.771	0.116	0.600	0.584	0.376	0.038
		N	99	99	99	99	99	99	99	99	99	99
12	Chloride	R	-0.019	-0.021	0.005	-0.032	-0.067	0.663*	ND	0.000	-0.018	-0.016
		Sig.	0.908	0.901	0.975	0.848	0.686	0.000	ND	1.000	0.912	0.922
		N	39	39	39	39	39	39	39	39	39	39
13	Acidity	R	0.528	-0.205	-0.362	-0.183	ND	-0.000	ND	ND	-0.311	-0.203
		Sig.	0.282	0.696	0.481	0.728	ND	1.000	ND	ND	0.549	0.699
		N	6	6	6	6	6	6	6	6	6	6
14	Alkalinity	R	0.366*	0.289*	0.127	-0.147	0.069	0.163	0.043	0.084	0.293*	0.451
		Sig.	0.001	0.008	0.254	0.186	0.536	0.142	0.702	0.448	0.007	0.000
		N	83	83	83	83	83	83	83	83	83	83
15	Nitrate-Nitrogen	R	-0.058	-0.050	-0.034	-0.014	-0.000	0.002	-0.023	-0.007	-0.050	-0.115
		Sig.	0.585	0.639	0.750	0.895	1.000	0.982	0.825	0.951	0.639	0.273
		N	92	92	92	92	92	92	92	92	92	92
16	Nitrite-Nitrogen	R	-0.975	-0.992	-0.890	ND	ND	-0.000	ND	ND	-0.940	-0.844
		Sig.	0.142	0.080	0.302	ND	ND	1.000	ND	ND	0.221	0.361
		N	3	3	3	3	3	3	3	3	3	3
17	Organic-Nitrogen	R	-0.354*	-0.407*	-0.324*	-0.000	ND	-0.167	0.145	-0.135	-0.432*	-0.325*
		Sig.	0.019	0.006	0.032	1.000	ND	0.280	0.347	0.381	0.003	0.031
		N	44	44	44	44	44	44	44	44	44	44
18	Total Nitrogen	R	-0.251	-0.379*	-0.323*	-0.106	ND	-0.058	0.139	-0.071	-0.393*	-0.228
		Sig.	0.073	0.006	0.020	0.457	ND	0.684	0.326	0.615	0.004	0.105
		N	52	52	52	52	52	52	52	52	52	52
19	Ammonia-Nitrogen	R	0.195	0.199	0.176	0.297	ND	-0.000	ND	ND	0.196	0.196
		Sig.	0.543	0.536	0.585	0.348	ND	1.000	ND	ND	0.541	0.541
		N	12	12	12	12	12	12	12	12	12	12
20	Sulfate	R	-0.036	-0.081	-0.169	0.045	-0.027	-0.054	ND	-0.020	-0.143	-0.056
		Sig.	0.808	0.580	0.245	0.756	0.855	0.712	ND	0.890	0.326	0.704
		N	49	49	49	49	49	49	49	49	49	49

Table 6. Correlation coefficient between water quality and abundance of zooplankton in each phylum. (continued)

No.	Water Quality Parameters	Statistical Values	Phylum								Total	Grand Total
			Protozoa	Rotifera	Arthropoda	Annelida	Nematoda	Chordata	Mollusca	Coelenterata	Zooplankton	Plankton
21	Total Phosphate	R	-0.054	-0.052	-0.080	-0.006	0.039	-0.115	-0.028	-0.065	-0.055	-0.173
		Sig.	0.600	0.616	0.441	0.956	0.706	0.263	0.787	0.531	0.596	0.092
		N	96	96	96	96	96	96	96	96	96	96
22	BOD	R	-0.004	-0.006	0.126	0.101	-0.079	0.325*	-0.000	0.069	0.006	0.230*
		Sig.	0.971	0.950	0.203	0.307	0.426	0.001	0.998	0.488	0.952	0.019
		N	104	104	104	104	104	104	104	104	104	104
23	COD	R	0.553	-0.166	-0.379	0.000	-0.057	0.000	ND	ND	-0.254	-0.322
		Sig.	0.062	0.605	0.225	1.000	0.860	1.000	ND	ND	0.427	0.307
		N	12	12	12	12	12	12	12	12	12	12
24	Oil & Grease	R	-0.211	-0.211	-0.185	-0.067	ND	0.000	ND	0.000	-0.209	-0.173
		Sig.	0.451	0.451	0.509	0.811	ND	1.000	ND	1.000	0.455	0.539
		N	15	15	15	15	15	15	15	15	15	15
25	Calcium	R	-0.001	-0.055	-0.072	0.132	0.030	-0.036	-0.024	-0.026	-0.058	-0.077
		Sig.	0.996	0.620	0.519	0.235	0.790	0.745	0.832	0.815	0.605	0.486
		N	83	83	83	83	83	83	83	83	83	83
26	Magnesium	R	0.072	-0.041	-0.122	0.442*	0.173	-0.086	-0.068	-0.102	-0.050	0.024
		Sig.	0.510	0.708	0.268	0.000	0.112	0.433	0.539	0.353	0.650	0.828
		N	85	85	85	85	85	85	85	85	85	85
27	Sodium	R	-0.005	0.034	0.033	-0.025	ND	-0.048	-0.027	-0.028	0.030	-0.045
		Sig.	0.966	0.772	0.775	0.830	ND	0.676	0.815	0.809	0.794	0.700
		N	77	77	77	77	77	77	77	77	77	77
28	Potassium	R	0.024	0.118	0.094	0.038	ND	0.017	-0.046	-0.073	0.108	0.038
		Sig.	0.861	0.386	0.491	0.780	ND	0.899	0.737	0.592	0.427	0.781
		N	56	56	56	56	56	56	56	56	56	56
29	Chlorophyll a	R	0.250	0.236	0.068	0.000	ND	0.324*	0.003	-0.116	0.221	0.090
		Sig.	0.098	0.118	0.658	1.000	ND	0.030	0.982	0.448	0.145	0.557
		N	45	45	45	45	45	45	45	45	45	45

Notes
R = Correlation coefficient
* = Correlation is significant at the 0.05 level
ND = Not detectable

Table 7. Correlation coefficient between water quality and number of phytoplankton species in each phylum.

No.	Water Quality Parameters	Statistical Values	Phylum						Total Phytoplankton
			Cyanophyta	Chlorophyta	Bacillariophyta	Chrysophyta	Pyrrophyta	Euglenophyta	
1	Water Temperature	R	0.023	-0.114	-0.223	-0.047	-0.049	0.057	-0.108
		Sig.	0.815	0.256	0.024*	0.640	0.623	0.570	0.279
		N	102	102	102	102	102	102	102
2	pH	R	0.502	0.143	0.288	-0.095	0.174	0.096	0.299
		Sig.	0.000*	0.138	0.002*	0.324	0.070	0.320	0.002*
		N	109	109	109	109	109	109	109
3	Transparency	R	0.280	0.264	0.246	0.156	0.314	0.072	0.301
		Sig.	0.012*	0.018*	0.028*	0.168	0.005*	0.527	0.007*
		N	80	80	80	80	80	80	80
4	Depth of Water	R	0.420	0.199	0.068	-0.154	0.290	0.004	0.243
		Sig.	0.000*	0.101	0.576	0.206	0.016*	0.977	0.045*
		N	69	69	69	69	69	69	69
5	Turbidity	R	-0.308	-0.303	-0.263	-0.040	-0.467	-0.049	-0.336
		Sig.	0.003*	0.004*	0.013*	0.709	0.000*	0.647	0.001*
		N	89	89	89	89	89	89	89
6	Conductivity	R	-0.019	-0.140	0.088	-0.037	-0.058	0.137	-0.037
		Sig.	0.855	0.167	0.388	0.714	0.569	0.175	0.715
		N	99	99	99	99	99	99	99
7	Dissolved Oxygen	R	0.430	0.344	0.143	0.051	0.343	0.037	0.359
		Sig.	0.000*	0.000*	0.138	0.597	0.000*	0.706	0.000*
		N	109	109	109	109	109	109	109
8	Total Solid	R	0.065	-0.495	0.100	-0.055	-0.350	-0.067	-0.298
		Sig.	0.686	0.001*	0.532	0.734	*0.025**	0.678	0.059
		N	41	41	41	41	41	41	41
9	Total Dissolved Solid	R	0.021	-0.092	0.161	-0.095	0.058	0.051	0.002
		Sig.	0.849	0.402	0.140	0.384	0.598	0.642	0.986
		N	86	86	86	86	86	86	86
10	Suspended Solid	R	-0.123	-0.259	-0.099	-0.007	-0.415	-0.079	-0.228
		Sig.	0.228	0.010*	0.335	0.945	0.000*	0.444	0.025*
		N	97	97	97	97	97	97	97

Table 7. Correlation coefficient between water quality and number of phytoplankton species in each phylum. (continued)

No.	Water Quality Parameters	Statistical Values	Phylum						Total
			Cyanophyta	Chlorophyta	Bacillariophyta	Chrysophyta	Pyrrophyta	Euglenophyta	Phytoplankton
11	Total Hardness	R	0.502	0.107	0.545	0.097	0.142	0.321	0.393
		Sig.	0.000*	0.290	0.000*	0.339	0.160	0.001*	0.000*
		N	99	99	99	99	99	99	99
12	Chloride	R	0.004	0.426	0.704	0.474	-0.239	0.455	0.597
		Sig.	0.979	0.007*	0.000*	0.002*	0.143	0.004*	0.000*
		N	39	39	39	39	39	39	39
13	Acidity	R	0.211	-0.267	0.920	-0.493	-0.231	-0.294	-0.100
		Sig.	0.689	0.608	0.009*	0.321	0.660	0.572	0.851
		N	6	6	6	6	6	6	6
14	Alkalinity	R	0.564	0.190	0.376	0.069	0.166	0.317	0.413
		Sig.	0.000*	0.086	0.000*	0.535	0.135	0.004*	0.000*
		N	83	83	83	83	83	83	83
15	Nitrate-Nitrogen	R	-0.056	-0.060	-0.039	0.162	-0.347	-0.141	-0.095
		Sig.	0.593	0.569	0.715	0.124	0.001*	0.181	0.368
		N	92	92	92	92	92	92	92
16	Nitrite-Nitrogen	R	-0.709	-0.980	-0.673	-0.965	-0.965	-0.965	-0.922
		Sig.	0.498	0.127	0.530	0.168	0.168	0.168	0.253
		N	3	3	3	3	3	3	3
17	Organic-Nitrogen	R	-0.053	0.049	-0.058	-0.212	0.049	-0.040	-0.028
		Sig.	0.732	0.751	0.710	0.168	0.750	0.797	0.857
		N	44	44	44	44	44	44	44
18	Total Nitrogen	R	-0.014	0.039	-0.100	-0.366	0.021	0.029	-0.021
		Sig.	0.921	0.786	0.481	0.008*	0.883	0.838	0.884
		N	52	52	52	52	52	52	52
19	Ammonia-Nitrogen	R	0.238	-0.550	-0.002	-0.184	-0.150	-0.427	-0.410
		Sig.	0.457	0.064	0.995	0.568	0.642	0.167	0.186
		N	12	12	12	12	12	12	12
20	Sulfate	R	0.001	-0.304	0.119	-0.073	-0.111	-0.124	-0.189
		Sig.	0.992	0.034*	0.414	0.619	0.448	0.396	0.192
		N	49	49	49	49	49	49	49

Table 7. Correlation coefficient between water quality and number of phytoplankton species in each phylum. (continued)

No.	Water Quality Parameters	Statistical Values	Phylum						Total Phytoplankton
			Cyanophyta	Chlorophyta	Bacillariophyta	Chrysophyta	Pyrrophyta	Euglenophyta	
21	Total Phosphate	R	-0.166	-0.269	-0.244	-0.114	-0.155	-0.107	-0.271
		Sig.	0.106	0.008*	0.017*	0.270	0.132	0.300	0.008*
		N	96	96	96	96	96	96	96
22	BOD	R	0.204	0.049	0.154	-0.103	-0.240	0.013	0.100
		Sig.	0.038*	0.619	0.119	0.297	0.014*	0.893	0.313
		N	104	104	104	104	104	104	104
23	COD	R	-0.165	-0.329	-0.146	-0.299	-0.442	-0.321	-0.356
		Sig.	0.608	0.296	0.651	0.345	0.150	0.309	0.257
		N	12	12	12	12	12	12	12
24	Oil & Grease	R	0.054	-0.174	-0.600	-0.139	-0.515	-0.446	-0.372
		Sig.	0.848	0.536	0.018*	0.622	0.049*	0.096	0.172
		N	15	15	15	15	15	15	15
25	Calcium	R	-0.066	-0.294	0.106	0.066	-0.201	-0.058	-0.160
		Sig.	0.553	0.007*	0.338	0.555	0.068	0.605	0.149
		N	83	83	83	83	83	83	83
26	Magnesium	R	-0.128	-0.397	-0.036	0.154	-0.047	-0.060	-0.256
		Sig.	0.244	0.000*	0.746	0.160	0.670	0.585	0.018*
		N	85	85	85	85	85	85	85
27	Sodium	R	-0.085	-0.215	0.015	-0.031	-0.110	0.092	-0.116
		Sig.	0.463	0.060	0.895	0.791	0.343	0.427	0.315
		N	77	77	77	77	77	77	77
28	Potassium	R	-0.198	-0.290	-0.105	0.015	-0.191	-0.095	-0.269
		Sig.	0.143	0.030*	0.441	0.915	0.158	0.484	0.045*
		N	56	56	56	56	56	56	56
29	Chlorophyll a	R	0.168	0.221	0.228	-0.254	0.121	-0.224	0.017
		Sig.	0.270	0.145	0.132	0.092	0.427	0.139	0.909
		N	45	45	45	45	45	45	45

Notes R = Correlation coefficient
* = Correlation is significant at the 0.05 level

Relationships between water temperature and number of zooplankton species in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton species, and grand total plankton species in terms of R are -0.033, 0.014, 0.007, 0.087, -0.112, -0.023, -0.164, -0.125, -0.008 and -0.084 respectively (Table 8).

Results of study show that water temperature has negative correlation with number of phytoplankton species in phylum Bacillariophyta. This agrees with result of the study of พันทวี มาไพโรจน์ และศิริเพ็ญ ตรัยไชยาพร (2543) that water temperature has direct and indirect impacts to phytoplankton. The direct impact is the capability of phytoplankton survive varies according to of plankton species. Generally, phytoplankton can grow in temperature range of 25-30 degree Celsius. Each plankton has different suitable temperature for growths such as there are most of diatom at temperature range of 20-28 degrees Celsius, there are most of green algae at temperature range of 30-35 degrees Celsius, there are most of blue-green algae at temperature range 35-45 degrees Celsius, etc. The indirect impact is temperature change would result in water environment condition change i.e. when temperature of water increases, dissolved oxygen would decrease. Therefore, it can be concluded that water temperature has effect on abundance and density of plankton in water source.

4.3.2 Relationships between pH and Plankton

Totally 102 records of data on pH and plankton were analyzed. The pH data ranged between 3.00-9.40. The correlation analysis results are concluded as follows:

Table 8. Correlation coefficient between water quality and number of zooplankton species in each phylum.

No.	Water Quality Parameters	Statistical Values	Phylum								Total Zooplankton	Grand Total Plankton
			Protozoa	Rotifera	Arthropoda	Annelida	Nematoda	Chordata	Mollusca	Coelenterata		
1	Water Temperature	R	-0.033	0.014	0.007	0.087	-0.112	-0.023	-0.164	-0.125	-0.008	-0.084
		Sig.	0.744	0.890	0.941	0.384	0.261	0.815	0.101	0.210	0.934	0.400
		N	102	102	102	102	102	102	102	102	102	102
2	pH	R	0.275	0.413	0.053	0.032	0.073	-0.108	0.242	0.013	0.373	0.371
		Sig.	0.004*	0.000*	0.582	0.740	0.450	0.264	0.011*	0.896	0.000*	0.000*
		N	109	109	109	109	109	109	109	109	109	109
3	Transparency	R	0.022	0.263	-0.268	0.028	0.031	0.070	0.228	-0.110	0.128	0.291
		Sig.	0.847	0.019*	0.016*	0.808	0.788	0.536	0.042*	0.333	0.259	0.009*
		N	80	80	80	80	80	80	80	80	80	80
4	Depth of Water	R	-0.034	0.076	-0.307	-0.112	0.164	-0.074	0.098	-0.000	-0.038	0.178
		Sig.	0.780	0.536	0.010*	0.358	0.178	0.547	0.424	1.000	0.754	0.143
		N	69	69	69	69	69	69	69	69	69	69
5	Turbidity	R	-0.217	-0.155	0.036	-0.073	-0.004	-0.073	-0.155	-0.047	-0.160	-0.314
		Sig.	0.041*	0.147	0.736	0.494	0.967	0.496	0.147	0.660	0.134	0.003*
		N	89	89	89	89	89	89	89	89	89	89
6	Conductivity	R	0.057	0.118	-0.105	-0.031	-0.016	-0.041	-0.025	-0.007	0.056	-0.005
		Sig.	0.575	0.243	0.300	0.759	0.872	0.688	0.807	0.942	0.580	0.963
		N	99	99	99	99	99	99	99	99	99	99
7	Dissolved Oxygen	R	0.137	0.369	0.291	0.101	-0.008	-0.058	0.346	0.039	0.394	0.424
		Sig.	0.155	0.000*	0.002*	0.298	-0.937	0.548	0.000*	0.689	0.000*	0.000*
		N	109	109	109	109	109	109	109	109	109	109
8	Total Solid	R	0.405	0.197	-0.084	ND	ND	0.035	ND	0.017	0.169	-0.131
		Sig.	0.009*	0.218	0.601	ND	ND	0.826	ND	0.918	0.290	0.416
		N	41	41	41	41	41	41	41	41	41	41
9	Total Dissolved Solid	R	0.108	0.075	-0.217	0.021	-0.011	-0.108	0.104	-0.044	0.006	0.004
		Sig.	0.322	0.495	0.044*	0.845	0.921	0.321	0.342	0.687	0.955	0.973
		N	86	86	86	86	86	86	86	86	86	86
10	Suspended Solid	R	0.034	-0.044	-0.068	-0.053	0.027	-0.072	-0.124	-0.050	-0.052	-0.188
		Sig.	0.740	0.670	0.507	0.608	0.792	0.486	0.225	0.625	0.612	0.065
		N	97	97	97	97	97	97	97	97	97	97

Table 8. Correlation coefficient between water quality and number of zooplankton species in each phylum. (continued)

No.	Water Quality Parameters	Statistical Values	Phylum								Total Zooplankton	Grand Total Plankton
			Protozoa	Rotifera	Arthropoda	Annelida	Nematoda	Chordata	Mollusca	Coelenterata		
11	Total Hardness	R	0.427	0.428	-0.135	0.015	0.052	-0.075	0.269	0.030	0.358	0.437
		Sig.	0.000*	0.000*	0.183	0.885	0.609	0.461	0.007*	0.771	0.000*	0.000*
		N	99	99	99	99	99	99	99	99	99	99
12	Chloride	R	0.078	0.494	0.402	ND	ND	-0.032	0.663	-0.067	0.467	0.615
		Sig.	0.639	0.001*	0.011*	ND	ND	0.848	0.000*	0.686	0.003*	0.000*
		N	39	39	39	39	39	39	39	39	39	39
13	Acidity	R	0.772	0.244	-0.230	ND	ND	-0.183	0.000	ND	0.474	0.016
		Sig.	0.072	0.641	0.660	ND	ND	0.728	1.000	ND	0.343	0.975
		N	6	6	6	6	6	6	6	6	6	6
14	Alkalinity	R	0.509	0.479	-0.166	-0.024	0.040	-0.188	0.219	0.069	0.400	0.471
		Sig.	0.000*	0.000*	0.134	0.828	0.719	0.088	0.047*	0.536	0.000*	0.000*
		N	83	83	83	83	83	83	83	83	83	83
15	Nitrate-Nitrogen	R	0.023	-0.005	-0.114	-0.027	-0.017	-0.049	-0.017	0.000	-0.037	-0.083
		Sig.	0.827	0.960	0.279	0.802	0.870	0.643	0.870	1.000	0.727	0.430
		N	92	92	92	92	92	92	92	92	92	92
16	Nitrite-Nitrogen	R	-0.709	-0.998	-0.945	ND	ND	ND	ND	ND	-0.995	-0.961
		Sig.	0.498	0.044*	0.212	ND	ND	ND	ND	ND	0.064	0.179
		N	3	3	3	3	3	3	3	3	3	3
17	Organic-Nitrogen	R	-0.092	-0.409	-0.107	-0.134	0.151	ND	-0.099	-0.000	-0.330	-0.218
		Sig.	0.553	0.006*	0.488	0.386	0.327	ND	0.525	1.000	0.028*	0.155
		N	44	44	44	44	44	44	44	44	44	44
18	Total Nitrogen	R	-0.078	-0.231	-0.113	-0.064	0.146	-0.106	-0.009	0.000	-0.202	-0.111
		Sig.	0.581	0.099	0.424	0.652	0.301	0.457	0.952	1.000	0.151	0.433
		N	52	52	52	52	52	52	52	52	52	52
19	Ammonia-Nitrogen	R	-0.559	-0.369	-0.544	ND	ND	0.297	0.000	0.000	-0.518	-0.477
		Sig.	0.059	0.238	0.068	ND	ND	0.348	1.000	1.000	0.084	0.117
		N	12	12	12	12	12	12	12	12	12	12
20	Sulfate	R	0.254	-0.040	-0.168	-0.020	ND	0.000	-0.051	-0.027	-0.037	-0.150
		Sig.	0.078	0.785	0.250	0.890	ND	1.000	0.730	0.855	0.802	0.303
		N	49	49	49	49	49	49	49	49	49	49

Table 8. Correlation coefficient between water quality and number of zooplankton species in each phylum. (continued)

No.	Water Quality Parameters	Statistical Values	Phylum								Total Zooplankton	Grand Total Plankton
			Protozoa	Rotifera	Arthropoda	Annelida	Nematoda	Chordata	Mollusca	Coelenterata		
21	Total Phosphate	R	-0.177	-0.105	-0.152	-0.072	-0.028	-0.013	-0.152	0.039	0.170	-0.269
		Sig.	0.084	0.308	0.141	0.488	0.788	0.898	0.140	0.706	0.098	0.008*
		N	96	96	96	96	96	96	96	96	96	96
22	BOD	R	0.371	0.480	0.190	0.048	-0.011	-0.116	0.309	-0.079	0.483	0.274
		Sig.	0.000*	0.000*	0.054	0.628	0.913	0.241	0.001*	0.426	0.000*	0.005*
		N	104	104	104	104	104	104	104	104	104	104
23	COD	R	0.258	0.037	-0.297	ND	ND	ND	0.000	-0.057	-0.082	-0.271
		Sig.	0.417	0.908	0.349	ND	ND	ND	1.000	0.860	0.800	0.394
		N	12	12	12	12	12	12	12	12	12	12
24	Oil & Grease	R	-0.387	-0.459	-0.215	0.000	0.000	-0.067	0.000	ND	-0.427	-0.426
		Sig.	0.154	0.085	0.442	1.000	1.000	0.811	1.000	ND	0.112	0.113
		N	15	15	15	15	15	15	15	15	15	15
25	Calcium	R	0.163	-0.024	-0.024	-0.017	-0.024	0.065	-0.056	0.030	0.009	-0.106
		Sig.	0.141	0.828	0.830	0.880	0.830	0.559	0.613	0.790	0.934	0.339
		N	83	83	83	83	83	83	83	83	83	83
26	Magnesium	R	0.032	-0.114	-0.108	-0.017	-0.068	0.259	-0.106	0.173	-0.105	-0.222
		Sig.	0.775	0.297	0.324	0.881	0.534	0.017*	0.333	0.112	0.338	0.041*
		N	85	85	85	85	85	85	85	85	85	85
27	Sodium	R	0.009	0.077	-0.094	-0.001	-0.027	-0.035	-0.056	0.000	0.020	-0.071
		Sig.	0.941	0.505	0.415	0.992	0.815	0.765	0.629	1.000	0.862	0.541
		N	77	77	77	77	77	77	77	77	77	77
28	Potassium	R	-0.007	0.109	0.016	0.032	-0.046	0.038	0.090	0.000	0.085	-0.131
		Sig.	0.958	0.423	0.906	0.818	0.734	0.780	0.508	1.000	0.533	0.336
		N	56	56	56	56	56	56	56	56	56	56
29	Chlorophyll a	R	0.122	0.181	-0.010	-0.124	-0.003	ND	0.291	0.000	0.170	0.116
		Sig.	0.424	0.235	0.949	0.419	0.984	ND	0.052	1.000	0.265	0.449
		N	45	45	45	45	45	45	45	45	45	45

Notes R = Correlation coefficient
* = Correlation is significant at the 0.05 level
ND = Not detectable

1) Abundance of Plankton

Relationships between pH and abundance of phytoplankton in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton in terms of R are 0.329*, 0.090, 0.164, -0.140, 0.086, 0.087 and 0.246* respectively (Table 5).

Relationships between pH and abundance of zooplankton in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton, and grand total plankton in terms of R are -0.074, -0.070, -0.024, -0.029, 0.013, -0.227*, 0.060, 0.047, -0.066 and 0.185 respectively (Table 6).

2) Number of Plankton Species

Relationships between pH and number of phytoplankton species in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton species in terms of R are 0.502*, 0.143, -0.288*, -0.095, 0.174, 0.096 and 0.299* respectively (Table 7).

Relationships between pH and number of zooplankton species in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton species, and grand total plankton species in terms of R are 0.275*, 0.413*, 0.053, 0.032, 0.073, -0.108, 0.242*, 0.013, 0.373* and 0.371* respectively (Table 8).

Results of the study show that pH has positive correlation with abundance of phytoplankton in phylum Cyanophyta and total phytoplankton including abundance of zooplankton in phylum Chordata. The pH has negative correlation with number of phytoplankton species in phylum Bacillariophyta. Moreover pH has positive correlation with number of phytoplankton species in phylum Cyanophyta, and total phytoplankton species as well as positive correlation with number of zooplankton species in phylum Protozoa, phylum Rotifera, phylum Mollusca, total zooplankton and grand total plankton. These agree with ธิดาพร หรบรรพ์ (2540) พัชริดา เหมมัน (2543) and พิศมัย เฉลยศักดิ์ (2543) who reported that pH had positive correlation with abundance of phytoplankton. In addition, ณฐกร ประดิษฐ์สรรพ์ (2543) reported that pH had positive correlation with abundance of phytoplankton in phylum Cyanophyta and total phytoplankton. Most natural water had pH values in the range of 6.5-9.0 (Boyd, 1982). เกษม จันทร์แก้ว (2530) reported that pH of use water was normally in the range of 6.5-8.5 or 5.0-9.0 for use water of fair quality. Water with pH less than 5.0 or more than 9.0 would cause danger to aquatic life. Generally, pH value of use water was close to 7.0. กรรณิการ์ สิริสิงห (2525) reported that pH of natural water was in the range of 4-9 but most of natural water was soft base due to carbonate and bicarbonate components in water. Water will higher or lower pH might have been contaminated by acid and strong base from industry effluent. However, กรรณิการ์ สิริสิงห (2525) said that in some condition natural water might have high content of carbonate and hydroxide; for surface water, with a lot of algae, the algae would use carbondioxide in water for photosynthesis process resulting in increase of pH value to about 9-10. These agree with ไมตรี ดวงสวัสดิ์ และจารุวรรณ สมศิริ (2528) who reported that pH in natural water was in soft base condition due to dissolved carbonate and bicarbonate in water including concentration of carbondioxide gas and acid compound matter. Phytoplankton and aquatic plant could use carbonmonoxide for photosynthesis process during the day causing increase of pH of water; during the night carbondioxide was released from respiration process, causing decrease of pH value in water. However, phytoplankton could grow well in water with pH range of 6-8. In water with high pH value, a few plankton species were found with large abundance in each species (Benson and William, 1975).

4.3.3 Relationships between Transparency and Plankton

Totally 80 records of data on transparency and plankton were analyzed. The transparency data ranged between 20-290 centimeters. The correlation analysis results are concluded as follows:

1) Abundance of Plankton

Relationships between transparency and abundance of phytoplankton in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton in terms of R are -0.094, -0.116, 0.033, 0.072, -0.046, -0.142 and -0.093 respectively (Table 5).

Relationships between transparency and abundance of zooplankton in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton, and grand total plankton in terms of R are -0.140, -0.160, -0.267*, 0.305*, 0.241*, -0.048, -0.055, 0.019, -0.216 and -0.097 respectively (Table 6).

2) Number of Plankton Species

Relationships between transparency and number of phytoplankton species in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton species in terms of R are -0.081, -0.300*, 0.150, -0.133, 0.292*, -0.245 and -0.222 respectively (Table 7).

Relationships between transparency and number of zooplankton species in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton species, and grand total plankton species in terms of R are -0.124, -0.179, -0.172, 0.001, -0.059, 0.311*, -0.043, 0.241*, -0.196 and -0.251* respectively (Table 8).

Results of study show that transparency has negative correlation with abundance of zooplankton in phylum Arthropoda and has positive correlation with abundance of zooplankton in phylum Annelida and phylum Nematoda. The transparency has negative correlation with number of phytoplankton species in phylum Chlorophyta and has positive correlation with number of phytoplankton species in phylum Pyrrophyta. The transparency has positive correlation with number of zooplankton species in phylum Chordata and phylum Coelenterata and has negative correlation with number of grand total plankton species. Mirza, M.R. Haque, A.K.M. Haque, and Chowdhury (1985) reported that transparency was a growth factor of plankton. ไมตรี ดวงสวัสดิ์ และจารุวรรณ สมศิริ (2528) reported that the low transparency of water (less than 30 cm), might be due to high abundance of plankton causing high turbidity and light could not penetrate into water. In water with high transparency (more than 60 cm), there were low abundance of plankton, and water was in poor condition. However, the photosynthesis rate was highest at water surface. วราภรณ์ พรหมพจน์ (2526) reported that in summer phytoplankton would decrease photosynthesis process near water surface and rate of primary productivity efficiency would be highest where light intensity decreased to suitable level. Shirota (1966) reported that light was very important for photosynthesis process of phytoplankton. As light penetrated into water, water would absorb some radiation of light. Some of light would be used by phytoplankton in photosynthesis process. The suspended particles in water i.e. soil sediment, organic matter, inorganic matter, plankton and small aquatic life caused light dispersion and absorb light. It would obstruct light from penetrating into the water. If intensity of light was suitable, abundance of phytoplankton would be high. The light would help distribution of plankton in vertical direction. In case intensity of light was excess, plankton would move to depth zone and plankton would come to water surface in nighttime (Raymont, 1963). In summary, it can be concluded that light is very important for photosynthesis process of phytoplankton. In condition with suitable intensity of light abundance of phytoplankton would increase, resulting in increase abundance of zooplankton.

4.3.4 Relationships between Depth of Water and Plankton

Totally 69 records of data on depth of water and plankton were analyzed. The depth of water data ranged between 0.5-20.5 meters. The correlation analysis results are concluded as follows:

1) Abundance of Plankton

Relationships between depth of water and abundance of phytoplankton in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton in terms of R are 0.303*, -0.029, 0.235, -0.102, -0.030, -0.104 and 0.195 respectively (Table 5).

Relationships between depth of water and abundance of zooplankton in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton, and grand total plankton in terms of R are -0.107, -0.050, -0.203, -0.026, cannot be analyzed, 0.075, 0.173, -0.071, -0.123 and 0.189 respectively (Table 6).

2) Number of Plankton Species

Relationships between depth of water and number of phytoplankton species in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton species in terms of R are 0.420*, 0.199, 0.068, -0.154, 0.290*, 0.004 and 0.243* respectively (Table 7).

Relationships between depth of water and number of zooplankton species in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton species, and grand total plankton species in terms of R are -0.034, 0.076, -0.307*, -0.112, 0.164, -0.074, 0.098, -0.000, -0.038 and 0.178 respectively (Table 8).

Results of study show that depth of water has positive correlation with abundance of phytoplankton in phylum Cyanophyta. Depth of water has also positive correlation with number of phytoplankton species in phylum Cyanophyta, phylum Pyrrophyta, and total phytoplankton but has negative correlation with number of zooplankton species in phylum Arthropoda. Odum (1959) found that density of phytoplankton was highest in range of light at level beneath water surface and continuously decreased when depth increased such as case of Mendota lake in

Wisconsin State, the abundance of phytoplankton was more than 5,000 units/liter at water surface but it was 1,000 units/liter at 20-meter depth. เดชาพล รุกขมธุร์ (2528) reported that water quality varied according to depth such as pH at water surface was higher than pH at water bed, DO at water surface and at mid-depth were also higher than DO at waterbed. Other factors might be additional factors for water quality variation at each depth to be suitable for different aquatic lives. Therefore, correlation between abundance of phytoplankton and water depth is limited to the depth of water where light can penetrate.

4.3.5 Relationships between Turbidity and Plankton

Totally 89 records of data on turbidity and plankton were analyzed. The turbidity data ranged between 0.9-166 mg/l. The correlation analysis results are concluded as follows:

1) Abundance of Plankton

Relationships between turbidity and abundance of phytoplankton in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton in terms of R are -0.206, -0.092, -0.161, -0.023, -0.040, -0.075 and -0.197 respectively (Table 5).

Relationships between turbidity and abundance of zooplankton in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton, and grand total plankton in terms of R are -0.048, -0.012, 0.094, -0.060, -0.047, -0.095, -0.006, -0.059, 0.013 and -0.193* respectively (Table 6).

2) Number of Plankton Species

Relationships between turbidity and number of phytoplankton species in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton species in terms of R are -0.308*, -0.303*, -0.263*, -0.040, -0.467*, -0.049 and -0.336* respectively (Table 5).

Relationships between turbidity and number of zooplankton species in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton species, and grand total plankton species in terms of R are -0.217*, -0.155, 0.036, -0.073, -0.004, -0.073, -0.155, -0.047, -0.160 and -0.314* respectively (Table 8).

Results of study show that turbidity has negative correlation with abundance of total zooplankton. The turbidity has also negative correlation with number of phytoplankton species in phylum Cyanophyta, phylum Chlorophyta, phylum Bacillariophyta, phylum Pyrrophyta, and total phytoplankton. The turbidity has negative correlation with number of zooplankton species in phylum Protozoa and grand total plankton. Lorenzen (1963) stated that turbidity of water showed suspended solids, which obstruct light from penetrating deep into water. The suspension matter would reflex and absorb light. The suspension matter comprised organic matter, inorganic matter and small aquatic life (1-10 micrometer). If intensity of light was suitable, abundance of phytoplankton would be high. The light would help distribution of plankton in vertical direction. In case intensity of light was excess, plankton would move to deep zone. Turbidity of natural water ranged between 25-27 JTU. Main important rivers in all regions of Thailand had turbidity more than 80 JTU (เกษม จันทร์แก้ว, 2530). The results of study of Welch (1952) revealed that abundance of phytoplankton had negative correlation with turbidity. It meant that when there was high turbidity from sediment or suspended solid, light could not penetrate into deep zone. The photosynthesis of phytoplankton would decrease, resulting in decrease of abundance of phytoplankton. Moreover, turbidity was very important to abundance of diatom. Abundance of diatom would decrease when turbidity increased even there was rich nutrient in the river (Kawecka, 1980). Patrick (1977) stated that when light penetrated into waterless, there would be effect on photosynthesis process and increase of phytoplankton. Hynes (1970) reported that turbidity would obstruct penetration of light into deep zone. The suspension matter would reflex or absorb light. In shoreline and sand or gravel water bed, turbidity value of water would be less than in area with clay or mud water bed. In addition, the high flow rate of water would cause more turbidity than low flow. Then, turbidity of water in river and stream was higher than turbidity in still water source. Nevertheless, result of study of McNeely, Neimais, and Dawyer (1979) reported that high turbidity would obstruct light penetration into deep zone and low intensity of light decreased growth of algae because light that penetrated into water was not enough for photosynthesis process. Consequently, abundance of total phytoplankton decreased.

4.3.6 Relationships between Conductivity and Plankton

Totally 99 records of data on conductivity and plankton were analyzed. Records of the conductivity ranged between 0.1-6,200 microhos/centimeter. The correlation analysis results are concluded as follows:

1) Abundance of Plankton

Relationships between conductivity and abundance of phytoplankton in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton in terms of R are -0.034, -0.066, -0.012, -0.062, 0.009, 0.022 and -0.046 respectively (Table 5).

Relationships between conductivity and abundance of zooplankton in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton, and grand total plankton in terms of R are -0.034, -0.033, -0.028, -0.014, -0.007, -0.018, -0.017, -0.004, -0.033 and -0.046 respectively (Table 6).

All of analysis results reveal that conductivity and abundance of plankton phylum do not correlate with each other.

2) Number of Plankton Species

Relationships between conductivity and number of phytoplankton species in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton species in terms of R are -0.019, -0.140, 0.088, -0.037, -0.058, 0.137 and -0.037 respectively (Table 7).

Relationships between conductivity and number of zooplankton species in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton species, and grand total plankton species in terms of R are 0.057, 0.118, -0.105, -0.031, -0.016, -0.041, -0.025, -0.007, 0.056 and -0.005 respectively (Table 8).

All of analysis results reveal that conductivity and number of plankton species in each phylum do not correlate with each other.

4.3.7 Relationships between Dissolved Oxygen (DO) and Plankton

Totally 109 records of data on DO and plankton were analyzed. The dissolved oxygen ranged between 0.2-11.60 mg/l. The correlation analysis results are concluded as follows:

1) Abundance of Plankton

Relationships between DO and abundance of phytoplankton in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton in terms of R are 0.280*, 0.154, 0.089, -0.036, 0.160, 0.105 and 0.247 respectively (Table 5).

Relationships between DO and abundance of zooplankton in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton, and grand total plankton in terms of R are -0.127, -0.125, -0.094, -0.039, 0.039, 0.331*, -0.041, 0.074, -0.123 and 0.171 respectively (Table 6).

All of analysis results reveal that DO and abundance of plankton phylum do not correlate with each other.

2) Number of Plankton Species

Relationships between DO and number of phytoplankton species in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton species in terms of R are 0.430*, 0.344*, 0.143, 0.051, 0.343*, 0.037 and 0.359* respectively (Table 7).

Relationships between DO and number of zooplankton species in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton species, and grand total plankton species in terms of R are 0.137, 0.369*, 0.291*, 0.101, -0.008, -0.058, 0.346*, 0.039, 0.394 and 0.424 respectively (Table 8).

Results of study show that DO has positive correlation with abundance of phytoplankton in phylum Cyanophyta. DO has also positive correlation with abundance of zooplankton in phylum Chordata. Moreover DO has positive correlation with phytoplankton species in phylum Cyanophyta, phylum Chlorophyta, phylum Pyrrophyta and total phytoplankton species. DO has positive correlation with number of zooplankton species in phylum Rotifera, phylum Arthropoda, and phylum Mollusca.

The increased abundance of phytoplankton and phytoplankton species would increase photosynthesis of phytoplankton, resulting in increase of DO. ณฐกร ประดิษฐ์สรรพ์ (2543) reported that DO has positive correlation with phytoplankton in phylum Cyanophyta. พัชริดา เหมมัน (2543) and พิศมัย เฉลยศักดิ์ (2543) reported that total phytoplankton has positive correlation with DO. เปี่ยมศักดิ์ เมนะเศวต (2539) stated that DO values in natural water sources in Thailand were in the range of 4.0-6.0 mg/l. The capacity for dissolving oxygen of fresh water was in the range of 14.6 mg/liter at $0^{o}C$ and 6.9 mg/l at $35^{o}C$ at 1 atmospheric pressure (ไมตรี ดวงสวัสดิ์ และจารุวรรณ สมศิริ, 2528). ไพเราะ เคาศิริกุล (2522) said that dissolved oxygen was very important factor, which had influence on abundance of plankton. DO was very important parameter of water quality because oxygen is important for the living of aquatic life (เสริมพล รัตสุข

และไชยยุทธ กลิ่นสุคนธ์, 2518). In addition, ไมตรี ดวงสวัสดิ์ และจารุวรรณ สมศิริ (2528) said that abundance of phytoplankton had correlation with dissolved oxygen. During daytime, phytoplankton would use light for photosynthesis process, which would release oxygen into water source, resulting in increase of DO. DO value could decrease because of community waste, industry waste, etc. including slow flow rate of water. This deteriorated water quality. When DO decreased the abundance of phytoplankton and zooplankton would also decrease or they could not live in that water source any longer (เฉลิม ชุมพล, 2527). Boyd (1982) stated that dissolved oxygen was product from photosynthesis process, DO would increase when there was richness of phytoplankton. Nevertheless, พิศมัย เฉลยศักดิ์ (2543) said that DO in water source with little depth and high flow rate is more than that in water source with still water or low flow rate.

4.3.8 Relationships between Total Solid and Plankton

Totally 41 records of data on total solid and plankton were analyzed. Records of the total solid data ranged between 10-651 mg/l. The correlation analysis results are concluded as follows:

1) Abundance of Plankton

Relationships between total solid and abundance of phytoplankton in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton in terms of R are 0.044, -0.289, -0.103, -0.098, 0.059, -0.051 and -0.010 respectively (Table 5).

Relationships between total solid and abundance of zooplankton in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton, and grand total plankton in terms of R are 0.161, -0.024, 0.045, 0.036, 0.017, cannot be analyzed, cannot be analyzed, 0.000, 0.050, and -0.005 respectively (Table 6).

All of analysis results reveal that total solid and abundance of plankton phylum do not correlate with each other.

2) Number of Plankton Species

Relationships between total solid and number of phytoplankton species in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton species in terms of R are 0.065, -0.495*, 0.100, -0.055, -0.350*, -0.067 and -0.298 respectively (Table 7).

Relationships between total solid and number of zooplankton species in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton species, and grand total plankton species in terms of R are 0.405*, 0.197, -0.084, cannot be analyzed, cannot be analyzed, 0.035, cannot be analyzed, 0.017, 0.169 and -0.131 respectively (Table 8).

Results of study show that total solid has negative correlation with number of phytoplankton species in phylum Chlorophyta and phylum Pyrrophyta but positive correlation with zooplankton species in phylum Protozoa. Raymont (1963) reported that the suspended particles in water i.e. soil sediment, organic matter, inorganic matter, plankton and small aquatic life would obstruct light from penetrating into the water. If intensity of light were suitable, abundance of phytoplankton would be high. On the contrary, if intensity of light were not suitable, abundance of phytoplankton would be low. It would have effect on number of phytoplankton species in water too. The total solid has positive correlation with number of zooplankton species in phylum Protozoa. ไมตรี ดวงสวัสดิ์ และจารุวรรณ สมศิริ (2528) and เสาวภา อังสุภานิช (2528) reported that total solid in water were plankton, inorganic matter in terms of inorganic salt i.e. NaCl, Na_2CO_3, and organic matter i.e. starch, sugar, amino acid, some of vitamin, detergent, etc. The organic and inorganic matters including mineral were nutrient of plankton in water. When, there was richness of nutrient, the phytoplankton growth would be high, and when there was high phytoplankton growth, the zooplankton would have high growth too. This agrees results of the study of ณฐกร ประดิษฐ์สรรพ์ (2543) which reported that zooplankton has correlation with suspended solid due to a lot of nutrient in water source. The nutrient of plankton came from agricultural activities, effluent from industry, wastewater from community, etc. The nutrients of plankton are organic and inorganic suspended solid. It can be concluded that high volume of suspended solid would result in high abundance of phytoplankton and consequently high abundance of zooplankton.

4.3.9 Relationships between Total Dissolved Solid and Plankton

Totally 86 records of data on total dissolved solid and plankton were analyzed. The total dissolved solid data ranged between 0-700 mg/l. The correlation analysis results are concluded as follows:

1) Abundance of Plankton

Relationships between total dissolved solid and abundance of phytoplankton in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton in terms of R are 0.057, -0.078, 0.116, -0.155, 0.179, 0.141 and 0.053 respectively (Table 5).

Relationships between total dissolved solid and abundance of zooplankton in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton, and grand total plankton in terms of R are -0.015, -0.025, -0.048, -0.044, -0.044, -0.036, -0.009, -0.018, -0.026 and 0.036 respectively (Table 6).

All of analysis results reveal that total dissolved solid and abundance of plankton phylum do not correlate with each other.

2) Number of Plankton Species

Relationships between total dissolved solid and number of phytoplankton species in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton species in terms of R are 0.021, -0.092, 0.161, -0.095, 0.058, 0.051 and 0.002 respectively (Table 7).

Relationships between total dissolved solid and number of zooplankton species in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton species, and grand total plankton species in terms of R are 0.108, 0.075, -0.217*, 0.021, -0.011, -0.108, 0.104, -0.044, 0.006 and 0.004 respectively (Table 8).

Results of study show that total dissolved solid has negative correlation with number of zooplankton species in phylum Arthropoda. Total dissolved solid might come from agriculture activities, industry effluent, and wastewater from community. Some of total dissolved solid are toxic to zooplankton in water resulting in decrease of abundance and number of species of phytoplankton and finally decrease in abundance and number of species of zooplankton.

4.3.10 Relationships between Suspended Solid and Plankton

Totally 97 records of data on suspended solid and plankton were analyzed. The suspended solid data ranged between 0-214 mg/l. The correlation analysis results are concluded as follows:

1) Abundance of Plankton

Relationships between suspended solid and abundance of phytoplankton in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton in terms of R are -0.158, -0.037, -0.120, -0.008, -0.083, -0.075 and -0.134 respectively (Table 5).

Relationships between suspended solid and abundance of zooplankton in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton, and grand total plankton in terms of R are -0.010, -0.005, 0.022, -0.066, -0.050, -0.077, 0.024, -0.053, -0.003 and -0.111 respectively (Table 6).

All of analysis results reveal that suspended solid and abundance of plankton phylum do not correlate with each other.

2) Number of Plankton Species

Relationships between suspended solid and number of phytoplankton species in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton species in terms of R are -0.123, -0.259*, -0.099, -0.007, -0.415, -0.079 and -0.228* respectively (Table 7).

Relationships between suspended solid and number of zooplankton species in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton species, and grand total plankton species in terms of R are 0.034, -0.044, -0.068, -0.053, 0.027, -0.072, -0.124, -0.050, -0.052 and -0.188 respectively (Table 8).

Results of study show that suspended solid have negative correlation with number of phytoplankton species in phylum Chlorophyta and total phytoplankton species. Suspension solid has direct effect on water source in terms of turbidity. In water with high turbidity, there is much suspension solid to disperse and to absorb light, they have effects on photosynthesis of phytoplankton, abundance and number of phytoplankton species in water.

4.3.11 Relationships between Total Hardness and Plankton

Totally 99 records of data on total hardness and plankton were analyzed. Records of total hardness data ranged between 0.0-317.0 mg/l as $CaCO_3$. The correlation analysis results are concluded as follows:

1) Abundance of Plankton

Relationships between total hardness and abundance of phytoplankton in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton in terms of R are 0.378*, -0.012, 0.279*, -0.143, 0.243*, 0.311* and 0.284* respectively (Table 5).

Relationships between total hardness and abundance of zooplankton in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton, and grand total plankton in terms of R are -0.083,

-0.092, -0.082, 0.015, 0.030, 0.159, 0.053, 0.056, -0.090 and 0.209 respectively (Table 6).

2) Number of Plankton Species

Relationships between total hardness and number of phytoplankton species in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton species in terms of R are 0.502*, 0.107, 0.545*, 0.097, 0.142, 0.321* and 0.393* respectively (Table 7).

Relationships between total hardness and number of zooplankton species in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton species, and grand total plankton species in terms of R are 0.427*, 0.428*, -0.135, 0.015, 0.052, -0.075, 0.269*, 0.030, 0.358* and 0.437* respectively (Table 8).

Results of the study show that total hardness has positive correlation with abundance of phytoplankton in phylum Cyanophyta, phylum Bacillariophyta, phylum Pyrrophyta, phylum Euglenophyta, and total phytoplankton. The total hardness has also positive correlation with number of phytoplankton species in phylum Cyanophyta, phylum Bacillariophyta, phylum Euglenophyta, and total phytoplankton species. Total hardness has positive correlation with number of zooplankton species in phylum Protozoa, phylum Rotifera, phylum Mollusca, total zooplankton species and grand total plankton species. This agrees with สมชาย สุรวิทย์ (2539) who reported that abundance of phytoplankton in phylum Bacillariophyta, phylum Pyrrophyta, phylum Euglenophyta, and total phytoplankton had positive correlation with total hardness. กรรณิการ์ สิริสิงห (2525) stated that total hardness of surface water ranged 80-100 mg/l in form of $CaCO_3$. Hardness in most natural water came from carbonate and bicarbonate alkalinity. ชาญยุทธ คงภิรมย์ชื่น (2533) said that hardness of water showed calcium and magnesium salts in form of water soluble calcium carbonate including 2 anion of metal. The calcium and magnesium were important to increase of number of plankton because they released bicarbonate to increase carbondioxide gas for photosynthesis process (Smith, 1950). It meant that when total hardness of water increased, plankton would increase too because there were many minerals essential for living of phytoplankton. Calcium was important component in cell and important component in production of cell wall (สมชาย สุรวิทย์, 2539). This agrees with result of plankton study in Ping-Wung Watershed of กรรณิการ์ พุทธาธร (2529) that abundance of plankton in phylum Bacillariophyta (diatom) had positive correlation with calcium. It could be concluded that when total hardness of water increased, phytoplankton would increase due to essential minerals in water. Therefore, when phytoplankton had high growth, it would result in high growth of zooplankton. Water hardness had impact on species and abundance of phytoplankton. The green algae in order Volvocales such as *Valvox* sp. and *Pandorina* sp. could be found in water with high hardness. There were many yellow-green algae in group of Coccolithophorids in high calcium water in tropical zone (Prescott, 1962). A large number of phytoplankton in desmids group, and some species of blue-green algae and green algae were found in water with low hardness (Chapman, 1969). Prescott (1962) reported that in Genwa lake, in water with low hardness, low abundance of phytoplankton (about 1,000 unit/liter) was found, but in water with high hardness about 9,000,000 filament/liter of *Oscillatoria* sp. were found.

4.3.12 Relationships between Chloride and Plankton

Totally 39 records of data on chloride and plankton were analyzed. The chloride data ranged between 0.1-120.0 mg/l. The correlation analysis results are concluded as follows:

1) Abundance of Plankton

Relationships between chloride and abundance of phytoplankton in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton in terms of R are -0.030, -0.003, -0.012, -0.029, -0.024, 0.168 and -0.015 respectively (Table 5).

Relationships between chloride and abundance of zooplankton in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton, and grand total plankton in terms of R are -0.019, -0.021, 0.005, -0.032, -0.067, 0.663*, cannot be analyzed, 0.000, -0.018 and -0.016 respectively (Table 6).

2) Number of Plankton Species

Relationships between chloride and number of phytoplankton species in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton species in terms of R are 0.004, 0.426*, 0.704*, 0.474*, -0.239, 0.455* and 0.597* respectively (Table 7).

Relationships between chloride and number of zooplankton species in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton species, and grand total plankton species in terms of R are 0.078, 0.494*, 0.402*, cannot be analyzed, cannot be analyzed, -0.032, 0.663*, -0.067, 0.467* and 0.615 respectively (Table 8).

Results of the study show that chloride has positive correlation with abundance of phytoplankton in phylum Chordata. The chloride has positive correlation with number of phytoplankton species in phylum Chlorophyta, phylum Bacillariophyta, phylum Chrysophyta, phylum Euglenophyta, and total phytoplankton species and has also positive correlation with number of zooplankton species in phylum Rotifera, phylum Arthropoda, phylum Mollusca, and total zooplankton species. Quantity of chloride would have more effect on number of plankton species on than abundance of plankton. Most of correlation are in positive direction. กรรณิการ์ สิริสิงห (2525) reported that chloride concentration varied in natural water, chloride would increase in correlation with mineral increase. Chloride was a water soluble ion which related with other water soluble such as sodium, sulfate, magnesium, calcium, potassium, bicarbonate, etc (Boyd, 1989). When, chloride increases other ions would also increase and there would be effect on abundance and number of species of plankton in water source. Therefore, quantity of chloride can be an indirect indicator for number of plankton species.

4.3.13 Relationships between Acidity and Plankton

Totally 6 records of data on acidity and plankton were analyzed. The acidity data ranged between 0.95-30.60 mg/l. The correlation analysis results are concluded as follows:

1) Abundance of Plankton

Relationships between acidity and abundance of phytoplankton in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton in terms of R are -0.139, -0.194, 0.094, -0.225, -0.188, -0.230 and -0.196 respectively (Table 5).

Relationships between acidity and abundance of zooplankton in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton, and grand total plankton in terms of R are 0.528, -0.205, -0.362, -0.183, cannot be analyzed, -0.000, cannot be analyzed, cannot be analyzed, -0.311 and -0.203 respectively (Table 6).

All of analysis results reveal that acidity and abundance of plankton do not correlate with each other.

2) Number of Plankton Species

Relationships between acidity and number of phytoplankton species in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta and total phytoplankton species in terms of R are 0.211, -0.267, 0.920*, -0.493, -0.231, -0.294 and -0.100 respectively (Table 7).

Relationships between acidity and number of zooplankton species in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton species, and grand total plankton species in terms of R are 0.772, 0.244, -0.230, cannot be analyzed, cannot be analyzed, -0.183, 0.000, cannot be analyzed, 0.474 and 0.016 respectively (Table 8).

Results of the study show that acidity has positive correlation with number of phytoplankton in phylum Bacillariophyta. กรรณิการ์ สิริสิงห (2525) said that water acidity was capability of water to release proton or hydrogen ion. The important acidity were carbondioxide acidity and mineral acidity. The carbondioxide acidity had carbondioxide gas which was important component of natural water. Carbondioxide or carbonic acid could not change pH to lower than 4.5. Mineral acidity was acidity from mineral acid which was strong acid. The water with this type of acidity had pH lower than 4.5. It could be found in effluent from industrial plants such as melting plant, organic matter production plant and natural waterway that flew past old mining area. Acidity was very important because it caused corrosion and it had effect on chemical and biological process. The pH change due to acidity of water would affect abundance of plankton. Scagel et al. (1967) studied relationship between distribution of diatom and pH of water and found that diatom would be in high number of families acidity of water (pH) ranging 4.0-6.5 but with low abundance of plankton in each family. พัชริดา เหมมัน (2543) also reported that high abundance of phytoplankton in

water source would use carbondioxide gas for photosynthesis process until there would be shortage of free CO_2, plankton would use carbondioxide from buffer system process causing of alkalinity compound from bicarbonate (HCO^-_3) to carbonate (CO^{2-}_3) and hydroxide (OH^-) respectively. It would result in increase of pH and change in abundance of plankton.

4.3.14 Relationships between Alkalinity and Plankton

Totally 83 records of data on alkalinity and plankton were analyzed. The alkalinity data ranged between 0.41-195 mg/l. The correlation analysis results are concluded as follows:

1) Abundance of Plankton

Relationships between alkalinity and abundance of phytoplankton in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton in terms of R are 0.530*, -0.021, 0.473*, -0.185, 0.300*, 0.372* and 0.452* respectively (Table 5).

Relationships between alkalinity and abundance of zooplankton in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton, and grand total plankton in terms of R are 0.366*, 0.289*, 0.127, -0.147, 0.069, 0.163, 0.043, 0.084, 0.293* and 0.451 respectively (Table 6).

2) Number of Plankton Species

Relationships between alkalinity and number of phytoplankton species in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton species in terms of R are 0.564*, 0.190, 0.376*, 0.069, 0.166, 0.317* and 0.413* respectively (Table 7).

Relationships between alkalinity and number of zooplankton species in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton species, and grand total plankton species in terms of R are 0.509*, 0.479*, -0.166, -0.024, 0.040, -0.188, 0.219*, 0.069, 0.400* and 0.471* respectively (Table 8).

Results of the study show that alkalinity has positive correlation with abundance of phytoplankton in phylum Cyanophyta, phylum Bacillariophyta, phylum Pyrrophyta, phylum Euglenophyta, and total phytoplankton and has positive correlation with abundance of zooplankton in phylum Protozoa, phylum Rotifera, and total zooplankton. Moreover, the alkalinity has positive correlation with number of phytoplankton species in phylum Cyanophyta, phylum Bacillariophyta, phylum Euglenophyta, and total phytoplankton species and positive correlation with number of zooplankton species in phylum Protozoa, phylum Rotifera, phylum Mollusca, total zooplankton species, and grand total plankton species. This agrees with the results of study of ณฐกร ประดิษฐ์สรรพ์ (2543) who reported that alkalinity value had positive correlation with number of phytoplankton species in phylum Cyanophyta and total phytoplankton and number of zooplankton species in phylum Protozoa, phylum Rotifera, and total zooplankton. In addition, พัชริดา เหมมัน (2543) reported that total phytoplankton species had positive correlation with alkalinity of water. ไมตรี ดวงสวัสดิ์ และจารุวรรณ สมศิริ (2528) stated that suitable criteria for the living of aquatic life was alkalinity in the range 100-120 mg/l. Generally, alkalinity of water comprised carbonate ($CO^{=}_3$), bicarbonate (HCO^{-}_3) and hydroxide (OH^{-}) but might consist of a little silicate, phosphate, borate, fluoride, arcinate, aluminate and other organic matter (ชาญยุทธ คงภิรมย์ชื่น, 2533). The nutrients i.e. carbonate was important to photosynthesis of plankton. In high carbonate condition, the abundance of plankton would increase (Smith, 1950). Therefore, increased alkalinity would result in increase of phytoplankton because there were a lot of nutrients and essential organic matters for phytoplankton life. When phytoplankton increased, there would be an increase in number of zooplankton species. If there was shortage of nutrients and essential organic matters for phytoplankton life, the growth of phytoplankton would decrease and number of zooplankton would decrease (เสาวภา อังสุภานิช, 2528). Zooplankton will consume phytoplankton and other zooplankton with little size for food.

4.3.15 Relationships between Nitrate-Nitrogen and Plankton

Totally 92 records of data on nitrate-nitrogen and plankton were analyzed. The nitrate data ranged between 0.001-2.68 mg/l. The correlation analysis results are concluded as follows:

1) Abundance of Plankton

Relationships between nitrate-nitrogen and abundance of phytoplankton in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton in terms of R are -0.111, -0.064, -0.132, 0.045, -0.075, -0.076 and -0.125 respectively (Table 5).

Relationships between nitrate-nitrogen and abundance of zooplankton in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton, and grand total plankton in terms of R are -0.058, -0.050, -0.034, -0.014, -0.000, 0.002, -0.023, -0.007, -0.050 and -0.115 respectively (Table 6).

All of analysis results reveal that nitrate and abundance of plankton phylum do not correlate with each other.

2) Number of Plankton Species

Relationships between nitrate-nitrogen and number of phytoplankton species in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton species in terms of R are -0.056, -0.060, -0.039, 0.162, -0.347, -0.141 and -0.095 respectively (Table 7).

Relationships between nitrate-nitrogen and number of zooplankton species in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton species, and grand total plankton species in terms of R are 0.023, -0.005, -0.114, -0.027, -0.017, -0.049, -0.017, 0.000, -0.037 and -0.083 respectively (Table 8).

All of analysis results reveal that nitrate and number of plankton species in each phylum do not correlate with each other.

4.3.16 Relationships between Nitrite-Nitrogen and Plankton

Totally 3 records of data on nitrite-nitrogen and plankton were analyzed. The nitrite data ranged between 0.003-0.04 mg/l. The correlation analysis results are concluded as follows:

1) Abundance of Plankton

Relationships between nitrite-nitrogen and abundance of phytoplankton in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton in terms of R are 0.036, -0.972, -0.959, 0.644, -0.965, -0.965 and -0.828 respectively (Table 5).

Relationships between nitrite-nitrogen and abundance of zooplankton in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton, and grand total plankton in terms of R are -0.975, -0.992, -0.890, cannot be analyzed, cannot be analyzed, -0.000, cannot be analyzed, cannot be analyzed, -0.940 and -0.844 respectively (Table 6).

All of analysis results reveal that nitrite and abundance of plankton phylum do not correlate with each other.

2) Number of Plankton Species

Relationships between nitrite-nitrogen and number of phytoplankton species in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton species in terms of R are -0.709, -0.980, -0.673, -0.965, -0.965, -0.965 and -0.922 respectively (Table 7).

Relationships between nitrite-nitrogen and number of zooplankton species in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton species, and grand total plankton species in terms of R are -0.709, -0.998*, -0.945, cannot be analyzed, cannot be analyzed, cannot be analyzed, cannot be analyzed, cannot be analyzed, -0.995 and -0.961 respectively (Table 8).

Results of study show that nitrite-nitrogen has negative correlation with number of zooplankton species in phylum Rotifera. It means that there are high number of zooplankton species in phylum Rotifera at low nitrite concentration in water. Nitrite is nitrogen compound that is rarely found in natural condition. Most of nitrite come from degradation process of organic nitrogen such as ammonia, nitrite, fertilizer used in agriculture (Alexopoulos and Bold, 1967). The most common forms of nitrogen used were nitrate and ammonia (Fogg, 1975). The fixed-nitrogen would produce amino acid and protein. When microorganism was degraded, the protein would be changed into amino acid and then changed into ammonium ion. This ammonium would be directly used by plant or changed into nitrate because some plant could live together with microorganism which could fix nitrogen (Keeney, 1970). If high nitrite concentration was found in water, it showed that there were high contamination organic nitrogen nutrient in water. Organic-nitrogen would change form into nitrite form. The high contaminated water would affect abundance and number of plankton species. However, some species of zooplankton could be survived in high organic nitrogen water especially plankton in phylum Rotifera.

4.3.17 Relationships between Organic-Nitrogen and Plankton

Totally 44 records of data on organic-nitrogen and plankton were analyzed. The organic nitrogen data ranged between 0.1-0.8 mg/l. The correlation analysis results are concluded as follows:

1) Abundance of Plankton

Relationships between organic-nitrogen and abundance of phytoplankton in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton in terms of R are -0.232, -0.041, -0.348*, 0.177, -0.274, -0.023 and -0.319 respectively (Table 5).

Relationships between organic-nitrogen and abundance of zooplankton in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton, and grand total plankton in terms of R are -0.354*, -0.407*, -0.324*, -0.000, cannot be analyzed, -0.167, 0.145, -0.135, -0.432* and -0.325* respectively (Table 6).

2) Number of Plankton Species

Relationships between organic-nitrogen and number of phytoplankton species in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton species in terms of R are -0.053, 0.049, -0.058, -0.212, 0.049, -0.040 and -0.028 respectively (Table 7).

Relationships between organic-nitrogen and number of zooplankton species in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton species, and grand total plankton species in terms of R are -0.092, -0.409*, -0.107, -0.134, 0.151, cannot be analyzed, -0.099, -0.000, -0.330* and -0.218 respectively (Table 8).

Results of study show that organic-nitrogen has negative correlation with abundance of phytoplankton in phylum Bacillariophyta and total phytoplankton as well as abundance of zooplankton in phylum Protozoa, phylum Rotifera, phylum Arthropoda, total zooplankton and grand total plankton. The organic nitrogen has negative correlation with number of zooplankton species in phylum Rotifera and total zooplankton species.

พันทวี มาไพโรจน์ และศิริเพ็ญ ตรัยไชยาพร (2543) reported that different forms of nitrogen found could indicate stage of contamination of water source. When high organic nitrogen and ammonia nitrogen were found from analysis result, it indicated that there had been recently contamination in water source. If analysis results showed that most of contaminants were nitrate nitrogen, it meant that the contamination had taken place long time ago. At pH 7 or pH less than 7, ammonia and nitrogen compound i.e. nitrate would be useful for growth of diatom but at pH more than 7, ammonia would change form into ammonia hydroxide which was toxic to diatom.

Moreover, abundance of blue-green algae had negative correlation with high dissolved organic matters in water; this algae would increase when intensity of organic matters (such as nitrate and phosphate) in water was low because nutrients would be used and collected in cells of the algae. Carpenter, Remsen, and Watson (1972) reported that nitrogen built up cells. Many organic matters had nitrogen component that could be found in plant especially high protein aquatic life such as algae that had amines, amino acids, nucleic acids and alkaloids. Organic-nitrogen could degrade in natural condition. Phytoplankton could use many type of nitrogen compound such as nitrate, ammonia, urea, and amino acid. The form of nitrogen used depended on species of phytoplankton (Carpenter, Remsen, and Watson, 1972) but the most common forms of nitrogen used were nitrate and ammonia (Fogg, 1975). Natural water with lot of organic nitrogen would have high contamination of organic matter, it had to use high oxygen in degradation process, then, oxygen would be low in water, and this would reduce abundance and number of plankton species in water. In addition, เฉลิม ชุมพล (2527) reported that when DO in water decreased, their phytoplankton and zooplankton would also decrease or could not survive in that water source.

4.3.18 Relationships between Total Nitrogen and Plankton

Totally 52 records of data on total nitrogen and plankton were analyzed. The total nitrogen data ranged between 0.003-3.60 mg/l. The correlation analysis results are concluded as follows:

1) Abundance of Plankton

Relationships between total nitrogen and abundance of phytoplankton in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton in terms of R are -0.197, -0.011, -0.240, -0.096, -0.184, -0.023 and -0.221 respectively (Table 5).

Relationships between total nitrogen and abundance of zooplankton in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton, and grand total plankton in terms of R are -0.251, -0.379*, -0.323*, -0.106, cannot be analyzed, -0.058, 0.139, -0.071, -0.393* and -0.228 respectively (Table 6).

2) Number of Plankton Species

Relationships between total nitrogen and number of phytoplankton species in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton species in terms of R are -0.014, 0.039, -0.100, -0.366*, 0.021, 0.029 and -0.021 respectively (Table 7).

Relationships between total nitrogen and number of zooplankton species in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton species, and grand total plankton species in terms of R are -0.078, -0.231, -0.113, -0.064, 0.146, -0.106, -0.009, 0.000, -0.202 and -0.111 respectively (Table 8).

Results of study show that total nitrogen has negative correlation with abundance of zooplankton in phylum Rotifera, phylum Arthropoda and total zooplankton. The total nitrogen has negative correlation with number of phytoplankton species in phylum Chrysophyta. กรรณิการ์ สิริสิงห (2525) reported that there were 2 types of nitrogen compound in water source comprising inorganic compound i.e. NH^+_4, NO^-_2, NO^-_3 in fertilizer or urea forms, and organic nitrogen i.e. protein, amino acid, nucleic acid which were compound of plant and organ of animal, fecal, fermented fertilizer, etc. Those nitrogen compounds could change from insoluble organic matter form to soluble organic matter form by bacteria in mineralization process. This process was very important in chemical cycle of fresh water because it produced nutrient for micro aquatic life and aquatic plant. Nevertheless, the water source which had rich nutrient, phytoplankton would highly grow rate and so as zooplankton.

4.3.19 Relationships between Ammonia-Nitrogen and Plankton

Totally 12 records of data on ammonia nitrogen and plankton were analyzed. The ammonia nitrogen data ranged between 0.001-0.1 mg/l. The correlation analysis results are concluded as follows:

1) Abundance of Plankton

Relationships between ammonia nitrogen and abundance of phytoplankton in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton in terms of R are 0.206, 0.188, 0.196, -0.276, 0.250, -0.533 and 0.196 respectively (Table 5).

Relationships between ammonia nitrogen and abundance of zooplankton in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton, and grand total plankton in terms of R are 0.195, 0.199, 0.176, 0.297, cannot be analyzed, -0.000, cannot be analyzed, cannot be analyzed, 0.196 and 0.196 respectively (Table 6).

All of analysis results reveal that ammonia nitrogen and abundance of plankton phylum do not correlate with each other.

2) Number of Plankton Species

Relationships between ammonia nitrogen and number of phytoplankton species in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton species in terms of R are 0.238, -0.550, -0.002, -0.184, -0.150, -0.427 and -0.410 respectively (Table 7).

Relationships between ammonia nitrogen and number of zooplankton species in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton species, and grand total plankton species in terms of R are -0.559, -0.369, -0.544, cannot be analyzed, cannot be analyzed, 0.297, 0.000, 0.000, -0.518 and -0.477 respectively (Table 8).

All of analysis results reveal that ammonia nitrogen and number of plankton species in each phylum do not correlate with each other.

4.3.20 Relationships between Sulfate and Plankton

Totally 49 records of data on sulfate and plankton were analyzed. The sulfate data ranged between 0.0-255.0 mg/l. The correlation analysis results are concluded as follows:

1) Abundance of Plankton

Relationships between sulfate and abundance of phytoplankton in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton in terms of R are 0.041, -0.054, -0.032, -0.068, -0.004, -0.132 and -0.052 respectively (Table 5).

Relationships between sulfate and abundance of zooplankton in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton, and grand total plankton in terms of R are -0.036, -0.081, -0.169, 0.045, -0.027, -0.054, cannot be analyzed, -0.020, -0.143 and -0.056 respectively (Table 6).

All of analysis results reveal that sulfate and abundance of plankton phylum do not correlate with each other.

2) Number of Plankton Species

Relationships between sulfate and number of phytoplankton species in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton species in terms of R are 0.001, -0.304*, 0.119, -0.073, -0.111, -0.124 and -0.189 respectively (Table 7).

Relationships between sulfate and number of zooplankton species in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton species, and grand total plankton species in terms of R are 0.254, -0.040, -0.168, -0.020, cannot be analyzed, 0.000, -0.051, -0.027, -0.037 and -0.150 respectively (Table 8).

Results of study show that sulfate has negative correlation with number of phytoplankton species in phylum Chlorophyta. It means that when sulfate increases, it would result in decrease in number of plankton species in phylum Chlorophyta. On the contrary, when sulfate decreases, there would be increase of number of plankton species in phylum Chlorophyta. Sulfate is indirect parameter to indicate number of phytoplankton species in phylum Chlorophyta. Boyd (1989) reported that sulfate was a water soluble ion in the same group with other ion in water such as sodium, magnesium, calcium, potassium, bicarbonate, etc. Moreover, กรรณิการ์ สิริสิงห (2525) reported that sulfate was generally found in the range from 2-3 mg/liter to 1,000 mg/liter in natural water. The found sulfate came from washing water of mining or effluent of industrial plants. Therefore, when sulfate was found in high value, it might come from high waste in water including organic matter and nutrient of plankton. This caused an increase in plankton abundance.

4.3.21 Relationships between Total Phosphate and Plankton

Totally 96 records of data on total phosphate and plankton were analyzed. The total phosphate data ranged between 0.002-0.49 mg/l. The correlation analysis results are concluded as follows:

1) Abundance of Plankton

Relationships between total phosphate and abundance of phytoplankton in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton in terms of R are -0.186, -0.151, -0.135, -0.057, -0.044, -0.052 and -0.193 respectively (Table 5).

Relationships between total phosphate and abundance of zooplankton in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton, and grand total plankton in terms of R are -0.054, -0.052, -0.080, -0.006, 0.039, -0.115, -0.028, -0.065, -0.055 and -0.173 respectively (Table 6).

All of analysis results reveal that total phosphate and abundance of plankton phylum do not correlate with each other.

2) Number of Plankton Species

Relationships between total phosphate and number of phytoplankton species in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton species in terms of R are -0.166, -0.269*, -0.244*, -0.114, -0.155, -0.107 and -0.271 respectively (Table 7).

Relationships between total phosphate and number of zooplankton species in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton species, and grand total plankton species in terms of R are -0.177, -0.105, -0.152, -0.072, -0.028, -0.013, -0.152, 0.039, 0.170 and -0.269 respectively (Table 8).

Results of the study show that total phosphate has negative correlation with number of phytoplankton species in phylum Chlorophyta and phylum Bacillariophyta. This agrees with result of the study of the Prescott (1962) that there would be only a few species of phytoplankton with high abundance in each species in high phosphorus water source such as blue-green algae in Genus *Microcystis, Oscillatoria, Anabaena,* a few of green algae species and high abundance of dinoflagellate such as *Peridinium bipes*, *Ceratium* sp. สถาบันวิจัยประมงน้ำจืด (2538) reported that phosphate or phosphorus could be found in form of organic phosphate and inorganic phosphate in water source. The phosphate in form of orthophosphate could be directly used by phytoplankton. Generally, there was a little of phosphate in water source, in phosphorus shortage period growth of plankton would stop and productivity of water source would be affected. Phosphate or phosphorus was nutrient element, which was used by plant or animal for growth and protoplasm production (ไมตรี ดวงสวัสดิ์ และจารุวรรณ สมศิริ, 2528). ลัดดา วงศ์รัตน์ (2530) reported that phosphate was a phosphorus compound, which could be found in natural water source. The important form was orthophosphate compound. Phytoplankton cell could accumulate high quantity of phosphorus compound, which came from orthophosphate. When, there was lack of phosphorus, phytoplankton would use alkaline phosphates enzyme to change phosphorus compound in cell into orthophosphate for the use of phytoplankton.

4.3.22 Relationships between Biochemical Oxygen Demand (BOD) and Plankton

Totally 104 records of data on BOD and plankton were analyzed. The BOD data ranged between 0.1-9.3 mg/l. The correlation analysis results are concluded as follows:

1) Abundance of Plankton

Relationships between BOD and abundance of phytoplankton in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton in terms of R are 0.322*, 0.279*, -0.012, -0.075, 0.072, 0.103 and 0.278* respectively (Table 5).

Relationships between BOD and abundance of zooplankton in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton, and grand total plankton in terms of R are -0.004, -0.006, 0.126, 0.101, -0.079, 0.325*, -0.000, 0.069, 0.006 and 0.230* respectively (Table 6).

2) Number of Plankton Species

Relationships between BOD and number of phytoplankton species in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton species in terms of R are 0.204*, 0.049, 0.154, -0.103, -0.240*, 0.013 and 0.100 respectively (Table 7).

Relationships between BOD and number of zooplankton species in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton species, and grand total plankton species in terms of R are 0.371*, 0.480*, 0.190, 0.048, -0.011, -0.309*, -0.079, 0.483* and 0.274* respectively (Table 8).

Results of the study show that BOD has positive correlation with abundance of phytoplankton in phylum Cyanophyta, phylum Chlorophyta, and total phytoplankton and has positive correlation with abundance of zooplankton in phylum Chordata and grand total plankton. The BOD has positive correlation with number of phytoplankton species in phylum Cyanophyta, number of zooplankton species in phylum Protozoa, phylum Rotifera, total zooplankton species, and grand total plankton species and has negative correlation with number of phytoplankton species in phylum Pyrrophyta and number of zooplankton in phylum Mollusca. BOD was value of oxygen demand to be used by bacteria for organic matter degradation in water. BOD was an indicator that present decay level of water source. In case water source needed high oxygen, it showed that there were many decayed organic matters which had to use many oxygen for degradation process resulting in the lack of oxygen in water source (ไมตรี ดวงสวัสดิ์ และจารุวรรณ สมศิริ, 2528). The organic matter which was degraded by microorganism would be changed into inorganic matter i.e. nitrite, nitrate, ammonia and phosphate. These compound matters were very important mineral for phytoplankton growth (เปี่ยมศักดิ์ เมนะเศวต, 2539). Then, Lager, Bardach, and Miller (1962) reported that the Chao Phraya river received wastewater that consisted of organic and inorganic matters from agriculture, industrial plants and many communities around the area. After organic matters had passed degradation process, it was used by phytoplankton or zooplankton. Some of plankton group could survive in high organic matter degradation condition especially the plankton group living on water bed. Therefore, it can be concluded that the high organic contaminants would have indirectly impact on growth of phytoplankton and number of zooplankton species in water source.

4.3.23 Relationships between Chemical Oxygen Demand (COD) and Plankton

Totally 12 records of data on COD and plankton were analyzed. The COD data ranged between 0.00-65.41 mg/l. The correlation analysis results are concluded as follows:

1) Abundance of Plankton

Relationships between COD and abundance of phytoplankton in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton in terms of R are -0.156, -0.334, -0.372, -0.270, -0.263, -0.330 and -0.316 respectively (Table 5).

Relationships between COD and abundance of zooplankton in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton, and grand total plankton in terms of R are 0.553, -0.166, -0.379, 0.000, -0.057, 0.000, cannot be analyzed, cannot be analyzed, -0.254 and -0.322 respectively (Table 6).

All of analysis results reveal that COD and abundance of plankton phylum do not correlate with each other.

2) Number of Plankton Species

Relationships between COD and number of phytoplankton species in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton species in terms of R are -0.165, -0.329, -0.146, -0.299, -0.442, -0.321 and -0.356 respectively (Table 7).

Relationships between COD and number of zooplankton species in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton species, and grand total plankton species in terms of R are 0.258, 0.037, -0.297, cannot be analyzed, cannot be analyzed, cannot be analyzed, 0.000, -0.057, -0.082 and -0.271 respectively (Table 8).

All of analysis results reveal that COD and number of plankton species in each phylum do not correlate with each other.

4.3.24 Relationships between Oil & Grease and Plankton

Totally 15 records of data on oil & grease and plankton were analyzed. The oil&grease data ranged between 0.003-6.50 mg/l. The correlation analysis results are concluded as follows:

1) Abundance of Plankton

Relationships between oil & grease and abundance of phytoplankton in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton in terms of R are -0.045, -0.214, -0.214, -0.171, -0.357, -0.157 and -0.154 respectively (Table 5).

Relationships between oil & grease and abundance of zooplankton in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton, and grand total plankton in terms of R are 0.553, -0.166, -0.379, 0.000, -0.057, 0.000, cannot be analyzed, 0.000, cannot be analyzed, 0.000, -0.209 and -0.173 respectively (Table 6).

All of analysis results reveal that oil & grease and abundance of plankton phylum do not correlate with each other.

2) Number of Plankton Species

Relationships between oil & grease and number of phytoplankton species in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton species in terms of R are 0.054, -0.174, -0.006*, -0.139, -0.515*, -0.446 and -0.372 respectively (Table 7).

Relationships between oil & grease and number of zooplankton species in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton species, and grand total plankton species in terms of R are -0.387, -0.459, -0.215, 0.000, 0.000, -0.067, 0.000, cannot be analyzed, -0.427 and -0.426 respectively (Table 8).

Results of the study show that oil & grease has negative correlation with number of phytoplankton in phylum Bacillariophyta and phylum Pyrrophyta. In case high quantity of oil & grease is found in water source, it shows that there is high contamination from industry, community, commercial and service activities in water source. The water source might be highly contaminated in term of BOD, COD, organic matter, etc. If quantity of oil & grease is high in water source, it would result in decrease of number of phytoplankton in phylum Bacillariophyta and phylum Pyrrophyta. Therefore, oil & grease is an indirect water quality indicator indicating contamination of compounds in water source.

4.3.25 Relationships between Calcium and Plankton

Totally 83 records of data on calcium and plankton were analyzed. The calcium data ranged between 0.0-346.0 mg/l. The correlation analysis results are concluded as follows:

1) Abundance of Plankton

Relationships between calcium and abundance of phytoplankton in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton in terms of R are -0.076, -0.058, -0.046, -0.048, 0.000, -0.018 and -0.077 respectively (Table 5).

Relationships between calcium and abundance of zooplankton in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton, and grand total plankton in terms of R are -0.001, -0.055, -0.072, 0.132, 0.030, -0.036, -0.024, -0.026, -0.058 and -0.077 respectively (Table 6).

All of analysis results reveal that calcium and abundance of plankton phylum do not correlate with each other.

2) Number of Plankton Species

Relationships between calcium and number of phytoplankton species in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton species in terms of R are -0.066, -0.294*, 0.106, 0.066, -0.201, -0.058 and -0.160 respectively (Table 7).

Relationships between calcium and number of zooplankton species in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton species, and grand total plankton species in terms of R are 0.163, -0.024, -0.024, -0.017, -0.024, 0.065, -0.056, 0.030, 0.009 and -0.106 respectively (Table 8).

Results of the study show that calcium has negative correlation with number of phytoplankton species in phylum Chlorophyta. Generally, calcium was important compound used to produce cell wall of phytoplankton. Calcium was a water soluble ion which related to other ions in water such as sodium, magnesium, sulfate, potassium, bicarbonate, etc (Boyd, 1989). Calcium was secondary essential element of nutrient of plants. Calcium in water came from rock and other mineral (สถาบันวิจัยประมงน้ำจืด, 2538). Calcium ion (Ca^{2+}) would be absorbed at the surface of colloid in soil, some parts were lost by water, therefore high quantity of calcium could be found in fresh water in form of carbonate in soft water. Quantity of calcium could indicate enrichment of water source. However, results of this study reveal that if calcium is high increase demand in water source, it would result in decrease of number of phytoplankton species in phylum Chlorophyta.

4.3.26 Relationships between Magnesium and Plankton

Totally 85 records of data on magnesium and plankton were analyzed. The magnesium data ranged between 0.001-24.0 mg/l. The correlation analysis results are concluded as follows:

1) Abundance of Plankton

Relationships between magnesium and abundance of phytoplankton in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton in terms of R are -0.020, -0.095, 0.109, -0.083, 0.231*, 0.044 and 0.025 respectively (Table 5).

Relationships between magnesium and abundance of zooplankton in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton, and grand total plankton in terms of R are 0.072,

-0.041, -0.122, 0.442*, 0.173, -0.086, -0.068, -0.102, -0.050 and 0.024 respectively (Table 6).

All of analysis results reveal that magnesium and abundance of plankton phylum do not correlate with each other.

2) Number of Plankton Species

Relationships between magnesium and number of phytoplankton species in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton species in terms of R are -0.128, -0.397*, -0.036, 0.154, -0.047, -0.060 and -0.256* respectively (Table 7).

Relationships between magnesium and number of zooplankton species in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton species, and grand total plankton species in terms of R are 0.032, -0.114, -0.108, -0.017, -0.068, 0.259*, -0.106, 0.173, -0.105 and -0.222* respectively (Table 8).

Results of the study show that magnesium has positive correlation with abundance of phytoplankton and zooplankton in phylum Pyrrophyta and phylum Annelida respectively. Magnesium has negative correlation with number of phytoplankton species in phylum Chlorophyta and total phytoplankton species and total zooplankton species. Magnesium has positive correlation with number of zooplankton species in phylum Chordata. Magnesium was important element to growth of plant and algae because magnesium was a component of chlorophyll that had function as phosphate carrier, it helped in inflation of plasma and acceleration of enzyme relating to respiratory process. Moreover, magnesium would help to produce lecithin, nucleoprotein, DNA and RNA (สถาบันวิจัยประมงน้ำจืด, 2538). Smith (1950) said that calcium and magnesium were important to increase in abundance of plankton because they produced bicarbonate, which would increase carbondioxide gas for photosynthesis process. สมชาย สุรวิทย์ (2539) reported that photosynthesis rate would be highest at water surface and light had effect on abundance of phytoplankton. High growth of phytoplankton would cause increase in number of zooplankton species.

4.3.27 Relationships between Sodium and Plankton

Totally 77 records of data on sodium and plankton were analyzed. The sodium data ranged between 13.0-1,025.0 mg/l. The correlation analysis results are concluded as follows:

1) Abundance of Plankton

Relationships between sodium and abundance of phytoplankton in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton in terms of R are -0.061, -0.046, -0.011, -0.036, 0.041, -0.021 and -0.046 respectively (Table 5).

Relationships between sodium and abundance of zooplankton in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton, and grand total plankton in terms of R are -0.005, 0.034, 0.033, -0.025, cannot be analyzed, -0.048, -0.027, -0.028, 0.030 and -0.045 respectively (Table 6).

All of analysis results reveal that sodium and abundance of plankton phylum do not correlate with each other.

2) Number of Plankton Species

Relationships between sodium and number of phytoplankton species in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton species in terms of R are -0.085, -0.215, 0.015, -0.031, -0.110, 0.092 and -0.116 respectively (Table 7).

Relationships between sodium and number of zooplankton species in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton species, and grand total plankton species in terms of R are 0.009, 0.077, -0.094, -0.001, -0.027, -0.035, -0.056, 0.000, 0.020 and -0.071 respectively (Table 8).

All of analysis results reveal that sodium and number of plankton species in each phylum do not correlate with each other.

4.3.28 Relationships between Potassium and Plankton

Totally 99 records of data on potassium and plankton were analyzed. The potassium data ranged between 0.18-18.10 mg/l. The correlation analysis results are concluded as follows:

1) Abundance of Plankton

Relationships between potassium and abundance of phytoplankton in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton in terms of R are -0.069, 0.143, -0.038, 0.036, 0.054, -0.045 and 0.036 respectively (Table 5).

Relationships between potassium and abundance of zooplankton in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton, and grand total plankton in terms of R are 0.024, 0.118, 0.094, 0.038, cannot be analyzed, 0.017, -0.046, -0.073, 0.108 and 0.038 respectively (Table 6).

All of analysis results reveal that potassium and abundance of plankton phylum do not correlate with each other.

2) Number of Plankton Species

Relationships between potassium and number of phytoplankton species in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton species in terms of R are -0.198, -0.290*, -0.105, 0.015, -0.191, -0.095 and -0.296 respectively (Table 7).

Relationships between potassium and number of zooplankton species in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton species, and grand total plankton species in terms of R are -0.007, 0.109, 0.016, 0.032, -0.046, 0.038, 0.090, 0.000, 0.085 and -0.131 respectively (Table 8).

The results of the study show that potassium has negative correlation with number of phytoplankton species in phylum Chlorophyta. Potassium is important nutrient element of plant, it is use for growth of plant. The results of analysis show that number of species of phytoplankton in phylum Chlorophyta will decrease when potassium increases. Boyd (1989) reported that potassium in water was soluble ion which related to other ions such as sodium, magnesium, sulfate, bicarbonate, etc. the other ions would have different impacts on abundance and number of plankton species such as, bicarbonate, if there was high quantity of bicarbonate in water, there would result in pH increase and would cause change on plankton species, etc. Therefore, potassium might have indirect impact on plankton in water.

4.3.29 Relationships between Chlorophyll a and Plankton

Totally 45 records of data on chlorophyll a and plankton were analyzed. The chlorophyll a data ranged between 1.71-29.94 mg/l. The correlation analysis results are concluded as follows:

1) Abundance of Plankton

Relationships between chlorophyll a and abundance of phytoplankton in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton in terms of R are -0.029, 0.029, -0.154, -0.298*, 0.169, -0.176 and 0.085 respectively (Table 5).

Relationships between chlorophyll a and abundance of zooplankton in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton, and grand total plankton in terms of R are 0.250, 0.236, 0.068, 0.000, cannot be analyzed, 0.324*, 0.003, -0.116, 0.221 and 0.090 respectively (Table 6).

2) Number of Plankton Species

Relationships between chlorophyll a and number of phytoplankton species in phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Euglenophyta, and total phytoplankton species in terms of R are 0.168, 0.221, -0.228, -0.254, 0.121, -0.224 and 0.017 respectively (Table 7).

Relationships between chlorophyll a and number of zooplankton species in phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, Coelenterata, total zooplankton species, and grand total plankton species in terms of R are 0.122, 0.181, -0.010, -0.124, -0.003, can not be analyzed, 0.291, 0.000, 0.170 and 0.116 respectively (Table 8).

All of analysis results reveal that chlorophyll a and number of plankton species phylum do not correlate with each other.

However, the results of the study show that chlorophyll a has negative correlation with abundance of phytoplankton in phylum Chrysophyta and has positive correlation with abundance of zooplankton in phylum Chordata. Phylum Chordata is fish larva group that consume phytoplankton and zooplankton for food. Therefore, if there are high chlorophyll a in water, it means that the water source has high abundance of phytoplankton and high productivity. It would result in high abundance of zooplankton too. Pennock (1985) said that quantity of chlorophyll a depended on physical, biological and chemical factors such as vertical level of water, flow rate of water, temperature, light and reflection of light, phytoplankton consumption of zooplankton and aquatic life and quantity of nutrient element. The nutrient element and light were very important factors. Therefore, abundance and scattering of chlorophyll a would mainly depend on light in high nutrient (Laws and Bannister, 1980). But Merlon, Merty, Denant, and Saliot (1991) studied concentration of chlorophyll a and found that light limitation factor had rather low effects in tropical zone. Usable essential nutrient element had high impact such as in rainy season, water source would have high nutrient, resulting in high abundance of phytoplankton. This agrees with results of สุวัจน์ ธัญรส (2536) study that chlorophyll a had positive correlation with soluble inorganic nitrogen. Duedall, Connors, Parker, Wilson, and

Robbins (1977) studied about scattering of chlorophyll a at New York Bight and found that there would be high quantity of chlorophyll a in area with high salinity and high quantity of nutrient elements.

4.4 Fittest Model Analysis

4.4.1 Fittest Model Analysis Results

Analysis of the fittest model for water quality and plankton data are to study data on water quality and abundance of plankton in each phylum because results of the study might be more accurate than result of study on water quality and number of plankton species in each phylum.

The fittest model analysis between 29 water quality parameters and abundance of plankton in 14 phyla including total phytoplankton, total zooplankton and grand total plankton are studied by research methodology. The details of water quality and plankton data for fittest model analysis are presented in Appendix E. The fittest model analysis results are detailed as follows:

1) Phylum Cyanophyta (blue-green algae)

Based on fittest model analysis on 109 sets of water quality and plankton data, it was found that there were 40 data sets for analysis of relationship between water quality and abundance of plankton in phylum Cyanophyta or blue-green algae (Table 1E in Appendix E). The fittest model results from MINITAB program are detailed below (Figure 11):

Results for: P2blue.MTW

Descriptive Statistics: log(BG), Twater, pH, Trans, Depth, Tur, Con, DO, TDS, SS

Variable	N	Mean	Median	TrMean	StDev	SE Mean
log(BG)	40	7.4050	7.5660	7.4848	0.6301	0.0996
Twater	40	27.795	27.350	27.744	1.980	0.313
pH	40	8.4410	8.5100	8.4492	0.4495	0.0711
Trans	40	100.34	99.00	99.44	49.31	7.80
Depth	40	5.887	3.950	5.372	5.938	0.939
Tur	40	6.51	3.50	5.24	8.26	1.31
Con	40	273.16	267.80	271.01	52.16	8.25
DO	40	8.054	8.240	8.056	1.481	0.234
TDS	40	182.43	168.50	180.17	52.78	8.35
SS	40	11.59	7.55	8.89	15.94	2.52
Hard	40	127.78	118.00	126.44	24.27	3.84
Alk	40	121.05	120.00	120.06	28.50	4.51
Nitrate	40	0.1786	0.1480	0.1772	0.0894	0.0141
Org-N	40	0.3337	0.3000	0.3242	0.1816	0.0287
Total-N	40	1.261	0.800	1.198	1.098	0.174
Total-P	40	0.02717	0.02200	0.02481	0.02275	0.00360
BOD	40	3.055	2.700	2.975	1.761	0.278
Ca	40	18.652	20.300	18.805	5.562	0.879
Mg	40	4.710	4.560	4.496	2.847	0.450
Na	40	16.10	13.41	12.59	19.86	3.14
K	40	1.655	1.827	1.634	0.783	0.124
Chlo-A	40	12.687	12.400	12.609	5.974	0.945

Variable	Minimum	Maximum	Q1	Q3
log(BG)	4.4533	7.9976	7.1440	7.8040
Twater	25.000	31.800	26.000	28.950
pH	7.2500	9.4000	8.1175	8.7950
Trans	10.00	220.00	67.00	140.00
Depth	0.800	20.500	2.000	5.950
Tur	0.90	46.30	2.45	6.70
Con	192.00	401.00	242.15	309.00
DO	4.000	11.600	7.025	8.938
TDS	110.00	312.00	137.00	217.00
SS	1.70	87.80	4.28	9.85
Hard	90.00	200.00	113.25	137.50
Alk	74.00	195.00	98.50	139.25
Nitrate	0.0300	0.4060	0.1235	0.2775
Org-N	0.1000	0.8000	0.2000	0.4875
Total-N	0.100	3.600	0.400	1.900
Total-P	0.00200	0.10200	0.01500	0.03225
BOD	0.100	7.200	1.850	3.800
Ca	5.380	30.230	14.343	21.648
Mg	0.580	17.360	2.913	6.088
Na	2.54	128.50	9.96	14.63
K	0.180	4.600	1.273	2.050
Chlo-A	1.710	24.640	7.903	17.110

Stepwise Regression: log(BG) versus Twater, pH, ...

Alpha-to-Enter: 0.15 Alpha-to-Remove: 0.15

Response is log(BG) on 21 predictors, with N =   40

Step	1	2	3	4	5	6
Constant	7.758	6.412	3.342	3.244	4.652	4.746
SS	-0.0305	-0.0274	-0.0261	-0.0261	-0.0244	-0.0235
T-Value	-7.47	-8.23	-8.68	-9.40	-9.36	-9.17
P-Value	0.000	0.000	0.000	0.000	0.000	0.000
Con		0.00480	0.00541	0.00545	0.00330	0.00324
T-Value		4.71	5.82	6.34	3.03	3.07
P-Value		0.000	0.000	0.000	0.005	0.004

pH			0.342	0.329	0.256	0.239
T-Value			3.21	3.34	2.75	2.63
P-Value			0.003	0.002	0.010	0.013
BOD				0.066	0.108	0.110
T-Value				2.68	4.02	4.22
P-Value				0.011	0.000	0.000
Nitrate					-2.02	-2.11
T-Value					-2.84	-3.06
P-Value					0.008	0.004
Depth						0.0119
T-Value						1.82
P-Value						0.078
S	0.406	0.326	0.291	0.269	0.245	0.237
R-Sq	59.49	74.68	80.32	83.68	86.80	88.01
R-Sq(adj)	58.42	73.31	78.68	81.82	84.86	85.83
C-p	68.5	31.3	18.8	12.1	6.1	4.9

Regression Analysis: log(BG) versus SS, Con, pH, BOD

The regression equation is

log(BG) = 3.24 - 0.0261 SS + 0.00545 Con + 0.329 pH + 0.0657 BOD

Predictor	Coef	SE Coef	T	P	VIF
Constant	3.2439	0.9152	3.54	0.001	
SS	-0.026112	0.002778	-9.40	0.000	1.1
Con	0.0054460	0.0008591	6.34	0.000	1.1
pH	0.32879	0.09838	3.34	0.002	1.1
BOD	0.06569	0.02447	2.68	0.011	1.0

S = 0.2687   R-Sq = 83.7%   R-Sq(adj) = 81.8%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	4	12.9560	3.2390	44.87	0.000
Residual Error	35	2.5263	0.0722		
Total	39	15.4823			

Source	DF	Seq SS
SS	1	9.2100
Con	1	2.3515
pH	1	0.8745
BOD	1	0.5201

Unusual Observations

Obs	SS	log(BG)	Fit	SE Fit	Residual	St Resid
28	87.8	4.4533	4.7474	0.2215	-0.2941	-1.94 X
33	7.6	7.1075	7.6719	0.0647	-0.5644	-2.16R

R denotes an observation with a large standardized residual
X denotes an observation whose X value gives it large influence.

Durbin-Watson statistic = 1.85

Residual Histogram for log(BG)

Normplot of Residuals for log(BG)

Residuals vs Fits for log(BG)

Residuals vs Order for log(BG)

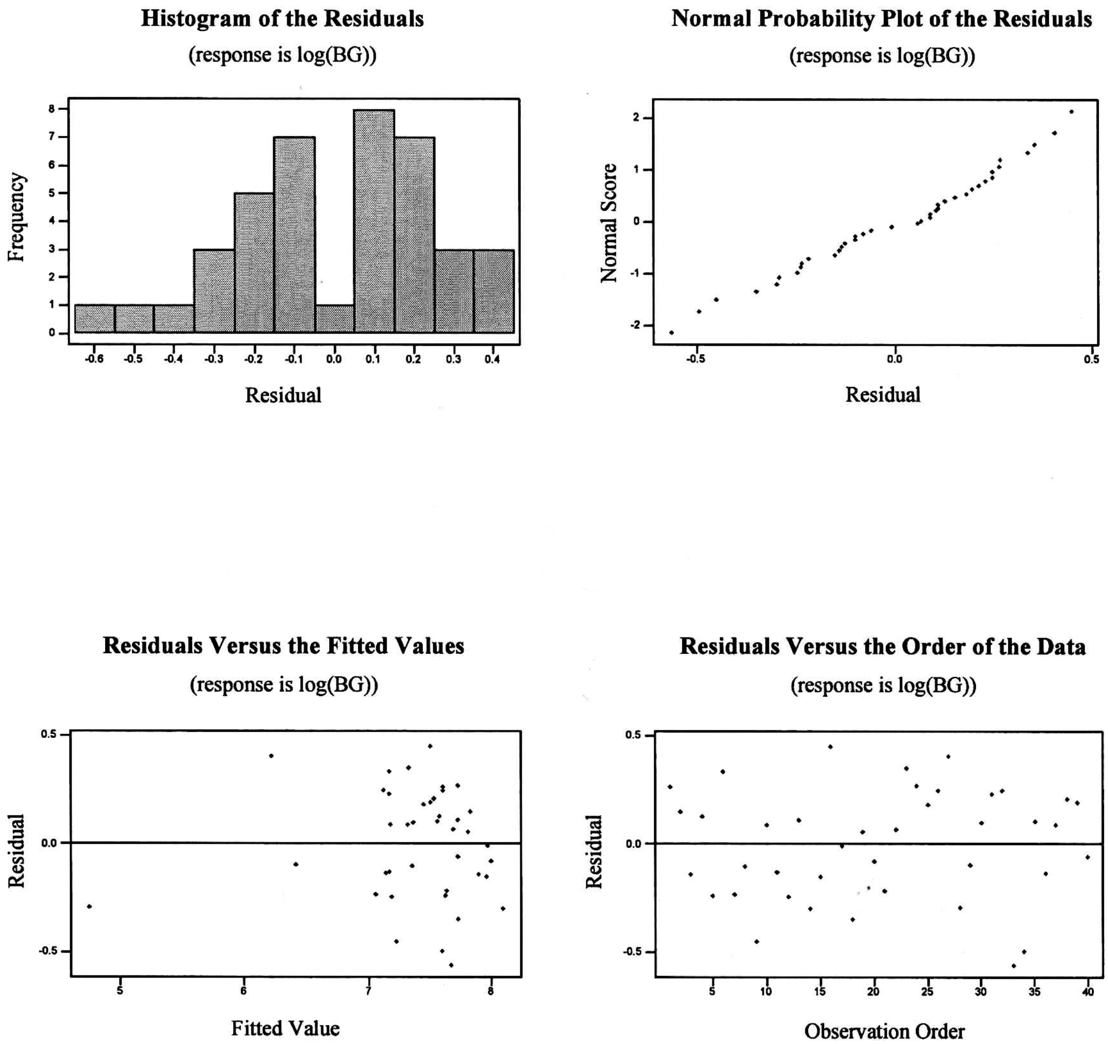

Figure 11. The fittest model results of phylum Cyanophyta from MINITAB program.

2) Phylum Chlorophyta (green algae)

Based on fittest model analysis on 109 sets of water quality and plankton data, it was found that there were 40 data sets for analysis of relationship between water quality and abundance of plankton in phylum Chlorophyta or green algae (Table 2E in Appendix E). The fittest model results from MINITAB program are detailed below (Figure 12):

Results for: P2Green.MTW

Descriptive Statistics: log(G), Twater, pH, Trans, Depth, Tur, Con, DO, TDS, SS,

Variable	N	Mean	Median	TrMean	StDev	SE Mean
log(G)	40	6.558	6.247	6.525	0.719	0.114
Twater	40	27.855	27.500	27.811	1.958	0.310
pH	40	8.4533	8.5100	8.4619	0.4262	0.0674
Trans	40	102.84	99.00	102.22	49.49	7.82
Depth	40	5.887	3.800	5.372	5.915	0.935
Tur	40	5.818	3.500	5.147	5.586	0.883
Con	40	274.15	267.80	272.11	50.82	8.04
DO	40	8.162	8.270	8.161	1.413	0.223
TDS	40	184.33	174.00	182.28	52.32	8.27
SS	40	9.85	7.45	8.21	10.34	1.63
Hard	40	128.10	117.50	126.67	23.72	3.75
Alk	40	122.83	120.50	121.89	27.22	4.30
Nitrate	40	0.1794	0.1485	0.1813	0.0843	0.0133
Org-N	40	0.3212	0.3000	0.3103	0.1785	0.0282
Total-N	40	1.143	0.800	1.067	1.085	0.172
Total-P	40	0.02500	0.02050	0.02239	0.02131	0.00337
BOD	40	3.240	2.750	3.181	1.905	0.301
Ca	40	19.150	20.775	19.241	5.091	0.805
Mg	40	4.830	4.573	4.629	2.760	0.436
Na	40	16.32	13.71	12.75	19.77	3.13
K	40	2.106	1.859	1.697	2.701	0.427
Chlo-A	40	13.122	12.755	13.036	5.730	0.906

Variable	Minimum	Maximum	Q1	Q3
log(G)	5.652	8.037	6.064	7.204
Twater	25.000	31.800	26.250	28.950
pH	7.2500	9.4000	8.1700	8.7650
Trans	10.00	220.00	67.00	140.00
Depth	0.800	20.500	2.025	5.950
Tur	0.900	23.300	2.375	6.700
Con	192.00	401.00	242.95	309.00
DO	4.000	11.600	7.303	8.998
TDS	110.00	312.00	137.75	217.00
SS	1.70	51.80	4.05	9.85
Hard	95.00	200.00	113.25	137.50
Alk	74.00	195.00	106.25	139.25
Nitrate	0.0300	0.2900	0.1255	0.2800
Org-N	0.1000	0.8000	0.2000	0.4150
Total-N	0.100	3.600	0.400	1.715
Total-P	0.00200	0.10200	0.01125	0.03000
BOD	0.100	7.200	1.850	4.200
Ca	6.050	30.230	14.970	21.648
Mg	0.580	17.360	3.427	6.088
Na	3.25	128.50	9.96	14.63
K	0.180	18.100	1.458	2.075
Chlo-A	3.420	24.640	8.518	17.110

Stepwise Regression: log(G) versus Twater, pH, ...

```
  Alpha-to-Enter: 0.15  Alpha-to-Remove: 0.15
 Response is  log(G)  on 21 predictors, with N =   40

    Step          1        2        3
Constant      5.731    5.457    5.151

BOD           0.255    0.257    0.221
T-Value        5.66     6.64     5.41
P-Value       0.000    0.000    0.000

SS                    0.0271   0.0309
T-Value                 3.79     4.37
P-Value                0.001    0.000

Chlo-A                          0.029
T-Value                          2.10
P-Value                         0.043

S             0.536    0.461    0.441

R-Sq          45.78    60.94    65.20

R-Sq(adj)     44.36    58.83    62.31

C-p            10.0     -0.9     -2.5
```

Regression Analysis: log(G) versus BOD, SS, Chlo-A

```
The regression equation is

log(G) = 5.15 + 0.221 BOD + 0.0309 SS + 0.0294 Chlo-A

Predictor        Coef     SE Coef          T        P       VIF
Constant       5.1511      0.2129      24.19    0.000
BOD           0.22116     0.04087       5.41    0.000       1.2
SS           0.030873    0.007071       4.37    0.000       1.1
Chlo-A        0.02939     0.01400       2.10    0.043       1.3

S = 0.4412      R-Sq = 65.2%     R-Sq(adj) = 62.3%

Analysis of Variance
Source            DF          SS          MS         F        P
Regression         3     13.1303      4.3768     22.49    0.000
Residual Error    36      7.0067      0.1946
Total             39     20.1370

Source       DF      Seq SS
BOD           1      9.2193
SS            1      3.0523
Chlo-A        1      0.8586

Unusual Observations
Obs        BOD     log(G)         Fit      SE Fit    Residual     St Resid
 29       3.80     7.2525      7.8171      0.2962     -0.5646       -1.73 X
 30       1.10     6.7460      6.9356      0.2494     -0.1896       -0.52 X
 31       4.30     7.8096      6.8867      0.0850      0.9228        2.13R
 32       1.80     7.8182      6.6264      0.1432      1.1918        2.86R

R denotes an observation with a large standardized residual
X denotes an observation whose X value gives it large influence.

Durbin-Watson statistic = 1.33
```

Residual Histogram for log(G)

Normplot of Residuals for log(G)

Residuals vs Fits for log(G)

Residuals vs Order for log(G)

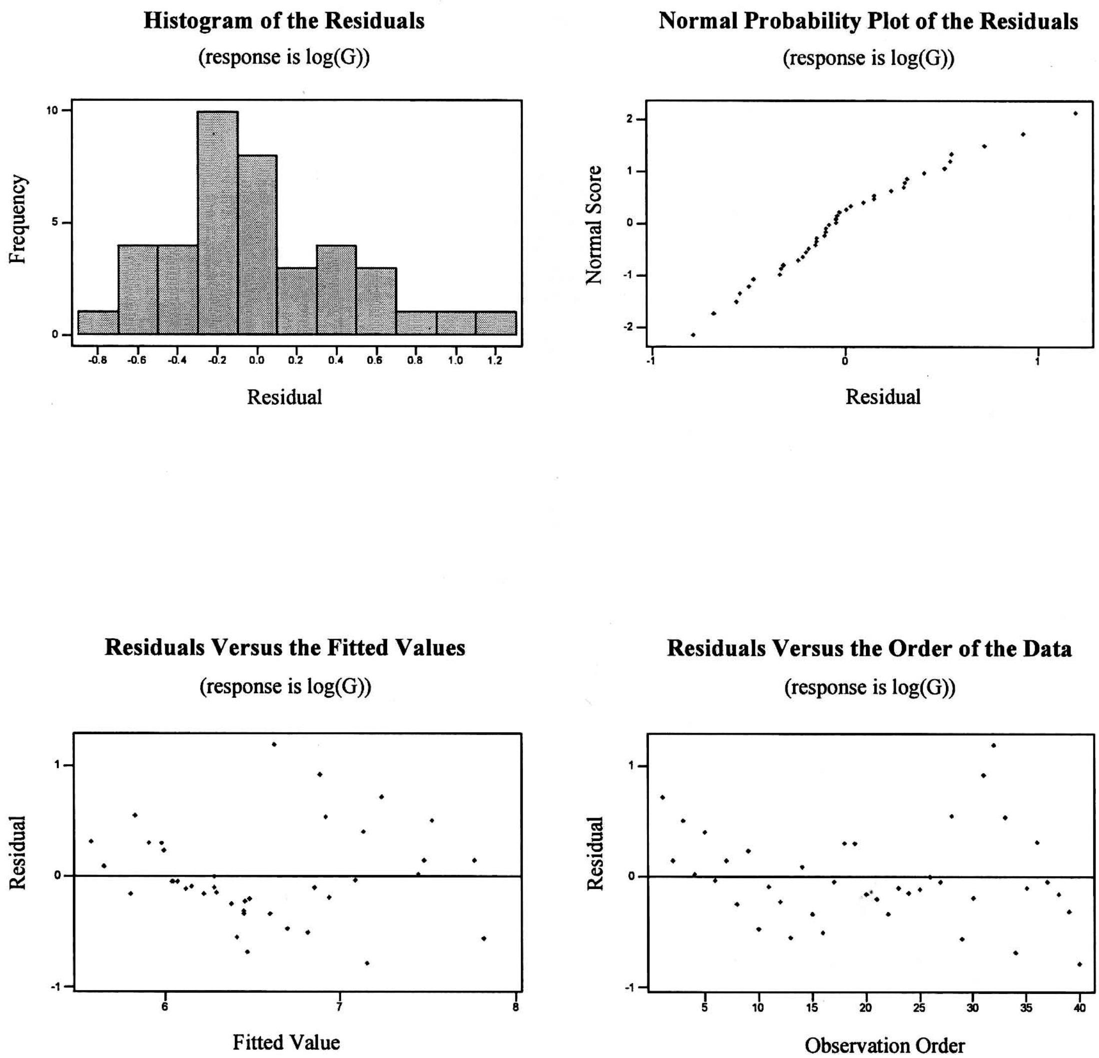

Figure 12. The fittest model results of phylum Chlorophyta from MINITAB program.

3) Phylum Bacillariophyta (diatom)

Based on fittest model analysis on 109 sets of water quality and plankton data, it was found that there were 41 data sets for analysis of relationship between water quality and abundance of plankton in phylum Bacillariophyta or diatom (Table 3E in Appendix E). The fittest model results from MINITAB program are detailed below (Figure 13):

Results for: P2Diatom.MTW

Descriptive Statistics: Diatom, Twater, pH, Trans, Depth, Tur, Con, DO, TDS, SS,

Variable	N	Mean	Median	TrMean	StDev	SE Mean
Diatom	41	13056404	7357600	12061865	14422666	2252442
Twater	41	27.722	27.400	27.665	1.892	0.296
pH	41	8.4351	8.4700	8.4424	0.4422	0.0691
Trans	41	100.33	98.00	99.46	50.45	7.88
Depth	41	5.434	3.700	4.884	5.463	0.853
Tur	41	6.80	3.60	5.61	8.39	1.31
Con	41	271.84	267.00	269.61	51.41	8.03
DO	41	8.044	8.210	8.045	1.462	0.228
TDS	41	181.93	166.00	179.68	52.79	8.24
SS	41	11.76	7.60	9.15	15.89	2.48
Hard	41	127.10	117.00	125.73	24.17	3.78
Alk	41	121.12	120.00	120.16	28.14	4.40
Nitrate	41	0.1865	0.1490	0.1859	0.0888	0.0139
Org-N	41	0.3354	0.3000	0.3262	0.1768	0.0276
Total-N	41	1.227	0.800	1.163	1.104	0.172
Total-P	41	0.02651	0.02100	0.02414	0.02276	0.00355
BOD	41	3.246	2.800	3.189	1.880	0.294
Ca	41	18.820	20.650	18.987	5.462	0.853
Mg	41	4.637	4.550	4.422	2.797	0.437
Na	41	14.90	13.30	12.34	18.55	2.90
K	41	1.649	1.810	1.628	0.772	0.121
Chlo-A	41	12.750	12.400	12.682	5.921	0.925

Variable	Minimum	Maximum	Q1	Q3
Diatom	149100	44694000	1764700	20337650
Twater	25.000	31.800	26.000	28.800
pH	7.2500	9.4000	8.1350	8.7900
Trans	10.00	220.00	64.50	140.00
Depth	0.800	20.500	2.000	5.750
Tur	0.90	46.30	2.45	7.30
Con	192.00	401.00	242.30	308.00
DO	4.000	11.600	7.050	8.870
TDS	110.00	312.00	136.50	217.00
SS	1.70	87.80	4.10	10.30
Hard	90.00	200.00	112.50	136.00
Alk	74.00	195.00	99.00	137.50
Nitrate	0.0300	0.4060	0.1260	0.2800
Org-N	0.1000	0.8000	0.2000	0.4750
Total-N	0.100	3.600	0.400	1.900
Total-P	0.00200	0.10200	0.01250	0.03150
BOD	0.100	7.200	1.900	4.100
Ca	5.380	30.230	14.635	21.625
Mg	0.580	17.360	2.925	5.990
Na	2.54	128.50	9.60	14.56
K	0.180	4.600	1.275	2.005
Chlo-A	1.710	24.640	8.105	17.110

Stepwise Regression: Diatom versus Twater, pH, ...

```
  Alpha-to-Enter: 0.15  Alpha-to-Remove: 0.15


 Response is  Diatom  on 21 predictors, with N =   41

    Step          1         2         3         4         5         6         7

Constant   -3063569 12315360   6821559     65129 -2236755 -1792550  1430806

Mg          3476032  2873832   2426406   2622520  4288216  4514696  4962488
T-Value        5.70     5.30      4.74      5.64     5.18     5.77     6.28
P-Value       0.000    0.000     0.000     0.000    0.000    0.000    0.000

Nitrate             -6.7E+07 -7.2E+07 -8.5E+07 -8.2E+07 -8.1E+07 -6.0E+07
T-Value                -3.95     -4.62     -5.82    -5.97    -6.22    -3.58
P-Value                0.000     0.000     0.000    0.000    0.000    0.001

Trans                            83217    131379   113021   121530   100235
T-Value                           3.05      4.53     3.99     4.53     3.55
P-Value                          0.004     0.000    0.000    0.000    0.001

SS                                        297367   302126   364795   335173
T-Value                                     3.12     3.36     4.13     3.88
P-Value                                    0.004    0.002    0.000    0.000

Na                                                -277556  -297917  -323408
T-Value                                             -2.37    -2.70    -3.02
P-Value                                             0.023    0.011    0.005

Total-P                                                    -1.2E+08 -1.7E+08
T-Value                                                       -2.40    -3.11
P-Value                                                       0.022    0.004

BOD                                                                 -1513485
T-Value                                                                -1.90
P-Value                                                                0.067


S          10788570  9199722   8332171   7495680  7056051  6621735  6382207

R-Sq          45.44    61.35     69.13     75.69    79.06    82.08    83.85

R-Sq(adj)     44.05    59.31     66.62     72.99    76.07    78.92    80.42

C-p            63.8     36.4      24.0      13.9      9.7      6.1      4.9
```

Regression Analysis: Diatom versus Mg, Nitrate, ...

```
The regression equation is

Diatom = 1430806 + 4962488 Mg -59688206 Nitrate + 100235 Trans + 335173 SS
           - 323408 Na -1.71E+08 Total-P - 1513485 BOD


Predictor         Coef     SE Coef          T        P       VIF

Constant       1430806     4479511       0.32    0.751
Mg             4962488      790111       6.28    0.000       4.8
Nitrate      -59688206    16667956      -3.58    0.001       2.2
Trans           100235       28203       3.55    0.001       2.0
SS              335173       86479       3.88    0.000       1.9
Na             -323408      107008      -3.02    0.005       3.9
Total-P     -170588282    54871121      -3.11    0.004       1.5
BOD           -1513485      797679      -1.90    0.067       2.2
```

```
S = 6382207     R-Sq = 83.8%     R-Sq(adj) = 80.4%

Analysis of Variance

Source            DF          SS          MS         F        P
Regression         7 6.97636E+15 9.96622E+14     24.47    0.000
Residual Error    33 1.34417E+15 4.07326E+13
Total             40 8.32053E+15


Source       DF      Seq SS

Mg            1 3.78119E+15
Nitrate       1 1.32321E+15
Trans         1 6.47397E+14
SS            1 5.46060E+14
Na            1 2.80093E+14
Total-P       1 2.51764E+14
BOD           1 1.46636E+14

Unusual Observations

Obs         Mg     Diatom         Fit      SE Fit    Residual    St Resid

 22       17.4   41188500    41142898     6362506       45602        0.09 X
 25        6.7   22302550    35039031     2520377   -12736481       -2.17R
 29        0.7     149100    -7829770     5296480     7978870        2.24RX

R denotes an observation with a large standardized residual

X denotes an observation whose X value gives it large influence.

Durbin-Watson statistic = 1.60
```

Residual Histogram for Diatom

Normplot of Residuals for Diatom

Residuals vs Fits for Diatom

Residuals vs Order for Diatom

4) Phylum Chrysophyta (yellow-brown algae)

Based on fittest model analysis on 109 sets of water quality and plankton data, it was found that there were 41 data sets for analysis of relationship between water quality and abundance of plankton in phylum Chrysophyta or yellow-brown algae (Table 4E in Appendix E). The fittest model results from MINITAB program are detailed below (Figure 14):

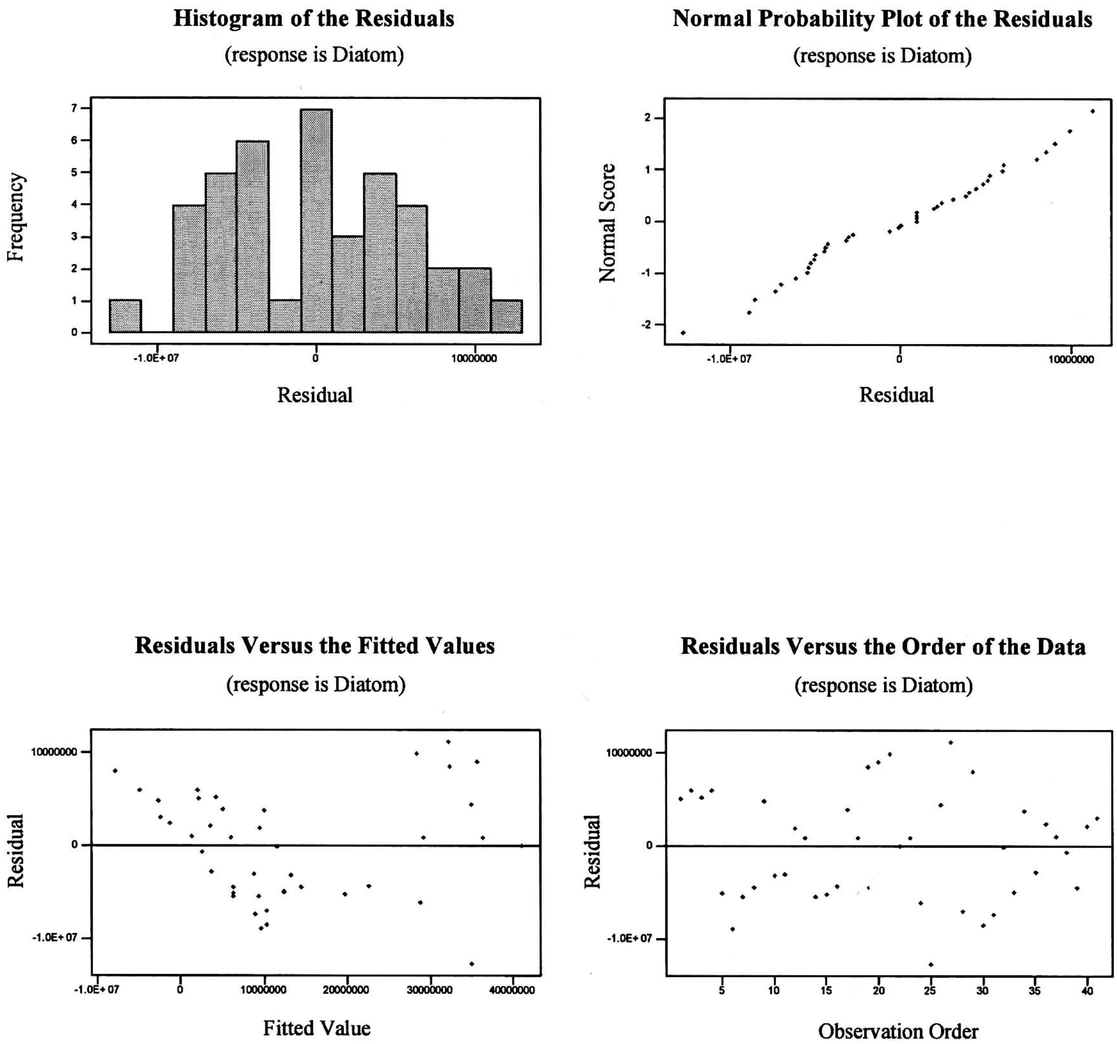

Figure 13. The fittest model results of phylum Bacillariophyta from MINITAB program.

Results for: P2YELLOWNEW.MTW

Descriptive Statistics: log(Yellow-b, Twater, pH, Trans, Depth, Tur, Con, DO, TDS

Variable	N	Mean	Median	TrMean	StDev	SE Mean
log(Yell	41	3.015	2.000	2.912	1.487	0.232
Twater	41	27.783	27.400	27.732	1.954	0.305
pH	41	8.4322	8.4700	8.4392	0.4398	0.0687
Trans	41	100.87	100.00	100.05	50.54	7.89
Depth	41	5.856	3.900	5.351	5.861	0.915
Tur	41	6.73	3.40	5.53	8.41	1.31
Con	41	272.96	268.60	270.85	51.71	8.08
DO	41	7.994	8.210	8.003	1.388	0.217
TDS	41	182.12	166.00	179.89	52.78	8.24
SS	41	11.77	7.60	9.16	15.88	2.48
Hard	41	127.41	118.00	126.08	24.08	3.76
Alk	41	121.15	120.00	120.19	28.14	4.40
Nitrate	41	0.1811	0.1480	0.1800	0.0896	0.0140
Org-N	41	0.3354	0.3000	0.3262	0.1768	0.0276
Total-N	41	1.232	0.800	1.168	1.099	0.172
Total-P	41	0.02685	0.02100	0.02451	0.02254	0.00352
BOD	41	3.134	2.700	3.065	1.811	0.283
Ca	41	18.655	19.950	18.805	5.500	0.859
Mg	41	4.689	4.550	4.479	2.815	0.440
Na	41	15.94	13.30	12.51	19.65	3.07
K	41	1.651	1.810	1.630	0.773	0.121
Chlo-A	41	12.545	12.400	12.478	5.670	0.886

Variable	Minimum	Maximum	Q1	Q3
log(Yell	2.000	5.964	2.000	4.339
Twater	25.000	31.800	26.000	28.900
pH	7.2500	9.4000	8.1350	8.7500
Trans	10.00	220.00	64.50	140.00
Depth	0.800	20.500	2.000	5.900
Tur	0.90	46.30	2.45	7.30
Con	192.00	401.00	242.30	309.00
DO	4.000	11.600	7.050	8.870
TDS	110.00	312.00	136.50	217.00
SS	1.70	87.80	4.10	10.30
Hard	90.00	200.00	112.50	136.00
Alk	74.00	195.00	99.00	137.50
Nitrate	0.0300	0.4060	0.1240	0.2800
Org-N	0.1000	0.8000	0.2000	0.4750
Total-N	0.100	3.600	0.400	1.900
Total-P	0.00200	0.10200	0.01500	0.03150
BOD	0.100	7.200	1.900	3.850
Ca	5.380	30.230	14.365	21.625
Mg	0.580	17.360	2.925	6.065
Na	2.54	128.50	9.60	14.61
K	0.180	4.600	1.275	2.040
Chlo-A	1.710	24.640	8.105	16.915

Stepwise Regression: log(Yellow-brown algae+100) versus Twater, pH, ...

Alpha-to-Enter: 0.15 Alpha-to-Remove: 0.15

Response is log(Yell on 21 predictors, with N = 41

Step	1	2	3	4	5	6	7
Constant	-2.6461	-2.5396	-1.2812	-0.8852	-1.0106	-1.7679	-1.5175
Hard	0.0444	0.0378	0.0326	0.0206	0.0217	0.0073	
T-Value	6.47	5.04	4.41	2.35	2.45	0.69	
P-Value	0.000	0.000	0.000	0.024	0.019	0.498	
K		0.45	0.61	0.35			
T-Value		1.92	2.64	1.44			
P-Value		0.062	0.012	0.157			

Chlo-A			-0.068	-0.094	-0.092	-0.093	-0.101
T-Value			-2.41	-3.22	-3.11	-3.33	-3.89
P-Value			0.021	0.003	0.004	0.002	0.000
TDS				0.0102	0.0132	0.0155	0.0174
T-Value				2.25	3.23	3.85	6.18
P-Value				0.030	0.003	0.000	0.000
Con						0.0081	0.0096
T-Value						2.24	3.37
P-Value						0.032	0.002
S	1.05	1.01	0.953	0.905	0.918	0.872	0.866
R-Sq	51.75	56.03	62.00	66.70	64.77	69.07	68.67
R-Sq(adj)	50.51	53.72	58.92	63.00	61.91	65.63	66.12
C-p	34.7	30.4	23.5	18.5	19.4	15.0	13.6

Step	8
Constant	-1.346
Hard	
T-Value	
P-Value	
K	
T-Value	
P-Value	
Chlo-A	-0.088
T-Value	-3.26
P-Value	0.002
TDS	0.0173
T-Value	6.25
P-Value	0.000
Con	0.0098
T-Value	3.48
P-Value	0.001
BOD	-0.117
T-Value	-1.48
P-Value	0.146
S	0.852
R-Sq	70.47
R-Sq(adj)	67.19
C-p	12.9

Regression Analysis: log(Yellow-brown algae+100) versus Chlo-A, TDS, Con, BOD

The regression equation is

log(Yellow-brown algae+100) = - 1.35 - 0.0875 Chlo-A + 0.0173 TDS + 0.00978 Con
- 0.117 BOD

Predictor	Coef	SE Coef	T	P	VIF
Constant	-1.3464	0.8726	-1.54	0.132	
Chlo-A	-0.08753	0.02688	-3.26	0.002	1.3
TDS	0.017337	0.002774	6.25	0.000	1.2
Con	0.009780	0.002808	3.48	0.001	1.2
BOD	-0.11723	0.07898	-1.48	0.146	1.1

S = 0.8520 R-Sq = 70.5% R-Sq(adj) = 67.2%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	4	62.362	15.591	21.48	0.000
Residual Error	36	26.130	0.726		
Total	40	88.492			

Source	DF	Seq SS
Chlo-A	1	8.119
TDS	1	44.145
Con	1	8.499
BOD	1	1.599

Unusual Observations

Obs	Chlo-A	log(Yell	Fit	SE Fit	Residual	St Resid
8	10.9	5.555	4.762	0.519	0.793	1.17 X
15	8.5	4.395	5.911	0.422	-1.516	-2.05R
20	9.7	5.964	4.255	0.210	1.709	2.07R
22	24.6	2.000	3.673	0.388	-1.673	-2.20R

R denotes an observation with a large standardized residual

X denotes an observation whose X value gives it large influence.

Durbin-Watson statistic = 2.32

Residual Histogram for log(Yell

Normplot of Residuals for log(Yell

Residuals vs Fits for log(Yell

Residuals vs Order for log(Yell

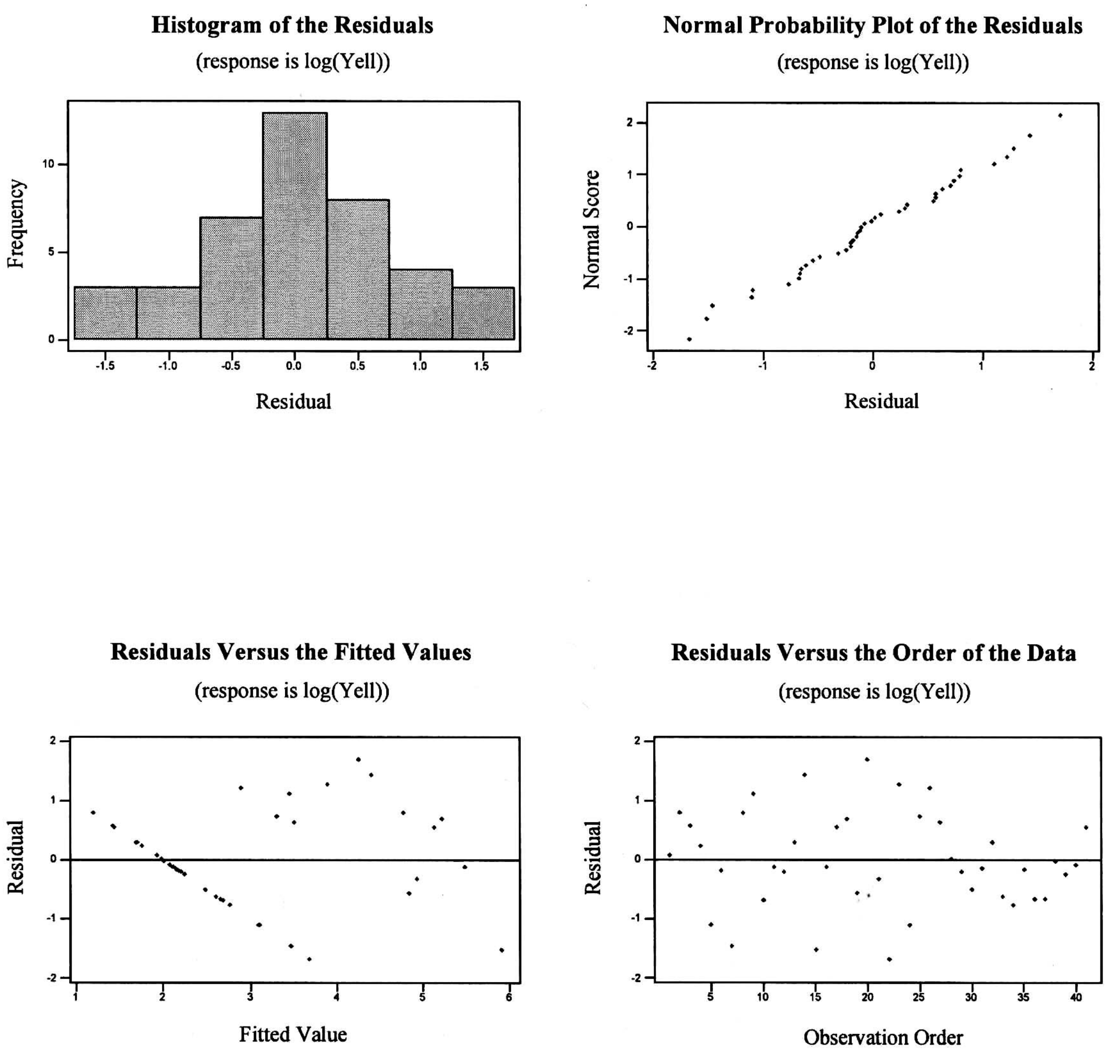

Figure 14. The fittest model results of phylum Chrysophyta from MINITAB program.

5) Phylum Pyrrophyta (dinoflagellate)

Based on fittest model analysis on 109 sets of water quality and plankton data, it was found that there were 42 data sets for analysis of relationship between water quality and abundance of plankton in phylum Pyrrophyta or dinoflagellate (Table 5E in Appendix E). The fittest model results from MINITAB program are detailed below (Figure 15):

Results for: P2Dino.MTW

Descriptive Statistics: ln(Dinoflage, Twater, pH, Trans, Depth, Tur, Con, DO, TDS

Variable	N	Mean	Median	TrMean	StDev	SE Mean
ln(Dinof	42	13.142	13.155	13.326	3.035	0.468
Twater	42	27.798	27.400	27.750	1.932	0.298
pH	42	8.4419	8.5100	8.4497	0.4390	0.0677
Trans	42	100.80	99.00	100.00	49.93	7.70
Depth	42	5.769	3.800	5.268	5.816	0.897
Tur	42	6.71	3.50	5.54	8.31	1.28
Con	42	272.72	267.80	270.64	51.10	7.89
DO	42	8.068	8.240	8.072	1.452	0.224
TDS	42	182.00	168.50	179.82	52.14	8.05
SS	42	11.65	7.55	9.11	15.71	2.42
Hard	42	127.10	117.50	125.76	23.88	3.68
Alk	42	121.12	120.00	120.18	27.80	4.29
Nitrate	42	0.1835	0.1485	0.1826	0.0898	0.0139
Org-N	42	0.3298	0.3000	0.3203	0.1783	0.0275
Total-N	42	1.205	0.800	1.140	1.100	0.170
Total-P	42	0.02633	0.02100	0.02400	0.02251	0.00347
BOD	42	3.217	2.750	3.158	1.867	0.288
Ca	42	18.709	20.300	18.860	5.443	0.840
Mg	42	4.686	4.560	4.481	2.781	0.429
Na	42	15.89	13.41	12.54	19.41	2.99
K	42	1.658	1.827	1.638	0.764	0.118
Chlo-A	42	12.812	12.540	12.752	5.862	0.905

Variable	Minimum	Maximum	Q1	Q3
ln(Dinof	4.610	18.270	11.380	15.545
Twater	25.000	31.800	26.000	28.850
pH	7.2500	9.4000	8.1525	8.7850
Trans	10.00	220.00	65.25	140.00
Depth	0.800	20.500	2.000	5.850
Tur	0.90	46.30	2.53	7.00
Con	192.00	401.00	242.45	309.00
DO	4.000	11.600	7.075	8.993
TDS	110.00	312.00	136.75	217.00
SS	1.70	87.80	4.15	10.15
Hard	90.00	200.00	112.75	134.50
Alk	74.00	195.00	99.50	135.75
Nitrate	0.0300	0.4060	0.1245	0.2800
Org-N	0.1000	0.8000	0.2000	0.4625
Total-N	0.100	3.600	0.400	1.900
Total-P	0.00200	0.10200	0.01375	0.03075
BOD	0.100	7.200	1.950	4.000
Ca	5.380	30.230	14.388	21.603
Mg	0.580	17.360	2.938	6.042
Na	2.54	128.50	9.73	14.58
K	0.180	4.600	1.278	2.030
Chlo-A	1.710	24.640	8.308	17.110

Stepwise Regression: ln(Dinoflagellate+100) versus Twater, pH, ...

Alpha-to-Enter: 0.15 Alpha-to-Remove: 0.15

Response is ln(Dinof on 21 predictors, with N = 42

Step	1	2	3	4	5	6	7
Constant	14.762	12.093	7.797	-5.464	-10.181	-12.309	-11.647
SS	-0.139	-0.110	-0.099	-0.090	-0.082	-0.082	-0.081
T-Value	-6.55	-6.16	-6.02	-6.20	-5.89	-5.86	-6.15
P-Value	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mg		0.497	0.366	0.273	0.114		
T-Value		4.93	3.70	3.00	1.10		
P-Value		0.000	0.001	0.005	0.277		
Hard			0.038	0.053	0.043	0.045	0.040
T-Value			3.26	4.80	3.93	4.16	3.76
P-Value			0.002	0.000	0.000	0.000	0.001
Twater				0.42	0.55	0.61	0.62
T-Value				3.49	4.52	5.61	6.05
P-Value				0.001	0.000	0.000	0.000
TDS					0.0166	0.0206	0.0230
T-Value					2.66	4.03	4.64
P-Value					0.012	0.000	0.000
BOD							-0.23
T-Value							-2.32
P-Value							0.026
S	2.13	1.70	1.52	1.34	1.24	1.24	1.17
R-Sq	51.78	70.29	76.78	82.53	85.40	84.90	86.86
R-Sq(adj)	50.57	68.77	74.94	80.64	83.37	83.27	85.04
C-p	102.0	50.2	33.4	18.7	12.4	11.8	8.1

Step	8	9	10	11
Constant	-8.980	-6.048	-2.894	-3.183
SS	-0.084	-0.087	-0.150	-0.155
T-Value	-6.42	-6.71	-4.79	-5.06
P-Value	0.000	0.000	0.000	0.000
Mg				
T-Value				
P-Value				
Hard	0.021			
T-Value	1.38			
P-Value	0.175			
Twater	0.51	0.42	0.32	0.31
T-Value	4.14	3.94	2.78	2.80
P-Value	0.000	0.000	0.009	0.008
TDS	0.0246	0.0283	0.0242	0.0243
T-Value	4.96	6.64	5.44	5.59
P-Value	0.000	0.000	0.000	0.000
BOD	-0.254	-0.287	-0.316	-0.320
T-Value	-2.54	-2.91	-3.34	-3.47
P-Value	0.016	0.006	0.002	0.001

Con	0.0093	0.0153	0.0175	0.0179
T-Value	1.57	3.86	4.49	4.70
P-Value	0.125	0.000	0.000	0.000
Tur			0.121	0.141
T-Value			2.19	2.55
P-Value			0.036	0.016
Depth				0.052
T-Value				1.70
P-Value				0.098
S	1.15	1.17	1.11	1.08
R-Sq	87.73	87.06	88.61	89.51
R-Sq(adj)	85.62	85.26	86.66	87.34
C-p	7.6	7.6	5.1	4.5

Regression Analysis: ln(Dinoflagellate+100) versus SS, Twater, ...

The regression equation is

ln(Dinoflagellate+100) = - 3.18 - 0.155 SS + 0.310 Twater + 0.0243 TDS
- 0.320 BOD + 0.0179 Con + 0.141 Tur + 0.0515 Depth

Predictor	Coef	SE Coef	T	P	VIF
Constant	-3.183	3.271	-0.97	0.337	
SS	-0.15523	0.03065	-5.06	0.000	8.2
Twater	0.3102	0.1109	2.80	0.008	1.6
TDS	0.024271	0.004339	5.59	0.000	1.8
BOD	-0.31974	0.09222	-3.47	0.001	1.0
Con	0.017898	0.003811	4.70	0.000	1.3
Tur	0.14069	0.05527	2.55	0.016	7.4
Depth	0.05154	0.03031	1.70	0.098	1.1

S = 1.080 R-Sq = 89.5% R-Sq(adj) = 87.3%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	7	337.996	48.285	41.42	0.000
Residual Error	34	39.631	1.166		
Total	41	377.627			

Source	DF	Seq SS
SS	1	195.521
Twater	1	10.854
TDS	1	87.626
BOD	1	14.480
Con	1	20.269
Tur	1	5.875
Depth	1	3.370

Unusual Observations

Obs	SS	ln(Dinof	Fit	SE Fit	Residual	St Resid
15	8.3	15.790	13.660	0.336	2.130	2.08R
29	51.8	4.610	6.814	0.485	-2.204	-2.29R
30	87.8	4.610	3.303	0.865	1.307	2.02RX
35	7.6	10.630	12.886	0.294	-2.256	-2.17R
39	8.2	14.520	12.191	0.337	2.329	2.27R

```
R denotes an observation with a large standardized residual
X denotes an observation whose X value gives it large influence.
Durbin-Watson statistic = 2.49
```

Residual Histogram for ln(Dinof

Normplot of Residuals for ln(Dinof

Residuals vs Fits for ln(Dinof

Residuals vs Order for ln(Dinof

6) Phylum Euglenophyta (euglenoids)

Based on fittest model analysis on 109 sets of water quality and plankton data, it was found that there were 42 data sets for analysis of relationship between water quality and abundance of plankton in phylum Euglenophyta or euglenoids (Table 6E in Appendix E). The fittest model results from MINITAB program are detailed below (Figure 16):

Results for: P2Eugle.MTW

Descriptive Statistics: log(Euglenoi, Twater, pH, Trans, Depth, Tur, Con, DO, TDS

Variable	N	Mean	Median	TrMean	StDev	SE Mean
log(Eugl	42	3.911	4.444	3.872	1.830	0.282
Twater	42	27.798	27.400	27.750	1.932	0.298
pH	42	8.4419	8.5100	8.4497	0.4390	0.0677
Trans	42	100.80	99.00	100.00	49.93	7.70
Depth	42	5.769	3.800	5.268	5.816	0.897
Tur	42	6.71	3.50	5.54	8.31	1.28
Con	42	272.72	267.80	270.64	51.10	7.89
DO	42	8.068	8.240	8.072	1.452	0.224
TDS	42	182.00	168.50	179.82	52.14	8.05
SS	42	11.65	7.55	9.11	15.71	2.42
Hard	42	127.10	117.50	125.76	23.88	3.68
Alk	42	121.12	120.00	120.18	27.80	4.29
Nitrate	42	0.1835	0.1485	0.1826	0.0898	0.0139
Org-N	42	0.3298	0.3000	0.3203	0.1783	0.0275
Total-N	42	1.205	0.800	1.140	1.100	0.170
Total-P	42	0.02633	0.02100	0.02400	0.02251	0.00347
BOD	42	3.217	2.750	3.158	1.867	0.288
Ca	42	18.709	20.300	18.860	5.443	0.840
Mg	42	4.686	4.560	4.481	2.781	0.429
Na	42	15.89	13.41	12.54	19.41	2.99
K	42	1.658	1.827	1.638	0.764	0.118
Chlo-A	42	12.812	12.540	12.752	5.862	0.905

Variable	Minimum	Maximum	Q1	Q3
log(Eugl	2.000	6.741	2.000	5.628
Twater	25.000	31.800	26.000	28.850
pH	7.2500	9.4000	8.1525	8.7850
Trans	10.00	220.00	65.25	140.00
Depth	0.800	20.500	2.000	5.850

Tur	0.90	46.30	2.53	7.00
Con	192.00	401.00	242.45	309.00
DO	4.000	11.600	7.075	8.993
TDS	110.00	312.00	136.75	217.00
SS	1.70	87.80	4.15	10.15
Hard	90.00	200.00	112.75	134.50
Alk	74.00	195.00	99.50	135.75
Nitrate	0.0300	0.4060	0.1245	0.2800
Org-N	0.1000	0.8000	0.2000	0.4625
Total-N	0.100	3.600	0.400	1.900
Total-P	0.00200	0.10200	0.01375	0.03075
BOD	0.100	7.200	1.950	4.000
Ca	5.380	30.230	14.388	21.603
Mg	0.580	17.360	2.938	6.042
Na	2.54	128.50	9.73	14.58
K	0.180	4.600	1.278	2.030
Chlo-A	1.710	24.640	8.308	17.110

Stepwise Regression: log(Euglenoid+100) versus Twater, pH, ...

Alpha-to-Enter: 0.15 Alpha-to-Remove: 0.15

Response is log(Eugl on 21 predictors, with N = 42

Step	1	2	3	4	5	6
Constant	6.346	1.458	-14.077	-19.099	-17.965	-17.596
Nitrate	-13.3	-10.6	-3.8			
T-Value	-5.43	-4.97	-1.43			
P-Value	0.000	0.000	0.160			
Hard		0.0346	0.0512	0.0580	0.0799	0.0751
T-Value		4.31	6.09	8.24	10.34	9.44
P-Value		0.000	0.000	0.000	0.000	0.000
Twater			0.438	0.563	0.521	0.530
T-Value			3.59	6.47	7.16	7.49
P-Value			0.001	0.000	0.000	0.000
Ca					-0.147	-0.124
T-Value					-4.33	-3.51
P-Value					0.000	0.001
BOD						-0.139
T-Value						-1.84
P-Value						0.074
S	1.41	1.17	1.03	1.04	0.862	0.836
R-Sq	42.43	61.03	70.88	69.31	79.45	81.16
R-Sq(adj)	40.99	59.03	68.59	67.74	77.82	79.13
C-p	82.1	45.3	26.7	28.0	8.9	7.3

Regression Analysis: log(Euglenoid+100) versus Hard, Twater, Ca, BOD

The regression equation is

log(Euglenoid+100) = - 17.6 + 0.0751 Hard + 0.530 Twater - 0.124 Ca - 0.139 BOD

Predictor	Coef	SE Coef	T	P	VIF
Constant	-17.596	2.268	-7.76	0.000	
Hard	0.075056	0.007953	9.44	0.000	2.1
Twater	0.53016	0.07077	7.49	0.000	1.1
Ca	-0.12412	0.03531	-3.51	0.001	2.2
BOD	-0.13886	0.07560	-1.84	0.074	1.2

S = 0.8361   R-Sq = 81.2%   R-Sq(adj) = 79.1%

```
Analysis of Variance

Source            DF          SS          MS         F        P

Regression         4     111.454      27.864     39.86    0.000
Residual Error    37      25.867       0.699
Total             41     137.322

Source       DF      Seq SS

Hard          1      49.956
Twater        1      45.225
Ca            1      13.915
BOD           1       2.359


Unusual Observations


Obs       Hard   log(Eugl         Fit      SE Fit    Residual    St Resid
 35        124      2.000       4.104       0.192      -2.104      -2.59R
 40        111      6.018       3.901       0.188       2.116       2.60R


R denotes an observation with a large standardized residual


Durbin-Watson statistic = 1.70
```

Residual Histogram for log(Eugl

Normplot of Residuals for log(Eugl

Residuals vs Fits for log(Eugl

Residuals vs Order for log(Eugl

7) Phylum Protozoa (protozoans)

Based on fittest model analysis on 109 sets of water quality and plankton data, it was found that there were 36 data sets for analysis of relationship between water quality and abundance of plankton in phylum Protozoa or protozoans (Table 7E in Appendix E). The fittest model results from MINITAB program are detailed below (Figure 17):

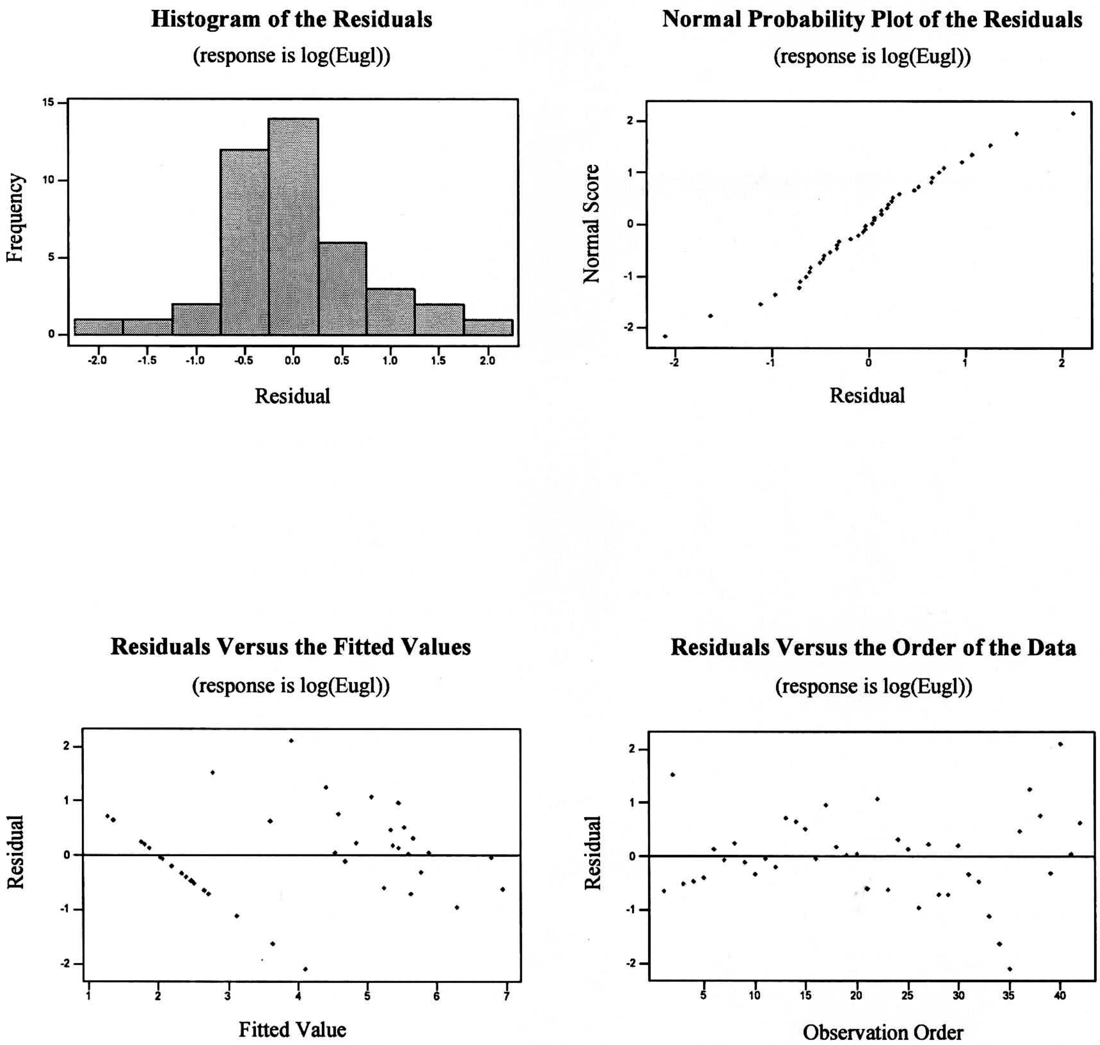

Figure 16. The fittest model results of phylum Euglenophyta from MINITAB program.

Results for: P2Proto.MTW

Descriptive Statistics: Protozoa, Twater, pH, Trans, Depth, Tur, Con, DO, TDS, SS

Variable	N	Mean	Median	TrMean	StDev	SE Mean
Protozoa	36	144581	71975	125467	155553	25926
Twater	36	27.644	27.300	27.578	1.885	0.314
pH	36	8.4372	8.4350	8.4459	0.4461	0.0744
Trans	36	102.14	100.00	102.72	47.32	7.89
Depth	36	6.23	3.95	5.69	6.15	1.03
Tur	36	6.83	3.70	5.44	8.71	1.45
Con	36	275.54	274.00	273.30	52.10	8.68
DO	36	7.853	7.745	7.889	1.363	0.227
TDS	36	186.03	178.50	183.63	51.81	8.64
SS	36	12.58	7.55	9.65	16.79	2.80
Hard	36	127.97	118.50	126.50	24.63	4.11
Alk	36	121.50	120.50	120.44	28.66	4.78
Nitrate	36	0.1808	0.1480	0.1794	0.0907	0.0151
Org-N	36	0.3458	0.3250	0.3366	0.1813	0.0302
Total-N	36	1.234	0.800	1.161	1.081	0.180
Total-P	36	0.02631	0.02200	0.02372	0.02113	0.00352
BOD	36	3.164	2.700	3.056	1.690	0.282
Ca	36	18.731	19.885	18.913	5.411	0.902
Mg	36	4.798	4.573	4.587	2.839	0.473
Na	36	16.40	13.41	12.49	20.88	3.48
K	36	1.683	1.827	1.662	0.785	0.131
Chlo-A	36	12.596	12.755	12.552	5.698	0.950

Variable	Minimum	Maximum	Q1	Q3
Protozoa	6550	631800	38563	225613
Twater	25.000	31.800	26.000	28.625
pH	7.2500	9.4000	8.1700	8.7800
Trans	10.00	190.00	64.75	140.00
Depth	0.80	20.50	2.03	6.90
Tur	1.00	46.30	2.38	6.70
Con	193.00	401.00	242.95	309.00
DO	4.000	11.100	6.940	8.930
TDS	115.00	312.00	140.00	217.00
SS	2.15	87.80	4.28	10.75
Hard	90.00	200.00	112.50	137.50
Alk	74.00	195.00	98.50	139.25
Nitrate	0.0300	0.4060	0.1235	0.2775
Org-N	0.1000	0.8000	0.2000	0.5000
Total-N	0.100	3.600	0.400	1.900
Total-P	0.00200	0.10200	0.01500	0.03000
BOD	1.100	7.200	2.000	3.875
Ca	5.380	30.230	14.523	21.648
Mg	0.670	17.360	3.058	6.088
Na	2.54	128.50	9.96	14.56
K	0.180	4.600	1.318	2.050
Chlo-A	1.710	23.770	7.903	17.013

Stepwise Regression: Protozoa versus Twater, pH, ...

Alpha-to-Enter: 0.15 Alpha-to-Remove: 0.15

Response is Protozoa on 21 predictors, with N = 36

Step	1	2	3	4	5	6	7
Constant	-113835	-90234	158161	213027	144821	-146526	-440701
Ca	13796	19957	18342	19468	12203	8724	7596
T-Value	3.19	4.25	4.52	4.96	2.07	1.49	1.35
P-Value	0.003	0.000	0.000	0.000	0.048	0.148	0.188

Trans		-1361	-2063	-2348	-2461	-2338	-1954
T-Value		-2.53	-4.11	-4.69	-4.99	-4.94	-3.97
P-Value		0.016	0.000	0.000	0.000	0.000	0.000
Org-N			-423428	-424074	-412650	-334072	-289716
T-Value			-3.56	-3.72	-3.71	-2.97	-2.64
P-Value			0.001	0.001	0.001	0.006	0.013
Total-P				-1772561	-2023348	-1654078	-772942
T-Value				-1.99	-2.30	-1.93	-0.83
P-Value				0.055	0.029	0.063	0.414
Alk					1798	2480	1691
T-Value					1.62	2.24	1.49
P-Value					0.117	0.033	0.147
DO						28551	41453
T-Value						2.05	2.80
P-Value						0.049	0.009
Con							843
T-Value							1.96
P-Value							0.060
S	138463	128585	110557	105752	103108	97998	93537
R-Sq	23.03	35.57	53.81	59.06	62.34	67.11	71.07
R-Sq(adj)	20.77	31.67	49.49	53.78	56.06	60.31	63.84
C-p	51.6	40.0	22.2	18.5	16.9	13.7	11.4

Step	8	9	10
Constant	-533650	-593918	-920194
Ca	7280		
T-Value	1.30		
P-Value	0.202		
Trans	-1771	-1643	-1413
T-Value	-4.05	-3.81	-3.53
P-Value	0.000	0.001	0.001
Org-N	-275686	-263363	-241000
T-Value	-2.56	-2.42	-2.43
P-Value	0.016	0.022	0.021
Total-P			
T-Value			
P-Value			
Alk	1452	2494	1754
T-Value	1.33	3.33	2.39
P-Value	0.193	0.002	0.023
DO	46113	51462	57484
T-Value	3.38	3.91	4.73
P-Value	0.002	0.000	0.000
Con	1015	1054	1895
T-Value	2.71	2.79	4.09
P-Value	0.011	0.009	0.000
Nitrate			585738
T-Value			2.71
P-Value			0.011
S	93030	94110	85485
R-Sq	70.36	68.63	74.98
R-Sq(adj)	64.23	63.40	69.80
C-p	10.2	10.1	5.2

Regression Analysis: Protozoa versus Trans, Org-N, Alk, DO, Con, Nitrate

The regression equation is

Protozoa = - 920194 - 1413 Trans - 241000 Org-N + 1754 Alk + 57484 DO
+ 1895 Con + 585738 Nitrate

Predictor	Coef	SE Coef	T	P	VIF
Constant	-920194	209128	-4.40	0.000	
Trans	-1413.3	400.6	-3.53	0.001	1.7
Org-N	-241000	99060	-2.43	0.021	1.5
Alk	1754.2	732.7	2.39	0.023	2.1
DO	57484	12162	4.73	0.000	1.3
Con	1894.7	462.7	4.09	0.000	2.8
Nitrate	585738	215921	2.71	0.011	1.8

S = 85485 R-Sq = 75.0% R-Sq(adj) = 69.8%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	6	6.34964E+11	1.05827E+11	14.48	0.000
Residual Error	29	2.11922E+11	7307648257		
Total	35	8.46886E+11			

Source	DF	Seq SS
Trans	1	2520908138
Org-N	1	2.04049E+11
Alk	1	2.15402E+11
DO	1	90450918413
Con	1	68764382522
Nitrate	1	53776958549

Unusual Observations

Obs	Trans	Protozoa	Fit	SE Fit	Residual	St Resid
2	98	631800	428095	46083	203705	2.83R

R denotes an observation with a large standardized residual

Durbin-Watson statistic = 1.99

Residual Histogram for Protozoa

Normplot of Residuals for Protozoa

Residuals vs Fits for Protozoa

Residuals vs Order for Protozoa

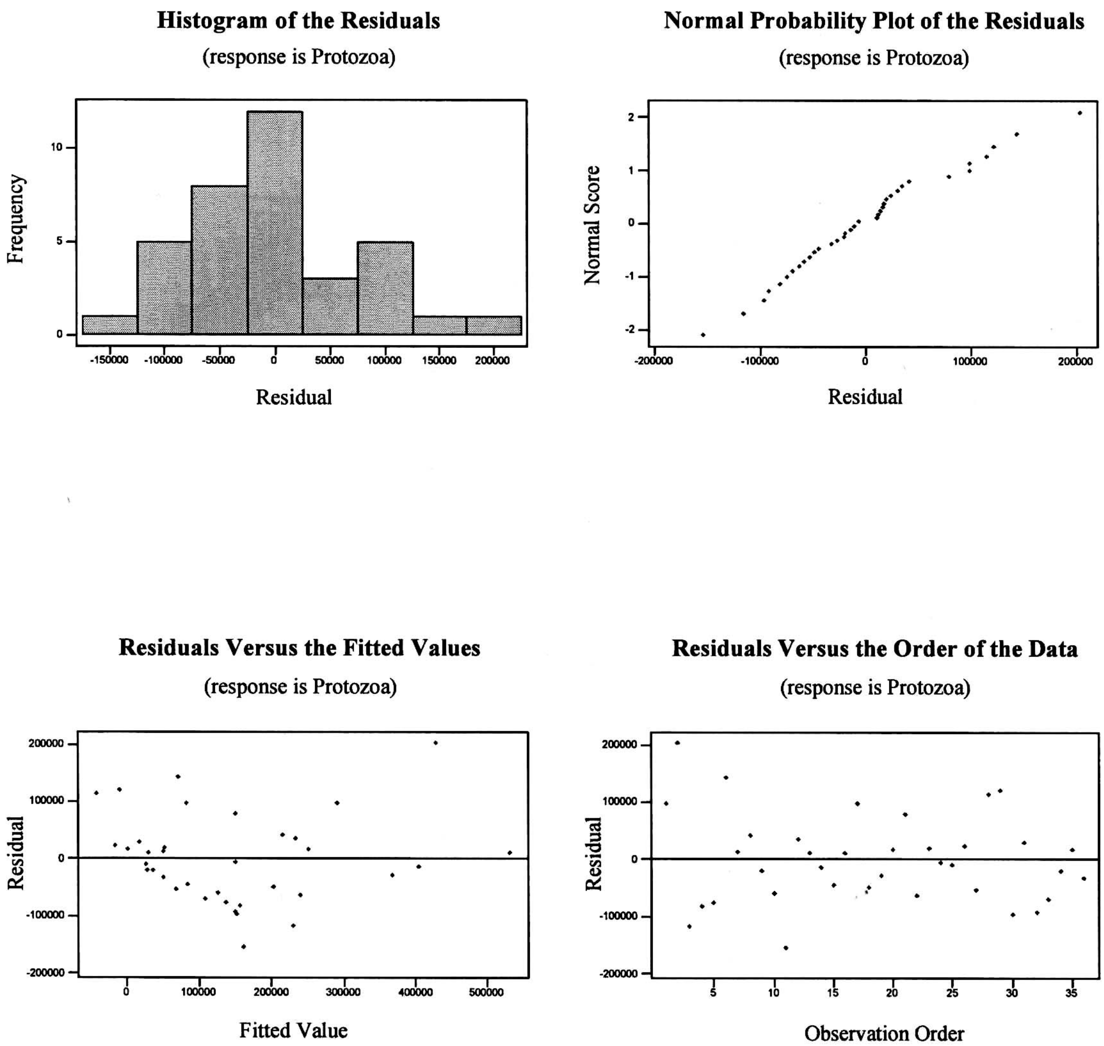

Figure 17. The fittest model results of phylum Protozoa from MINITAB program.

8) Phylum Rotifera (rotifers)

Based on fittest model analysis on 109 sets of water quality and plankton data, it was found that there were 40 data sets for analysis of relationship between water quality and abundance of plankton in phylum Rotifera or rotifers (Table 8E in Appendix E). The fittest model results from MINITAB program are detailed below (Figure 18):

Results for: P2Roti.MTW

Descriptive Statistics: ln(Rotifer), Twater, pH, Trans, Depth, Tur, Con, DO, TDS

Variable	N	Mean	Median	TrMean	StDev	SE Mean
ln(Rotif	40	13.246	13.041	13.223	0.884	0.140
Twater	40	27.853	27.500	27.808	1.958	0.310
pH	40	8.4513	8.5100	8.4597	0.4243	0.0671
Trans	40	103.79	100.00	103.28	49.04	7.75
Depth	40	5.705	3.800	5.169	5.802	0.917
Tur	40	5.693	3.300	5.008	5.594	0.885
Con	40	275.17	270.80	273.25	50.76	8.03
DO	40	8.153	8.270	8.150	1.421	0.225
TDS	40	184.63	174.00	182.61	52.05	8.23
SS	40	9.58	7.45	7.90	10.25	1.62
Hard	40	128.43	118.00	127.03	23.57	3.73
Alk	40	123.15	120.50	122.25	26.86	4.25
Nitrate	40	0.1796	0.1485	0.1814	0.0842	0.0133
Org-N	40	0.3212	0.3000	0.3103	0.1785	0.0282
Total-N	40	1.111	0.800	1.031	1.037	0.164
Total-P	40	0.02473	0.02050	0.02208	0.02124	0.00336
BOD	40	3.247	2.750	3.189	1.900	0.300
Ca	40	19.127	20.775	19.216	5.110	0.808
Mg	40	4.819	4.573	4.617	2.766	0.437
Na	40	16.36	13.71	12.80	19.76	3.12
K	40	1.692	1.846	1.674	0.757	0.120
Chlo-A	40	12.982	12.540	12.881	5.698	0.901

Variable	Minimum	Maximum	Q1	Q3
ln(Rotif	11.252	15.405	12.545	13.887
Twater	25.000	31.800	26.250	28.950
pH	7.2500	9.4000	8.1700	8.7650
Trans	10.00	220.00	70.50	140.00
Depth	0.800	20.500	2.025	5.775
Tur	0.900	23.300	2.375	6.675
Con	192.00	401.00	242.95	309.00
DO	4.000	11.600	7.150	8.998
TDS	110.00	312.00	140.00	217.00
SS	1.70	51.80	4.05	9.30
Hard	95.00	200.00	114.00	137.50
Alk	74.00	195.00	106.25	139.25
Nitrate	0.0300	0.2900	0.1255	0.2800
Org-N	0.1000	0.8000	0.2000	0.4150
Total-N	0.100	3.600	0.400	1.715
Total-P	0.00200	0.10200	0.01125	0.02950
BOD	0.100	7.200	2.000	4.200
Ca	6.050	30.230	14.523	21.648

Mg	0.580	17.360	3.105	6.088
Na	3.25	128.50	10.20	14.63
K	0.180	4.600	1.318	2.050
Chlo-A	3.420	24.640	8.518	17.013

Stepwise Regression: ln(Rotifer) versus Twater, pH, ...

Alpha-to-Enter: 0.15 Alpha-to-Remove: 0.15

Response is ln(Rotif on 21 predictors, with N = 40

Step	1	2	3	4
Constant	13.858	13.000	10.995	8.636
Total-N	-0.551	-0.432	-0.444	-0.318
T-Value	-5.22	-4.83	-5.07	-3.08
P-Value	0.000	0.000	0.000	0.004
BOD		0.223	0.217	0.245
T-Value		4.58	4.54	5.14
P-Value		0.000	0.000	0.000
Twater			0.073	0.112
T-Value			1.65	2.41
P-Value			0.108	0.021
Alk				0.0086
T-Value				2.08
P-Value				0.045
S	0.683	0.553	0.541	0.518
R-Sq	41.78	62.85	65.45	69.25
R-Sq(adj)	40.25	60.84	62.57	65.74
C-p	24.3	4.5	3.8	1.8

Regression Analysis: ln(Rotifer) versus Total-N, BOD, Twater

The regression equation is

ln(Rotifer) = 11.0 - 0.444 Total-N + 0.217 BOD + 0.0732 Twater

Predictor	Coef	SE Coef	T	P	VIF
Constant	10.995	1.238	8.88	0.000	
Total-N	-0.44444	0.08765	-5.07	0.000	1.1
BOD	0.21714	0.04781	4.54	0.000	1.1
Twater	0.07321	0.04447	1.65	0.108	1.0

S = 0.5409   R-Sq = 65.5%   R-Sq(adj) = 62.6%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	3	19.9561	6.6520	22.73	0.000
Residual Error	36	10.5344	0.2926		
Total	39	30.4905			

Source	DF	Seq SS
Total-N	1	12.7402
BOD	1	6.4228
Twater	1	0.7930

Unusual Observations

Obs	Total-N	ln(Rotif	Fit	SE Fit	Residual	St Resid
21	1.00	14.4310	13.3309	0.0962	1.1001	2.07R

R denotes an observation with a large standardized residual

Durbin-Watson statistic = 2.03

Residual Histogram for ln(Rotif

Normplot of Residuals for ln(Rotif

Residuals vs Fits for ln(Rotif

Residuals vs Order for ln(Rotif

9) Phylum Arthropoda (arthropods)

Based on fittest model analysis on 109 sets of water quality and plankton data, it was found that there were 40 data sets for analysis of relationship between water quality and abundance of plankton in phylum Arthropoda or arthropods (Table 9E in Appendix E). The fittest model results from MINITAB program are detailed below (Figure 19):

Results for: P2Arthro.MTW

Descriptive Statistics: ln(Arthropod, Twater, pH, Trans, Depth, Tur, Con, DO, TDS

Variable	N	Mean	Median	TrMean	StDev	SE Mean
ln(Arthr	40	12.491	12.300	12.510	1.038	0.164
Twater	40	27.670	27.350	27.606	1.888	0.299
pH	40	8.4378	8.5100	8.4561	0.4037	0.0638
Trans	40	100.54	99.00	99.67	50.59	8.00
Depth	40	5.805	3.800	5.281	5.924	0.937
Tur	40	6.90	3.60	5.68	8.47	1.34
Con	40	272.70	267.80	270.50	51.77	8.18
DO	40	8.060	8.240	8.062	1.451	0.229
TDS	40	183.08	174.00	180.89	53.22	8.41
SS	40	11.92	7.55	9.26	16.04	2.54
Hard	40	128.00	117.50	126.69	23.91	3.78
Alk	40	122.10	120.00	121.22	27.75	4.39
Nitrate	40	0.1877	0.1500	0.1873	0.0893	0.0141
Org-N	40	0.3243	0.3000	0.3144	0.1727	0.0273
Total-N	40	1.191	0.800	1.121	1.098	0.174
Total-P	40	0.02653	0.02100	0.02408	0.02300	0.00364
BOD	40	3.210	2.750	3.147	1.862	0.294
Ca	40	18.842	20.775	19.016	5.480	0.866
Mg	40	4.712	4.560	4.499	2.787	0.441
Na	40	16.10	13.41	12.59	19.86	3.14
K	40	1.685	1.827	1.667	0.750	0.119
Chlo-A	40	12.565	12.400	12.474	5.899	0.933

Variable	Minimum	Maximum	Q1	Q3
ln(Arthr	8.868	14.901	11.848	13.037
Twater	25.000	31.800	26.000	28.775
pH	7.2500	9.2000	8.1700	8.7650
Trans	10.00	220.00	63.75	140.00
Depth	0.800	20.500	2.000	5.775
Tur	0.90	46.30	2.68	7.60
Con	192.00	401.00	242.95	308.50
DO	4.000	11.600	7.150	8.930
TDS	110.00	312.00	136.25	217.00
SS	1.70	87.80	4.28	10.45
Hard	90.00	200.00	113.25	137.50
Alk	74.00	195.00	101.25	139.25

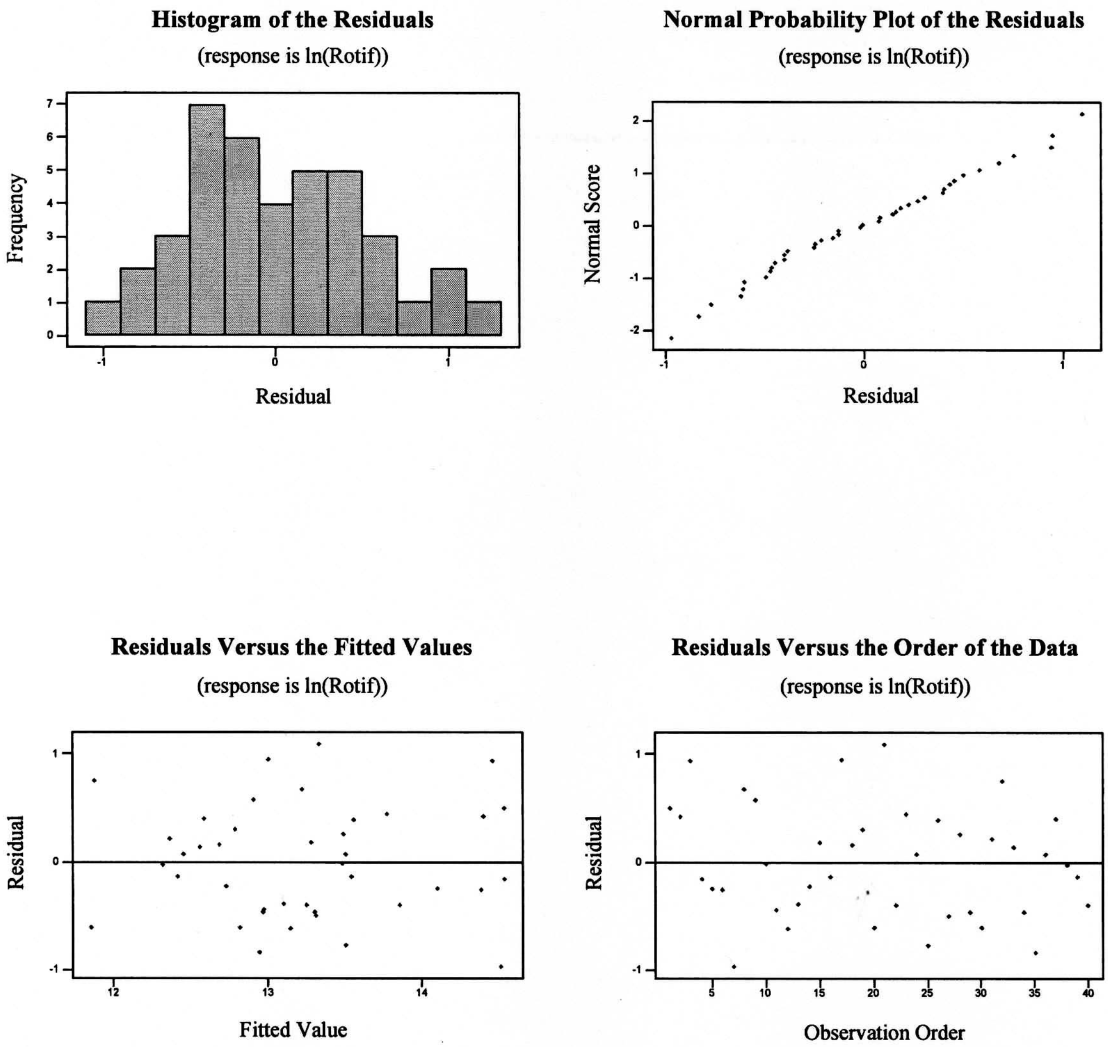

Figure 18. The fittest model results of phylum Rotifera from MINITAB program.

Nitrate	0.0300	0.4060	0.1255	0.2800
Org-N	0.1000	0.8000	0.2000	0.4425
Total-N	0.100	3.600	0.400	1.870
Total-P	0.00200	0.10200	0.01125	0.03225
BOD	0.100	7.200	2.000	3.875
Ca	5.380	30.230	14.523	21.648
Mg	0.580	17.360	3.058	6.005
Na	2.54	128.50	9.96	14.56
K	0.180	4.600	1.318	2.050
Chlo-A	1.710	24.640	7.903	16.700

Stepwise Regression: ln(Arthropoda) versus Twater, pH, ...

Alpha-to-Enter: 0.15 Alpha-to-Remove: 0.15

Response is ln(Arthr on 21 predictors, with N = 40

Step	1	2	3	4	5	6
Constant	11.538	11.899	13.070	13.168	9.164	8.383
BOD	0.297	0.296	0.259	0.258	0.266	0.215
T-Value	3.88	4.56	4.43	4.56	4.84	3.46
P-Value	0.000	0.000	0.000	0.000	0.000	0.002
SS		-0.0300	-0.0450	-0.0455	-0.0431	-0.0378
T-Value		-3.98	-5.63	-5.88	-5.64	-4.65
P-Value		0.000	0.000	0.000	0.000	0.000
Trans			-0.0087	-0.0076	-0.0069	-0.0083
T-Value			-3.38	-3.00	-2.75	-3.21
P-Value			0.002	0.005	0.010	0.003
Depth				-0.033	-0.036	-0.037
T-Value				-1.83	-2.03	-2.12
P-Value				0.076	0.050	0.042
pH					0.46	0.61
T-Value					1.81	2.31
P-Value					0.079	0.027
Total-N						-0.22
T-Value						-1.64
P-Value						0.111
S	0.890	0.755	0.667	0.646	0.626	0.611
R-Sq	28.36	49.84	61.95	65.27	68.33	70.71
R-Sq(adj)	26.47	47.13	58.78	61.30	63.67	65.39
C-p	53.7	28.8	15.6	13.5	11.6	10.7

Regression Analysis: ln(Arthropoda) versus BOD, SS, ...

The regression equation is

ln(Arthropoda) = 8.38 + 0.215 BOD - 0.0378 SS - 0.00834 Trans - 0.0367 Depth + 0.613 pH - 0.216 Total-N

Predictor	Coef	SE Coef	T	P	VIF
Constant	8.383	2.241	3.74	0.001	
BOD	0.21496	0.06217	3.46	0.002	1.4
SS	-0.037754	0.008118	-4.65	0.000	1.8
Trans	-0.008336	0.002601	-3.21	0.003	1.8
Depth	-0.03674	0.01734	-2.12	0.042	1.1
pH	0.6135	0.2650	2.31	0.027	1.2
Total-N	-0.2158	0.1316	-1.64	0.111	2.2

```
S = 0.6107      R-Sq = 70.7%     R-Sq(adj) = 65.4%

Analysis of Variance

Source            DF          SS          MS         F        P

Regression         6     29.7182      4.9530     13.28    0.000
Residual Error    33     12.3092      0.3730
Total             39     42.0275

Source       DF      Seq SS

BOD           1     11.9172
SS            1      9.0313
Trans         1      5.0868
Depth         1      1.3946
pH            1      1.2863
Total-N       1      1.0020

Unusual Observations

Obs        BOD   ln(Arthr         Fit      SE Fit    Residual    St Resid

 29       3.40     8.8679      9.6411      0.5044     -0.7732      -2.25RX
 36       3.40    11.6479     13.0885      0.1730     -1.4406      -2.46R
 37       0.10    13.1933     12.0739      0.2757      1.1194       2.05R

R denotes an observation with a large standardized residual

X denotes an observation whose X value gives it large influence.


Durbin-Watson statistic = 2.47
```

Residual Histogram for ln(Arthr

Normplot of Residuals for ln(Arthr

Residuals vs Fits for ln(Arthr

Residuals vs Order for ln(Arthr

10) Phylum Chordata (chordates)

Based on fittest model analysis on 109 sets of water quality and plankton data, it was found that there were 37 data sets for analysis of relationship between water quality and abundance of plankton in phylum Chordata or chordates (Table 10E in Appendix E). The fittest model results from MINITAB program are detailed below (Figure 20):

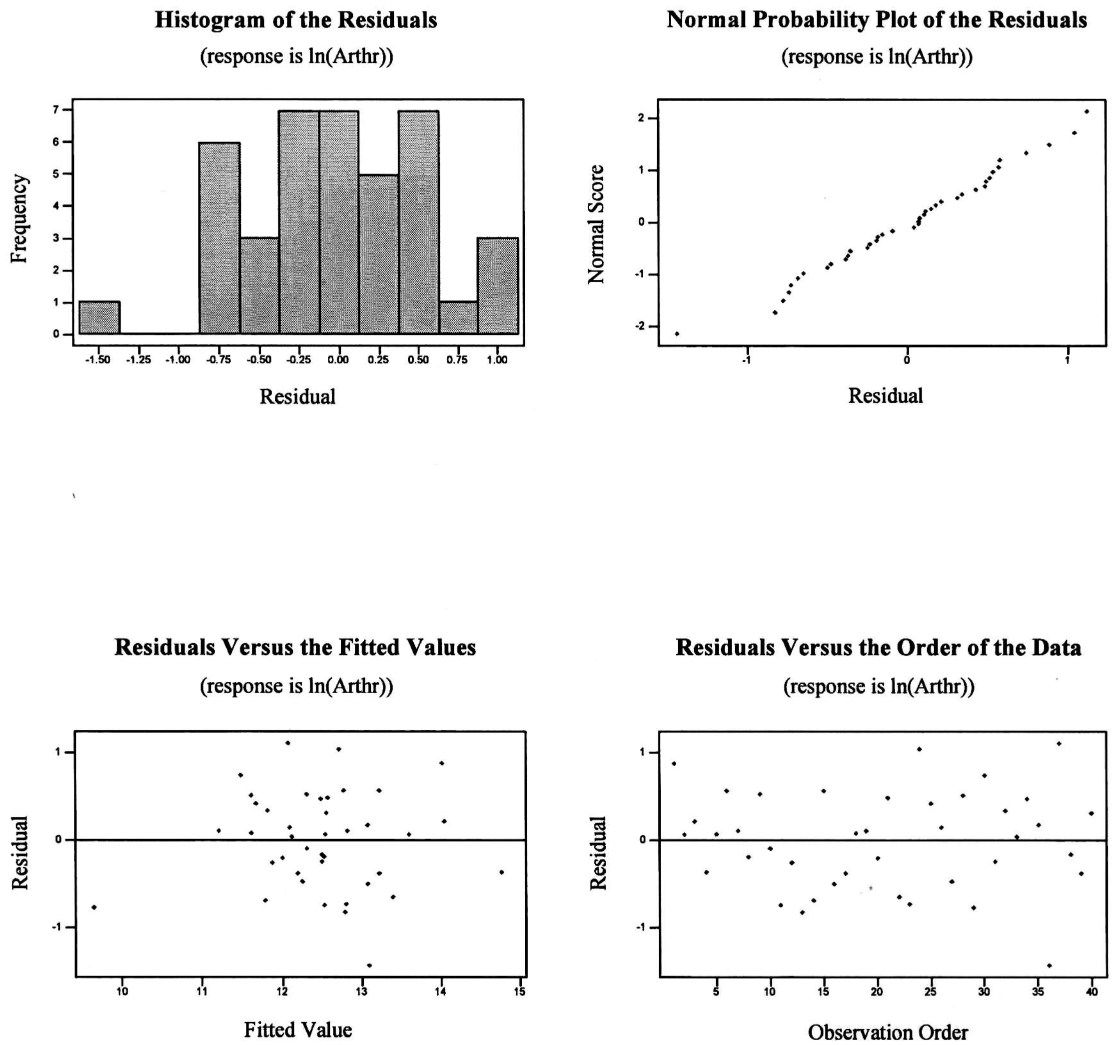

Figure 19. The fittest model results of phylum Arthropoda from MINITAB program.

Results for: P2Chor.MTW

Descriptive Statistics: log(Chordata, Twater, pH, Trans, Depth, Tur, Con, DO, TDS

Variable	N	Mean	Median	TrMean	StDev	SE Mean
log(Chor	37	2.820	2.000	2.753	1.081	0.178
Twater	37	27.805	27.300	27.752	1.942	0.319
pH	37	8.3862	8.4000	8.4036	0.4189	0.0689
Trans	37	105.55	100.00	105.21	50.89	8.37
Depth	37	5.732	3.700	5.142	6.004	0.987
Tur	37	6.44	3.20	5.05	8.61	1.41
Con	37	276.78	273.00	274.88	52.29	8.60
DO	37	7.974	8.000	7.967	1.489	0.245
TDS	37	185.57	177.00	183.48	53.82	8.85
SS	37	10.96	7.40	7.94	16.28	2.68
Hard	37	129.32	119.00	128.06	24.44	4.02
Alk	37	123.81	121.00	123.06	27.94	4.59
Nitrate	37	0.1828	0.1490	0.1818	0.0920	0.0151
Org-N	37	0.3127	0.3000	0.3006	0.1757	0.0289
Total-N	37	1.090	0.800	1.005	0.994	0.163
Total-P	37	0.02651	0.02100	0.02385	0.02364	0.00389
BOD	37	3.154	2.800	3.079	1.863	0.306
Ca	37	19.040	20.900	19.254	5.606	0.922
Mg	37	4.866	4.624	4.652	2.898	0.476
Na	37	16.65	14.02	12.89	20.58	3.38
K	37	1.708	1.870	1.691	0.777	0.128
Chlo-A	37	12.286	11.980	12.153	6.013	0.989

Variable	Minimum	Maximum	Q1	Q3
log(Chor	2.000	4.914	2.000	4.058
Twater	25.000	31.800	26.000	28.900
pH	7.2500	9.2000	8.0750	8.7100
Trans	10.00	220.00	74.50	140.00
Depth	0.800	20.500	2.000	5.750
Tur	0.90	46.30	2.15	6.70
Con	192.00	401.00	243.80	309.50
DO	4.000	11.600	6.960	8.740
TDS	110.00	312.00	138.00	217.50
SS	1.70	87.80	4.10	8.70
Hard	90.00	200.00	113.50	147.50
Alk	74.00	195.00	107.50	143.50
Nitrate	0.0300	0.4060	0.1250	0.2800
Org-N	0.1000	0.8000	0.2000	0.4100
Total-N	0.100	3.500	0.400	1.650
Total-P	0.00200	0.10200	0.01250	0.03000
BOD	0.100	7.200	1.800	3.850
Ca	5.380	30.230	14.635	21.690
Mg	0.580	17.360	2.925	6.280
Na	2.54	128.50	10.55	14.82
K	0.180	4.600	1.350	2.070
Chlo-A	1.710	24.640	7.485	16.295

Stepwise Regression: log(Chordata+100) versus Twater, pH, ...

Alpha-to-Enter: 0.15 Alpha-to-Remove: 0.15

Response is log(Chor on 21 predictors, with N = 37

Step	1	2	3	4	5	6	7
Constant	1.5585	0.9208	5.1786	5.0537	4.4308	3.1357	4.7056
BOD	0.400	0.302	0.285	0.244	0.244	0.237	0.230
T-Value	5.64	4.60	4.75	4.08	4.19	4.21	4.40
P-Value	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Chlo-A		0.077	0.090	0.074	0.076	0.070	0.080
T-Value		3.78	4.73	3.82	3.99	3.77	4.52
P-Value		0.001	0.000	0.001	0.000	0.001	0.000

Twater			-0.157	-0.192	-0.169	-0.132	-0.174
T-Value			-2.90	-3.57	-3.10	-2.38	-3.20
P-Value			0.007	0.001	0.004	0.024	0.003
DO				0.178	0.189	0.183	0.195
T-Value				2.15	2.33	2.35	2.69
P-Value				0.039	0.027	0.025	0.012
Na					-0.0079	-0.0185	-0.0271
T-Value					-1.61	-2.55	-3.54
P-Value					0.116	0.016	0.001
K						0.36	0.94
T-Value						1.91	3.14
P-Value						0.065	0.004
Ca							-0.077
T-Value							-2.39
P-Value							0.024
S	0.793	0.675	0.612	0.581	0.567	0.544	0.506
R-Sq	47.57	63.09	70.61	74.31	76.31	78.88	82.35
R-Sq(adj)	46.07	60.92	67.93	71.10	72.49	74.66	78.10
C-p	50.0	27.4	17.5	13.6	12.5	10.4	6.9

Regression Analysis: log(Chordata+100) versus BOD, Chlo-A, Twater, DO, Na

The regression equation is

log(Chordata+100) = 4.43 + 0.244 BOD + 0.0756 Chlo-A - 0.169 Twater + 0.189 DO - 0.00790 Na

Predictor	Coef	SE Coef	T	P	VIF
Constant	4.431	1.432	3.09	0.004	
BOD	0.24444	0.05837	4.19	0.000	1.3
Chlo-A	0.07559	0.01896	3.99	0.000	1.5
Twater	-0.16852	0.05444	-3.10	0.004	1.3
DO	0.18900	0.08121	2.33	0.027	1.6
Na	-0.007904	0.004895	-1.61	0.116	1.1

S = 0.5668 R-Sq = 76.3% R-Sq(adj) = 72.5%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	5	32.0722	6.4144	19.97	0.000
Residual Error	31	9.9583	0.3212		
Total	36	42.0305			

Source	DF	Seq SS
BOD	1	19.9946
Chlo-A	1	6.5237
Twater	1	3.1581
DO	1	1.5581
Na	1	0.8376

Unusual Observations

Obs	BOD	log(Chor	Fit	SE Fit	Residual	St Resid
13	3.80	3.9031	2.7700	0.1626	1.1331	2.09R
14	4.80	2.0000	3.1483	0.1760	-1.1483	-2.13R
20	3.90	2.0000	2.0647	0.5260	-0.0647	-0.31 X

```
R denotes an observation with a large standardized residual
X denotes an observation whose X value gives it large influence.

Durbin-Watson statistic = 2.46
```

Residual Histogram for log(Chor

Normplot of Residuals for log(Chor

Residuals vs Fits for log(Chor

Residuals vs Order for log(Chor

11) Total phytoplankton

Based on fittest model analysis on 109 sets of water quality and plankton data, it was found that there were 40 data sets for analysis of relationship between water quality and abundance of plankton in total phytoplankton (Table 11E in Appendix E). The fittest model results from MINITAB program are detailed below (Figure 21):

Results for: P2TotalPhyto.MTW

Descriptive Statistics: log(Total Ph, Twater, pH, Trans, Depth, Tur, Con, DO, TDS

Variable	N	Mean	Median	TrMean	StDev	SE Mean
log(Tota	40	7.7122	7.8380	7.7636	0.5286	0.0836
Twater	40	27.795	27.350	27.744	1.980	0.313
pH	40	8.4410	8.5100	8.4492	0.4495	0.0711
Trans	40	100.34	99.00	99.44	49.31	7.80
Depth	40	5.887	3.950	5.372	5.938	0.939
Tur	40	6.51	3.50	5.24	8.26	1.31
Con	40	273.16	267.80	271.01	52.16	8.25
DO	40	8.054	8.240	8.056	1.481	0.234
TDS	40	182.43	168.50	180.17	52.78	8.35
SS	40	11.59	7.55	8.89	15.94	2.52
Hard	40	127.78	118.00	126.44	24.27	3.84
Alk	40	121.05	120.00	120.06	28.50	4.51
Nitrate	40	0.1786	0.1480	0.1772	0.0894	0.0141
Org-N	40	0.3337	0.3000	0.3242	0.1816	0.0287
Total-N	40	1.261	0.800	1.198	1.098	0.174
Total-P	40	0.02717	0.02200	0.02481	0.02275	0.00360
BOD	40	3.055	2.700	2.975	1.761	0.278
Ca	40	18.652	20.300	18.805	5.562	0.879
Mg	40	4.710	4.560	4.496	2.847	0.450
Na	40	16.10	13.41	12.59	19.86	3.14
K	40	1.655	1.827	1.634	0.783	0.124
Chlo-A	40	12.687	12.400	12.609	5.974	0.945

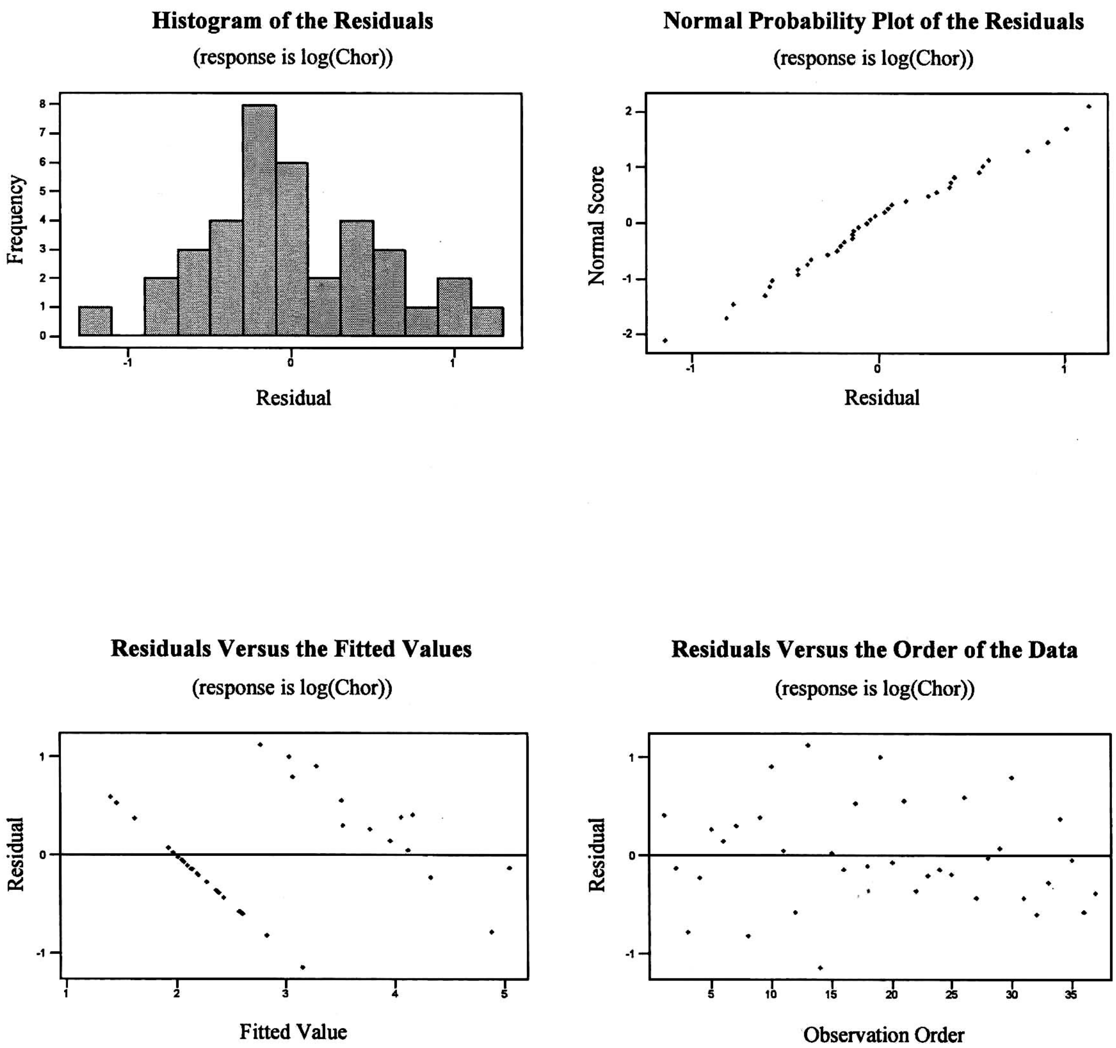

Figure 20. The fittest model results of phylum Chordata from MINITAB program.

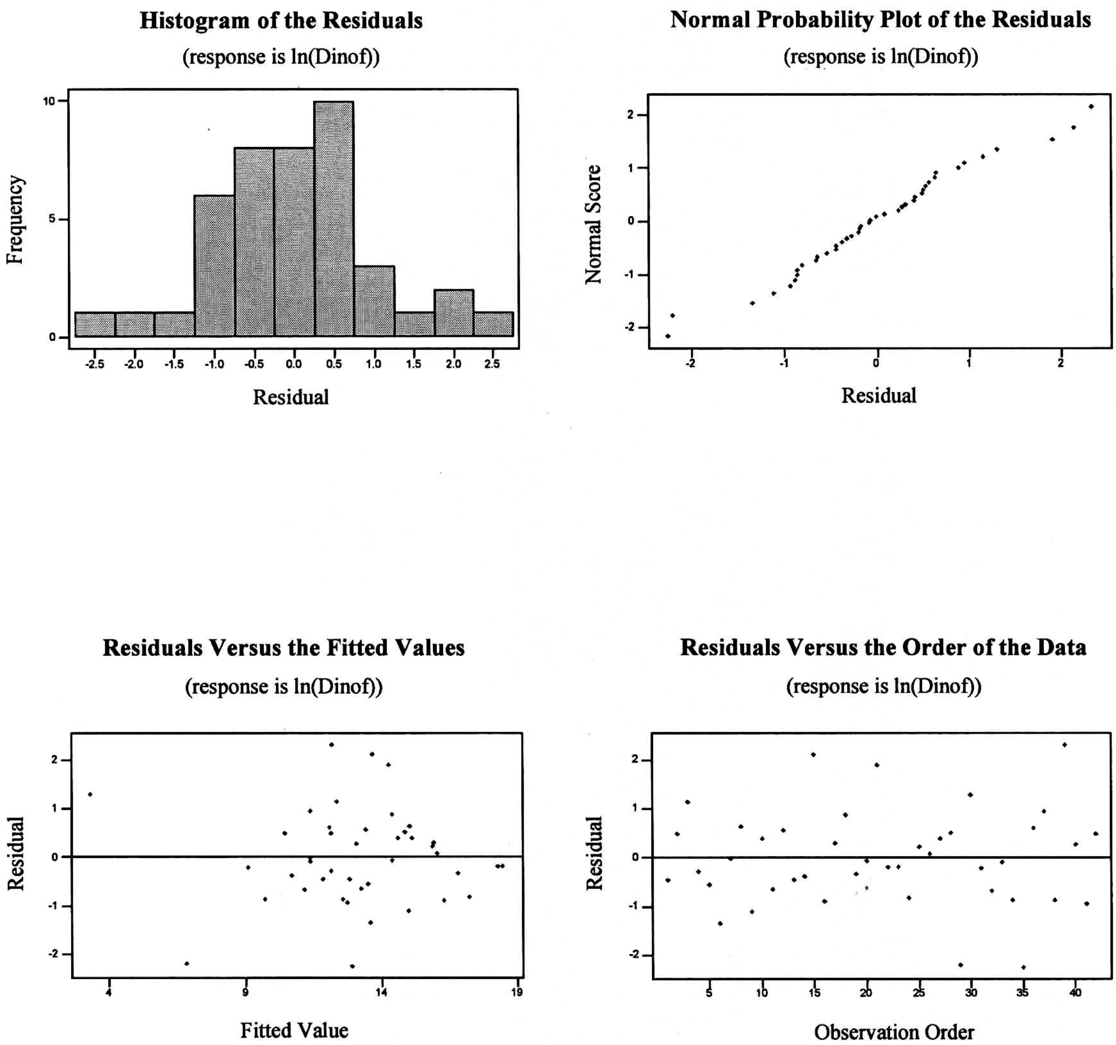

Figure 15. The fittest model results of phylum Pyrrophyta from MINITAB program.

Variable	Minimum	Maximum	Q1	Q3
log(Tota	5.3953	8.3335	7.4935	8.0032
Twater	25.000	31.800	26.000	28.950
pH	7.2500	9.4000	8.1175	8.7950
Trans	10.00	220.00	67.00	140.00
Depth	0.800	20.500	2.000	5.950
Tur	0.90	46.30	2.45	6.70
Con	192.00	401.00	242.15	309.00
DO	4.000	11.600	7.025	8.938
TDS	110.00	312.00	137.00	217.00
SS	1.70	87.80	4.28	9.85
Hard	90.00	200.00	113.25	137.50
Alk	74.00	195.00	98.50	139.25
Nitrate	0.0300	0.4060	0.1235	0.2775
Org-N	0.1000	0.8000	0.2000	0.4875
Total-N	0.100	3.600	0.400	1.900
Total-P	0.00200	0.10200	0.01500	0.03225
BOD	0.100	7.200	1.850	3.800
Ca	5.380	30.230	14.343	21.648
Mg	0.580	17.360	2.913	6.088
Na	2.54	128.50	9.96	14.63
K	0.180	4.600	1.273	2.050
Chlo-A	1.710	24.640	7.903	17.110

Stepwise Regression: log(Total Phytoplankton) versus Twater, pH, ...

Alpha-to-Enter: 0.15 Alpha-to-Remove: 0.15

Response is log(Tota on 21 predictors, with N = 40

Step	1	2	3	4	5	6	7
Constant	7.959	6.603	6.351	7.387	7.519	7.760	7.757
SS	-0.0213	-0.0182	-0.0182	-0.0155	-0.0128	-0.0125	-0.0111
T-Value	-5.17	-5.42	-5.86	-5.65	-4.83	-4.79	-5.01
P-Value	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Con		0.00484	0.00490	0.00216	0.00084		
T-Value		4.70	5.17	1.99	0.78		
P-Value		0.000	0.000	0.054	0.443		
BOD			0.076	0.133	0.134	0.140	0.156
T-Value			2.76	4.78	5.29	5.86	7.60
P-Value			0.009	0.000	0.000	0.000	0.000
Nitrate				-2.75	-3.19	-3.54	-4.58
T-Value				-3.81	-4.73	-7.23	-9.37
P-Value				0.001	0.000	0.000	0.000
K					0.164	0.182	0.683
T-Value					2.86	3.54	5.09
P-Value					0.007	0.001	0.000
Mg							-0.149
T-Value							-3.94
P-Value							0.000
S	0.410	0.329	0.303	0.258	0.235	0.234	0.197
R-Sq	41.33	63.24	69.68	78.57	82.74	82.43	87.94
R-Sq(adj)	39.79	61.26	67.15	76.12	80.20	80.43	86.16
C-p	137.2	74.5	57.5	33.2	23.0	21.9	7.6

Step	8	9	10	11	12
Constant	6.435	5.873	5.786	5.425	5.668
SS	-0.0105	-0.0097	-0.0090	-0.0087	-0.0082
T-Value	-4.93	-4.58	-4.37	-4.22	-4.06
P-Value	0.000	0.000	0.000	0.000	0.000
Con					
T-Value					
P-Value					
BOD	0.150	0.148	0.147	0.142	0.125
T-Value	7.60	7.72	8.04	7.81	6.26
P-Value	0.000	0.000	0.000	0.000	0.000
Nitrate	-4.42	-4.33	-4.25	-3.95	-3.69
T-Value	-9.42	-9.39	-9.66	-10.21	-9.26
P-Value	0.000	0.000	0.000	0.000	0.000
K	0.673	0.611	0.544	0.388	0.391
T-Value	5.27	4.71	4.27	6.42	6.70
P-Value	0.000	0.000	0.000	0.000	0.000
Mg	-0.139	-0.089	-0.063		
T-Value	-3.82	-1.93	-1.38		
P-Value	0.001	0.062	0.176		
pH	0.151	0.209	0.211	0.247	0.228
T-Value	2.14	2.73	2.89	3.59	3.38
P-Value	0.040	0.010	0.007	0.001	0.002
Na		-0.0052	-0.0062	-0.0089	-0.0085
T-Value		-1.70	-2.11	-3.93	-3.92
P-Value		0.099	0.043	0.000	0.000
Depth			0.0103	0.0122	0.0104
T-Value			2.07	2.51	2.18
P-Value			0.047	0.017	0.037
Total-P					-2.7
T-Value					-1.83
P-Value					0.077
S	0.187	0.182	0.173	0.176	0.170
R-Sq	89.41	90.28	91.46	90.94	91.82
R-Sq(adj)	87.48	88.16	89.26	88.95	89.71
C-p	5.3	4.7	3.2	2.8	2.2

Regression Analysis: log(Total Phytoplankton) versus SS, BOD, Nitrate, K

The regression equation is

log(Total Phytoplankton) = 7.76 - 0.0125 SS + 0.140 BOD - 3.54 Nitrate
+ 0.182 K

Predictor	Coef	SE Coef	T	P	VIF
Constant	7.7595	0.1305	59.48	0.000	
SS	-0.012478	0.002603	-4.79	0.000	1.2
BOD	0.14018	0.02392	5.86	0.000	1.3
Nitrate	-3.5417	0.4898	-7.23	0.000	1.4
K	0.18222	0.05146	3.54	0.001	1.2

S = 0.2339   R-Sq = 82.4%   R-Sq(adj) = 80.4%

```
Analysis of Variance

Source            DF          SS          MS         F        P

Regression         4      8.9831      2.2458     41.06    0.000
Residual Error    35      1.9144      0.0547
Total             39     10.8975

Source       DF      Seq SS

SS            1      4.5043
BOD           1      0.6366
Nitrate       1      3.1562
K             1      0.6860

Unusual Observations

Obs         SS   log(Tota         Fit      SE Fit    Residual    St Resid
 17        7.8     8.1759      7.7172      0.0610      0.4587       2.03R
 20        5.4     8.2973      8.7584      0.1538     -0.4610      -2.62RX
 28       87.8     5.3953      5.7792      0.1890     -0.3839      -2.79RX

R denotes an observation with a large standardized residual

X denotes an observation whose X value gives it large influence.


Durbin-Watson statistic = 1.96
```

Residual Histogram for log(Tota

Normplot of Residuals for log(Tota

Residuals vs Fits for log(Tota

Residuals vs Order for log(Tota

12) Total zooplankton

Based on fittest model analysis on 109 sets of water quality and plankton data, it was found that there were 42 data sets for analysis of relationship between water quality and abundance of plankton in total zooplankton (Table 12E in Appendix E). The fittest model results from MINITAB program are detailed below (Figure 22):

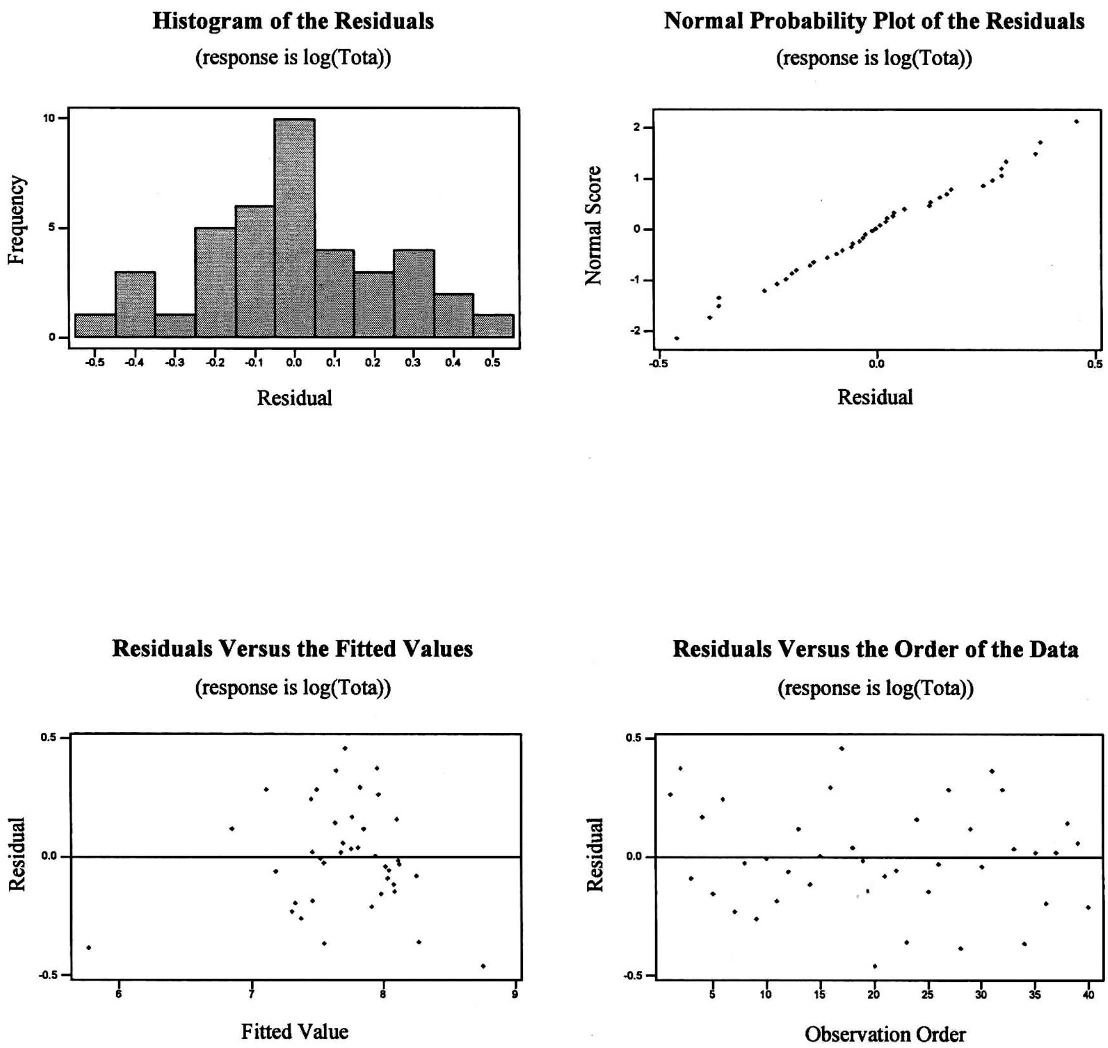

Figure 21. The fittest model results of total phytoplankton from MINITAB program.

Results for: P2TotalZoo.MTW

Descriptive Statistics: log(Total Zo, Twater, pH, Trans, Depth, Tur, Con, DO, TDS

```
Variable            N       Mean     Median     TrMean      StDev    SE Mean

log(Tota           42     5.9646     5.9263     5.9783     0.4551     0.0702
Twater             42     27.798     27.400     27.750      1.932      0.298
pH                 42     8.4419     8.5100     8.4497     0.4390     0.0677
Trans              42     100.80      99.00     100.00      49.93       7.70
Depth              42      5.769      3.800      5.268      5.816      0.897
Tur                42       6.71       3.50       5.54       8.31       1.28
Con                42     272.72     267.80     270.64      51.10       7.89
DO                 42      8.068      8.240      8.072      1.452      0.224
TDS                42     182.00     168.50     179.82      52.14       8.05
SS                 42      11.65       7.55       9.11      15.71       2.42
Hard               42     127.10     117.50     125.76      23.88       3.68
Alk                42     121.12     120.00     120.18      27.80       4.29
Nitrate            42     0.1835     0.1485     0.1826     0.0898     0.0139
Org-N              42     0.3298     0.3000     0.3203     0.1783     0.0275
Total-N            42      1.205      0.800      1.140      1.100      0.170
Total-P            42    0.02633    0.02100    0.02400    0.02251    0.00347
BOD                42      3.217      2.750      3.158      1.867      0.288
Ca                 42     18.709     20.300     18.860      5.443      0.840
Mg                 42      4.686      4.560      4.481      2.781      0.429
Na                 42      15.89      13.41      12.54      19.41       2.99
K                  42      1.658      1.827      1.638      0.764      0.118
Chlo-A             42     12.812     12.540     12.752      5.862      0.905

Variable      Minimum    Maximum         Q1         Q3

log(Tota       4.1523     6.8555     5.6969     6.1907
Twater         25.000     31.800     26.000     28.850
pH             7.2500     9.4000     8.1525     8.7850
Trans           10.00     220.00      65.25     140.00
Depth           0.800     20.500      2.000      5.850
Tur              0.90      46.30       2.53       7.00
Con            192.00     401.00     242.45     309.00
DO              4.000     11.600      7.075      8.993
TDS            110.00     312.00     136.75     217.00
SS               1.70      87.80       4.15      10.15
Hard            90.00     200.00     112.75     134.50
Alk             74.00     195.00      99.50     135.75
Nitrate        0.0300     0.4060     0.1245     0.2800
Org-N          0.1000     0.8000     0.2000     0.4625
Total-N         0.100      3.600      0.400      1.900
Total-P       0.00200    0.10200    0.01375    0.03075
BOD             0.100      7.200      1.950      4.000
Ca              5.380     30.230     14.388     21.603
Mg              0.580     17.360      2.938      6.042
Na               2.54     128.50       9.73      14.58
K               0.180      4.600      1.278      2.030
Chlo-A          1.710     24.640      8.308     17.110
```

Stepwise Regression: log(Total Zooplankton) versus Twater, pH, ...

```
  Alpha-to-Enter: 0.15  Alpha-to-Remove: 0.15

 Response is log(Tota on 21 predictors, with N =   42

    Step          1         2         3         4         5         6

Constant      6.163     5.784     5.211     4.135     4.287     5.155

SS          -0.0170   -0.0171   -0.0158   -0.0115   -0.0091   -0.0134
T-Value       -4.59     -5.69     -5.39     -3.60     -2.62     -3.46
P-Value       0.000     0.000     0.000     0.001     0.013     0.001


BOD                     0.118     0.120     0.086     0.073     0.063
T-Value                  4.68      4.99      3.32      2.76      2.46
P-Value                 0.000     0.000     0.002     0.009     0.019
```

Con			0.00202	0.00313	0.00300	0.00222
T-Value			2.25	3.33	3.24	2.32
P-Value			0.031	0.002	0.003	0.026
DO				0.103	0.101	0.068
T-Value				2.60	2.62	1.71
P-Value				0.013	0.013	0.096
Total-N					-0.074	-0.121
T-Value					-1.61	-2.47
P-Value					0.117	0.019
Trans						-0.0025
T-Value						-2.14
P-Value						0.040
S	0.373	0.302	0.288	0.268	0.262	0.250
R-Sq	34.54	58.05	62.97	68.70	70.80	74.16
R-Sq(adj)	32.90	55.90	60.04	65.32	66.74	69.73
C-p	67.2	31.4	25.5	18.3	16.9	13.5

Regression Analysis: log(Total Zooplankton) versus SS, BOD, ...

The regression equation is

log(Total Zooplankton) = 5.15 - 0.0134 SS + 0.0635 BOD + 0.00222 Con
+ 0.0684 DO - 0.121 Total-N - 0.00247 Trans

Predictor	Coef	SE Coef	T	P	VIF
Constant	5.1550	0.6150	8.38	0.000	
SS	-0.013371	0.003865	-3.46	0.001	2.4
BOD	0.06349	0.02582	2.46	0.019	1.5
Con	0.0022157	0.0009552	2.32	0.026	1.6
DO	0.06844	0.04004	1.71	0.096	2.2
Total-N	-0.12099	0.04905	-2.47	0.019	1.9
Trans	-0.002474	0.001158	-2.14	0.040	2.2

S = 0.2504 R-Sq = 74.2% R-Sq(adj) = 69.7%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	6	6.2967	1.0494	16.74	0.000
Residual Error	35	2.1936	0.0627		
Total	41	8.4903			

Source	DF	Seq SS
SS	1	2.9325
BOD	1	1.9963
Con	1	0.4172
DO	1	0.4872
Total-N	1	0.1777
Trans	1	0.2859

Unusual Observations

Obs	SS	log(Tota	Fit	SE Fit	Residual	St Resid
30	87.8	4.1523	4.6030	0.2016	-0.4508	-3.04RX

R denotes an observation with a large standardized residual

X denotes an observation whose X value gives it large influence.

Durbin-Watson statistic = 1.89

Residual Histogram for log(Tota

Normplot of Residuals for log(Tota

Residuals vs Fits for log(Tota

Residuals vs Order for log(Tota

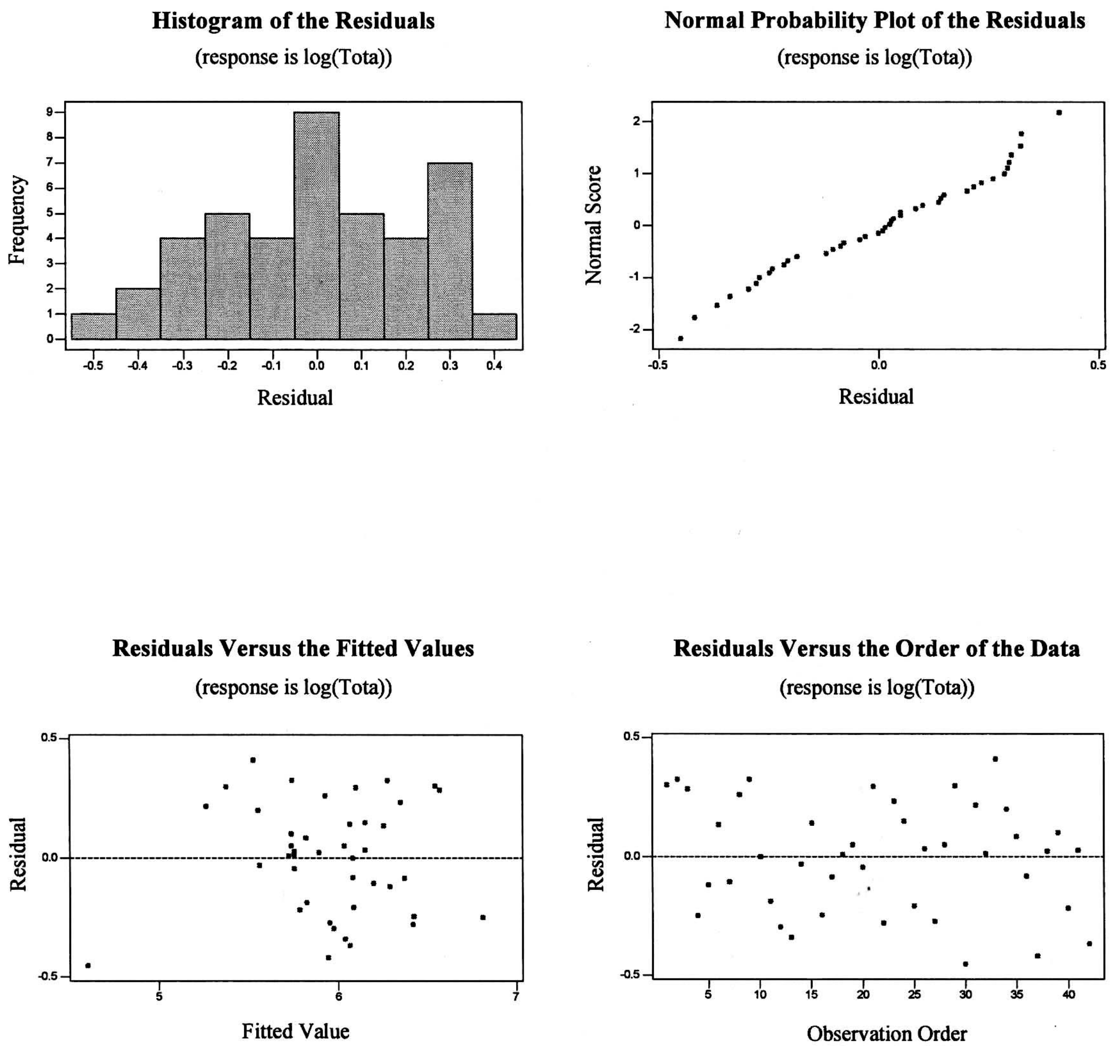

Figure 22. The fittest model results of total zooplankton from MINITAB program.

13) Grand total plankton

Based on fittest model analysis on 109 sets of water quality and plankton data, it was found that there were 42 data sets for analysis of relationship between water quality and abundance of plankton in grand total plankton (Table 13E in Appendix E). The fittest model results from MINITAB program are detailed below (Figure 23):

Results for: P2GrandTotal.MTW

Descriptive Statistics: log(Grand To, Twater, pH, Trans, Depth, Tur, Con, DO, TDS

Variable	N	Mean	Median	TrMean	StDev	SE Mean
log(Gran	42	7.7255	7.8436	7.7741	0.5207	0.0803
Twater	42	27.798	27.400	27.750	1.932	0.298
pH	42	8.4419	8.5100	8.4497	0.4390	0.0677
Trans	42	100.80	99.00	100.00	49.93	7.70
Depth	42	5.769	3.800	5.268	5.816	0.897
Tur	42	6.71	3.50	5.54	8.31	1.28
Con	42	272.72	267.80	270.64	51.10	7.89
DO	42	8.068	8.240	8.072	1.452	0.224
TDS	42	182.00	168.50	179.82	52.14	8.05
SS	42	11.65	7.55	9.11	15.71	2.42
Hard	42	127.10	117.50	125.76	23.88	3.68
Alk	42	121.12	120.00	120.18	27.80	4.29
Nitrate	42	0.1835	0.1485	0.1826	0.0898	0.0139
Org-N	42	0.3298	0.3000	0.3203	0.1783	0.0275
Total-N	42	1.205	0.800	1.140	1.100	0.170
Total-P	42	0.02633	0.02100	0.02400	0.02251	0.00347
BOD	42	3.217	2.750	3.158	1.867	0.288
Ca	42	18.709	20.300	18.860	5.443	0.840
Mg	42	4.686	4.560	4.481	2.781	0.429
Na	42	15.89	13.41	12.54	19.41	2.99
K	42	1.658	1.827	1.638	0.764	0.118
Chlo-A	42	12.812	12.540	12.752	5.862	0.905

Variable	Minimum	Maximum	Q1	Q3
log(Gran	5.4195	8.3477	7.4743	8.0335
Twater	25.000	31.800	26.000	28.850
pH	7.2500	9.4000	8.1525	8.7850
Trans	10.00	220.00	65.25	140.00
Depth	0.800	20.500	2.000	5.850
Tur	0.90	46.30	2.53	7.00
Con	192.00	401.00	242.45	309.00
DO	4.000	11.600	7.075	8.993
TDS	110.00	312.00	136.75	217.00
SS	1.70	87.80	4.15	10.15
Hard	90.00	200.00	112.75	134.50
Alk	74.00	195.00	99.50	135.75
Nitrate	0.0300	0.4060	0.1245	0.2800
Org-N	0.1000	0.8000	0.2000	0.4625
Total-N	0.100	3.600	0.400	1.900
Total-P	0.00200	0.10200	0.01375	0.03075
BOD	0.100	7.200	1.950	4.000
Ca	5.380	30.230	14.388	21.603
Mg	0.580	17.360	2.938	6.042
Na	2.54	128.50	9.73	14.58
K	0.180	4.600	1.278	2.030
Chlo-A	1.710	24.640	8.308	17.110

Stepwise Regression: log(Grand Total) versus Twater, pH, ...

Alpha-to-Enter: 0.15 Alpha-to-Remove: 0.15

Response is log(Gran on 21 predictors, with N =   42

Step	1	2	3	4	5	6	7
Constant	7.958	6.678	5.233	5.769	6.011	6.751	7.746
SS	-0.0199	-0.0169	-0.0117	-0.0114	-0.0101	-0.0081	-0.0097
T-Value	-4.75	-4.65	-3.13	-3.16	-2.84	-2.30	-3.03
P-Value	0.000	0.000	0.003	0.003	0.007	0.028	0.005
Con		0.0046	0.0060	0.0052	0.0042	0.0023	0.0002
T-Value		4.09	5.33	4.60	3.36	1.59	0.13
P-Value		0.000	0.000	0.000	0.002	0.120	0.895
DO			0.124	0.097	0.076	0.073	0.007
T-Value			2.99	2.30	1.79	1.81	0.17
P-Value			0.005	0.027	0.082	0.080	0.863
Total-P				-4.8	-5.8	-6.5	-4.4
T-Value				-1.96	-2.40	-2.79	-1.99
P-Value				0.057	0.022	0.009	0.055
K					0.135	0.180	0.196
T-Value					1.79	2.43	2.93
P-Value					0.081	0.020	0.006
Nitrate						-1.52	-3.11
T-Value						-2.25	-3.86
P-Value						0.031	0.000
BOD							0.106
T-Value							3.02
P-Value							0.005
S	0.422	0.357	0.325	0.314	0.305	0.289	0.260
R-Sq	36.06	55.28	63.81	67.22	69.91	73.72	79.27
R-Sq(adj)	34.46	52.99	60.95	63.68	65.73	69.21	75.01
C-p	86.7	51.2	36.6	31.9	28.7	23.2	14.4

Step	8	9	10	11	12	13	14
Constant	7.827	7.858	7.826	7.769	6.290	5.637	5.205
SS	-0.0097	-0.0099	-0.0092	-0.0099	-0.0092	-0.0083	-0.0083
T-Value	-3.09	-3.46	-3.46	-3.71	-3.58	-3.24	-3.18
P-Value	0.004	0.001	0.001	0.001	0.001	0.003	0.003
Con							
T-Value							
P-Value							
DO	0.004						
T-Value	0.12						
P-Value	0.905						
Total-P	-4.4	-4.4	-2.8				
T-Value	-2.07	-2.11	-1.37				
P-Value	0.046	0.042	0.180				
K	0.200	0.200	0.606	0.660	0.650	0.577	0.396
T-Value	3.49	3.54	3.68	4.08	4.17	3.63	5.11
P-Value	0.001	0.001	0.001	0.000	0.000	0.001	0.000
Nitrate	-3.18	-3.17	-4.18	-4.57	-4.40	-4.28	-3.91
T-Value	-5.57	-5.66	-6.45	-7.75	-7.66	-7.56	-7.91
P-Value	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BOD	0.108	0.109	0.131	0.152	0.146	0.144	0.138
T-Value	3.55	3.85	4.75	6.49	6.40	6.44	6.25
P-Value	0.001	0.000	0.000	0.000	0.000	0.000	0.000

Mg			-0.124	-0.143	-0.132	-0.073	
T-Value			-2.60	-3.13	-2.97	-1.30	
P-Value			0.013	0.003	0.005	0.203	
pH					0.169	0.236	0.282
T-Value					1.96	2.52	3.21
P-Value					0.058	0.017	0.003
Na						-0.0060	-0.0091
T-Value						-1.62	-3.16
P-Value						0.114	0.003
S	0.257	0.253	0.235	0.238	0.229	0.224	0.226
R-Sq	79.26	79.25	82.62	81.69	83.50	84.69	83.93
R-Sq(adj)	75.71	76.37	79.64	79.15	80.67	81.53	81.17
C-p	12.4	10.4	5.9	5.7	4.2	3.9	3.3

Step	15	16	17
Constant	5.280	5.493	5.750
SS	-0.0074	-0.0098	-0.0093
T-Value	-2.95	-3.38	-3.25
P-Value	0.006	0.002	0.003
Con			
T-Value			
P-Value			
DO			
T-Value			
P-Value			
Total-P			-2.8
T-Value			-1.53
P-Value			0.135
K	0.393	0.424	0.427
T-Value	5.29	5.62	5.77
P-Value	0.000	0.000	0.000
Nitrate	-3.98	-3.74	-3.47
T-Value	-8.37	-7.63	-6.81
P-Value	0.000	0.000	0.000
BOD	0.141	0.128	0.109
T-Value	6.63	5.67	4.32
P-Value	0.000	0.000	0.000
Mg			
T-Value			
P-Value			
pH	0.264	0.253	0.232
T-Value	3.12	3.04	2.81
P-Value	0.004	0.005	0.008
Na	-0.0091	-0.0097	-0.0094
T-Value	-3.29	-3.54	-3.48
P-Value	0.002	0.001	0.001
Depth	0.0121	0.0141	0.0124
T-Value	2.03	2.36	2.08
P-Value	0.051	0.024	0.046
Trans		-0.00145	-0.00147
T-Value		-1.56	-1.61
P-Value		0.129	0.117
S	0.217	0.212	0.208
R-Sq	85.66	86.64	87.56
R-Sq(adj)	82.71	83.40	84.06
C-p	2.0	2.0	2.3

Regression Analysis: log(Grand To versus SS, Total-P, K, Nitrate, BOD

```
The regression equation is

log(Grand Total) = 7.86 - 0.00989 SS - 4.44 Total-P + 0.200 K - 3.17 Nitrate
           + 0.109 BOD

Predictor        Coef     SE Coef          T        P       VIF
Constant       7.8576      0.1461      53.78    0.000
SS          -0.009886    0.002858      -3.46    0.001       1.3
Total-P        -4.443       2.108      -2.11    0.042       1.4
K             0.19991     0.05649       3.54    0.001       1.2
Nitrate       -3.1746      0.5610      -5.66    0.000       1.6
BOD           0.10916     0.02836       3.85    0.000       1.8

S = 0.2531      R-Sq = 79.3%     R-Sq(adj) = 76.4%

Analysis of Variance

Source            DF          SS          MS         F        P
Regression         5      8.8096      1.7619     27.51    0.000
Residual Error    36      2.3060      0.0641
Total             41     11.1156

Source       DF      Seq SS

SS            1      4.0079
Total-P       1      1.3786
K             1      1.3366
Nitrate       1      1.1373
BOD           1      0.9493

Unusual Observations

Obs         SS   log(Gran         Fit      SE Fit    Residual    St Resid

  2       23.0     8.2426      7.7085      0.0844      0.5341        2.24R
  6        3.0     7.3510      7.9784      0.0850     -0.6274       -2.63R
 22        5.4     8.3003      8.7483      0.1662     -0.4480       -2.35RX
 30       87.8     5.4195      5.7959      0.2062     -0.3765       -2.57RX

R denotes an observation with a large standardized residual

X denotes an observation whose X value gives it large influence.

Durbin-Watson statistic = 1.68
```

Residual Histogram for log(Gran

Normplot of Residuals for log(Gran

Residuals vs Fits for log(Gran

Residuals vs Order for log(Gran

Nevertheless, phylum Annelida (segmented worms), phylum Nematoda, phylum Mollusca (mollusks) and phylum Coelenterata (cnidaria) cannot be analyzed for regression because data on abundance of plankton in each phylum (Appendix C) analyzed are mostly zero values.

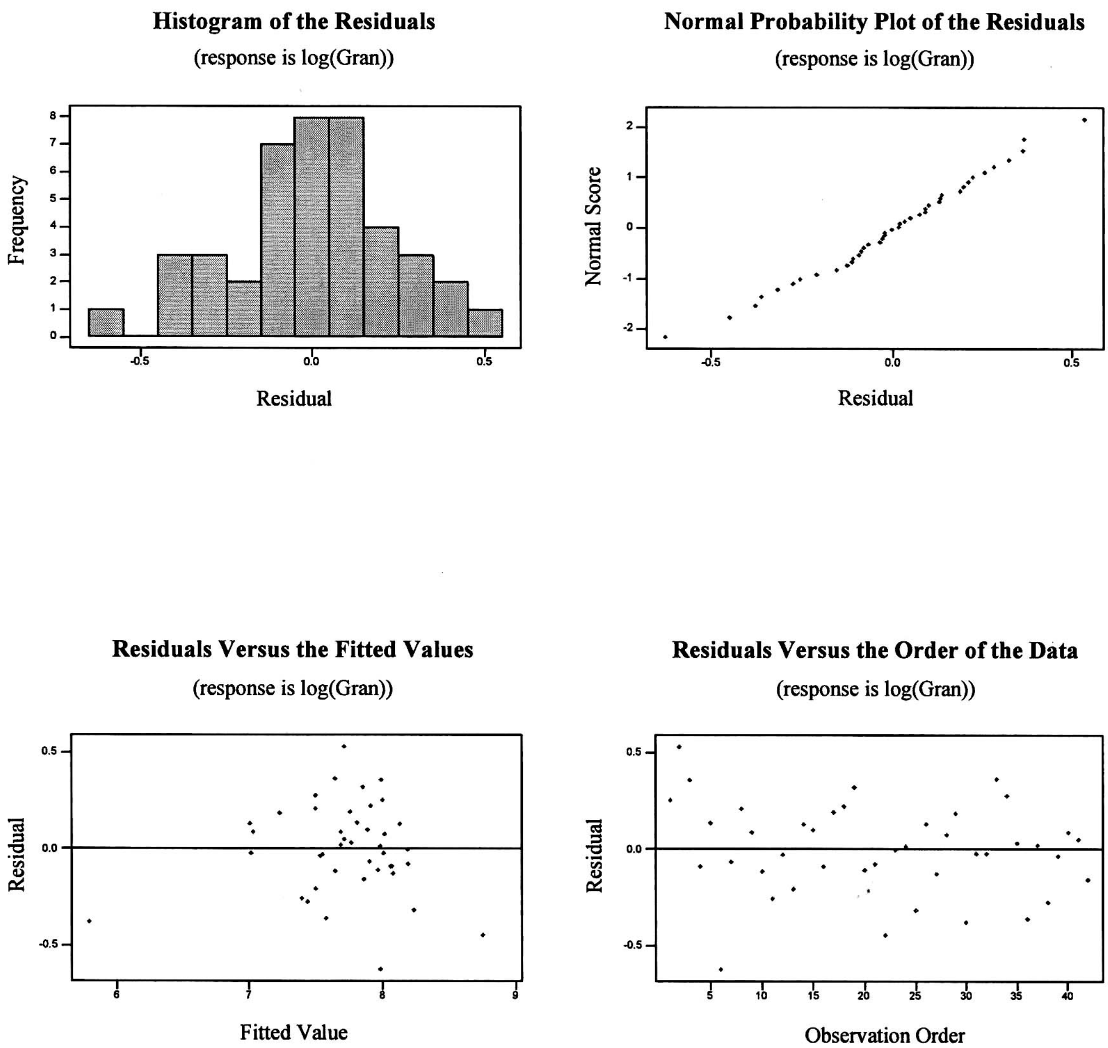

Figure 23. The fittest model results of grand total plankton from MINITAB program.

4.4.2 Summary of Fittest Model Analysis Results

The fittest model analysis between 29 water quality parameters and abundance of plankton in 14 phyla including total phytoplankton, total zooplankton and grand total plankton are studied by MINITAB program. The summary results are 13 fittest models as follows:

1) Phylum Cyanophyta

log (abundance of plankton in phylum Cyanophyta) = 3.24 - 0.0261 SS + 0.00545 Conductivity + 0.329 pH + 0.0657 BOD; R^2 = 0.84

2) Phylum Chlorophyta

log (abundance of plankton in phylum Chlorophyta) = 5.15 + 0.221 BOD + 0.0309 SS + 0.0294 Chlorophyll a; R^2 = 0.65

3) Phylum Bacillariophyta

Abundance of plankton in phylum Bacillariophyta = 1430806 + 4962488 Mg -59688206 Nitrate + 100235 Transparency + 335173 SS - 323408 Na - 1.71E+08 Total phosphate - 1513485 BOD; R^2 = 0.84

4) Phylum Chrysophyta

log (abundance of plankton in phylum Chrysophyta+100) = -1.35 + 0.0875 Chlorophyll a + 0.0173 TDS + 0.00978 Conductivity - 0.117 BOD; R^2 = 0.71

5) Phylum Pyrrophyta

ln (abundance of plankton in phylum Pyrrophyta+100) = -3.18 - 0.155 SS + 0.310 Water temperature + 0.0243 TDS; R^2 = 0.90

6) Phylum Euglenophyta

log (abundance of plankton in phylum Euglenophyta+100) = -17.6 + 0.0751 Total hardness + 0.530 Water temperature - 0.124 Ca - 0.139 BOD; R^2 = 0.81

7) Phylum Protozoa

Abundance of plankton in phylum Protozoa = -920194 - 1413 Transparency - 241000 Organic nitrogen + 1754 Alkalinity + 57484 DO + 1895 Conductivity + 585738 Nitrate; R^2 = 0.75

8) Phylum Rotifera

ln (abundance of plankton in phylum Rotifera) = 11.0 - 0.444 Total nitrogen + 0.217 BOD + 0.0732 Water temperature; R^2 = 0.66

9) Phylum Arthropoda

ln (abundance of plankton in phylum Arthropoda) = 8.38 + 0.215 BOD - 0.0378 SS - 0.00834 Transparency - 0.0367 Depth of water + 0.613 pH - 0.216 Total nitrogen; R^2 = 0.71

10) Phylum Chordata

log (abundance of plankton in phylum Chordata+100) = 4.43 + 0.244 BOD + 0.0756 Chlorophyll a - 0.169 Water temperature + 0.189 DO - 0.00790 Na; R^2 = 0.76

11) Total phytoplankton

log (abundance of total phytoplankton) = 7.76 - 0.0125 SS + 0.140 BOD - 3.54 Nitrate + 0.182 K; R^2 = 0.82

12) Total zooplankton

log (abundance of total zooplankton) = 5.15 - 0.0134 SS + 0.0635 BOD + 0.00222 Conductivity + 0.0684 DO - 0.121 Total nitrogen - 0.00247 Transparency; R^2 = 0.74

13) Grand total plankton

log (abundance of grand total plankton) = 7.86 - 0.00989 SS - 4.44 Total phosphate + 0.200 K - 3.17 Nitrate + 0.109 BOD; R^2 = 0.79

4.5 Field Survey Study

The 13 fittest model results from fittest model analysis have been compared with result from field survey on water quality and plankton composition in Lam Ta Khong reservoir, Nakhon Ratchasima province.

4.5.1 Field survey results

The investigation on surface water quality and plankton organisms in Lam Ta Khong reservoir were undertaken on October 27, 2003 at 4 sampling stations comprising southern part of reservoir, western part of reservoir, northern part of reservoir and eastern part of reservoir (Figure 1). The results can be discussed as follows:

1) Characteristic of Reservoir

Lam Ta Khong reservoir is under the responsibility of the Royal Irrigation Department (RID), Ministry of Agriculture and Cooperatives. It is located in Si Khiu district and Pak Chong district, Nakhon Ratchasima province. The reservoir has capacity of 324 million cubic meters with 23,125 rai (3,700 hectares) of water surface. At the present, Electricity Generating Authority of Thailand (EGAT) uses the reservoir to produce electric energy in Lam Ta Khong Pump Storage Project. This project is located on the east of Lam Ta Khong reservoir and produces totally 1,000 MW of electricity energy. The general condition of sampling stations are presented below:

Station 1: southern part of reservoir, The general condition of the site is idle area that is flooded in rainy season (Figure 24). Ban Pa Pai community is located on the bank of the reservoir. Water depth at this station is 3.2 meters.

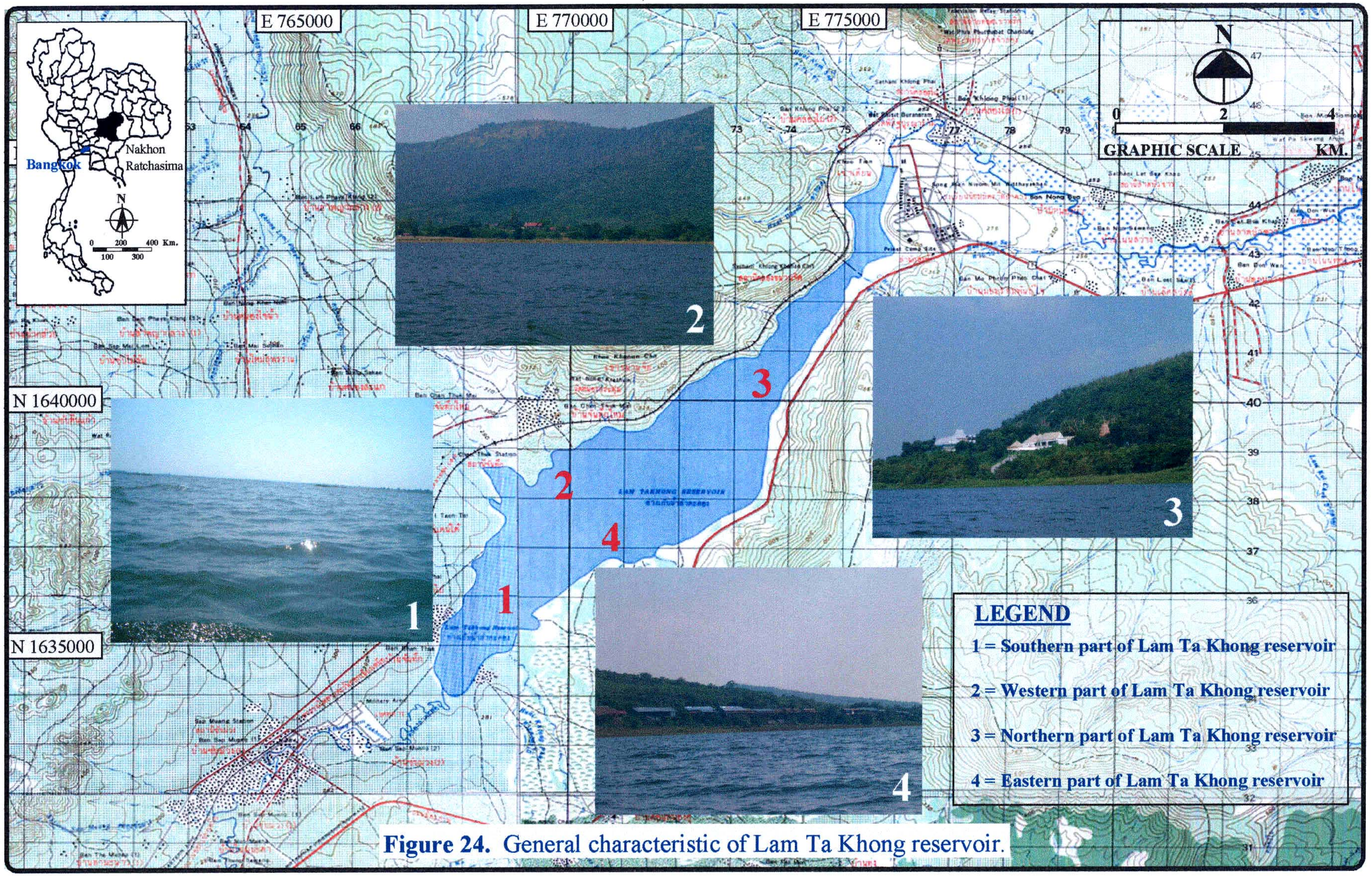

Figure 24. General characteristic of Lam Ta Khong reservoir.

Station 2: western part of reservoir, This station is located near northeastern railway from Saraburi province to Nakhon Ratchasima province. The general condition is idle area and forest (Figure 24). The Ban Chan Tuk Mai is community nearby this station. Water depth at this station is 5.7 meters.

Station 3: northern part of reservoir, On the bank of reservoir close to Mitraphab road. There is rest area of Mitraphab road on the way from Saraburi province to Nakhon Ratchasima province (Figure 24). There are some restaurants along the reservoir bank. Water depth at this station is 16.6 meters.

Station 4: eastern part of reservoir, The general condition of the site is community with many restaurants near Ban Pa Mun along the reservoir bank (Figure 24). Water depth at this station is 6.45 meters.

2) Surface Water Quality Results

The result of water quality field survey and analysis of 4 stations are presented in Table 9. The result of water quality analysis can be summarized as follows:

Station 1: southern part of reservoir. Water temperature was 28.0 degree Celsius. Transparency was 63 centimeters, pH was 8.9 and dissolved oxygen (DO) was 7.70 mg/liter. When, there was consider on BOD value. It was found that BOD was high (about 5.65 mg/liter) because this area is idle land covered with grasses and shrub in summer season and is flooded in rainy season. The grasses and shrub decompose and remain under water. It results high organic matter in the water and bacteria must use high oxygen to degrade high organic matters. Then, the result of water quality shows high BOD (Table 9).

Table 9. Water quality analysis result of Lam Ta Khong reservoir on October 27, 2003.

No.	Parameter	Unit	Water quality sampling station			
			1	2	3	4
1	Air temperature	degree Celsius	32.6	35.6	33.5	39.0
2	Water temperature	degree Celsius	28.0	26.0	27.4	27.4
3	pH	-	8.9	8.7	8.6	8.8
4	Transparency	centimeter	63	93	92	67
5	Depth of water	meter	3.20	5.70	16.60	6.45
6	Turbidity	mg/l	5.45	5.01	5.24	6.24
7	Conductivity	microhos/cm	250	247	254	256
8	Dissolved oxygen	mg/l	7.70	6.87	7.07	10.47
9	Total solid	mg/l	162	154	152	188
10	Total dissolved solid	mg/l	166	116	158	164
11	Suspended solid	mg/l	7.30	5.00	5.00	7.30
12	Total hardness	mg/l as $CaCO_3$	65.68	55.08	53.56	63.50
13	Chloride	mg/l	27.49	19.49	18.24	15.99
14	Acidity	mg/l	0.5	0.5	0.5	0.5
15	Alkalinity	mg/l	133.25	125.48	122.49	130.26
16	Nitrate-nitrogen	mg/l	0.05	0.05	0.06	0.06
17	Nitrite-nitrogen	mg/l	0.05	0.05	0.05	0.05
18	Organic-nitrogen	mg/l	0.08	0.73	0.27	1.50
19	Total nitrogen	mg/l	1.00	0.93	0.40	1.50
20	Ammonia-nitrogen	mg/l	0.20	0.20	0.13	0.07
21	Sulfate	mg/l	9.75	6.75	5.65	7.40
22	Total phosphate	mg/l	0.05	0.03	0.04	0.04
23	Biochemical oxygen demand	mg/l	5.65	1.80	1.88	3.74
24	Chemical oxygen demand	mg/l	44.8	22.4	38.6	36.6
25	Oil & grease	mg/l	0.5	0.4	0.4	0.4
26	Calcium	mg/l	90.04	91.10	82.63	87.92
27	Magnesium	mg/l	24.4	25.4	27.6	24.4
28	Sodium	mg/l	17	12	11	10
29	Potassium	mg/l	4.2	3.7	3.1	2.7
30	Chlorophyll a	mg/m^3 of water	24.1	20.3	22.4	35.3

Notes Station 1 = Southern part of Lam Ta Khong reservoir.
Station 2 = Western part of Lam Ta Khong reservoir.
Station 3 = Northern part of Lam Ta Khong reservoir.
Station 4 = Eastern part of Lam Ta Khong reservoir.

Station 2: western part of reservoir. The water temperature was 26.0 degree Celsius. Transparency was 93 centimeters, pH was 8.7 and dissolved oxygen (DO) was 6.87 mg/liter. BOD value was about 1.80 mg/liter (Table 9). BOD was not high value, it may be due to wastewater from northeastern railway and community nearby the station.

Station 3: northern part of reservoir. The water temperature was 27.4 degree Celsius. Transparency was 92 centimeters, pH was 8.6 and dissolved oxygen (DO) was 7.07 mg/liter. BOD value was about 1.88 mg/liter (Table 9). BOD was not high value, it may be due to wastewater from rest area of Mitraphab road and some restaurants along the Mitraphab road.

Station 4: eastern part of reservoir. The water temperature was 27.4 degree Celsius. Transparency was 67 centimeters, pH was 8.8 and dissolved oxygen (DO) was 10.47 mg/liter. DO value was quite high because the water sample was collected in the afternoon when phytoplankton and aquatic plant released much oxygen from phytosynthesis process into water environment. However, BOD value was about 3.74 mg/liter (Table 9). BOD was quite high value, it may be due to wastewater from community and many restaurants along the Mitraphab road.

3) Plankton Results

The result of the analysis of plankton sampling in 4 stations conducted on October 27, 2003 in Lam Ta Khong reservoir are presented in Table 10 and can be summarized as follows:

Station 1: southern part of reservoir. The result of the analysis of plankton revealed totally 77 species altogether comprising 49 species of phytoplankton and 28 species of zooplankton. Phytoplankton found could be identified into 5 phyla of

Table 10. Abundance and plankton species of Lam Ta Khong reservoir on October 27, 2003.

Phylum/Species	Station 1	Station 2	Station 3	Station 4
Phytoplankton				
Cyanophyta (Blue-green algae)				
Oscillatoria sp.	156,367,250	61,838,000	50,112,000	170,275,000
Microcystis aeroginosa	1,495,650	254,800	384,000	1,470,000
M. incerta	253,500	156,800	96,000	450,800
Chroococcus minutus	16,900	39,200	96,000	254,800
C. dispersus	-	49,000	28,800	196,000
Merismopedia punctata	338,000	539,000	403,200	784,000
M. elegans	50,700	39,200	19,200	-
M. convolutus	16,900	-	19,200	39,200
Spirulina platensis	67,600	58,800	19,200	58,800
Anabaena spiroides	50,700	19,600	9,600	78,400
A. azollae	16,900	-	19,200	-
Anabaenopsis sp.	50,700	-	-	-
Rhaphidiopsis sp.	135,200	88,200	105,600	147,000
Lyngbya contorta	-	9,800	9,600	-
Aphanocapsa sp.	-	98,000	38,400	343,000
Nostoc sp.	-	-	-	19,600
Bacillariophyta (Diatom)				
Synedra acus	4,740,450	10,682,000	7,584,000	24,794,000
S. ulna	84,500	-	57,600	-
Nitzschia acicularis	152,100	813,400	672,000	2,371,600
Strephanodiscus hanzschii	42,250	264,600	28,800	39,200
Surirella elegans	-	-	9,600	-
Chlorophyta (Green algae)				
Ulothrix aqualis	9,041,500	1,156,400	1,555,200	15,386,000
U. variabilis	1,706,900	813,400	1,641,600	7,056,000
U. zonata	236,600	19,600	76,800	117,600
Mougeotia japonica	726,700	58,800	115,200	4,214,000
M. scalaris	16,900	-	-	-
Pediastrum simplex	1,394,250	1,038,800	1,056,000	2,548,000
P. duplex	42,250	-	38,400	-
Staurastrum sp.	304,200	284,200	192,000	686,000
Treubaria crassipes	169,000	19,600	28,800	-
Actinastrum hanzschii	405,600	196,000	249,600	401,800
A. gracillimum	16,900	29,400	38,400	-
Pandorina morum	397,150	19,600	-	-
Pleodorina sp.	16,900	-	-	-
Eudorina elegans	16,900	39,200	-	-
Tetraedron lobatum	33,800	58,800	57,600	58,800
T. trigonum	-	39,200	19,200	-
T. gracile	-	19,600	-	-
Volvox aureus	67,600	-	-	-

Table 10. Abundance and plankton species of Lam Ta Khong reservoir on October 27, 2003. (continued)

Phylum/Species	Station 1	Station 2	Station 3	Station 4
Ankistrodesmus falcatus	25,350	-	19,200	19,600
Crucigenia rectangularis	177,450	39,200	134,400	254,800
Arthrodesmus incus	84,500	117,600	115,200	343,000
Scenedesmus armatus	16,900	19,600	19,200	9,800
S. bijuga	-	29,400	19,200	-
S. dimorphus	-	-	-	19,600
S. arcuatus	-	-	-	39,200
Selenastrum gracile	8,450	-	-	-
Coelastrum microphorum	33,800	333,200	115,200	372,400
C. sphaericum	-	39,200	19,200	88,200
Closteriopsis longissima	42,250	58,800	48,000	58,800
Closterium porrectum	-	49,000	19,200	19,600
C. gracile	-	-	-	19,600
Kirchneriella subsolitaria	-	19,600	19,200	39,200
Sphaerozosma granutatum	-	9,800	-	19,600
Chodatella groescheri	-	19,600	-	19,600
Spirogyra sp.	-	-	28,800	19,600
Chamydomonas angulosa	-	-	-	39,200
Pyrrophyta (Dinoflagellate)				
Peridinium sp.	22,984,000	686,000	96,000	431,200
Ceratium hirundinella	2,070,250	176,400	172,800	1,195,600
Euglenophyta (Euglenoids)				
Euglena caudatus	118,300	-	-	-
E. spirogyra	33,800	-	-	-
E. acus	8,450	-	-	-
E. proxima	-	-	-	9,800
Phacus torta	42,250	-	-	-
P. ranula	8,450	-	9,600	-
P. longicauda	25,350	-	-	-
Trachelomonas oblonga	185,900	98,000	172,800	137,200
T. volvocina	16,900	39,200	19,200	19,600
<u>Zooplankton</u>				
Arthropoda				
*Nauplius	236,600	303,800	134,400	274,400
*Ostracods	8,450	-	-	-
*Copepods	67,600	39,200	48,000	176,400
Moina sp.	8,450	-	9,600	9,800
Rotifera				
Polyarthra vulgaris	414,050	49,000	163,200	1,078,000
Trichocerca capucina	59,150	29,400	57,600	58,800
T. pusilla	16,900	49,000	28,800	19,600
T. similis	8,450	9,800	9,600	254,800
T. weberi	-	58,800	-	19,600
T. elongata	-	-	9,600	98,000

Table 10. Abundance and plankton species of Lam Ta Khong reservoir on October 27, 2003. (continued)

Phylum/Species	Station 1	Station 2	Station 3	Station 4
Brachionus caudatus	101,400	-	-	39,200
B. falcatus	25,350	-	-	-
B. plicatilis	16,900	-	-	58,800
B. quadridentatus	8,450	9,800	-	-
B. bidentatus	-	9,800	-	19,600
B. forficula	-	9,800	-	-
B. diversicornis	-	-	-	78,400
B. angularis	-	-	-	19,600
Keratella cochlearis	202,800	78,400	67,200	352,800
K. valga	228,150	117,600	105,600	343,000
Anuraeopsis fissa	194,350	39,200	48,000	235,200
A. navicula	33,800	-	-	19,600
Filinia terminaris	25,350	-	-	19,600
Mytilina sp.	8,450	-	-	-
Horaella sp.	8,450	-	-	39,200
Hexarthra mira	8,450	9,800	-	19,600
Synchaeta oblonga	8,450	-	-	215,600
Trichotria tetractis	8,450	-	-	-
Pompholyx salcata	8,450	19,600	48,000	39,200
Lecane hamata	-	-	-	9,800
Trochosphaera sp.	-	-	-	39,200
Asplanchna priodonta	-	-	-	19,600
Protozoa				
Difflugia lebes	777,400	107,800	192,000	2,303,000
D. bewae	50,700	-	38,400	137,200
D. urceolata	-	-	-	58,800
Centropyxis ecornis	295,750	-	-	9,800
Tintinnopsis cratera	354,900	695,800	816,000	2,842,000
Tintinnidium sp.	8,450	-	-	19,600
Prorodon sp.	-	-	-	58,800
Total of Phytoplankton	**204,354,800**	**80,477,600**	**65,808,000**	**234,964,800**
Total of Zooplankton	**3,194,100**	**1,636,600**	**1,776,000**	**8,986,600**
Grand Total Plankton	**207,548,900**	**82,114,200**	**67,584,000**	**243,951,400**

Notes * = Unidentified Species
Unit = cell/m^3 of water
Station 1 : Southern part of Lam Ta Khong reservoir.
Station 2 : Western part of Lam Ta Khong reservoir.
Station 3 : Northern part of Lam Ta Khong reservoir.
Station 4 : Eastern part of Lam Ta Khong reservoir.

Cyanophyta (12 species), Bacillariophyta (4 species), Chlorophyta (23 species), Pyrrophyta (2 species), and Euglenophyta (8 species). Zooplankton found could be identified into 3 phyla of Arthropoda (4 species), Rotifera (19 species), and Protozoa (5 species).

The abundance of plankton was totally 207,548,900 cells/m^3 of water comprising 204,354,800 cells of phytoplankton/m^3 of water and 3,194,100 cells of zooplankton/m^3 of water. The dominant species was *Oscillatoria* sp. with abundance equal 156,367,250 cells/m^3 of water in phylum Cyanophyta. The next rank were *Peridinium* sp., *Ulothrix aqualis*, *Synedra acus* and *Ulothrix variabilis* with abundance of 22,984,000 9,041,500 4,740,450 and 1,706,900 cells/m^3 of water respectively. The details are presented in Table 10.

Station 2: western part of reservoir. The result of the analysis of plankton revealed totally 61 species altogether comprising 44 species of phytoplankton and 17 species of zooplankton. Phytoplankton found could be identified into 5 phyla of Cyanophyta (12 species), Bacillariophyta (3 species), Chlorophyta (25 species), Pyrrophyta (2 species), and Euglenophyta (2 species). Zooplankton found could be identified into 3 phyla of Arthropoda (2 species), Rotifera (13 species), and Protozoa (2 species).

The abundance of plankton was totally 82,114,200 cells/m^3 of water comprising 80,477,600 cells of phytoplankton/m^3 of water and 1,636,600 cells of zooplankton/m^3 of water. The dominant species was *Oscillatoria* sp. with abundance of 61,838,000 cells/m^3 of water in phylum Cyanophyta. The next rank were *Synedra acus*, *Ulothrix aqualis* and *Pediastrum* with abundance of 10,682,000 1,156,400 and 1,038,800 cells/m^3 of water respectively. The details are presented in Table 10.

Station 3: northern part of reservoir. The result of the analysis of plankton revealed totally 62 species altogether comprising 47 species of phytoplankton and 15 species of zooplankton. Phytoplankton found could be identified into 5 phyla of Cyanophyta (14 species), Bacillariophyta (5 species), Chlorophyta (23 species), Pyrrophyta (2 species), and Euglenophyta (3 species). Zooplankton found could be identified into 3 phyla of Arthropoda (3 species), Rotifera (9 species), and Protozoa (3 species).

The abundance of plankton was totally 67,584,000 cells/m^3 of water comprising 65,808,000 cells of phytoplankton/m^3 of water and 1,776,000 cells of zooplankton/m^3 of water. The dominant species was *Oscillatoria* sp. with abundance of 50,112,000 cells/m^3 of water in phylum Cyanophyta. The next rank was *Synedra acus*, *Ulothrix variabilis*, *Ulothrix aqualis* and *Pediastrum simplex* with abundance of 7,584,000 1,641,600 1,555,200 and 1,056,000 cells/m^3 of water respectively. The details are presented in Table 10.

Station 4: eastern part of reservoir. The result of the analysis of plankton revealed totally 77 species altogether comprising 44 species of phytoplankton and 33 species of zooplankton. Phytoplankton found could be identified into 5 phyla of Cyanophyta (12 species), Bacillariophyta (3 species), Chlorophyta (24 species), Pyrrophyta (2 species), and Euglenophyta (3 species). Zooplankton found could be identified into 3 phyla of Arthropoda (3 species), Rotifera (23 species), and Protozoa (7 species).

The abundance of plankton was totally 243,951,400 cells/m^3 of water comprising 234,964,800 cells of phytoplankton/m^3 of water and 8,986,600 cells of zooplankton/m^3 of water. The dominant species was *Oscillatoria* sp. with abundance of

170,275,000 cells/m^3 of water in phylum Cyanophyta. The next rank was *Synedra acus*, *Ulothrix aqualis*, *Ulothrix variabilis*, *Mougeotia japonica* and *Tintinnopsis cratera* with abundance of 24,794,000 15,386,000 7,056,000 4,214,000 and 2,842,000 cells/m^3 of water respectively. The details are presented in Table 10.

4.5.2 Fittest Model Comparison

After conducting water quality and plankton sampling at 4 stations in Lam Ta Khong reservoir on October 27, 2003, the results of water quality investigation from field survey and laboratory analysis of each station were substituted in 13 fittest models. The abundance of plankton in each phylum from substituted water quality value is called expected value. The expected values were compared with abundance of plankton in each phylum from field survey and directly counted in laboratory (observed value). The expected values were compared with observed values in each fittest model as below:

1) Phylum Cyanophyta

Fittest model

log(abundance of plankton in phylum Cyanophyta) = 3.24 - 0.0261 SS + 0.00545 Conductivity + 0.329 pH + 0.0657 BOD

The detail of water quality analysis result is presented in Table 9. The result of water quality analysis substituted in phylum Cyanophyta model is shown in Table 11. The answer from water quality substitution in model of phylum in 4 stations are 51,436,925.27 27,302,976.80 27,971,515.68 and 38,511,284.12 cells/m^3 of water respectively. All of abundance of plankton from substitution results or expected values are compared with abundance of plankton from laboratory analysis or observed values. The detail of substitution in phylum Cyanophyta model result is shown in Table 12.

Table 11. The water quality analysis results to be substituted in phylum Cyanophyta model.

Station	SS	Conductivity	pH	BOD
1	7.3	250	8.9	5.65
2	5.0	247	8.7	1.80
3	5.0	254	8.6	1.88
4	7.3	256	8.8	3.74
Range of Data*	1.70-87.80	192-401	7.25-9.40	0.10-7.20
Unit	mg/l	microhos/cm	-	mg/l

Notes Station 1 = Southern part of Lam Ta Khong reservoir.

Station 2 = Western part of Lam Ta Khong reservoir.

Station 3 = Northern part of Lam Ta Khong reservoir.

Station 4 = Eastern part of Lam Ta Khong reservoir.

* = All of data on water quality for fittest model analysis (lower limit-upper limit).

Comparison between expected values and observed values of phylum Cyanophyta shows that expected values are lower than observed values in all stations (Figure 25). But both of graphs tend to be in same direction. In fittest model consideration, it is found that major water quality parameter is pH, the next are BOD, SS, and conductivity respectively. However, pH values are little different in range (about 8.6-8.9) from field survey and these pH values are in range of pH data from

Table 12. Comparison between abundance of plankton from laboratory analysis (observed values) and abundance of plankton from substitution in phylum Cyanophyta model (expected values).

Station	Observed values (cell/m^3 of water)	Expected values (cell/m^3 of water)
1	158,860,000.00	51,436,925.27
2	63,190,400.00	27,302,976.80
3	51,360,000.00	27,971,515.68
4	174,116,600.00	38,511,284.12

Notes Station 1 = Southern part of Lam Ta Khong reservoir.

Station 2 = Western part of Lam Ta Khong reservoir.

Station 3 = Northern part of Lam Ta Khong reservoir.

Station 4 = Eastern part of Lam Ta Khong reservoir.

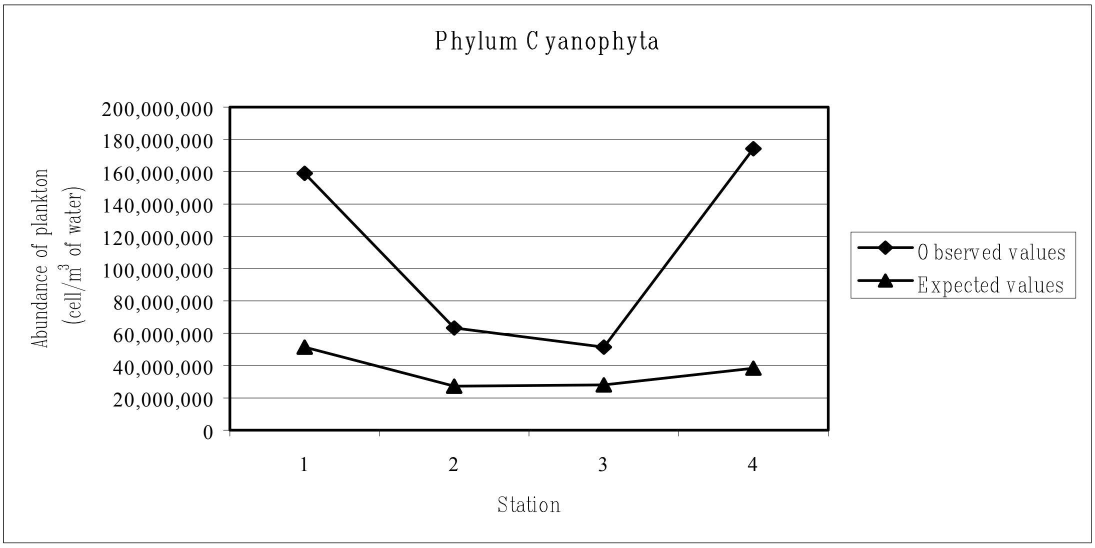

Figure 25. Comparison between abundance of plankton from laboratory analysis (observed values) and abundance of plankton from substitution in phylum Cyanophyta model (expected values).

fittest model analysis (7.25-9.45) in Table 11 and detail of fittest model data in topic fittest model analysis. Then, pH value is not major parameter having effect on abundance of plankton in this model. The major water quality parameters are BOD and SS because graphs of BOD and SS values from laboratory analysis are in the same direction. The BOD and SS values in station 1 and 4 are higher than station 2 and 3. The BOD values from laboratory analysis range between 1.80-5.65 mg/l, they are within the range of BOD data from fittest model analysis (0.1-7.2 mg/l). The SS values from laboratory analysis range between 5.0-7.3 mg/l, they are within the range of SS data from fittest model analysis (1.7-87.3 mg/l) in fittest model data topic. The BOD and SS values have direct effect on abundance of plankton, when BOD values are high; it shows that there are high soluble organic matter. The soluble organic matter affects growth of phytoplankton. Therefore, when BOD values are high; it would result in high abundance of plankton in phylum Cyanophyta. On the other hand, in water with high SS values; there would be effect on photosynthesis process of phytoplankton, resulting in decrease in abundance of plankton in the water. The conductivity values are in the range of 247-256 microhos/cm, they are within the range of conductivity data (192-401 microhos/cm) from fittest model analysis. When conductivity values are substituted in fittest model of phylum Cyanophyta in each station, there are a little changes of abundance of plankton. The details are shown in Table 12 and Figure 25.

2) Phylum Chlorophyta

Fittest model

log(abundance of plankton in phylum Chlorophyta) = 5.15 + 0.221 BOD + 0.0309 SS + 0.0294 Chlorophyll a

The detail of water quality analysis is presented in Table 9. The result of water quality analysis substituted in phylum Chlorophyta model is shown in Table 13. The answer from water quality substitution in model of phylum in 4 stations are 21,457,741.05 1,992,571.89 2,395,642.45 and 17,351,698.79 cells/m^3 of water respectively. All of substitution results are compared with abundance of plankton from laboratory analysis. The detail of model result is shown in Table 14 and Figure 26.

Table 13. The water quality analysis results to be substituted in phylum Chlorophyta model.

Station	BOD	SS	Chlorophyll a
1	5.65	7.3	24.06
2	1.80	5.0	20.31
3	1.88	5.0	22.43
4	3.74	7.3	35.28
Range of Data*	0.10-7.20	1.70-51.80	3.42-24.64
Unit	mg/l	mg/l	mg/m^3 of water

Notes Station 1 = Southern part of Lam Ta Khong reservoir.

Station 2 = Western part of Lam Ta Khong reservoir.

Station 3 = Northern part of Lam Ta Khong reservoir.

Station 4 = Eastern part of Lam Ta Khong reservoir.

* = All of data on water quality for fittest model analysis (lower limit-upper limit).

Table 14. Comparison between observed values and expected values of phylum Chlorophyta.

Station	Observed values (cell/m^3 of water)	Expected values (cell/m^3 of water)
1	14,981,850.00	21,457,741.05
2	4,527,600.00	1,992,571.89
3	5,625,600.00	2,395,642.45
4	31,850,000.00	17,351,698.79

Notes Station 1 = Southern part of Lam Ta Khong reservoir.

Station 2 = Western part of Lam Ta Khong reservoir.

Station 3 = Northern part of Lam Ta Khong reservoir.

Station 4 = Eastern part of Lam Ta Khong reservoir.

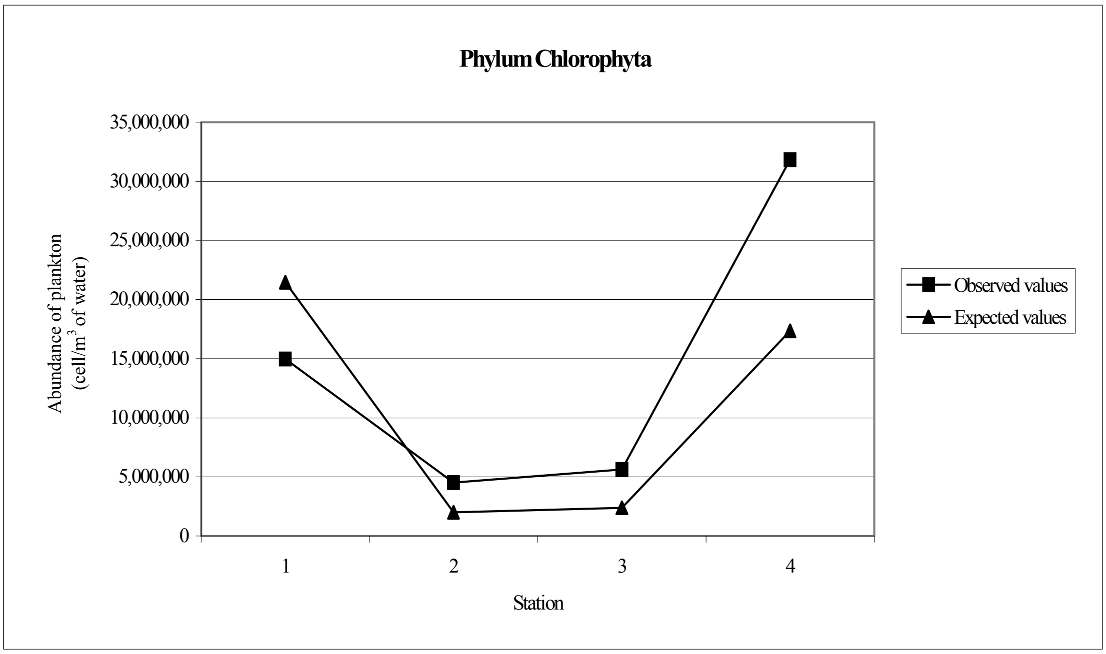

Figure 26. Comparison between observed values and expected values of phylum Chlorophyta.

From Figure 26, it can be seen that expected values and observed values of phylum Chlorophyta in 4 stations tend to be in the same direction. The BOD values from laboratory analysis range between 1.80-5.65 mg/l, they are within the range of BOD data from fittest model analysis (0.1-7.2 mg/l). The SS values from laboratory analysis range between 5.0-7.3 mg/l, they are within the range of SS data from fittest model analysis (1.7-51.80 mg/l) in fittest model data topic.

The chlorophyll a values from laboratory analysis range between 20.31-35.28 mg/m^3 of water. Chlorophyll a value is 35.28 mg/m^3 of water in station 4 (Table 13). It is higher than upper limit of chlorophyll a values data from fittest model analysis (3.42-24.64 mg/l) in fittest model data topic and Table 14. However, when chlorophyll a is substituted in fittest model of phylum Chlorophyta, the abundance of plankton from substitution in phylum Chlorophyta model (expected values) is lower than abundance of plankton from laboratory analysis (observed value). In consideration of abundance of plankton in each station, it is found that expected values and observed values in station 1 and station 4 are higher than in station 2 and station 3. it may be because BOD, SS and chlorophyll a from laboratory analysis in station 1 and 4 are higher than station 2 and 3 (Table 14 and Figure 26). For station 1, the expected value is higher than observed value because BOD value in this station is higher than other stations. The BOD value may have direct effect on abundance of plankton, when BOD values are high; it shows that there is high soluble organic matter. Some of soluble organic matter may be nutrient element for growth of plankton in phylum Chlorophyta. Then, when BOD values are high; it might result in high abundance of plankton in phylum Chlorophyta.

3) Phylum Bacillariophyta

Fittest model

Abundance of plankton in phylum Bacillariophyta = 1430806 + 4962488 Mg -59688206 Nitrate + 100235 Transparency + 335173 SS - 323408 Na - 1.71E+08 Total-P - 1513485 BOD

All of water quality analysis results are presented in Table 9. The result of water quality analysis substituted in phylum Bacillariophyta model is shown in Table 15. The answers from water quality substitution in model of phylum in 4 stations are 105,495,045.03 123,905,016.54 132,220,703.24 and 112,163,715.32 cells/m^3 of water respectively. All of substitution results are compared with abundance of plankton from laboratory analysis. The detail of model result is shown in Table 16 and Figure 27.

From comparison of graphs, it can be seen that expected values and observed values of phylum Bacillariophyta are different in 4 stations. The expected values are higher than observed values in phylum Bacillariophyta (Table 16 and Figure 27). The magnesium (Mg) values from laboratory analysis range between 24.36-27.55 mg/l, they are higher than upper limit of Mg data from fittest model analysis (0.58-17.36 mg/l). Mg is important nutrient element for growth of plant and algae because magnesium is a component of chlorophyll which has function as phosphate carrier, it helps in inflation of plasma and acceleration of enzyme relating to respiratory process. Therefore, when Mg values from laboratory analysis are higher than upper limit of Mg data from fittest model analysis, it would result in expected values error. The water quality parameters i.e. nitrite, transparency, SS, Na, total-P and BOD from field survey and laboratory analysis are in range of data from fittest model analysis (Table 15), these water quality parameters have little effect on abundance of plankton from substitution in phylum Bacillariophyta fittest model.

Table 15. The water quality analysis results to be substituted in phylum Bacillariophyta model.

Station	Mg	Nitrate	Transparency	SS	Na	Total-P	BOD
1	24.36	0.05	63	7.3	17	0.05	5.65
2	25.43	0.05	93	5.0	12	0.03	1.80
3	27.55	0.06	92	5.0	11	0.04	1.88
4	24.36	0.06	67	7.3	10	0.04	3.74
Range of Data*	0.58-17.36	0.03-0.406	10-220	1.70-87.80	2.54-128.50	0.002-0.102	0.10-7.20
Unit	mg/l	mg/l	cm	mg/l	mg/l	mg/l	mg/l

Notes Station 1 = Southern part of Lam Ta Khong reservoir.

Station 2 = Western part of Lam Ta Khong reservoir.

Station 3 = Northern part of Lam Ta Khong reservoir.

Station 4 = Eastern part of Lam Ta Khong reservoir.

* = All of data on water quality for fittest model analysis (lower limit-upper limit).

4) Phylum Chrysophyta

Fittest model

log(abundance of plankton in phylum Chrysophyta+100) = - 1.35 - 0.0875 Chlorophyll a + 0.0173 TDS + 0.00978 Conductivity - 0.117 BOD

Table 16. Comparison between observed values and expected values of phylum Bacillariophyta.

Station	Observed values (cell/m^3 of water)	Expected values(cell/m^3 of water)
1	5,019,300.00	105,495,045.03
2	11,760,000.00	123,905,016.54
3	8,352,000.00	132,220,703.24
4	27,204,800.00	112,163,715.32

Notes Station 1 = Southern part of Lam Ta Khong reservoir.

Station 2 = Western part of Lam Ta Khong reservoir.

Station 3 = Northern part of Lam Ta Khong reservoir.

Station 4 = Eastern part of Lam Ta Khong reservoir.

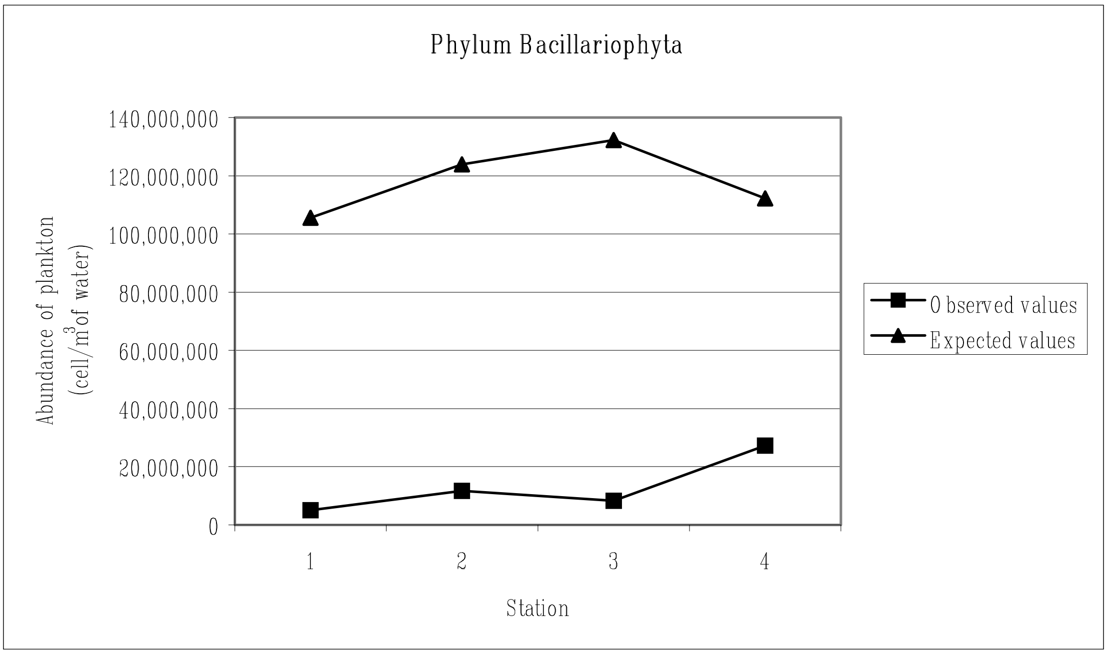

Figure 27. Comparison between observed values and expected values of phylum Bacillariophyta.

All of water quality analysis results are presented in Table 9. The result of water quality analysis substituted in phylum Chrysophyta model is shown in Table 17. The answer from water quality substitution in model of phylum in 4 stations are -84.13 -87.85 -51.59 and -97.07 cells/m^3 of water respectively. All of substitution results are compared with abundance of plankton from laboratory analysis. The detail of model result is shown in Table 18 and Figure 28.

Table 17. The water quality analysis results to be substituted in phylum Chrysophyta model.

Station	**TDS**	**Chlorophyll a**	**Conductivity**	**BOD**
1	166	24.06	250	5.65
2	116	20.31	247	1.80
3	158	22.43	254	1.88
4	164	35.28	256	3.74
Range of Data*	110-312	1.71-24.64	192-401	0.10-7.20
Unit	mg/l	mg/m^3 of water	microhos/cm.	mg/l

Notes Station 1 = Southern part of Lam Ta Khong reservoir.

Station 2 = Western part of Lam Ta Khong reservoir.

Station 3 = Northern part of Lam Ta Khong reservoir.

Station 4 = Eastern part of Lam Ta Khong reservoir.

* = All of data on water quality for fittest model analysis (lower limit-upper limit).

Table 18. Comparison between observed values and expected values of phylum Chrysophyta.

Station	Observed values (cell/m^3 of water)	Expected values (cell/m^3 of water)
1	0.00	-84.13
2	0.00	-87.85
3	0.00	-51.59
4	0.00	-97.07

Notes Station 1 = Southern part of Lam Ta Khong reservoir.

Station 2 = Western part of Lam Ta Khong reservoir.

Station 3 = Northern part of Lam Ta Khong reservoir.

Station 4 = Eastern part of Lam Ta Khong reservoir.

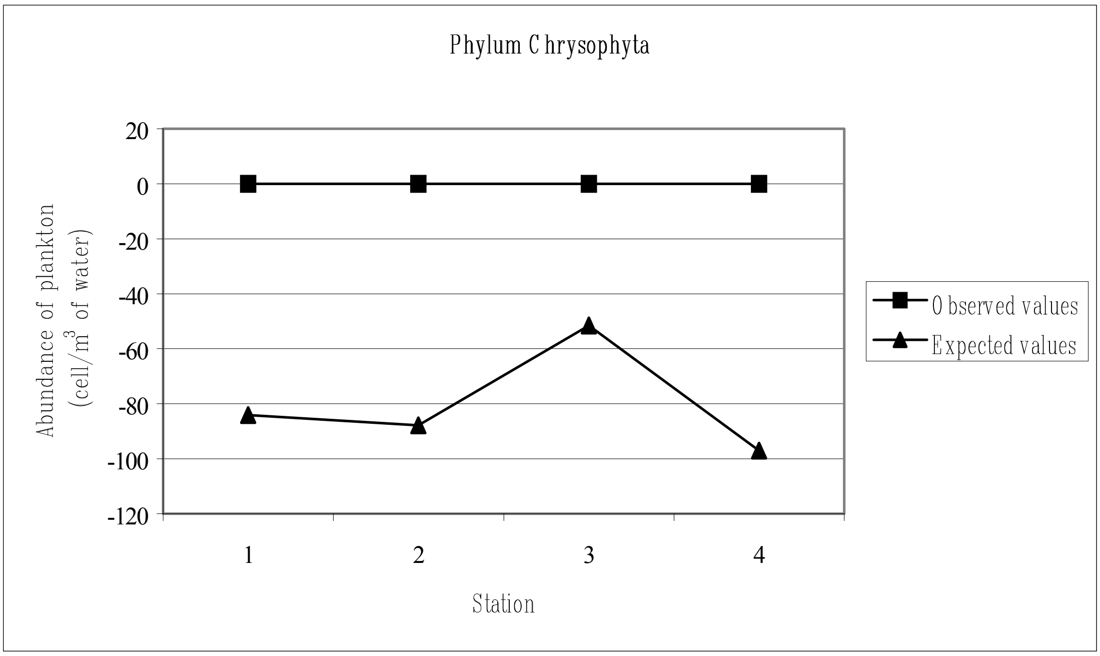

Figure 28. Comparison between observed values and expected values of phylum Chrysophyta.

From comparison of graphs in Figure 28, it can be seen that expected values are not abundance of plankton in 4 stations. The expected values range between -97.07 to -51.59 cells/m^3 of water while there are not abundance of plankton in phylum Chrysophyta (observed values are 0). The water quality parameters i.e. TDS, chlorophyll a, conductivity and BOD from substitution in phylum Chrysophyta are all in range of data from fittest model analysis (Table 17). However, from graphs consideration, it can be seen that the abundance of plankton from expected values and observed values are not different the values of abundance of plankton are nearly the same as presented in Table 18.

5) Phylum Pyrrophyta

Fittest model

ln(abundance of plankton in phylum Pyrrophyta+100) = - 3.18 - 0.155 SS + 0.310 Water temperature + 0.0243 TDS-0.320 BOD + 0.0179 Conductivity + 0.141 Turbidity + 0.0515 Depth of water

All of water quality analysis results are presented in Table 9. The result of water quality analysis substituted in phylum Pyrrophyta model is shown in Table 19. The answer from water quality substitution in model of phylum in 4 stations are 163,070.35 129,092.65 1,106,873.20 and 349,769.32 cells/m^3 of water respectively. All of substitution results are compared with abundance of plankton from laboratory analysis. The detail of model result is shown in Table 20 and Figure 29.

Table 19. The water quality analysis results to be substituted in phylum Pyrrophyta model.

Station	SS	Water temperature	TDS	BOD	Conductivity	Turbidity	Depth
1	7.3	28.0	166	5.65	250	5.45	3.20
2	5.0	26.0	116	1.80	247	5.01	5.70
3	5.0	27.4	158	1.88	254	5.24	16.60
4	7.3	27.4	164	3.74	256	6.24	6.45
Range of Data*	1.70-87.80	25.0-31.8	110-312	0.10-7.20	192-401	0.90-46.30	0.80-20.50
Unit	mg/l	Celsius	mg/l	mg/l	microhos/cm	mg/l	m

Notes Station 1 = Southern part of Lam Ta Khong reservoir.

Station 2 = Western part of Lam Ta Khong reservoir.

Station 3 = Northern part of Lam Ta Khong reservoir.

Station 4 = Eastern part of Lam Ta Khong reservoir.

* = All of data on water quality for fittest model analysis (lower limit-upper limit).

From comparison of graphs, it can be seen that expected values and observed values of phylum Pyrrophyta in 2-4 stations tend to be in the same direction. The 7 water quality parameters from field survey and laboratory analysis comprising SS, water temperature, TDS, BOD, conductivity, turbidity and depth of water are substituted in phylum Pyrrophyta fittest model. All of water quality parameters from field survey and laboratory analysis are within the range of data from fittest model analysis. The details are presented in Table 19.

Table 20. Comparison between observed values and expected values of phylum Pyrrophyta.

Station	Observed values (cell/m^3 of water)	Expected values (cell/m^3 of water)
1	25,054,250.00	163,070.35
2	862,400.00	129,092.65
3	268,800.00	1,106,873.20
4	1,626,800.00	349,769.32

Notes Station 1 = Southern part of Lam Ta Khong reservoir.

Station 2 = Western part of Lam Ta Khong reservoir.

Station 3 = Northern part of Lam Ta Khong reservoir.

Station 4 = Eastern part of Lam Ta Khong reservoir.

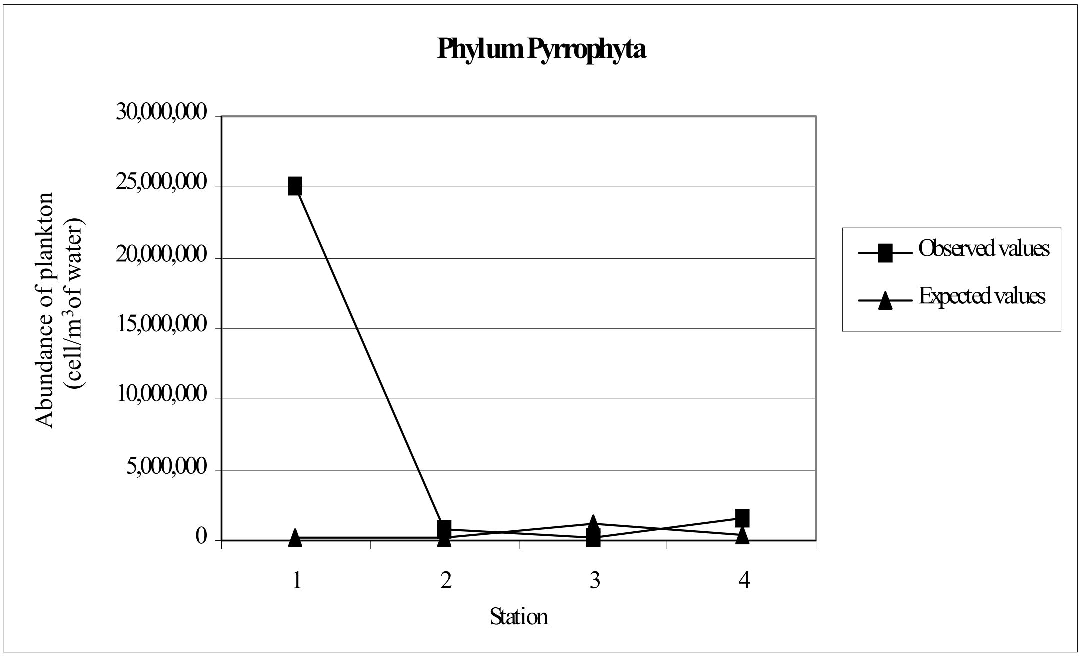

Figure 29. Comparison between observed values and expected values of phylum Pyrrophyta.

The observed values are higher than expected values in station 1 because BOD value (5.65 mg/l) is higher than other stations (1.80-3.74 mg/l). The BOD value is within the range of data from fittest model analysis (0.1-7.2 mg/l). The high BOD value might result in high abundance of plankton from field survey. BOD value has direct effect on abundance of plankton, if BOD values are high; it shows that there is high soluble organic matter. The organic matter degraded by microorganism would be changed into inorganic matter i.e. nitrite, nitrate, ammonia and phosphate. These compound matters are very important minerals for phytoplankton growth. Then, it can be summarized that if BOD values from field survey are high; it might result in high abundance of plankton in laboratory analysis. The result of observed values and expected values are different. The details are presented in Table 19 and Figure 29.

6) Phylum Euglenophyta

Fittest model

log(abundance of plankton in phylum Euglenophyta +100) = - 17.6 + 0.0751 Total hardness + 0.530 Water temperature - 0.124 Ca - 0.139 BOD

All of water quality analysis results are presented in Table 9. The result of water quality analysis substituted in phylum Euglenophyta model is shown in Table 21. The answer from water quality substitution in model of phylum in 4 stations are -99.99 -99.99 -99.99 and -99.99 cells/m^3 of water respectively. All of substitution results are compared with abundance of plankton from laboratory analysis. The detail of model result is shown in Table 22 and Figure 30.

From comparison of graphs, it can be seen that expected values and observed values of phylum Euglenophyta are different in 4 stations especially expected

Table 21. The water quality analysis results to be substituted in phylum Euglenophyta model.

Station	Total hardness	Water temperature	Ca	BOD
1	65.68	28.0	90.04	5.65
2	55.08	26.0	91.10	1.80
3	53.56	27.4	82.63	1.88
4	63.50	27.4	87.92	3.74
Range of Data*	90-200	25.0-31.8	5.38-30.23	0.10-7.20
Unit	mg/l as $CaCO_3$	Celsius	mg/l	mg/l

Notes Station 1 = Southern part of Lam Ta Khong reservoir.

Station 2 = Western part of Lam Ta Khong reservoir.

Station 3 = Northern part of Lam Ta Khong reservoir.

Station 4 = Eastern part of Lam Ta Khong reservoir.

* = All of data on water quality for fittest model analysis (lower limit-upper limit).

values are minus values. They show that they are not abundance of plankton of phylum Euglenophyta in 4 stations (Table 22 and Figure 30). Four water quality parameters comprising total hardness, water temperature, calcium and BOD are used for substitution in phylum Euglenophyta fittest model. The total hardness and calcium values are out of range of data from fittest model analysis. The total hardness values from laboratory analysis are in the range of 53.56-65.68 mg/l as $CaCO_3$, they are lower than lower limit of total hardness data from fittest model analysis (90-200 mg/l as $CaCO_3$). Calcium values from laboratory analysis range between 82.63-91.10 mg/l, they are higher than upper limit of calcium data from fittest model analysis (5.38-30.23

Table 22. Comparison between observed values and expected values of phylum Euglenophyta.

Station	Observed values (cell/m^3 of water)	Expected values (cell/m^3 of water)
1	439,400.00	-99.99
2	137,200.00	-99.99
3	201,600.00	-99.99
4	166,600.00	-99.99

Notes Station 1 = Southern part of Lam Ta Khong reservoir.

Station 2 = Western part of Lam Ta Khong reservoir.

Station 3 = Northern part of Lam Ta Khong reservoir.

Station 4 = Eastern part of Lam Ta Khong reservoir.

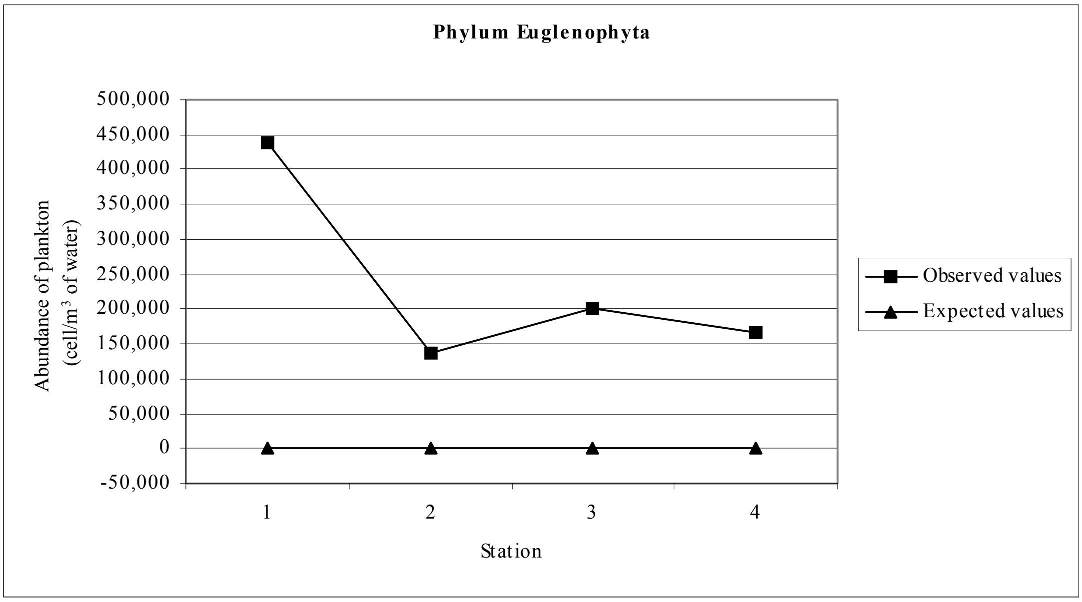

Figure 30. Comparison between observed values and expected values of phylum Euglenophyta.

mg/l). The water quality parameters i.e. water temperature and BOD are within the range of data from fittest model analysis (Table 21). The total hardness and calcium values have direct effect on phytoplankton. The hardness of water shows calcium and magnesium salts in form of water soluble calcium carbonate. The calcium is important for increase of number of plankton because they release bicarbonate to increase carbondioxide gas for photosynthesis process (Smith, 1950). It means that when total hardness of water increases, plankton would increase too because there are many minerals essential for living of phytoplankton. Calcium is important component in cell and important component in production of cell wall. However, the total hardness and calcium values are suitable demand for living of phytoplankton. They are good for growth of plankton.

7) Phylum Protozoa

Fittest model

Abundance of plankton in phylum Protozoa = - 920194 - 1413 Transparency - 241000 Organic nitrogen + 1754 Alkalinity + 57484 DO + 1895 Conductivity + 585738 Nitrate

All of water quality analysis results are presented in Table 9. The result of water quality analysis substituted in phylum Protozoa model is shown in Table 23. The answer from water quality substitution in model of phylum in 4 stations are 5,978,992.30 5,712,927.00 5,844,717.34 and 5,796,476.52 cells/m^3 of water respectively. All of substitution results are compared with abundance of plankton from laboratory analysis. The detail of model result is shown in Table 24 and Figure 31.

Table 23. The water quality analysis results to be substituted in phylum Protozoa model.

Station	Transparency	Organic nitrogen	Alkalinity	DO	Conductivity	Nitrate
1	63	0.08	133.25	7.70	250	0.05
2	93	0.73	125.48	6.87	247	0.05
3	92	0.27	122.49	7.07	254	0.06
4	67	1.50	130.26	10.47	256	0.06
Range of Data*	10-190	0.10-0.80	74-195	4.00-11.10	193-401	0.03-0.406
Unit	cm	mg/l	mg/l	mg/l	microhos/cm	mg/l

Notes Station 1 = Southern part of Lam Ta Khong reservoir.

Station 2 = Western part of Lam Ta Khong reservoir.

Station 3 = Northern part of Lam Ta Khong reservoir.

Station 4 = Eastern part of Lam Ta Khong reservoir.

* = All of data on water quality for fittest model analysis (lower limit-upper limit).

From comparison of graphs, it can be seen that expected values and observed values of phylum Protozoa are different values in all stations except station 4, where values are nearly the same. The expected values are higher than observed values in station 1-3. (Table 24). The water quality parameters such as transparency, alkalinity, DO, conductivity and nitrate have effect on abundance of plankton at all of the 4 stations, all except organic nitrogen values are within the range of data from fittest model analysis. The organic nitrogen values from field survey range between 0.08-1.50 mg/l. The organic nitrogen value in station 4 is 1.5 mg/l and is higher than

Table 24. Comparison between observed values and expected values of phylum Protozoa.

Station	Observed values (cell/m^3 of water)	Expected values (cell/m^3 of water)
1	1,487,200.00	5,978,992.30
2	803,600.00	5,712,927.00
3	1,046,400.00	5,844,717.34
4	5,429,200.00	5,796,476.52

Notes Station 1 = Southern part of Lam Ta Khong reservoir.

Station 2 = Western part of Lam Ta Khong reservoir.

Station 3 = Northern part of Lam Ta Khong reservoir.

Station 4 = Eastern part of Lam Ta Khong reservoir.

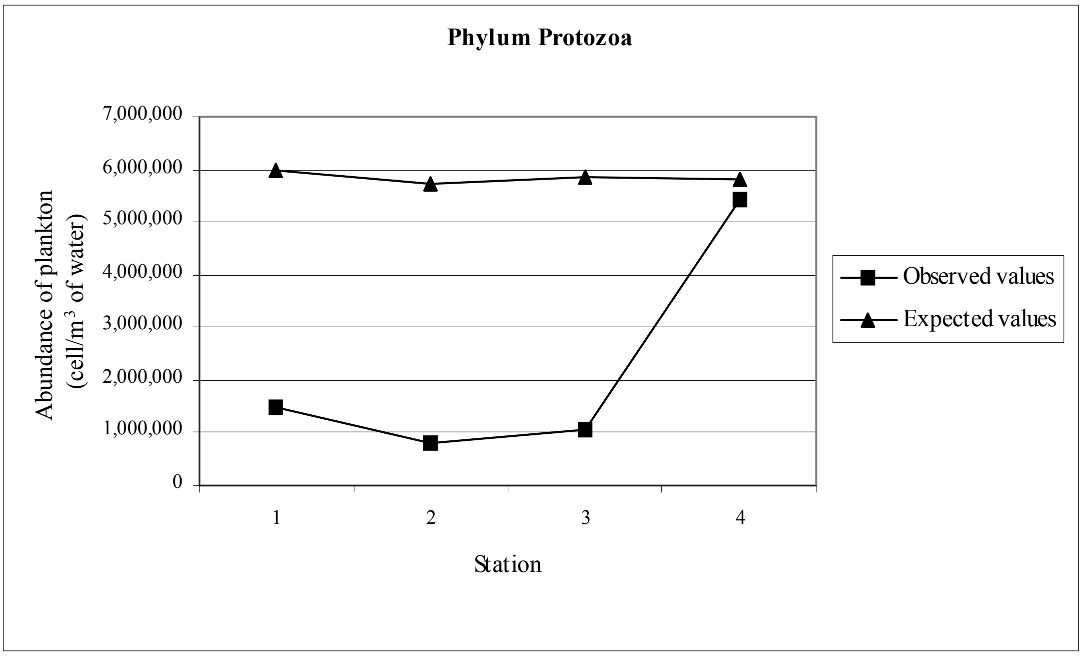

Figure 31. Comparison between observed values and expected values of phylum Protozoa.

upper limit of organic nitrogen data from fittest model analysis (0.1-0.8 mg/l). In consideration of water quality parameters in station 4, the expected value is close to observed value while organic nitrogen and DO values are higher than other stations. The organic nitrogen value has effect on abundance of plankton. Organic nitrogen could degrade in natural condition. Phytoplankton could use many type of nitrogen compound for living. Natural water with lot of organic nitrogen would have high contamination of organic matter, it has to use high oxygen in degradation process, then, oxygen would be low in water, this would reduce abundance of plankton in water. Then, when DO decreases, abundance of plankton would also decrease. In addition to, เฉลิม ชุมพล (2527) reported that when DO in water decreased, there phytoplankton and zooplankton would also decrease or could not survive in that water source.

8) Phylum Rotifera

Fittest model

ln (abundance of plankton in phylum Rotifera) = 11.0 - 0.444 Total nitrogen + 0.217 BOD + 0.0732 Water temperature

All of water quality analysis results are presented in Table 9. The result of water quality analysis substituted in phylum Rotifera model is shown in Table 25. The answer from water quality substitution in model of phylum in 4 stations are 1,016,270.39 392,730.93 560,194.88 and 514,659.09 cells/m^3 of water respectively. All of substitution results are compared with abundance of plankton from laboratory analysis. The detail of model result is shown in Table 26 and Figure 32.

Table 25. The water quality analysis results to be substituted in phylum Rotifera model.

Station	Total nitrogen	BOD	Water temperature
1	1.00	5.65	28.0
2	0.93	1.80	26.0
3	0.40	1.88	27.4
4	1.50	3.74	27.4
Range of Data*	0.10-3.60	0.10-7.20	25.0-31.8
Unit	mg/l	mg/l	Celsius

Notes Station 1 = Southern part of Lam Ta Khong reservoir.

Station 2 = Western part of Lam Ta Khong reservoir.

Station 3 = Northern part of Lam Ta Khong reservoir.

Station 4 = Eastern part of Lam Ta Khong reservoir.

* = All of data on water quality for fittest model analysis (lower limit-upper limit).

From comparison of graphs, it can be seen that expected values and observed values of phylum Rotifera tend to be in the same direction in station 1-3 but in station 4 observed values are higher than expected values. There are 3 water quality parameters as total nitrogen, BOD and water temperature in phylum Rotifera fittest model. All of water quality parameters are within the range of data from fittest model analysis (Table 25). The observed value is higher than expected value in station 4 because total nitrogen from laboratory analysis (1.5 mg/l) is higher than other stations. Total nitrogen compound in water source comprising inorganic-nitrogen and organic-nitrogen, organic-nitrogen is compound of plant. The nitrogen compounds could change

Table 26. Comparison between observed values and expected values of phylum Rotifera.

Station	Observed values (cell/m^3 of water)	Expected values (cell/m^3 of water)
1	1,385,800.00	1,016,270.39
2	490,000.00	392,730.93
3	537,600.00	560,194.88
4	3,096,800.00	514,659.09

Notes Station 1 = Southern part of Lam Ta Khong reservoir.

Station 2 = Western part of Lam Ta Khong reservoir.

Station 3 = Northern part of Lam Ta Khong reservoir.

Station 4 = Eastern part of Lam Ta Khong reservoir.

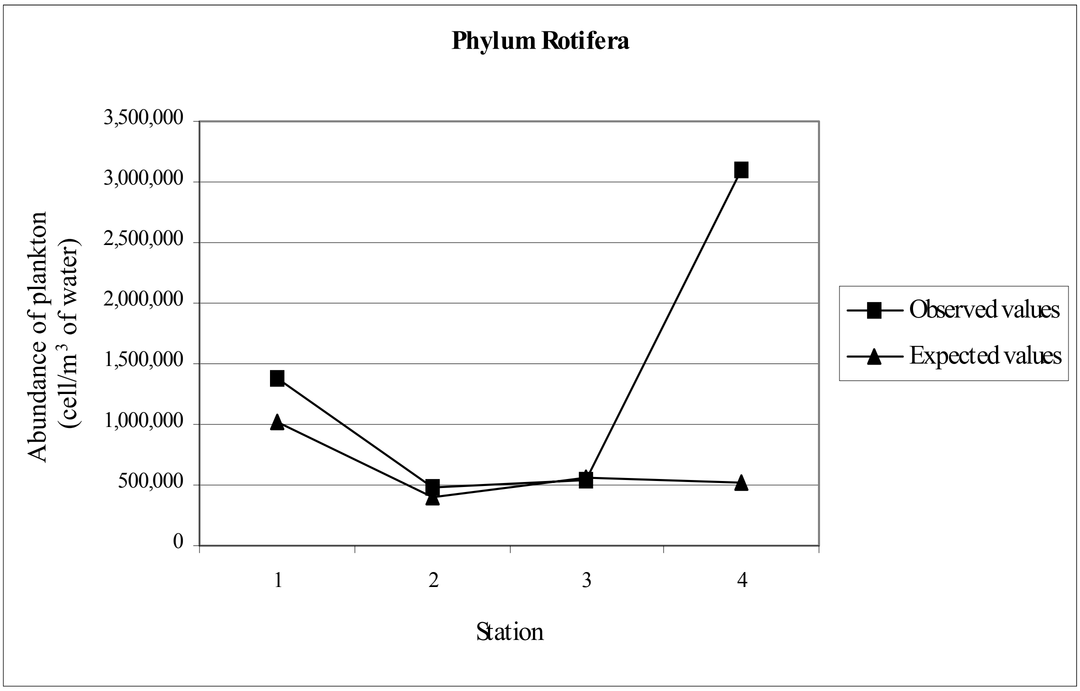

Figure 32. Comparison between observed values and expected values of phylum Rotifera.

from insoluble organic matter form to soluble organic matter form by bacteria in mineralization process. This process is very important in chemical cycle of fresh water because it produces nutrient for micro aquatic life and aquatic plant. The water source, which has rich nutrient, phytoplankton would have high growth rate and so as zooplankton. Then, total nitrogen in station 4 should have direct effect on zooplankton in phylum Rotifera too.

9) Phylum Arthropoda

Fittest model

ln (abundance of plankton in phylum Arthropoda) = 8.38 + 0.215 BOD - 0.0378 SS - 0.00834 Transparency - 0.0367 Depth of water + 0.613 pH - 0.216 Total nitrogen

All of water quality analysis results are presented in Table 9. The result of water quality analysis substituted in phylum Arthropoda model is shown in Table 27. The answer from water quality substitution in model of phylum in 4 stations are 1,105,325.04 336,182.69 243,799.15 and 531,290.91 cells/m^3 of water respectively. All of substitution results are compared with abundance of plankton from laboratory analysis. The detail of model result is shown in Table 28 and Figure 33.

From comparison of graphs, it can be seen that observed values and expected values of phylum Arthropoda tend to be in the same direction in all stations except station 1 where both of values are different. The expected values are higher than observed values in all stations. There are 6 water quality parameters comprising BOD, SS, transparency, depth of water, pH and total nitrogen in phylum Arthropoda fittest model. All of water quality parameters are within the range of data from fittest model analysis (Table 27).

Table 27. The water quality analysis results to be substituted in phylum Arthropoda model.

Station	BOD	SS	Transparency	Depth	pH	Total nitrogen
1	5.65	7.3	63	3.20	8.9	1.00
2	1.80	5.0	93	5.70	8.7	0.93
3	1.88	5.0	92	16.60	8.6	0.40
4	3.74	7.3	67	6.45	8.8	1.50
Range of Data*	0.10-7.20	1.70-87.80	10-220	0.80-20.50	7.25-9.20	0.10-3.60
Unit	mg/l	mg/l	cm	m	-	mg/l

Notes Station 1 = Southern part of Lam Ta Khong reservoir.

Station 2 = Western part of Lam Ta Khong reservoir.

Station 3 = Northern part of Lam Ta Khong reservoir.

Station 4 = Eastern part of Lam Ta Khong reservoir.

* = All of data on water quality for fittest model analysis (lower limit-upper limit).

The expected value is higher than observed value in station 1 because BOD value from laboratory analysis (5.65 mg/l) is higher than other stations. Depth of water from field survey (3.20 m) is lower than other stations. BOD value might have be direct effect on abundance of plankton, when BOD values are high, it shows that there is high soluble organic matter. Some of soluble organic matter might be nutrient element for growth of phytoplankton. If abundance of phytoplankton is high, it might result in high abundance of zooplankton. It is the for light penetrating into water. If the depth of water is low, penetration of light into water source would be high,

Table 28. Comparison between observed values and expected values of phylum Arthropoda.

Station	Observed values (cell/m^3 of water)	Expected values (cell/m^3 of water)
1	321,100.00	1,105,325.04
2	343,000.00	336,182.69
3	192,000.00	243,799.15
4	460,600.00	531,290.91

Notes Station 1 = Southern part of Lam Ta Khong reservoir.

Station 2 = Western part of Lam Ta Khong reservoir.

Station 3 = Northern part of Lam Ta Khong reservoir.

Station 4 = Eastern part of Lam Ta Khong reservoir.

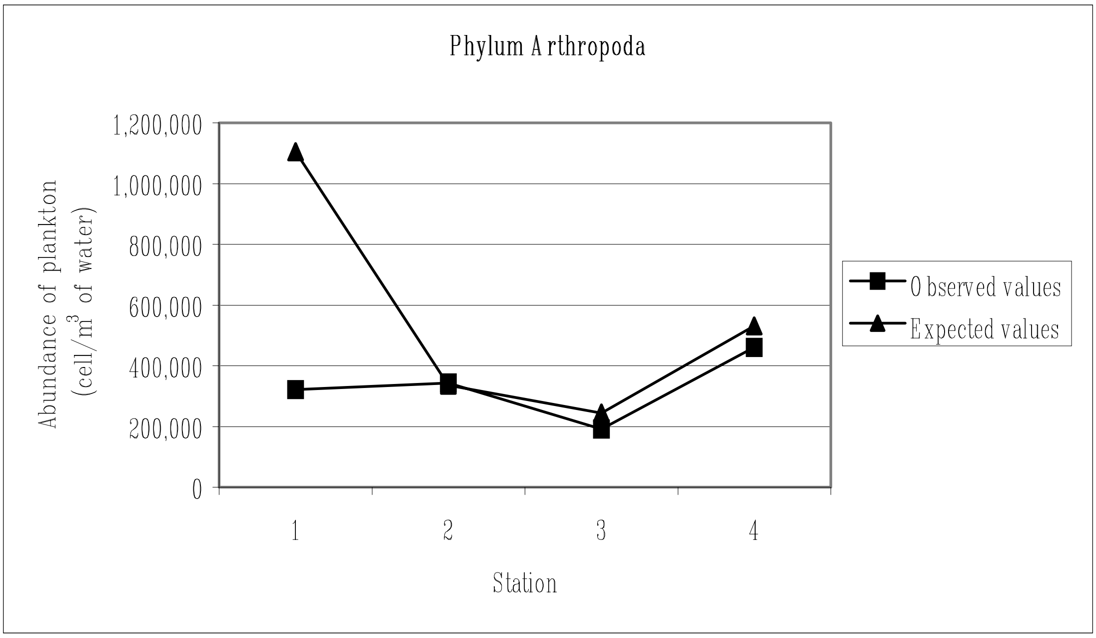

Figure 33. Comparison between observed values and expected values of phylum Arthropoda.

resulting in high photosynthesis of phytoplankton and high abundance of phytoplankton and zooplankton. Then, high BOD values and low depth of water might have effect on abundance of phytoplankton and zooplankton in phylum Arthropada.

10) Phylum Chordata

Fittest model

log (abundance of plankton in phylum Chordata+100) = 4.43 + 0.244 BOD + 0.0756 Chlorophyll a - 0.169 Water temperature + 0.189 DO - 0.00790 Na

All of water quality analysis results are presented in Table 9. The result of water quality analysis substituted in phylum Chordata model is shown in Table 29. The answers from water quality substitution in model of phylum Chordata in 4 stations are 16,364.02 1,537.82 1,496.46 and 189,989.44 cells/m^3 of water respectively. All of substitution results are compared with abundance of plankton from laboratory analysis. The detail of model result is shown in Table 30 and Figure 34.

From comparison of graphs, it can be seen that observed values and expected values of phylum Chordata tend to be in the same direction in all stations except station 4 where expected values are higher than observed values. There are 5 water quality parameters comprising BOD, chlorophyll a, water temperature, DO and Na in phylum chordata fittest model. All of water quality parameters are within the range of data from fittest model analysis except chlorophyll a. Chlorophyll a is about 35.28 mg/m^3 of water in station 4, it is higher than range of data from fittest model analysis (1.71-24.64 mg/m^3 of water). The details are shown in Table 29. The expected value is higher than observed value in station 4 because chlorophyll a from laboratory analysis is higher than other station. The chlorophyll a value is abundance of phytoplankton in water resource. If there is high abundance of phytoplankton in water source, it might result in high abundance of zooplankton in phylum Chordata. Phylum Chordata is zooplankton in group of larvae of aquatic life, it consumes phytoplankton for growth. In consideration of DO in station 4, it is found that DO is high (10.47 mg/l) and is suitable for living of aquatic life. It is the same to chlorophyll a values from laboratory analysis. Then, it can be concluded that chlorophyll a and DO are important factors having effect on change of abundance of zooplankton in phylum Chordata as shown in Table 30 and Figure 34.

Table 29. The water quality analysis results to be substituted in phylum Chordata model.

Station	BOD	Chlorophyll a	Water temperature	DO	Na
1	5.65	24.06	28.0	7.70	17
2	1.80	20.31	26.0	6.87	12
3	1.88	22.43	27.4	7.07	11
4	3.74	35.28	27.4	10.47	10
Range of	0.10-	1.71-	25.0-	4.00-	2.54-
Data*	7.20	24.64	31.8	11.60	128.50
Unit	mg/l	mg/m^3 of water	Celsius	mg/l	mg/l

Notes Station 1 = Southern part of Lam Ta Khong reservoir.

Station 2 = Western part of Lam Ta Khong reservoir.

Station 3 = Northern part of Lam Ta Khong reservoir.

Station 4 = Eastern part of Lam Ta Khong reservoir.

* = All of data on water quality for fittest model analysis (lower limit-upper limit).

Table 30. Comparison between observed values and expected values of phylum Chordata.

Station	Observed values (cell/m^3 of water)	Expected values (cell/m^3 of water)
1	0	16,364.02
2	0	1,537.82
3	0	1,496.46
4	0	189,989.44

Notes Station 1 = Southern part of Lam Ta Khong reservoir.

Station 2 = Western part of Lam Ta Khong reservoir.

Station 3 = Northern part of Lam Ta Khong reservoir.

Station 4 = Eastern part of Lam Ta Khong reservoir.

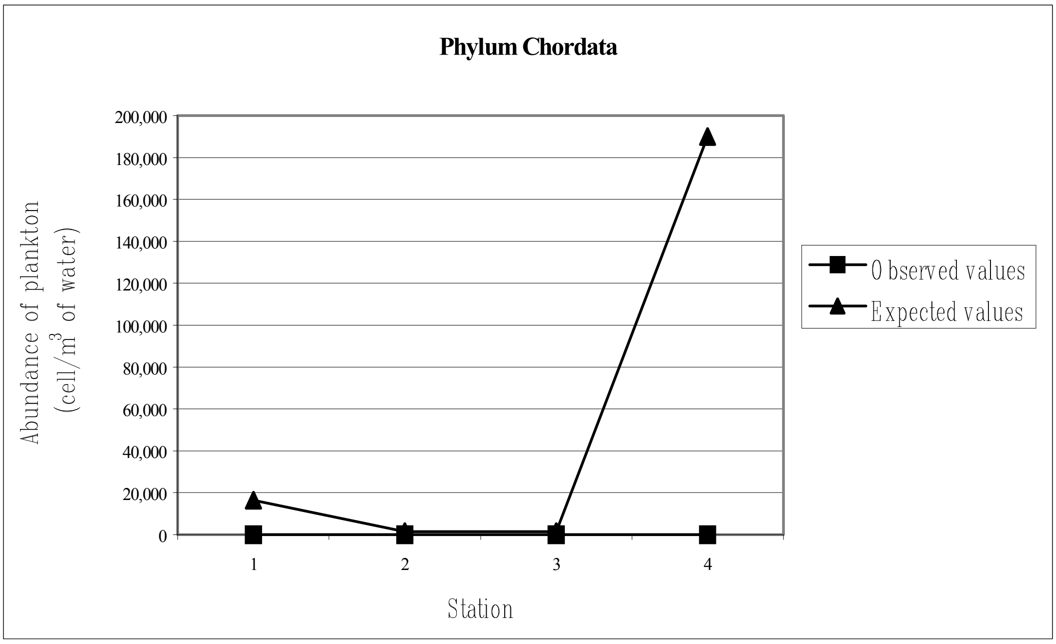

Figure 34. Comparison between observed values and expected values of phylum Chordata.

11) Total phytoplankton

Fittest model

log (abundance of total phytoplankton) = 7.76 - 0.0125 SS + 0.140 BOD - 3.54 Nitrate + 0.182 K

All of water quality analysis results are presented in Table 9. The result of water quality analysis substituted in total phytoplankton model is shown in Table 31. The answer from water quality substitution in model of total phytoplankton in 4 stations are 1,114,679,463.76 279,190,090.83 205,352,502.65 and 296,039,730.38 cells/m^3 of water respectively. All of substitution results are compared with abundance of plankton from laboratory analysis. The detail of model result is shown in Table 32 and Figure 35.

From comparison between expected values and observed values, it is found that expected values are higher than observed values in all stations. Both of graphs tend to be in the same direction. There are 4 water quality parameters as SS, BOD, nitrate, and potassium in phytoplankton fittest model. All of water quality parameters are within the range of data from fittest model analysis (Table 31). When consideration on abundance of plankton at station 1, it is found that expected value and observed value are very different values. The expected value is about 204,354,800.00 cells/m^3 of water while observed value is about 1,114,679,463.76 cells/m^3 of water (Table 32) because BOD and potassium values are higher than other stations.

The BOD values are high; it shows that there is high soluble organic matter. Some of soluble organic matter may be nutrient element for growth of phytoplankton. Then, if BOD values is high, it might result in high abundance of phytoplankton. Potassium in water is soluble ion which relates to other ions especially bicarbonate. It affects change on abundance of plankton. Therefore, it can be concluded that if BOD and potassium values change, there would be effect on phytoplankton abundance in water.

Table 31. The water quality analysis results to be substituted in total phytoplankton model.

Station	**SS**	**BOD**	**Nitrate**	**K**
1	7.3	5.65	0.05	4.20
2	5.0	1.80	0.05	3.70
3	5.0	1.88	0.06	3.10
4	7.3	3.74	0.06	2.70
Range of Data*	1.70-87.80	0.10-7.20	0.03-0.406	0.18-4.60
Unit	mg/l	mg/l	mg/l	mg/l

Notes Station 1 = Southern part of Lam Ta Khong reservoir.

Station 2 = Western part of Lam Ta Khong reservoir.

Station 3 = Northern part of Lam Ta Khong reservoir.

Station 4 = Eastern part of Lam Ta Khong reservoir.

* = All of data on water quality for fittest model analysis (lower limit-upper limit).

Table 32. Comparison between observed values and expected values of total phytoplankton.

Station	Observed values (cell/m^3 of water)	Expected values (cell/m^3 of water)
1	204,354,800.00	1,114,679,463.76
2	80,477,600.00	279,190,090.83
3	65,808,000.00	205,352,502.65
4	234,964,800.00	296,039,730.38

<u>Notes</u> Station 1 = Southern part of Lam Ta Khong reservoir.

Station 2 = Western part of Lam Ta Khong reservoir.

Station 3 = Northern part of Lam Ta Khong reservoir.

Station 4 = Eastern part of Lam Ta Khong reservoir.

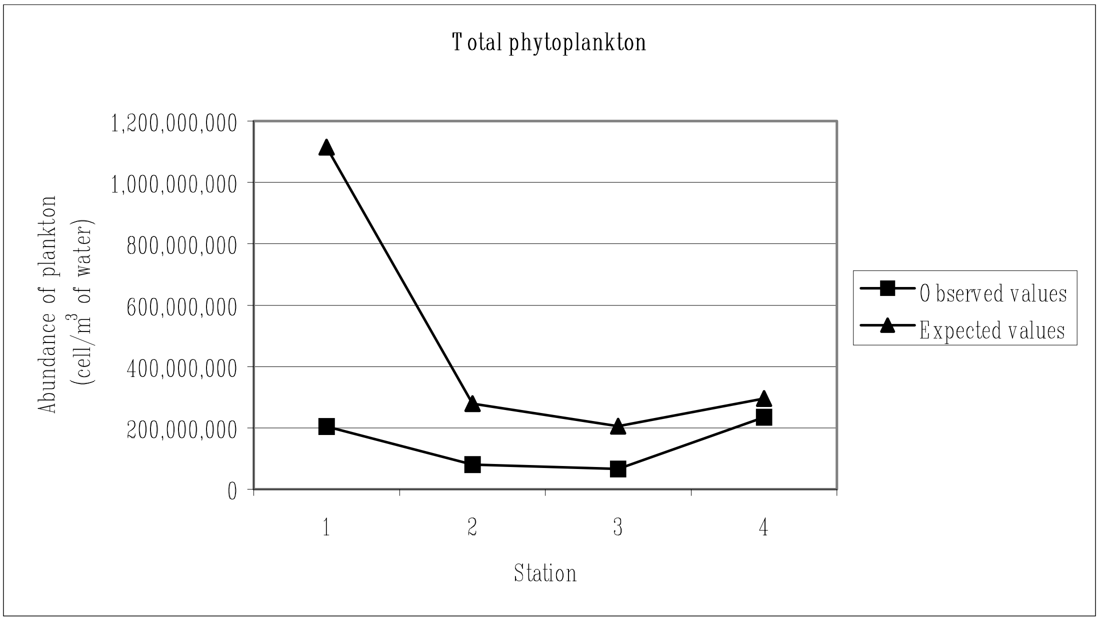

Figure 35. Comparison between observed values and expected values of total phytoplankton.

12) Total zooplankton

Fittest model

log (abundance of total zooplankton) = 5.15 - 0.0134 SS + 0.0635 BOD + 0.00222 Conductivity + 0.0684 DO - 0.121 Total nitrogen - 0.00247 Transparency

All of water quality analysis results are presented in Table 9. The result of water quality analysis substituted in total zooplankton model is shown in Table 33. The answer from water quality substitution in model of total zooplankton in 4 stations are 1,644,466.38 746,978.32 942,340.81 and 1,687,127.87 cells/m^3 of water respectively. All of substitution results are compared with abundance of plankton from laboratory analysis. The detail of model result is shown in Table 34 and Figure 36.

From comparison of graphs, it can be seen that observed values and expected values of total zooplankton tend to be in the same direction in all stations except station 4 where observed values are higher than expected values. There are 6 water quality parameters comprising SS, BOD, conductivity, DO, total nitrogen, and transparency in total zooplankton fittest model (Table 33).

The observed value is higher than expected value in station 4 because DO and total nitrogen value from laboratory analysis are higher than other stations. DO from field survey is 10.47 mg/l, DO is very important factor having influence on abundance of plankton. DO is very important parameter of water quality because oxygen is important for the living of aquatic life. In addition, total nitrogen value from laboratory analysis is 1.5 mg/l which is higher than other stations. Total nitrogen compound in water source comprises inorganic compound and organic nitrogen. The organic nitrogen is important compound of plant. The nitrogen compounds could change from insoluble organic matter form to soluble organic matter form by bacteria in mineralization process. This process is very important in chemical cycle of fresh water because it produces nutrient for micro aquatic life and aquatic plant. Nevertheless, the water source which has rich nutrient, growth rates of phytoplankton and abundance of zooplankton. Then, total nitrogen in station 4 might have direct effect on total zooplankton too. The details are presented in Table 34 and Figure 36.

Table 33. The water quality analysis results to be substituted in total zooplankton model.

Station	**SS**	**BOD**	**Conductivity**	**DO**	**Total nitrogen**	**Transparency**
1	7.3	5.65	250	7.70	1.00	63
2	5.0	1.80	247	6.87	0.93	93
3	5.0	1.88	254	7.07	0.40	92
4	7.3	3.74	256	10.47	1.50	67
Range of Data*	1.70-87.80	0.10-7.20	192-401	4.00-11.60	0.10-3.60	10-220
Unit	mg/l	mg/l	microhos/cm	mg/l	mg/l	cm

Notes Station 1 = Southern part of Lam Ta Khong reservoir.

Station 2 = Western part of Lam Ta Khong reservoir.

Station 3 = Northern part of Lam Ta Khong reservoir.

Station 4 = Eastern part of Lam Ta Khong reservoir.

* = All of data on water quality for fittest model analysis (lower limit-upper limit).

Table 34. Comparison between observed values and expected values of total zooplankton.

Station	Observed values (cell/m^3 of water)	Expected values (cell/m^3 of water)
1	3,194,100.00	1,644,466.38
2	1,636,600.00	746,978.32
3	1,776,000.00	942,340.81
4	8,986,600.00	1,687,127.87

Notes Station 1 = Southern part of Lam Ta Khong reservoir.

Station 2 = Western part of Lam Ta Khong reservoir.

Station 3 = Northern part of Lam Ta Khong reservoir.

Station 4 = Eastern part of Lam Ta Khong reservoir.

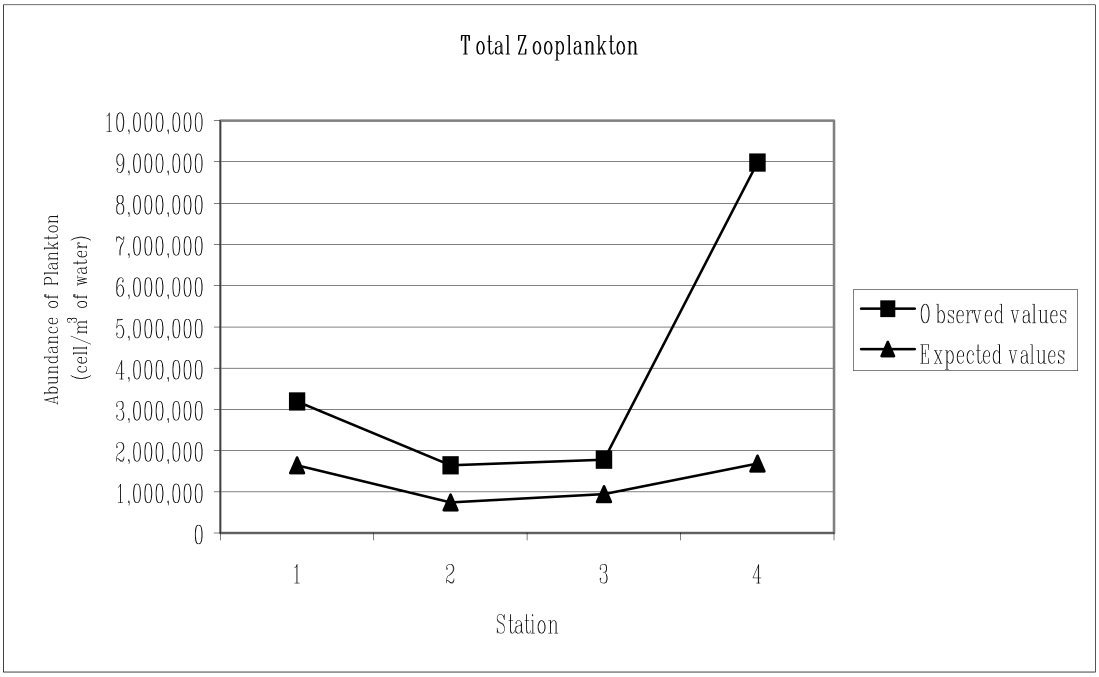

Figure 36. Comparison between observed values and expected values of total zooplankton.

13) Grand total plankton

Fittest model

log(abundance of grand total plankton) = 7.86 - 0.00989 SS - 4.44 Total P + 0.200 K - 3.17 Nitrate + 0.109 BOD

All of water quality analysis results are presented in Table 9. The result of water quality analysis substituted in grand total plankton model is shown in Table 35. The answer from water quality substitution in model of phylum in 4 stations are 729,714,540.14 285,134,652.20 185,212,374.67 and 233,164,806.84 cells/m^3 of water respectively. All of substitution results are compared with abundance of plankton from laboratory analysis. The detail of model result is shown in Table 36 and Figure 37.

From comparison of expected values and observed values, it is found that expected values are higher than observed values in station 1-3. Both of graphs tend to be in the same direction. There are 5 water quality parameters comprising SS, total-P, nitrite and BOD in grand total plankton fittest model, all of water quality parameters are within the range of data from fittest model (Table 35). When consideration on plankton in station 1, it is found that expected value and observed value have little difference. The observed value is about 207,548,900.00 cells/m^3 of water and expected value is about 729,714,540.14 cells/m^3 of water because SS, K and BOD values are higher than other stations (Table 36). SS value has direct effect on abundance of plankton. SS is solid or suspend solid in water. If it is organic matter in water, it might be degradable or it could change form for phytoplankton usage. It might increase abundance of phytoplankton. Potassium in water is soluble ion that relates to other ions especially bicarbonate. It would cause change on abundance of plankton. BOD values have direct effect on abundance of plankton. If BOD values are high, it shows that there is high soluble organic matter. Some of soluble organic matter may be nutrient element for growth of phytoplankton.

It can be concluded that if SS, potassium and BOD values change, it would result in change in abundance of phytoplankton and zooplankton in water and also consequent effect on abundance of grand total plankton in water source. The details are presented in Table 36 and Figure 37.

Table 35. The water quality analysis results to be substituted in grand total plankton model.

Station	SS	Total-P	K	Nitrate	BOD
1	7.3	0.05	4.2	0.05	5.65
2	5.0	0.03	3.7	0.05	1.80
3	5.0	0.04	3.1	0.06	1.88
4	7.3	0.04	2.7	0.06	3.74
Range of Data*	1.70-87.80	0.002-0.102	0.18-4.60	0.03-0.406	0.10-7.20
Unit	mg/l	mg/l	mg/l	mg/l	mg/l

Notes Station 1 = Southern part of Lam Ta Khong reservoir.

Station 2 = Western part of Lam Ta Khong reservoir.

Station 3 = Northern part of Lam Ta Khong reservoir.

Station 4 = Eastern part of Lam Ta Khong reservoir.

* = All of data on water quality for fittest model analysis (lower limit-upper limit).

Table 36. Comparison between observed values and expected values of grand total plankton.

Station	Observed values (cell/m^3 of water)	Expected values (cell/m^3 of water)
1	207,548,900.00	729,714,540.14
2	82,114,200.00	285,134,652.20
3	67,584,000.00	185,212,374.67
4	243,951,400.00	233,164,806.84

Notes Station 1 = Southern part of Lam Ta Khong reservoir.

Station 2 = Western part of Lam Ta Khong reservoir.

Station 3 = Northern part of Lam Ta Khong reservoir.

Station 4 = Eastern part of Lam Ta Khong reservoir.

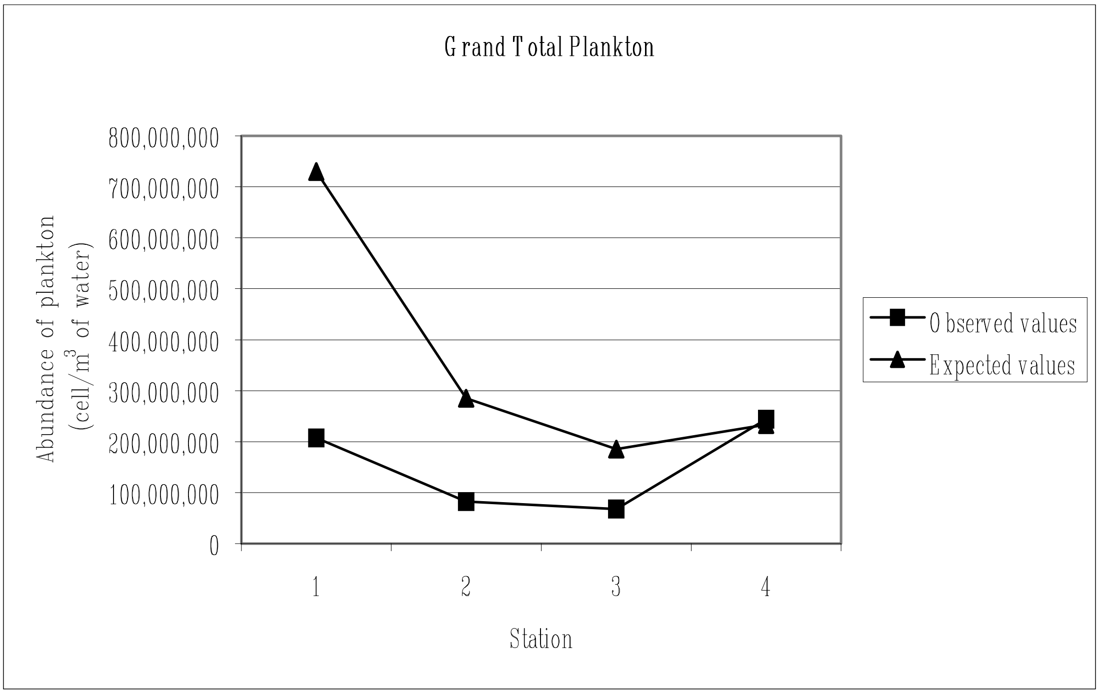

Figure 37. Comparison between observed values and expected values of grand total plankton.

4.6 Database System of Water Quality and Plankton in Reservoirs of Thailand

4.6.1 Structure of Database System

The structure of database system comprises 4 pages as follows:

First Page: Stations: a form containing data regarding stations where samples are collected.

Fields under stations are:

- **Station Number:** code number of sampling station.
- **Station Name:** sampling station's name.
- **Location:** location of sampling station such as sub-district, district, province.

Second Page: Data Sources: a form containing data regarding source of information, It could be primary source or secondary source.

Fields under Data Source are:-

- **Data Source Number:** code number of data source.
- **Source Type:** type of source such as primary source from field survey and secondary source from data collection.
- **Source Name:** detail name of the data source such as report title, name of the project, station name and place.
- **Source Date:** report date.
- **Owner:** data source owner such as personal, department, government organization, private agency.
- **Sample Date:** collecting sample date.

Third Page: Plankton Species: a form containing data regarding plankton species of information.

Fields under plankton species are:-

- **Plankton Number:** code number of plankton species.
- **Phylum:** a phylum of entering plankton species.
- **Genus:** identify genus name
- **Species:** identify species name
- **Gender:** identify name follow to International Code of Botanical Nomenclature (ICBN) and International Code of Zoological Nomenclature (ICZN).
- **Species Quantity:** abundance of plankton species
- **Station Number:** code number of sampling station (as same as station number from the "Station Page".
- **Picture Main:** main microscopic picture of plankton species.
- **Picture 1:** other microscopic picture from different angels, different lens and different viewing point.

Forth Page: Water Quality: a form containing data regarding water quality in 3 categories, Physical, Biological, and Chemical properties.

Fields under Data Source are:-

- **Water Quality Number:** code number of water quality.
- **Water Data Set Number:** code number of water quality set. A water quality data set consists of 3 properties such as:

(1) Physical Properties i.e. air temperature, water temperature, transparency and depth of water.

(2) Biological Properties i.e. chlorophyll a

(3) Chemical Properties i.e. pH, turbidity, conductivity, dissolved oxygen, total solid, total dissolved solid, suspended solid, total hardness, chloride, acidity, alkalinity, nitrate-nitrogen, nitrite-nitrogen, organic-nitrogen, total nitrogen, ammonia-nitrogen, sulfate, total phosphate, biochemical oxygen demand, chemical oxygen demand, oil & grease, calcium, magnesium, sodium and potassium.

4.6.2 Schematic Diagram of Database System Structure

The structure of database system comprises 2 main components as database data on system and searching system in database system. The schematic diagram of database system structure is presented in Figure 38.

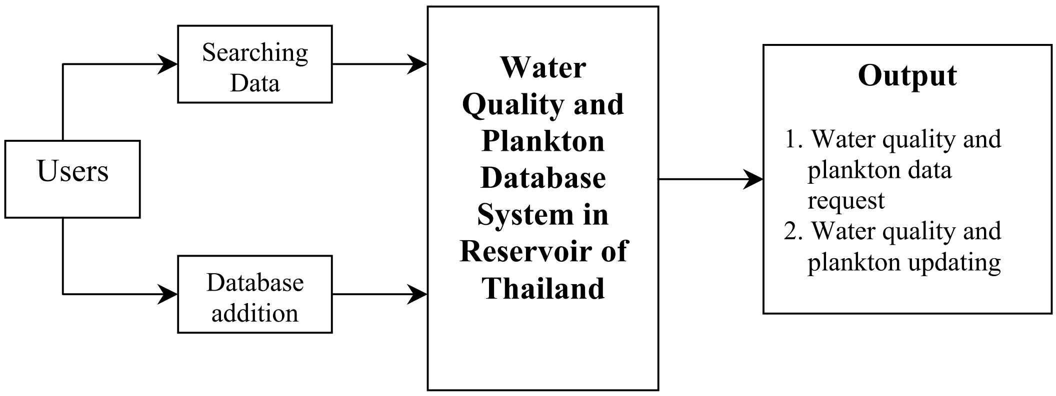

Figure 38. Schematic diagram of water quality and plankton database system.

4.6.3 Water Quality and Plankton Database Program

4.6.3.1 Operation Program

Water Quality and Plankton Database Program is a Database Management System (DBMS) which is Microsoft Access type. This program has to be operated on Microsoft office system, which is generally used in Thailand. Then, this program is easy and suitable to use for user in term of program installation and database system operation. However, user should study Water Quality and Plankton

Manual prior to program operation. The Water Quality and Plankton Manual and Database are presented in Appendix F.

The operation program can be separated into 2 parts such as

1) Data searching part: This part has function to search water quality and plankton data. General user can retrieve data that is requested in addition user can edit or correct data in database system. The data searching can be categorized in 2 parts as follows:

- Water quality data searching by selecting parameter.
- Plankton data searching by selecting parameter.

2) Water Quality and Plankton Database Program is designed form for user to enter data, to improve and to correct operation system. The operation program can be categorized in 2 sections as follows:

- Data entering, improvement and correction of system in water quality data section
- Data entering, improvement and correction of system in plankton data section

4.6.3.2 Program Implementation

Water Quality and Plankton Database Program is a Microsoft Access that is operated on Microsoft Office System. When, program starts up implementation, it shows on monitor as Figure 39. The implementation steps are as follows:

Steps to Enter Data

1) Open the file “Water Quality & Plankton Database” and the program will kick off a switchboard.

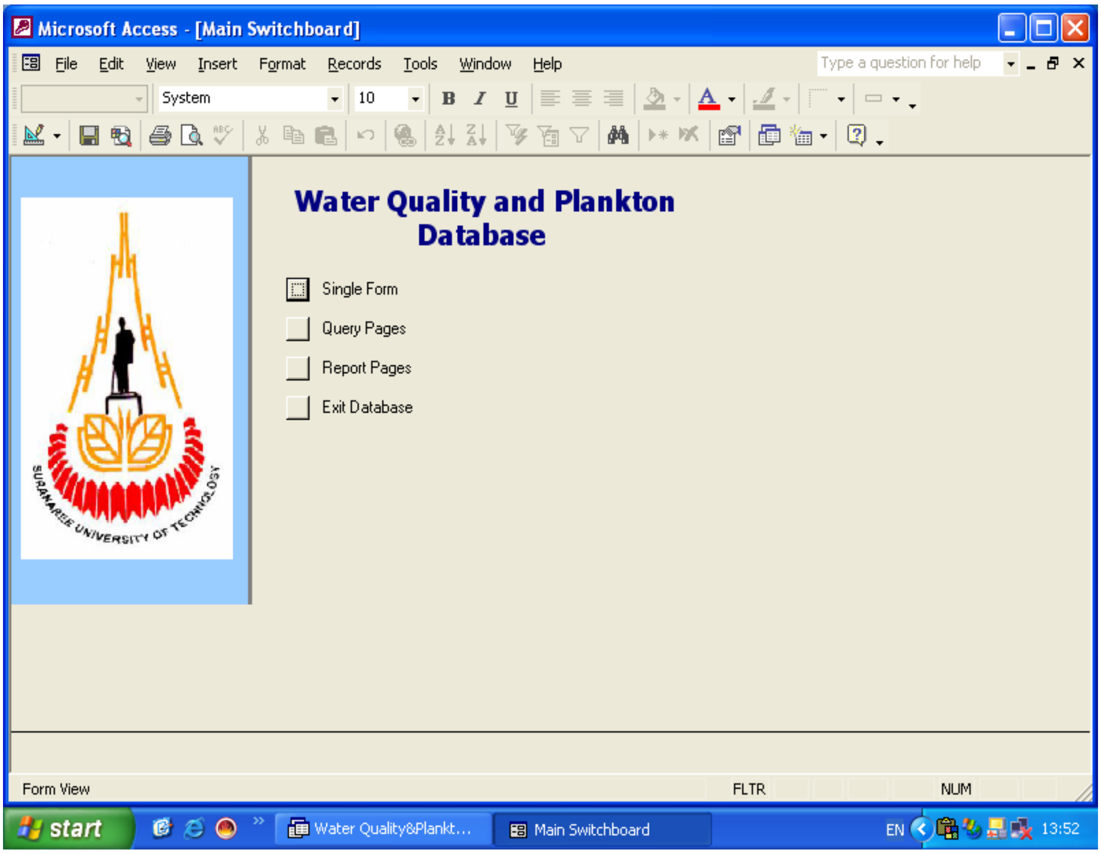

Figure 39. Main page of water quality and plankton database.

2) Click on main form button to enter data into different forms.

3) Next Step is to enter data into the following sheets in sequence.

a) First Page: Stations: a form collecting data regarding stations where samples are collected. This page shows on monitor as Figure 40.

Fields under stations are:

- Station No.: can either be text or number, range is from 1 digit to 10 digits.

- Station Name: State station's name.

- Station Location: enter brief location of the station.

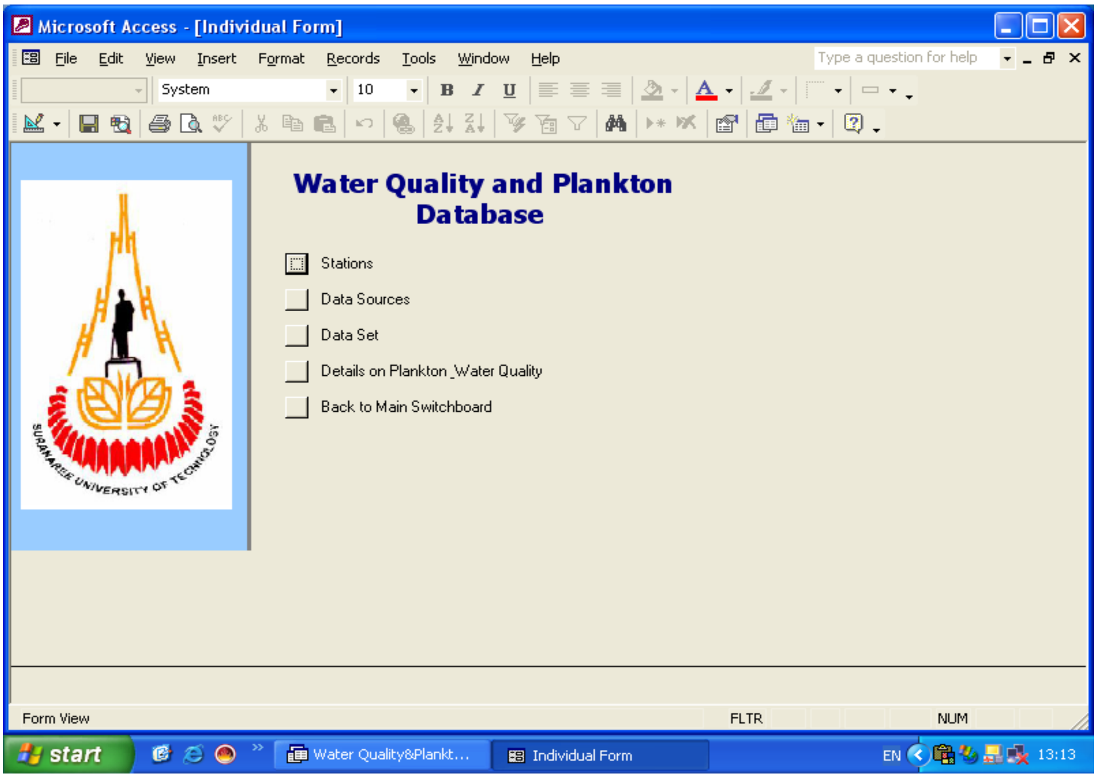

Figure 40. First page of water quality and plankton database.

b) Second Page: Data Sources: a form collecting data regarding source of information, It could be from primary source or secondary source. This page shows on monitor as Figure 41.

Fields under Data Source are:

- Data Source No.: Text or number range from 1 to 10 degits.

- Source Type: Primary or secondary (select from provided list).

- Source Name: Identify name of the data source. In case of secondary source, it would be a report title. In case of primary source, it could be the name of the project/ stations/place.

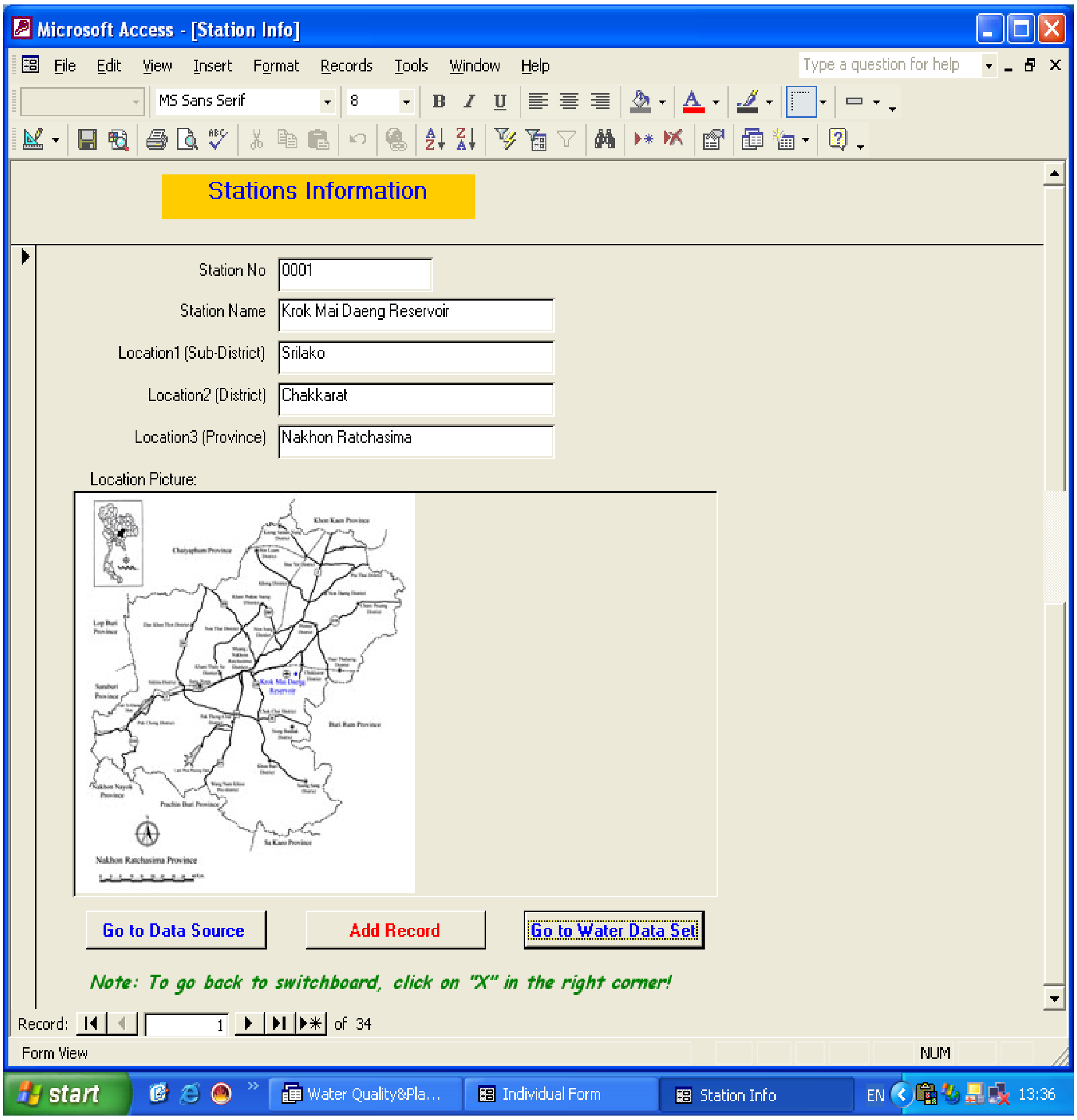

Figure 41. Second page of water quality and plankton database.

- Source Date: Date of data source. It could be report date or the date collecting sample
- Owner: Owner of the data source, personal or department
- Sample Date: Date collecting sample

c) Third Page: Plankton Species: a form collecting data regarding plankton species of information. This page shows on monitor as Figure 42. Fields under plankton species are:

- Plankton No.: Text or number range from 1 to 10 degits.
- Phylum: A phylum of entering species. List is provided but if it does not belong to any of the list, type in the name.
- Species Name: Identify species name
- Station No.: Type in the station number from the "Station Page"
- Picture Main: Main microscopic picture of species found
- Picture 1: other microscopic picture from different angels, different lens and different viewing point.

d) Forth Page: Water Quality: a form collecting data regarding water quality in 3 categories, physical, biological, and chemical properties. This page shows on monitor as Figure 43.

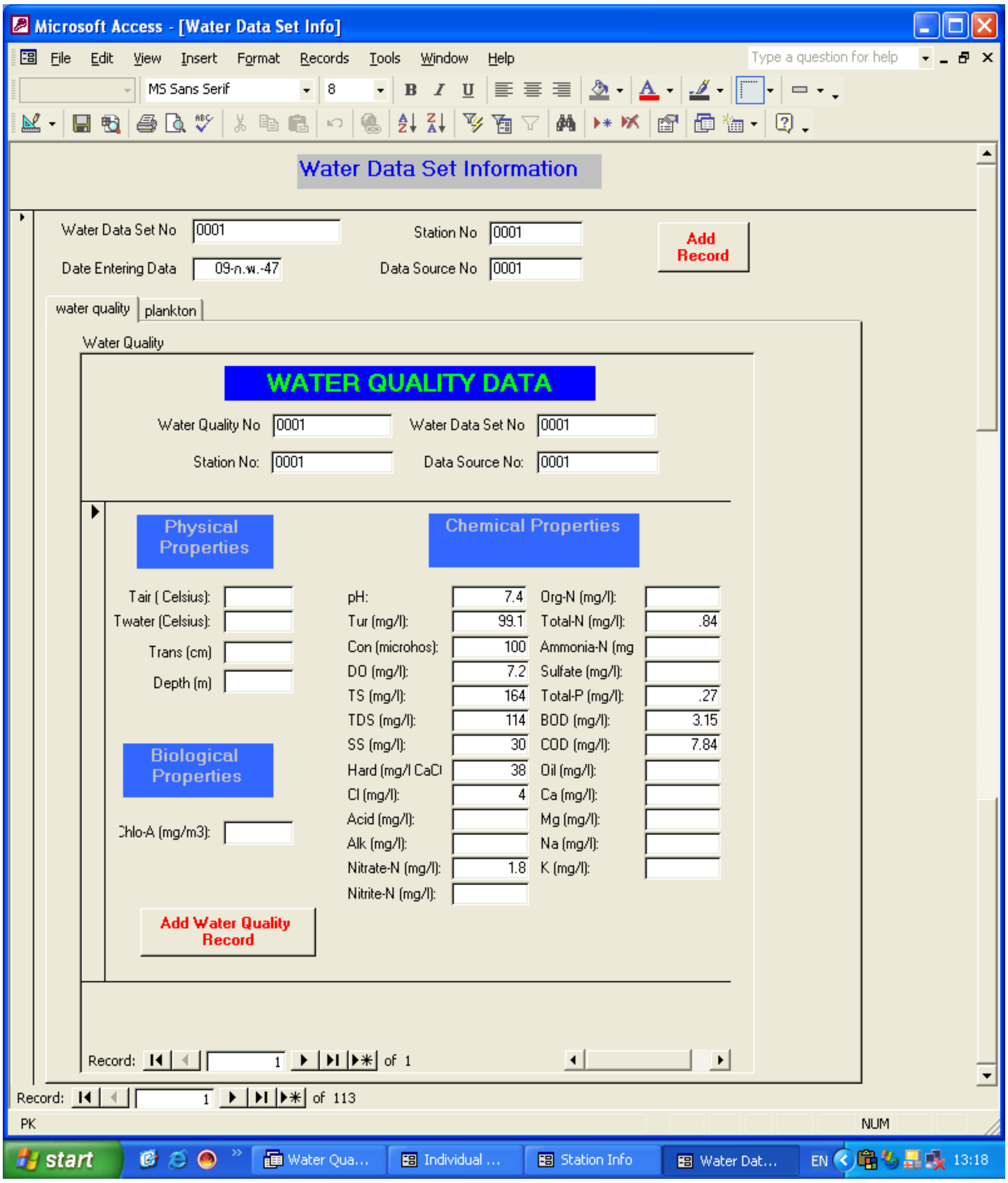

Figure 42. Third page of water quality and plankton database.

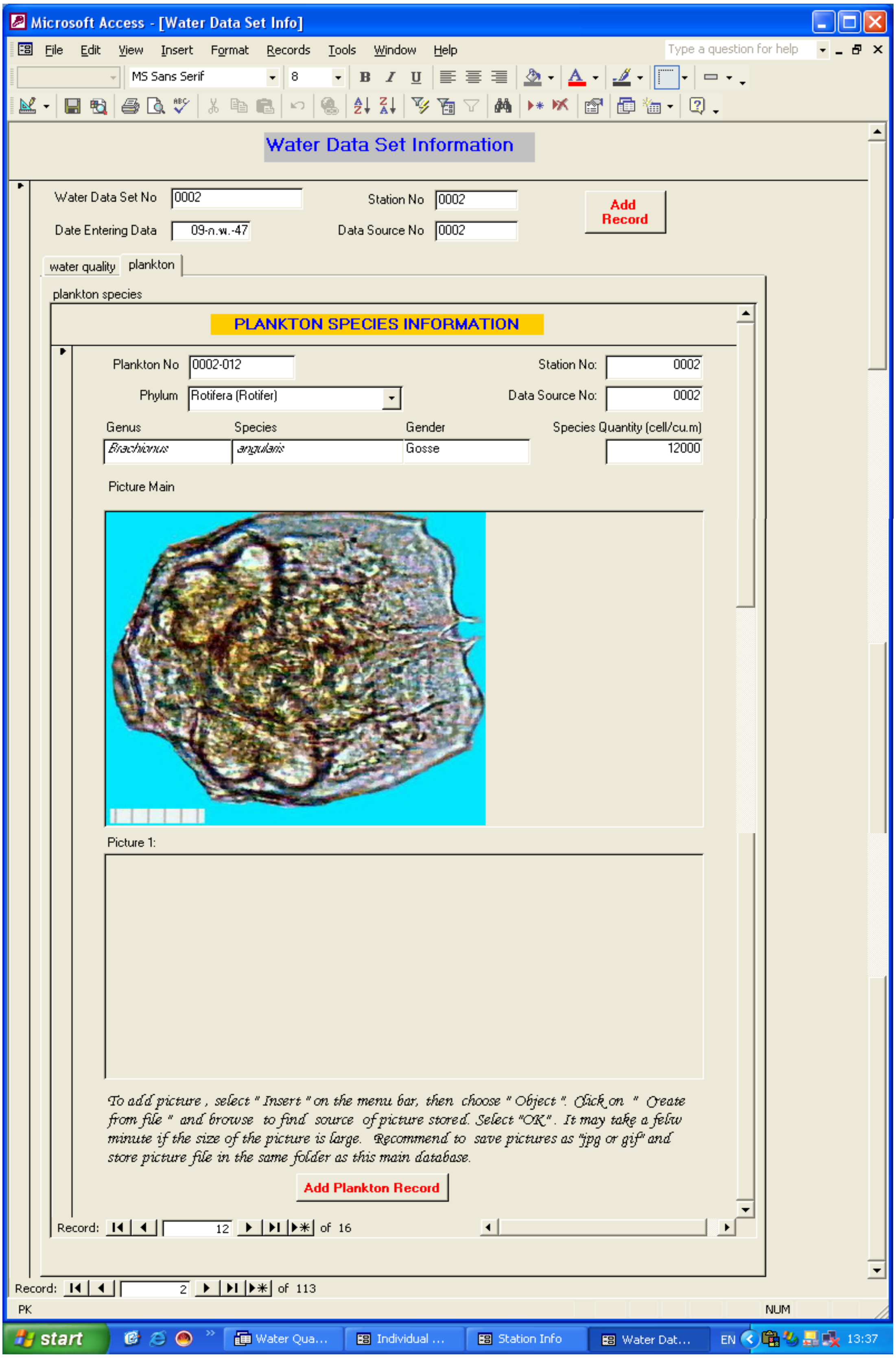

Figure 43. Forth page of water quality and plankton database.

Fields under Data Source are:

– Water Quality No.: Text or number range from 1 to 10 digits.

– Water Data Set No.: Text or number range from 1 to 10 digits.

The data use here should reflect the number from the top page.

- **Physical properties:**

  Tair = Air temperature in Celsius

  Twater = Water temperature in Celsius

  Trans = Transparency of water in centimeter

  Depth = Depth of water in meter

- **Biological properties:**

  Ch-A = Chlorophyll a in mg/cubic meter of water

- **Chemical properties:**

  pH = pH

  Tur = Turbidity in mg/l

  Con = Conductivity in microhos/centimeter

  DO = Dissolved oxygen in mg/l

  TS = Total solid in mg/l

  TDS = Total dissolved solid in mg/l

  SS = Suspended solid in mg/l

  Hard = Total hardness in mg/l as $CaCO_3$

  Cl = Chloride in mg/l

Acid	=	Total acidity in mg/l
Alk	=	Total alkalinity in mg/l
NO_3-N	=	Nitrate-nitrogen in mg/l
NO_2-N	=	Nitrite-nitrogen in mg/l
Org-N	=	Organic-nitrogen in mg/l
Total-N	=	Total nitrogen in mg/l
NH_3-N	=	Ammonia-nitrogen in mg/l
Sulfate	=	Sulfate in mg/l
Total-P	=	Total phosphate in mg/l
BOD	=	Biochemical oxygen demand in mg/l
COD	=	Chemical oxygen demand in mg/l
Oil	=	Oil & grease in mg/l
Ca	=	Calcium in mg/l
Mg	=	Magnesium in mg/l
Na	=	Sodium in mg/l
K	=	Potassium in mg/l

4.6.3.3 Testing Program

After water quality and plankton data were completely entered to database system, it was tested to find out bug and problem, then correct, debug. It was found that it was complete to work. When program was tested by plankton expert from Fishery Department. It was found that some plankton species names were incorrect but database program could be operated according to command order. However, user has to study steps to use program before database use or implementation. The incorrect plankton species names were immediately corrected after expert comment.

Chapter V

Conclusion

5.1 Conclusion

5.1.1 Summary of data collection and analysis

This objective research comprises to study relationships between water quality and plankton in reservoirs of Thailand, study appropriate model for reservoirs in Thailand, set up database system of water quality and plankton in reservoirs of Thailand, and analyze trend of water quality change from group of plankton in reservoirs of Thailand. The study complied data on water quality and plankton of stagnant water resource. The data were collected in the same time and were selected from related document and reports such as EIA, research paper, etc. These were analyzed relationships between water quality and plankton and determined fittest model of each plankton phylum. In addition, the investigation on surface water quality and plankton were carried out on October 27, 2003 within Lam Ta Khong reservoir. The field survey data were analyzed and compared between abundance of plankton from laboratory analysis and abundance of plankton from substitute water quality values in fittest model.

One hundred and nine data on water quality and plankton of stagnant water resources were selected from EIA reports and related reports. The data on water quality consisted of 29 parameters as water temperature, pH, transparency, depth of water, turbidity, conductivity, dissolved oxygen, total solid, total dissolved solid, suspended solid, total hardness, chloride, acidity, alkalinity, nitrate-nitrogen, nitrite-nitrogen, organic-nitrogen, total nitrogen, ammonia-nitrogen, sulfate, phosphate, BOD, COD, oil & grease, calcium, magnesium, sodium, potassium and chlorophyll a. The data on plankton comprised abundance of plankton and number of plankton species in each phylum. There were totally 14 phyla of plankton comprising Cyanophyta (blue-green algae), Chlorophyta (green algae), Bacillariophyta (diatom), Chrysophyta (yellow-brown algae), Pyrrophyta (dinoflagellate), and Euglenophyta (euglenoids) in phytoplankon and Protozoa (protozoans), Rotifera (rotifers), Arthropoda (arthropods), Annelida (segmented worms) Nematoda (nematods), Chordata (chordates), Mollusca (mollusks), and Coelenterata (cnidaria) in zooplankton including total phytoplankton, total zooplankton and grand total plankton species and abundance. Six hundred and thirteen plankton species were collected. They consisted of 388 of phytoplankton species in phyla Cyanophyta 67 species, Chlorophyta 179 species, Bacillariophyta 97 species, Chrysophyta 8 species, Pyrrophyta 10 species, and Euglenophyta 27 species, and in addition, 225 of zooplankton species in phyla Protozoa 47 species, Rotifera 112 species, Arthropoda 57 species, Annelida 2 species, Nematoda 1 species, Chordata 2 species, Mollusca 3 species, and Coelenterata 1 species. Basic statistics of data were studied and analyzed in each water quality and plankton parameters. It found that most of water quality and plankton data are of quite low values.

The study on relationships and correlation of water quality and plankton comprise 2 aspects as correlation between water quality and abundance of plankton and correlation between water quality and number of plankton species. The correlation between 29 parameters of water quality and abundance of plankton in each of 14 phyla including total phytoplankton, total zooplankton and grand total plankton were studied. The relationship was analyzed with confidential level of 95%. The result of study can be concluded that the results of study on relationships and correlation of water quality and abundance and number of plankton are vary depending on each water quality parameter and plankton phylum.

One hundred and nine data of water quality and plankton were analyzed relationships between water quality values and abundance of plankton by regression analysis method. It found that there were 13 fittest models such as phyla Cyanophyta, Chlorophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, and Euglenophyta in phytoplankon and phyla Protozoa, Rotifera, Arthropoda, Annelida, Nematoda, Chordata, Mollusca, and Coelenterata in zooplankton including total phytoplankton, total zooplankton and grand total plankton. The 29 parameters of water quality were related to abundance of plankton such as water temperature, pH, transparency, depth of water, turbidity, conductivity, dissolved oxygen, total solid, total dissolved solid, suspended solid, total hardness, chloride, acidity, alkalinity, nitrate-nitrogen, nitrite-nitrogen, organic-nitrogen, total nitrogen, ammonia-nitrogen, sulfate, phosphate, BOD, COD, oil & grease, calcium, magnesium, sodium, potassium and chlorophyll a. The coefficient of determination (R^2) of each model ranges between 0.65-0.90.

The investigation on surface water quality and plankton organisms in Lam Ta Khong reservoir were undertaken on October 27, 2003 at 4 sampling stations comprising southern part of reservoir, western part of reservoir, northern part of reservoir and eastern part of reservoir. The result of water quality analysis found that water temperature was range 26.0-28.0 degree Celsius. Transparency was range 63-93 centimeters, pH was range 8.6-8.9, DO was range 6.87-10.47 mg/liter. TS was range 152-188 mg/liter. TDS was range 116-166 mg/liter. SS was range 5.0-7.3 mg/liter. BOD was range 1.80-5.65 mg/liter and chlorophyll a was 20.3-35.3 mg/m^3. The water quality properties were not different of each station. It can be conclude that water quality properties were normal condition of surface water. The result of the analysis of plankton found phytoplankton 5 phyla of Cyanophyta, Chlorophyta, Bacillariophyta, Pyrrophyta, and Euglenophyta and zooplankton 3 phyla of Arthropoda, Rotifera, and Protozoa. The plankton species were found 44-49 species of phytoplankton and 15-33 species of zooplankton. The abundance of plankton was range 67,584,000-243,951,400 cells/m^3 of water comprising 65,808,000-234,964,800 cells of phytoplankton/m^3 of water and 1,636,600-8,986,600 cells of zooplankton/m^3 of water. The dominant species was *Oscillatoria* sp. in phylum Cyanophyta.

5.1.2 Fittest model analysis

5.1.2.1 Fittest model results

In summary, it can be concluded that 109 set of water quality and plankton data compiled can be analyzed in term of 13 fittest models as follows:

1) Phylum Cyanophyta

log (abundance of plankton in phylum Cyanophyta) = 3.24 - 0.0261 SS + 0.00545 Conductivity + 0.329 pH + 0.0657 BOD; R^2 = 0.84

2) Phylum Chlorophyta

log (abundance of plankton in phylum Chlorophyta) = 5.15 + 0.221 BOD + 0.0309 SS + 0.0294 Chlorophyll a; R^2 = 0.65

3) Phylum Bacillariophyta

Abundance of plankton in phylum Bacillariophyta = 1430806 + 4962488 Mg -59688206 Nitrate + 100235 Transparency + 335173 SS - 323408 Na - 1.71E+08 Total phosphate - 1513485 BOD; R^2 = 0.84

4) Phylum Chrysophyta

log (abundance of plankton in phylum Chrysophyta+100) = -1.35 + 0.0875 Chlorophyll a + 0.0173 TDS + 0.00978 Conductivity - 0.117 BOD; R^2 = 0.71

5) Phylum Pyrrophyta

ln (abundance of plankton in phylum Pyrrophyta+100) = -3.18 - 0.155 SS + 0.310 Water temperature + 0.0243 TDS; R^2 = 0.90

6) Phylum Euglenophyta

log (abundance of plankton in phylum Euglenophyta+100) = -17.6 + 0.0751 Total hardness + 0.530 Water temperature - 0.124 Ca - 0.139 BOD; R^2 = 0.81

7) Phylum Protozoa

Abundance of plankton in phylum Protozoa = -920194 - 1413 Transparency - 241000 Organic nitrogen + 1754 Alkalinity + 57484 DO + 1895 Conductivity + 585738 Nitrate; R^2 = 0.75

8) Phylum Rotifera

ln (abundance of plankton in phylum Rotifera) = 11.0 - 0.444 Total nitrogen + 0.217 BOD + 0.0732 Water temperature; R^2 = 0.66

9) Phylum Arthropoda

ln (abundance of plankton in phylum Arthropoda) = 8.38 + 0.215 BOD - 0.0378 SS - 0.00834 Transparency - 0.0367 Depth of water + 0.613 pH - 0.216 Total nitrogen; $R^2 = 0.71$

10) Phylum Chordata

log (abundance of plankton in phylum Chordata+100) = 4.43 + 0.244 BOD + 0.0756 Chlorophyll a - 0.169 Water temperature + 0.189 DO - 0.00790 Na; $R^2 = 0.76$

11) Total phytoplankton

log (abundance of total phytoplankton) = 7.76 - 0.0125 SS + 0.140 BOD - 3.54 Nitrate + 0.182 K; $R^2 = 0.82$

12) Total zooplankton

log (abundance of total zooplankton) = 5.15 - 0.0134 SS + 0.0635 BOD + 0.00222 Conductivity + 0.0684 DO - 0.121 Total nitrogen - 0.00247 Transparency; $R^2 = 0.74$

13) Grand total plankton

log (abundance of grand total plankton) = 7.86 - 0.00989 SS - 4.44 Total phosphate + 0.200 K - 3.17 Nitrate + 0.109 BOD; $R^2 = 0.79$

Nevertheless, phylum Annelida, phylum Nematoda, phylum Mollusca, and phylum Coelenterata cannot be analyzed for regression because data on abundance of plankton in each phylum analyzed are mostly zero values.

Then, it can be concluded that all of water quality parameters in the 13 fittest models from water quality and plankton regression analysis can be used to preliminarily estimate abundance of plankton in stagnant water.

5.1.2.2 Fittest model and their limitation

The accuracy of 13 fittest models for abundance of plankton organism estimation is tested by comparing between abundance of plankton organism from substitution of water quality in fittest model and abundance of plankton organism from laboratory analysis in 4 stations. It can be concluded that 7 fittest models namely fittest model of phylum Chlorophyta, phylum Chrysophyta, phylum Rotifera, phylum Arthropoda, phylum Chordata, total phytoplankton and fittest model of total zooplankton can be used for estimating abundance of plankton organism. Each fittest model has limitation on water quality parameters as follows:

1) Phylum Chlorophyta

log (abundance of plankton in phylum Chlorophyta) = 5.15 + 0.221 BOD + 0.0309 SS + 0.0294 Chlorophyll a

Limitations: BOD values must be in the range of 0.10-7.20 mg/l.

SS values must range between 1.70-51.80 mg/l.

Chlorophyll a values must be in the range of 3.42-24.64 mg/m^3 of water.

2) Phylum Chrysophyta

log (abundance of plankton in phylum Chrysophyta+100) = -1.35 + 0.0173 TDS - 0.0875 Chlorophyll a + 0.00978 Conductivity - 0.117 BOD

Limitations: TDS values must range between 110-312 mg/l.

Chlorophyll a values must be in the range 1.71-24.64 mg/m^3 of water.

Conductivity values must range between 192-401 microhos/cm.

BOD values must be in the range of 0.10-7.20 mg/l.

3) Phylum Rotifera

ln (abundance of plankton in phylum Rotifera) = 11.0 - 0.444 Total nitrogen + 0.217 BOD + 0.0732 Water temperature

Limitations: Total nitrogen values must range between 0.1-3.6 mg/l.

BOD values must range between 0.1-7.2 mg/l.

Water temperature values must be in the range of 25.0-31.80 Celsius.

4) Phylum Arthropoda

ln (abundance of plankton in phylum Arthropoda) = 8.38 + 0.215 BOD - 0.0378 SS - 0.00834 Transparency - 0.0367 Depth of water + 0.613 pH - 0.216 Total nitrogen

Limitations: BOD values must range between 0.10-7.20 mg/l.

SS values must range between 1.7-87.8 mg/l.

Transparency values must range between 10-220 cm.

Depth of water values must be in the range of 0.8-20.5 m.

pH values must range between 7.25-9.2.

Total nitrogen values must range between 0.1-3.6 mg/l.

5) Phylum Chordata

log (abundance of plankton in phylum Chordata+100) = 4.43 + 0.244 BOD + 0.0756 Chlorophyll a - 0.169 Water temperature + 0.189 DO - 0.00790 Na

Limitations: BOD values must be in the range of 0.1-7.2 mg/l.

Chlorophyll a values must in the range 1.71-24.64 mg/m^3 of water.

Water temperature values must be in the range of 25.0-31.8 Celsius.

DO values must range between 4.0-11.6 mg/l.

Na values must range between 2.54-128.50 mg/l.

6) Total phytoplankton

log (abundance of total phytoplankton) = 7.76 - 0.0125 SS + 0.140 BOD - 3.54 Nitrate + 0.182 K

Limitations: SS values must be in the range of 1.7-87.8 mg/l.

BOD values must be in the range of 0.1-7.2 mg/l.

Nitrate values must range between 0.03-0.406 mg/l.

K values must range between 0.18-4.60 mg/l.

7) Total zooplankton

log (abundance of total zooplankton) = 5.15 - 0.0134 SS + 0.0635 BOD + 0.00222 Conductivity + 0.0684 DO - 0.121 Total nitrogen - 0.00247 Transparency

Limitations: SS values must be in the range of 1.7-87.8 mg/l.

BOD values must range between 0.1-7.2 mg/l.

Conductivity values must be range between 192-401 microhos/cm.

DO values must range between 4.0-11.6 mg/l.

Total nitrogen values must be in the range of 0.1-3.6 mg/l.

Transparency values must range between 10-220 cm.

When consideration on 7 fittest models, It is found that there are total 14 water quality parameters namely BOD, SS, chlorophyll a, TDS, conductivity, total nitrogen, water temperature, transparency, depth of water, pH , sodium, nitrate-nitrogen, potassium and DO. The BOD is important parameter which is found in all fittest models. The next water quality parameters often found in fittest model are such as SS, chlorophyll a, total nitrogen, conductivity, water temperature, transparency and DO respectively. Then, the next research topic about relationship between water quality and plankton, the researcher should concentrate on these water quality parameter especially BOD, SS, chlorophyll a and total nitrogen.

The 6 remaining fittest models are namely fittest model of phylum Cyanophyta, phylum Bacillariophyta, phylum Pyrrophyta, phylum Euglenophyta, phylum Protozoa and fittest model of grand total plankton. Though, most of water quality parameters of fittest model are within the range of data for fittest model analysis, the estimated abundance of plankton organism from substitution in fittest model are not close to abundance of plankton organism from laboratory analysis due to the following reasons:

1) The comparison of the abundance of plankton resulted from substitution in fittest model and abundance of plankton from laboratory analysis result are based on only 4 samples which are a few data for analysis. There might be error during data collection, data analysis, etc. The error would affect analysis results. It means that the abundance of plankton from substitution in fittest model are not close to abundance of plankton from laboratory analysis result. Both of values might become close together if more samples are collected.

2) The fittest models from regression analysis are preliminarily forecasted or estimated abundance of plankton from some factors (water quality parameters). From water quality and plankton data, the regression analysis methodology is appropriate for fittest model. If it is needed to check and test accuracy of fittest model, it is necessary to prepare work plan and systematic research design including sample data collection for specific variable test. In addition, it is needed to minimize error from other factors and to collect enough data for fittest model analysis and to check accuracy of model.

Therefore, it can be concluded that from 13 fittest models from water quality and plankton regression analysis, only 7 fittest models can be used to estimate abundance of plankton organism in stagnant water source. The 6 remaining fittest models need more water quality data to support for more accuracy of abundance of plankton organism analysis in the fittest model.

5.1.3 Summary of Water Quality and Plankton in Reservoir of Thailand Database System

Database system of water quality and plankton in reservoir of Thailand was constructed by Microsoft Access. The database system can effectively compile water quality and plankton data of reservoirs. It has many benefit to user e.g. it can be used for preparation of environmental mitigation plan and development plan to solve environmental problem. Nevertheless, it is a initial point to systematically collect water quality and plankton data which would be high benefit to water quality and plankton data use in the future. However, water quality and plankton database system is a guideline system for related organization that is initially use database management program to systematically collect related data for high efficiency.

5.2 Research Limitation

This research has limitation on water quality and plankton data in reservoir because it is needed to analyze for relationship among compiled data. Then, the water quality and plankton data had to be collected in the same time from stagnant water as pond, lake, reservoir, etc. The collected data are not large in number. In addition, water quality parameters had been differently analyzed to suit each project development. Thus, water quality parameters of samples collected were different. Therefore, in relationship analysis some of collected data had to be deleted. Moreover, some of plankton data could not be identified by species especially plankton data in the first sets. For field survey, the plankton data collection did not have systematic records of photo of plankton species. This caused problem for collection of data for plankton database. Species of plankton have to be identified by plankton expert who has experience and expertise in plankton identification. This makes plankton data be limited only within plankton researcher group. However, if water quality and plankton researchers widely use this database model to collect more water quality and plankton database in reservoirs of Thailand, there would be adequate water quality and plankton data in reservoirs of Thailand to be analyzed for different type of relationship and to set up water quality and plankton modeling in reservoirs of Thailand.

5.3 Research Application

The water quality and plankton relationship in reservoirs of Thailand study result is initial point of systematic collection of water quality and plankton and start point of using database system to manage data. It is convenient to use, to save and to retrieve data. The database system is a Microsoft Access, with 113 data of water quality and plankton in reservoirs of Thailand including water quality and plankton manual for user.

Moreover, this water quality and plankton database system in reservoirs of Thailand is initial point to develop systematic collection of other types of data including database system application to collect other data e.g. water quality data and plankton in sea water or rivers in Thailand, water quality data and benthos data, water quality data and fish or other aquatic life data, etc. Then, if the related data are systematically managed and if there are a lot of raw data, there would be more use and development of data in the future such as water quality and other collected data modeling, development project in appropriate area, etc. In addition, the water quality, plankton and other factors database system setting up on available source (Internet) by related organizations would make data collection of different organizations be in the same system, to reduce operation process, to share data for maximum benefits, and to reduce operation cost including to enhance cooperation in planning among related organizations for maximum benefit in data collection.

5.4 Suggestion and Recommendation for Further Research

The next research topic about relationships between water quality and plankton, the researcher should concentrate on these water quality parameter especially BOD, SS, chlorophyll a and total nitrogen.

The research on water quality data and plankton or other factors in reservoirs of Thailand should use database system for data management. It would be benefit in many aspects such as systematic data collection, complete data for user request, and application for other related data in the future, etc.

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Appendics

Appendix A

The Fittest Equation Selection

The Fittest Equation Selection

From literature review of ทัศนีย์ ชังเทศ และ สมภพ ถาวรยิ่ง (2537), ฉันทลักษณ์ ณ ป้อมเพชร, เยาวมาลย์ เมธาภิรักษ์ และ ศรีเพ็ญ ทรัพย์มนชัย (2537), ทรงศิริ แต้สมบัติ (2541), กัลยา วานิชย์บัญชา (2543), Townend (2002), and Johnson and Wichern (2002) it can be determined that method and step of fitted equation selection are as follows :

Step 1: Determine variable

Dependent variable is variable of which characteristic depends on other variable. In this research, dependent variable is abundance of plankton.

Independent variable is control variable which have effect on dependent variable. In this research, Independent variable is water quality parameters.

Step 2: To selected independent variable which has correlation with dependent variable by Stepwise Regression Procedure from statistic Program, this methodology is addition method for Forward Selection. This methodology will add each independent variable into regression equation and eliminate other independent variable into regression before new independent variable by Backward Elimination. The stepwise regression is based on principle that “Independent variable is selected into each steps of regression model and high reduce error from prediction process”. In the same way, it means that Independent variable or Independent variable set has the highest coefficient of regression (r^2) and it can be presented in terms of multi linear regression model as follows:

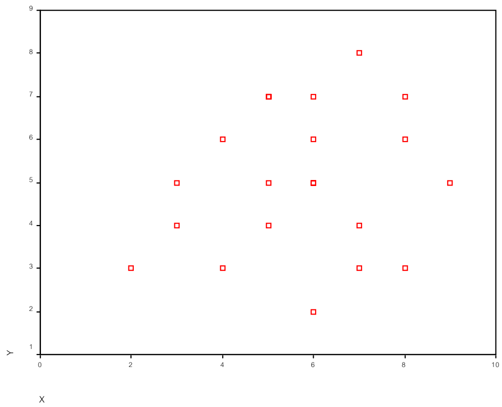
$$Y = \beta_0 + \beta_1 x_2 + \beta_2 x_2 + \ldots + \beta_p x_p + \varepsilon$$

Step 3: The regression analysis has many limit about analysis of data and determination of data has specific characteristics which bring to different confident analysis. Therefore, data which do not meet determination will be of low confidence. It means that summary of analysis may be error. Therefore, it is essential to concentrate on data that follow to assignment. Therefore, multiple linear regression model from step 2 would be used to test correlation between Dependent variable and Independent variable to follow requirements below:

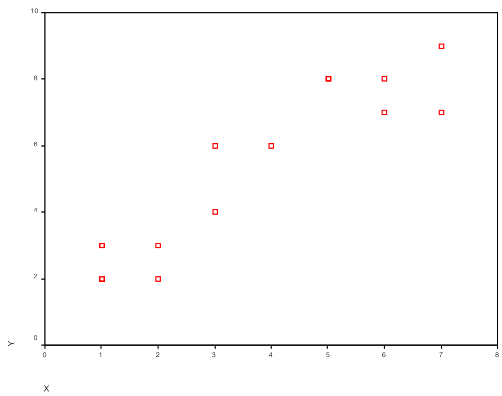
3.1 Error value(e_i) is of normality distribution curve, it considered from Normal Probability Plot (NPP) which plot graph between expected ordinary error $(E(e_i))$ and ordinary error i (e_i). When error value (e_i) has normal distribution and mean is equal to zero and standard deviation is equal to σ^2 and $e_1 \leq e_2 \leq \ldots \leq e_n$. If $(E(e_i), e_i)$ from graph plotted has correlation in linear line, it can be concluded that error value has normal distribution. But if it is not located within linear line, it can be concluded that error value does not have normal distribution or consider from error value histogram.

3.2 Error value must be independent from each other or error value is not autocorrelation. It can be considered as follows:

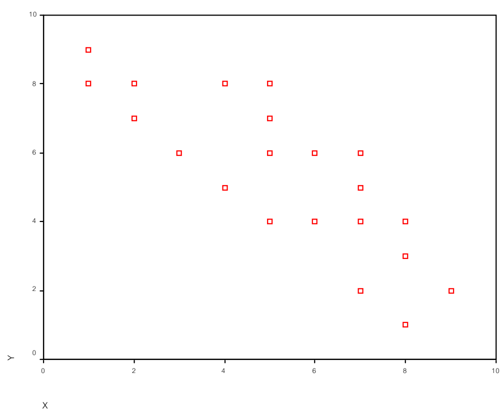
Procedure 1: Check graph plotted between e_i and independent X_i or estimate value $(\hat{Y}_i)$



No Autocorrelation means being independent from each other



Positive Autocorrelation means positive correlation



Positive Autocorrelation means positive correlation

Procedure 2: Durbin-Watson $(D-W)$ value is statistical test in condition as follows:

$H_0 : \rho = 0$ (error value is not autocorrelation)

$H_a : \rho \neq 0$ or $H_a : \rho > 0$ or $H_a : \rho < 0$

Calculation for $D-W$ value can be calculated from formula as follows

$$D-W = \frac{\sum_{i=2}^{n}(e_i - e_{i-1})^2}{\sum_{i=1}^{n} e_i^2}$$

$D-W$ value ranging between 0-4 and $D-W$ has approximate values $2(1-r)$ when r is continuous correlation coefficient of error value with one interval range. The formula is as follows:

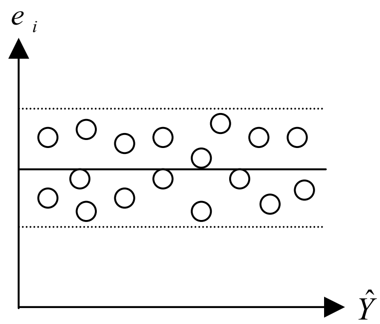
$$r = \frac{\sum_{i=2}^{n} e_i e_{i-1}}{\sum_{i=1}^{n} e_i^2}$$

Then, it is shown that $D-W$ value is close to 2 when $\rho = 0$ and close to 0 when $\rho = 1$. It can be concluded that $D-W$ value is close to 2, the data is autocorrelation. Then, autocorrelation data examination can be operated from $D-W$ value comparison in Table of Durbin-Watson as follows:

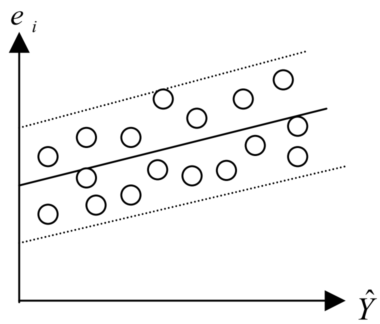
Hypothesis, H_a	**Crisis range**
$H_a : \rho \neq 0$	$D-W \leq D_L$ or $D-W \geq 4-D_L$ reject H_0 $D_U \leq D-W \leq 4-D_U$ acceptable H_0 $D_L < D-W < D_U$ or $4-D_U < D-W < 4-D_L$ can not determine
$H_a : \rho > 0$	$0 \leq D-W \leq D_L$ reject H_0 $D_U \leq D-W \leq 2$ acceptable H_0 $D_L < D-W < D_U$ can not determine
$H_a : \rho < 0$	$4-D_L \leq D-W \leq 4$ reject H_0 $2 \leq D-W \leq 4-D_u$ acceptable H_0 $4-D_U < D-W < 4-D_L$ can not determine

3.3 Zero Mean $E(e) = 0$

3.4 Variance of error is constant (Common Variance). When variance of e_i is not constant, it would be incorrect range estimation of parameter. In case $Var(e)$ is not constant value, it is called Heteroscedastic problem which can be considered from plotting graph $\hat{Y}$ and e_i .

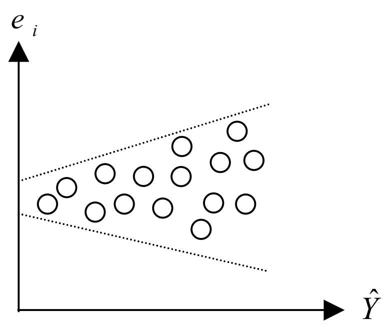


(A)

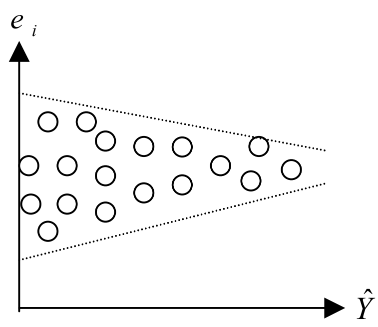


(B)

A and B $Var(e)$ constant



(C)



(D)

C and D $Var(e)$ do not constant (Heteroscedastic)

3.5 Examine if there is abnormal value (Outlier) in data by preliminary consideration of scatter graph or plotted graph of error value. If a data point in photo or graph is separated from group of data, the observation of Y may be outlier.

3.6 X_i and X_j Independent variables must be independent from each other. In case more independent variable, independent variable may have relation of multicollinearity pattern. The multicollinearity correlation can be examined by using 4 statistical values as follows:

Statistic value No.1: Tolerance of X_i variable is $1-R_i^2$. If tolerance of variable is of low value, it shows that X_i has high correlation with other independent variable because Tolerance of X_i = $1-R_i^2$. If tolerance of X_i variable is of low values, it presents that R_i^2 is high value and R_i^2 is coefficient of determination which shows correlation between X_i and high value of other $X's$, or other $X's$ can explain more about X_i change. It means X_i has high correlation with other $X's$. It can be concluded that if tolerance value is close to zero, it shows that independent variable X_i has high correlation with other independent variables $(X_1, X_2, ..., X_k)$. It is multicollinearity event which is conflict to multi regression analysis.

Statistic value No.2: Variance Inflation Factor: VIF

$$VIF \text{ of independent variable } X_i = VIF_i = \frac{1}{1-R_i^2}$$

If VIF is high value, it shows that X_i independent variable has high correlation with other independent variables.

Statistic value No.3: Eigenvalue, addition result of eigenvalue must be equal to k+1, while k is equal to number of independent variable. If eigenvalue is close to zero, it shows that independent variable has correlation with other independent variables.

Statistic value No.4: Condition Index, if it is high value such as more than 20, it shows that this independent variable has high correlation with other independent variables.

When data is out of requirement, there must be corrective action as follows:

1) when abnormal value is found from topic 3.5, corrective method may be finding out cause and considering if this value is reasonable. If it is too high value or too low value due to data collection error, this data must be cut off but if it is actual value, it must be taken into analysis process.

2) in case of e_{i1} has autocorrelation (topic 3.2) form of variables must be changed Y as follow:

$$Y' = \ln(Y); \qquad Y > 0$$

3) if Var (e)) increases value when y increases, distribution of e_{i1} will be right skew. Y must be changed.

$$Y' = \log(Y); \qquad Y > 0$$

4) if Var (e) is in proportion to expected Y, increase distribution of $e_{i\,1}$ will be left skew. Y must be changed.

$$Y' = Y^2$$

5) if e_I is in proportion to with expected y. Y must be changed.

$$Y' = \sqrt{Y}; \qquad Y > 0$$

6) if Var (e) increases when Y increases with a condition Y must be changed.

$$Y' = \frac{1}{Y}$$

7) Multicollinearity has 6 corrective action methods as follows:

a) Nothing: there may be not high correlation or analysis person may be interested in regression equation for prediction or forecasting. It focus on high R^2 value for prediction.

b) Additional data collection (if possible): Try to find out another independent variable that don't have correlation with other independent variable. If it is impossiable another data should be found out to add sample number. Thus, it can reduce expected variance coefficient of regression.

c) Select and fix one of (correlated) independent variable from regression equation, this method will result in a little reduction of R^2 value but prediction error will increase a little. It will result in passing examination of all coefficient of independent variable in regression equation.

d) Change unit of one of independent variable or two independent variable.

e) Correction by principle component.

f) Use Ridge Regression Analysis.

Appendix B

Source of Water Quality and Aquatic Ecology Data

Table 1B. Source of water quality and aquatic ecology data.

Data No.	Sampling Station Name	Sampling Date	Source of Data	Owner
1.	Krok Mai Daeng Reservoir, Chakkarat District, Nakhon Ratchasima Province.	September 17, 1993.	Final Report, Environmental Impact Assessment of Nakhon Ratchasima Airport Project. March, 1995. (Thai Version)	Department of Aviation (DOA), Ministry of Transport and Communications.
2.	Krok Mai Daeng Reservoir, Chakkarat District, Nakhon Ratchasima Province.	January 22, 1994.	Final Report, Environmental Impact Assessment of Nakhon Ratchasima Airport Project. March, 1995. (Thai Version)	DOA, Ministry of Transport and Communications.
3.	Nong Song Hong Reservoir, Chakkarat District, Nakhon Ratchasima Province.	September 17, 1993.	Final Report, Environmental Impact Assessment of Nakhon Ratchasima Airport Project. March, 1995. (Thai Version)	DOA, Ministry of Transport and Communications.
4.	Nong Song Hong Reservoir, Chakkarat District, Nakhon Ratchasima Province.	January 22, 1994.	Final Report, Environmental Impact Assessment of Nakhon Ratchasima Airport Project. March, 1995. (Thai Version)	DOA, Ministry of Transport and Communications.
5.	Bueng Tan Dieo (Pond), Kaeng Khoi District, Saraburi Province.	July 14, 1996.	Final Report, Environmental Impact Assessment of The SPP-Kaeng Khoi Cogeneration Project at Tambon Tan Dieo, Amphoe Kaeng Khoi, Changwat Saraburi. Main Report; July, 1997.	Gulf Cogeneration Company Limited.
6.	Bueng Bang Amphan (Pond), Bamnet Narong District, Chaiyaphum Province.	February15-16, 1996.	Final Report, Environmental Impact Assessment of The ASEAN Potash Mining Project, Amphoe Bamnet Narong, Changwat Chaiyaphum. Main Report; April, 1997.	ASEAN Potash Mining Company Limited.
7.	Bueng Thale (Pond), Bamnet Narong District, Chaiyaphum Province.	February15-16, 1996.	Final Report, Environmental Impact Assessment of The ASEAN Potash Mining Project, Amphoe Bamnet Narong, Changwat Chaiyaphum. Main Report; April, 1997.	ASEAN Potash Mining Company Limited.
8.	Sakaeo (Pond), Bamnet Narong District, Chaiyaphum Province.	February15-16, 1996.	Final Report, Environmental Impact Assessment of The ASEAN Potash Mining Project, Amphoe Bamnet Narong, Changwat Chaiyaphum. Main Report; April, 1997.	ASEAN Potash Mining Company Limited.
9.	Small Reservoir of EGAT, Nua Khlong Pre-district, Krabi Province.	January 20, 1996.	Final Report, Environmental Impact Assessment of Krabi Thermal Power Plant Project at Tambon Khlong Khanan, King Amphoe Nua Khlong, Changwat Krabi. Main Report; May. 1997.	EGAT.
10.	Small Reservoir of EGAT, Nua Khlong Pre-district, Krabi Province.	March 13-14, 1996.	Final Report, Environmental Impact Assessment of Krabi Thermal Power Plant Project at Tambon Khlong Khanan, King Amphoe Nua Khlong, Changwat Krabi. Main Report; May, 1997.	EGAT.

Table 1B. Source of water quality and aquatic ecology data. (continued)

Data No.	Sampling Station Name	Sampling Date	Source of Data	Owner
11.	Major Reservoir of EGAT, Nua Khlong Pre-district, Krabi Province.	March 13-14, 1996.	Final Report, Environmental Impact Assessment of Krabi Thermal Power Plant Project at Tambon Khlong Khanan, King Amphoe Nua Khlong, Changwat Krabi. Main Report; May, 1997.	EGAT.
12.	Nong Han Kumphawapi (Bueng Kumphawapi Reservoir), Kumphawapi District, Udon Thani Province.	September 28, 1996.	Final Report of Environmental Impact Assessment for the Somboon Potash Mine, Main Report; April, 1999.	ASIA PACIFIC POTASH CORP., LTD.
13.	Nong Nam Tan (Reservoir), Kumphawapi District, Udon Thani Province.	September 28, 1996.	Final Report of Environmental Impact Assessment for the Somboon Potash Mine, Main Report; April, 1999.	ASIA PACIFIC POTASH CORP., LTD.
14.	Nong Lat (Pond), Thawat Buri District, Roi Et Province.	December 1, 1994.	Final Report, Environmental Impact Assessment of Roi Et Airport Project, at Thawat Buri District, Roi Et Province. March, 1996. (Thai Version).	DOA, Ministry of Transport and Communications.
15.	Nong Hong (Pond), Thawat Buri District, Roi Et Province.	December 1, 1994.	Final Report, Environmental Impact Assessment of Roi Et Airport Project, at Thawat Buri District, Roi Et Province. March, 1996. (Thai Version)	DOA, Ministry of Transport and Communications.
16.	Thale Noi (Lake), Khwuan Khanun District, Patthalung Province.	September 25-29, 1993.	Draft Final Report, Environmental Impact Assessment of Saline Water Regulator Project, at Songkhla Lake, Songkhla and Patthalung Provinces. August, 1994. (Thai Version)	Royal Irrigation Department (RID), Ministry of Agriculture and Cooperatives
17.	Thale Noi (Lake), Khwuan Khanun District, Patthalung Province.	January 27 - February 1, 1994.	Draft Final Report, Environmental Impact Assessment of Saline Water Regulator Project, at Songkhla Lake, Songkhla and Patthalung Provinces. August, 1994. (Thai Version)	RID, Ministry of Agriculture and Cooperatives.
18.	Bung Kaeng Nam Ton (Pond), Muang District, Khon Kaen Province.	January 11-12, 1991.	Final Report, Environmental Impact Assessment of La Han Na Dam Project, at Chaiyaphum and Khon Kaen Provinces. June, 2002. (Thai Version)	Department of Energy Development and Promotion, Ministry of Science, Technology and Environment
19.	Nong Leng Sai (Pond), Mai Jai District, Phayao Province.	April 2, 1997.	Final Report, Environmental Impact Assessment of Nong Leng Sai Project, Phayao Province. March, 1998. (Thai Version)	Phayao Province.
20.	Nong Leng Sai (Pond), Mai Jai District, Phayao Province.	April 2, 1997.	Final Report, Environmental Impact Assessment of Nong Leng Sai Project, Phayao Province. March, 1998. (Thai Version)	Phayao Province.

Table 1B. Source of water quality and aquatic ecology data. (continued)

Data No.	Sampling Station Name	Sampling Date	Source of Data	Owner
21.	Nong Han Kumphawapi (Reservoir), Muang District, Udon Thani Province.	January 21-22, 1991.	Final Report, Initial Environmental Examination of Huai Luang, Dam Project at Nong Khai Province. November, 1992. (Thai Version)	Department of Energy Development and Promotion, Ministry of Science, Technology and Environment
22.	Mae Kham Reservoir, Mae Moh District, Lampang Province.	November 19, 1993.	Final Report, Environmental Impact Assessment of Mae Kham FBC Thermal Power Plant Project. November, 1995. (Thai Version)	EGAT.
23.	Mae Kham Reservoir, Mae Moh District, Lampang Province.	November 19, 1993.	Final Report, Environmental Impact Assessment of Mae Kham FBC Thermal Power Plant Project. November, 1995. (Thai Version)	EGAT.
24.	Mae Chang Reservoir, Mae Moh District, Lampang Province.	November 19, 1993.	Final Report, Environmental Impact Assessment of Mae Kham FBC Thermal Power Plant Project. November, 1995. (Thai Version)	EGAT.
25.	Kew Lom Reservoir, Chae Hom District, Lampang Province.	November 6, 1995.	Final Report, Environmental Impact Assessment of Kew Kho Ma Dam Project at Lam Pang Province. February, 1998. (Thai Version)	RID, Ministry of Agriculture and Cooperatives.
26.	Kew Lom Reservoir, Chae Hom District, Lampang Province.	December 26, 1995.	Final Report, Environmental Impact Assessment of Kew Kho Ma Dam Project at Lam Pang Province. February, 1998. (Thai Version)	RID, Ministry of Agriculture and Cooperatives.
27.	Kew Lom Reservoir, Chae Hom District, Lampang Province.	March 7, 1996.	Final Report, Environmental Impact Assessment of Kew Kho Ma Dam Project at Lam Pang Province. February, 1998. (Thai Version)	RID, Ministry of Agriculture and Cooperatives.
28.	Kew Lom Reservoir (near resort), Chae Hom District, Lampang Province.	May, 1989.	Final Report, Environmental Impact Assessment of Mae Mho Water Supply Project: Kew Kho Ma Reservoir. November, 1991. (Thai Version)	EGAT.
29.	Kew Lom Reservoir (near resort), Chae Hom District, Lampang Province.	August, 1989.	Final Report, Environmental Impact Assessment of Mae Mho Water Supply Project: Kew Kho Ma Reservoir. November, 1991. (Thai Version)	EGAT.
30.	Kew Lom Reservoir (near resort), Chae Hom District, Lampang Province.	November, 1989.	Final Report, Environmental Impact Assessment of Mae Mho Water Supply Project: Kew Kho Ma Reservoir. November, 1991. (Thai Version)	EGAT.

Table 1B. Source of water quality and aquatic ecology data. (continued)

Data No.	Sampling Station Name	Sampling Date	Source of Data	Owner
31.	Kew Lom Reservoir (near resort), Chae Hom District, Lampang Province.	February, 1990.	Final Report, Environmental Impact Assessment of Mae Mho Water Supply Project: Kew Kho Ma Reservoir. November, 1991. (Thai Version)	EGAT.
32.	Kew Lom Reservoir (in front of the dam), Chae Hom District, Lampang Province.	May, 1989.	Final Report, Environmental Impact Assessment of Mae Mho Water Supply Project: Kew Kho Ma Reservoir. November, 1991. (Thai Version)	EGAT.
33.	Kew Lom Reservoir (in front of the dam), Chae Hom District, Lampang Province.	August, 1989.	Final Report, Environmental Impact Assessment of Mae Mho Water Supply Project: Kew Kho Ma Reservoir. November, 1991. (Thai Version)	EGAT.
34.	Kew Lom Reservoir (in front of the dam), Chae Hom District, Lampang Province.	November, 1989.	Final Report, Environmental Impact Assessment of Mae Mho Water Supply Project: Kew Kho Ma Reservoir. November, 1991. (Thai Version)	EGAT.
35.	Kew Lom Reservoir (in front of the dam), Chae Hom District, Lampang Province.	February, 1990.	Final Report, Environmental Impact Assessment of Mae Mho Water Supply Project: Kew Kho Ma Reservoir. November, 1991. (Thai Version)	EGAT.
36.	Nong Han (Pond), Muang District, Sakon Nakhon Province.	December 24, 1993.	Main Report, Environmental Management Action Plan for Water Source Improvement at Nam Phung River Basin, Sakon Nakhon and Nakhon Phanom Provinces. March, 1995. (Thai Version)	Office of Environment Policy and Planning (OEPP), Ministry of Science, Technology and Environment.
37.	Nong Han (Pond), Muang District, Sakon Nakhon Province.	December 24, 1993.	Main Report, Environmental Management Action Plan for Water Source Improvement at Nam Phung River Basin, Sakon Nakhon and Nakhon Phanom Provinces. March, 1995. (Thai Version)	OEPP, Ministry of Science, Technology and Environment.
38.	Nong Han (Pond), Muang District, Sakon Nakhon Province.	December 24, 1993.	Main Report, Environmental Management Action Plan for Water Source Improvement at Nam Phung River Basin, Sakon Nakhon and Nakhon Phanom Provinces. March, 1995. (Thai Version)	OEPP, Ministry of Science, Technology and Environment.
39.	Nong Han (Pond), Muang District, Sakon Nakhon Province.	December 24, 1993.	Main Report, Environmental Management Action Plan for Water Source Improvement at Nam Phung River Basin, Sakon Nakhon and Nakhon Phanom Provinces. March, 1995. (Thai Version)	OEPP, Ministry of Science, Technology and Environment.
40.	Nong Han (Pond), Muang District, Sakon Nakhon Province.	December 24, 1993.	Main Report, Environmental Management Action Plan for Water Source Improvement at Nam Phung River Basin, Sakon Nakhon and Nakhon Phanom Provinces. March, 1995. (Thai Version)	OEPP, Ministry of Science, Technology and Environment.

Table 1B. Source of water quality and aquatic ecology data. (continued)

Data No.	Sampling Station Name	Sampling Date	Source of Data	Owner
41.	Nong Yai (Pond), Ban Kok Salung, Tha Luang District, Lop Buri Province.	August 31-September 1, 1996.	Final Report, Environmental Impact Assessment of Replacement Railway Construction due to Flooding from Pasak Dam Project. September, 1997. (Thai Version)	State Railway of Thailand (SRT), Ministry of Transport and Communications.
42.	Nong Yai (Pond), Ban Kok Salung, Tha Luang District, Lop Buri Province.	August 31-September 1, 1996.	Final Report, Environmental Impact Assessment of Replacement Railway Construction due to Flooding from Pasak Dam Project. September, 1997. (Thai Version)	SRT, Ministry of Transport and Communications.
43.	Pond in front of Udon Thani Airport (within airport boundary), Muang District, Udon Thani Province.	September 24, 2000.	Final Report, Environmental Impact Assessment of Udon Thani Airport Project. May, 2001. (Thai Version)	DOA, Ministry of Transport and Communications.
44.	Huai Nong Khem Reservoir, Hua Bo Subdistrict, Phonsawan District, Nakhon Phanom Province.	September 29-30, 1997.	Final Report, Main Report, Initial Environmental Examination and Detailed Design of Huai Thuy Reservoir Project. September, 1999. (Thai Version)	RID, Ministry of Agriculture and Cooperatives.
45.	Huai Nong Khem Reservoir, Hua Bo Subdistrict, Phonsawan District, Nakhon Phanom Province.	March 5-6, 1998.	Final Report, Main Report, Initial Environmental Examination and Detailed Design of Huai Thuy Reservoir Project. September, 1999. (Thai Version)	RID, Ministry of Agriculture and Cooperatives.
46.	Kud Pla Khao (Pond), Tha U Then District, Nakhon Phanom Province.	September 29-30, 1997.	Final Report, Main Report, Initial Environmental Examination and Detailed Design of Huai Thuy Reservoir Project. September, 1999. (Thai Version)	RID, Ministry of Agriculture and Cooperatives.
47.	Kud Pla Khao (Pond), Tha U Then District, Nakhon Phanom Province.	March 5-6, 1998.	Final Report, Main Report, Initial Environmental Examination and Detailed Design of Huai Thuy Reservoir Project. September, 1999. (Thai Version)	RID, Ministry of Agriculture and Cooperatives.
48.	Lam Ta Khong Reservoir (to the North of Pipe), Pak Chong District, Nakhon Ratchasima Province.	July 22, 1994.	Final Report , Environmental Impact Assessment of The 230 KV Transmission Line of Lam Ta Khong Hydro Power Plant (First and Second Stage) Project. December, 1994. (Thai Version)	EGAT.

Table 1B. Source of water quality and aquatic ecology data. (continued)

Data No.	Sampling Station Name	Sampling Date	Source of Data	Owner
49.	Lam Ta Khong Reservoir (to the South of Pipe), Pak Chong District, Nakhon Ratchasima Province.	July 22, 1994.	Final Report , Environmental Impact Assessment of The 230 KV Transmission Line of Lam Ta Khong Hydro Power Plant (First and Second Stage) Project. December, 1994. (Thai Version)	EGAT.
50.	Small Reservoir, Salaeng Sub-district, Muang District, Chanthaburi Province.	March 16-24, 1994.	Final Report , Environmental Impact Assessment of The 230 KV Transmission System Expansion Project, Khiritharn-Chanthaburi, Chantaburi Province. October, 1995.	EGAT.
51.	Small Reservoir, Salaeng Sub-district, Muang District, Chanthaburi Province.	August 11-14, 1994.	Final Report , Environmental Impact Assessment of The 230 KV Transmission System Expansion Project, Khiritharn-Chanthaburi, Chantaburi Province. October, 1995.	EGAT.
52.	Khiritharn Reservoir, Makham District, Chanthaburi Province.	March 16-24, 1994.	Final Report , Environmental Impact Assessment of Khiritharn Pumped Storage Project. October, 1995.	EGAT.
53.	Khiritharn Reservoir, Makham District, Chanthaburi Province.	March 16-24, 1994.	Final Report, Environmental Impact Assessment of Khiritharn Pumped Storage Project. October, 1995.	EGAT.
54.	Khiritharn Reservoir, Makham District, Chanthaburi Province.	March 16-24, 1994.	Final Report , Environmental Impact Assessment of Khiritharn Pumped Storage Project. October, 1995.	EGAT.
55.	Khiritharn Reservoir, Makham District, Chanthaburi Province.	March 16-24, 1994.	Final Report, Environmental Impact Assessment of Khiritharn Pumped Storage Project. October, 1995.	EGAT.
56.	Khiritharn Reservoir, Makham District, Chanthaburi Province.	March 16-24, 1994.	Final Report, Environmental Impact Assessment of Khiritharn Pumped Storage Project. October, 1995.	EGAT.
57.	Khiritharn Reservoir, Makham District, Chanthaburi Province.	August 11-14, 1994.	Final Report, Environmental Impact Assessment of Khiritharn Pumped Storage Project. October, 1995.	EGAT.

Table 1B. Source of water quality and aquatic ecology data. (continued)

Data No.	Sampling Station Name	Sampling Date	Source of Data	Owner
58.	Khiritharrn Reservoir, Makham District, Chanthaburi Province.	August 11-14, 1994.	Final Report, Environmental Impact Assessment of Khiritharn Pumped Storage Project. October, 1995.	EGAT.
59.	Khiritharn Reservoir, Makham District, Chanthaburi Province.	August 11-14, 1994.	Final Report, Environmental Impact Assessment of Khiritharn Pumped Storage Project. October, 1995.	EGAT.
60.	Khiritharn Reservoir, Makham District, Chanthaburi Province.	August 11-14, 1994.	Final Report, Environmental Impact Assessment of Khiritharn Pumped Storage Project. October, 1995.	EGAT.
61.	Khiritharn Reservoir, Makham District, Chanthaburi Province.	August 11-14, 1994.	Final Report, Environmental Impact Assessment of Khiritharn Pumped Storage Project. October, 1995.	EGAT.
62.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	September 15-16, 2000.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
63.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	September 15-16, 2000.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
64.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	September 15-16, 2000.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
65.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	September 15-16, 2000.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
66.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	September 15-16, 2000.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
67.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	September 15-16, 2000.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.

Table 1B. Source of water quality and aquatic ecology data. (continued)

Data No.	Sampling Station Name	Sampling Date	Source of Data	Owner
68.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	September 15-16, 2000.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
69.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	December 21-22, 2000.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
70.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	December 21-22, 2000.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
71.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	December 21-22, 2000.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
72.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	December 21-22, 2000.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
73.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	December 21-22, 2000.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
74.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	December 21-22, 2000.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
75.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	December 21-22, 2000.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
76.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	February 24-25, 2001.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
77.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	February 24-25, 2001.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.

Table 1B. Source of water quality and aquatic ecology data. (continued)

Data No.	Sampling Station Name	Sampling Date	Source of Data	Owner
78.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	February 24-25, 2001.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
79.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	February 24-25, 2001.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
80.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	February 24-25, 2001.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
81.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	February 24-25, 2001.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
82.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	February 24-25, 2001.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
83.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	May 8-9, 2001.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
84.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	May 8-9, 2001	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003 (Thai Version).	EGAT.
85.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	May 8-9, 2001.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
86.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	May 8-9, 2001:	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
87.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	May 8-9, 2001.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
88.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	May 8-9, 2001.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.

Table 1B. Source of water quality and aquatic ecology data. (continued)

Data No.	Sampling Station Name	Sampling Date	Source of Data	Owner
89	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	May 8-9, 2001.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
90	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	August 12-13, 2002.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003 (Thai Version).	EGAT.
91.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	August 12-13, 2002.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
92.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	August 12-13, 2002.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
93.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	August 12-13, 2002.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003 (Thai Version).	EGAT.
94.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	August 12-13, 2002.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
95.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	August 12-13, 2002.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
96.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	August 12-13, 2002.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
97.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	October 23-24, 2002.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
98.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	October 23-24, 2002.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
99.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	October 23-24, 2002.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.

Table 1B. Source of water quality and aquatic ecology data. (continued)

Data No.	Sampling Station Name	Sampling Date	Source of Data	Owner
100.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	October 23-24, 2002.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
101.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	October 23-24, 2002.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
102.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	October 23-24, 2002.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
103.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	October 23-24, 2002	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
104.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	October 23-24, 2002.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
105.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	October 23-24, 2002.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
106.	Lam Ta Khong Reservoir, Pak Chong District, Nakhon Ratchasima Province.	October 31, 2002.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
107.	Upper Retention Pond, Pak Chong District, Nakhon Ratchasima Province.	October 31, 2002.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
108.	Upper Retention Pond, Pak Chong District, Nakhon Ratchasima Province.	October 31, 2002.	Final Report, The Study of Aquatic Ecology and Fishery in Lam Ta Khong Reservoir, Lam Ta Khong Pumped Storage Project. January, 2003. (Thai Version)	EGAT.
109.	Reservoir of Huai Phan Sadet, Ban Phan Radet, Klang District, Rayong Province.	March 8,1995.	Final Report for Preliminary Environmental Impact Assessment of The IPP Project (1050 MW). June, 1995.	HEMARAJ LAND AND DEVELOPMENT PUBLIC CO., LTD.

Appendix C

Water Quality and Aquatic Ecology Data

Table 1C. Water quality data.

No.	Ta	Tw	pH	Tran	Dep	Tur	Con	DO	TS	TDS	SS	Hard	Cl	Acid	Alk	NO_3-N	NO_2-N	Org-N	Total N	NH_3-N	Sulfate	Total P	BOD	COD	Oil	Ca	Mg	Na	K	Ch-A
1			7.40			99.10	100.00	7.20	164.00	114.0	30.0	38.0	4.0			1.800			0.84			0.27	3.15	7.84						
2			8.10				60.00	4.20		50.0	20.0					0.100							1.65		5.10					
3			7.40			114.50	110.00	6.30	144.00	108.0	56.0	46.0	6.0			0.003			1.96			0.49	7.65	54.88						
4			7.80				80.00	3.00	144.00	68.0	32.0					0.130							9.30		6.40					
5	29.0	29.0	6.80	130.00	2.50	2.45	920.00	0.20	651.00	645.0	6.0	317.0	0.1	30.6	140.0	0.700					255.00	0.02	2.20	65.41	2.00	346.00	15.00			
6	35.0	28.0	9.20	40.00	2.00		1320.00	2.30		200.0	188.0												7.00		0.80			177.80	7.91	
7	36.0	28.0	9.00	40.00	2.00		6200.00	3.60		700.0	89.5												2.00		0.20			1025.00	9.34	
8	34.0	26.0	7.50	55.00	4.00		560.00	3.80		100.0	29.0												7.10		0.20			56.95	7.55	
9	32.0	28.0	7.80	270.00	4.00	1.90	235.00	7.20	148.00	147.0	2.0	110.0	6.0		18.0	0.170			0.34	0.06	29.50	0.02	0.80		1.60	74.00	24.00	4.80		
10	36.0	31.8	8.30	200.00	2.50	2.40	340.00	5.80	224.00	223.0	1.0	117.0	7.5		78.0	0.010			0.05	0.05	67.50	0.02	0.10		0.60	108.00	9.00	8.32		
11	30.5	32.0	8.70	270.00	2.90	2.40	320.00	7.40	204.00	203.0	5.0	109.0	9.0		72.0	0.010			0.05	0.05	68.00	0.02	0.60		0.40	90.00	19.00	12.00		
12	30.0	28.5	7.80	10.00	2.10		168.00	1.20	112.50	99.5	13.0	24.8	25.9			2.680	0.03				2.37		1.80				6.02	32.00		
13	33.0	33.0	7.80	60.00	1.50		56.00	3.80	135.00	88.7	46.3	14.4	3.9			2.600	0.04				2.00		1.95				1.40	14.90		
14			7.07					7.90			62.0					0.580							2.78		2.70					
15			5.91					6.70			214.0					1.000							3.75		6.50					
16		30.9	7.80	100.00	1.00	2.60	0.10	8.40		233.5		60.1			24.5	0.088					10.10	0.02	2.60			27.80	10.70	68.90	5.60	
17		31.0	6.70	160.00	1.60	4.70	0.05	7.10		70.7		20.0		3.0	16.0	0.003					3.72	0.0113	1.33			9.05	2.48	5.92	3.10	
18		23.2	8.75				510.00	7.80			2.0	200.0	120.0		54.0						2.16		2.74			12.00	3.20	66.00	1.00	
19	34.0	28.0	7.60	20.00	1.80		24.00	4.80	200.00	174.5	25.5	22.0	2.8			0.080				0.02	0.05	0.005	4.20							
20	34.0	28.0	7.60	20.00	1.50		86.00	4.40	217.50	179.5	38.0	42.0	8.9			0.130				0.02	2.50	0.03	6.30							
21		23.0	5.91				450.00	9.20	10.00	0.003	0.003	50.0	120.0		26.0	0.300	0.003		0.003	0.003	2.16	0.022	2.86	0.003	0.003	8.00	3.20	74.00	2.60	
22		29.0	7.70	180.00		5.30	300.00	7.80		220.0		138.0			121.0						41.50	0.04								
23		28.0	7.70	190.00		3.80	296.00	8.20		231.0		136.0			121.0						30.00	0.04			5.00					
24		27.0	7.90	233.00		3.20	229.00	9.20		168.0		112.0			99.0						14.00	0.04			0.78					
25		29.9	7.11	275.00		2.40	238.00	6.40	142.00	140.0		84.0			105.0						3.80	0.07	0.74							
26		24.4	7.40	277.00		1.80	216.00	4.30	141.00	140.6	0.4	68.0			105.0						13.00	0.07	1.50							
27		26.5	7.80	223.00		3.00	204.00	4.40	154.00	150.0	4.0	120.0			100.0						12.00	0.04	0.47							
28		31.0	8.50			4.00	218.00	7.42	111.00	105.0	11.9	83.0	0.9		100.0	0.040					10.50	0.06	3.31	8.4		3.92	3.23			
29		30.5	8.20	110.00		5.80	234.00	6.75	140.00	130.0	9.3	90.0	1.2		95.6	0.010					10.80	0.04	1.93	15.9		32.50	9.60			
30		28.0	7.90	290.00		2.20	233.00	7.05	135.00	132.0	1.9	99.0	0.3		116.0						9.20	0.04	0.74	10.0		31.06	10.48			
31		25.5	8.00	280.00		1.40	248.00	7.79	139.00	135.0	1.2	107.0	0.3		122.0						8.40	0.060	0.96	13.8		35.47	12.88			
32		30.5	8.30			3.60	213.00	7.82	98.00	103.0	4.7	84.9	1.1		98.2	0.040					9.50	0.050	2.91	6.4		3.92	3.29			
33		30.5	8.70	195.00		1.80	232.00	7.35	158.00	140.0	6.3	94.0	1.2		97.2						11.20	0.020	0.93	9.35		28.20	8.40			
34		27.2	8.40	280.00		2.30	212.00	7.65	119.00	117.0	2.1	95.0	0.3		97.0						8.60	0.040	0.81	10.4		29.17	10.07			
35		24.8	8.30	260.00		1.70	224.00	8.39	155.00	151.0	2.2	110.0	0.3		125.0						9.52	0.030	1.52	7.62		39.12	13.16			
36		26.5	6.80		2.00			9.50				0.001	0.001			0.001				0.001	0.001	0.020	0.60			0.001	0.001	2.60	0.59	

Table 1C. Water quality data. (continued)

No.	Ta	Tw	pH	Tran	Dep	Tur	Con	DO	TS	TDS	SS	Hard	Cl	Acid	Alk	NO_3-N	NO_2-N	Org-N	Total N	NH_3-N	Sulfate	Total P	BOD	COD	Oil	Ca	Mg	Na	K	Ch-A
37		26.5	6.90		2.50			9.00				0.001	0.001			0.050				0.001	0.001	0.030	0.40			0.001	0.001	3.70	2.85	
38		27.0	6.90		3.00			6.90				4.0				0.001				0.100	0.001	0.050	0.80			1.200	0.20	1.82	0.75	
39		27.0	7.30		4.00			6.80				4.0				0.001				0.001	0.001	0.030	1.00			1.300	0.20	4.35	0.55	
40		27.0	7.30		3.00			6.00				0.001	0.001			0.001				0.001	0.001	0.010	0.60			0.001	0.001	5.85	0.80	
41		33.0	7.50	30.00		56.00		6.50			18.0								0.30				3.00							
42		31.0	7.10	32.00		122.00		3.10			18.5								0.50				1.20							
43			7.80					3.40								0.067							3.20							
44	29.0	28.5	8.10	35.00	1.50	21.40	58.00	5.20	60.00	40.4	19.6	12.0	7.9	2.7	16.9	0.080					0.63	0.010	1.27			8.96	2.990	4.91		
45	29.0	27.0	7.40	0.30	0.80	74.30	300.00	6.80	197.50	182.3	15.2	27.6	46.7	1.0	5.9	0.200					13.75	0.010	1.13			14.76	12.80	36.20		
46	31.0	30.0	6.80	25.00	0.50	30.20	26.00	5.40	44.00	35.4	8.6	17.9	2.3	4.2	11.3	0.180					0.31	0.030	1.62			10.96	6.97	1.34		
47	32.0	30.0	7.80	0.20	0.80	166.00	64.00	7.20	200.00	174.7	25.3	10.8	12.7	2.4	0.4	0.180					0.05	0.010	1.03			7.88	2.95	8.96		
48	32.0	29.0	8.14	28.00		25.00	250.00	6.50	210.00	185.0	24.8	114.0	11.0			0.120					7.50	0.040				96.00	18.00			
49	32.0	28.5	8.21	78.00		4.90	290.00	6.40	190.00	189.0	1.2	133.0	10.0			0.030					8.25	0.010				120.00	13.00			
50		30.0	3.00			2.40	320.00	6.20	192.60		0.6	12.0	3.5			0.130					45.50	0.008	1.10			10.00	6.00	2.59		
51		30.0	4.20			2.90	77.00	6.30	47.00		0.8	7.0	2.0			0.010					13.00	0.110	0.70			4.00	3.00	3.14		
52		29.0	7.80			6.00	40.00	6.80	25.60		1.6	14.0	1.5		21.0	0.010					2.25	0.008	0.70			6.00	7.00	2.80		
53		29.0	7.80			7.00	40.00	7.60	25.80		1.8	14.0	2.0		18.0	0.010					2.25	0.008	1.20			7.00	7.00	2.85		
54		29.0	7.60			8.00	40.00	7.70	27.60		3.6	15.0	1.0		19.0	0.010					2.25	0.010	0.70			6.00	7.00	2.63		
55		29.0	7.90			8.00	40.00	7.00	25.20		1.2	20.0	1.0		17.0	0.010					2.25	0.008	1.00			5.00	8.00	2.70		
56		29.0	7.80			7.00	40.00	7.70	27.00		3.0	12.0	1.0		17.0	0.010					2.25	0.015	0.70			6.00	7.00	2.86		
57		28.0	7.00			13.00	35.00	5.50	23.80		2.8	9.0	1.5		10.0	0.040					3.00	0.100	0.90			5.00	4.00	2.38		
58		27.0	7.00			12.00	33.00	5.90	23.00		3.2	8.0	1.5		8.0	0.040					3.70	0.100	1.30			5.00	3.00	2.44		
59		28.0	7.20			13.00	33.00	6.80	25.00		5.2	8.0	1.5		11.0	0.040					3.00	0.100	0.50			5.00	3.00	2.44		
60		26.0	7.10			13.00	35.00	6.90	23.80		2.8	9.0	1.5		9.0	0.050					3.70	0.040	0.50			4.00	5.00	2.48		
61		27.0	7.00			13.00	30.00	6.20	22.40		4.4	8.0	1.5		11.0	0.040					4.00	0.070	0.60			5.00	3.00	2.57		
62		28.8	8.78	89.00	4.00	8.80	227.00	11.60		164.0	8.0	114.0			105.0	0.280		0.20	0.10			0.004	6.80			21.24	4.399	15.34	1.91	11.31
63		28.1	8.56	50.00	3.10	19.00	244.00	8.99		137.0	23.0	115.0			120.0	0.280		0.30	0.10			0.009	6.40			18.17	3.786	9.04	1.54	16.72
64		28.4	8.84	98.00	2.20	5.80	263.00	11.10		177.0	7.0	114.0			120.0	0.280		0.10	0.10			0.005	6.60			20.90	4.576	13.90	1.94	23.77
65		28.2	8.70	13.50	4.70	3.10	264.00	10.62		165.0	4.0	116.0			115.0	0.280		0.10	0.10			0.002	7.00			21.19	4.666	14.02	1.85	21.12
66		27.3	8.05	120.00	19.80	3.20	267.00	8.37		180.0	4.5	118.0			120.0	0.290		0.20	0.10			0.010	5.30			20.97	4.624	14.22	1.920	22.88
67		27.6	8.36	170.00	3.70	2.60	284.00	7.71		210.0	3.0	112.0			125.0	0.280		0.20	0.10			0.010	6.50			21.53	4.637	14.16	1.87	13.91
68		27.3	8.17	150.00	13.00	1.80	273.00	7.30		171.0	10.0	118.0			110.0	0.280		0.10	0.10			0.026	7.20			21.51	4.648	14.16	18.10	14.45
69		26.0	8.10	120.00	5.40	4.60	210.00	7.78		274.0	2.3	115.0			114.0	0.280		0.20	0.60			0.025	2.70			21.67	5.96	13.30	1.84	19.12
70		25.0	8.20	140.00	2.90	1.90	193.00	7.38		312.0	2.5	169.0			177.0	0.280		0.40	0.80			0.102	2.00			27.34	4.55	13.51	1.603	10.90
71		27.0	7.90	160.00	3.00	1.50	250.00	9.65		263.0	3.8	116.0			134.0	0.290		0.30	0.70			0.006	3.80			20.65	4.57	12.83	1.798	20.10
72		26.0	8.60	140.00	4.00	2.00	198.20	8.37		218.0	2.2	114.0			130.0	0.270		0.40	0.80			0.036	2.00			19.61	4.43	12.53	1.76	16.64

Table 1C. Water quality data. (continued)

No.	Ta	Tw	pH	Tran	Dep	Tur	Con	DO	TS	TDS	SS	Hard	Cl	Acid	Alk	NO_3-N	NO_2-N	Org-N	Total N	NH_3-N	Sulfate	Total P	BOD	COD	Oil	Ca	Mg	Na	K	Ch-A
73		25.0	8.20	140.00	20.50	3.20	204.00	9.45		205.0	2.4	127.0			130.0	0.270		0.30	0.70			0.026	2.90			20.95	4.51	12.94	1.870	19.98
74		25.0	8.40	100.00	5.30	6.60	199.00	9.55		204.0	3.9	115.0			120.0	0.270		0.30	0.70			0.027	2.70			21.25	4.47	12.66	1.800	18.48
75		25.0	8.80	220.00	3.70	0.90	192.00	8.32		119.0	1.7	112.0			130.0	0.280		0.30	0.60			0.088	0.80			21.00	4.49	12.63	1.78	9.20
76		26.0	8.40	120.00	1.30	3.10	311.00	7.40		215.0	8.3	168.0			159.0	0.215		0.40	1.00			0.021	3.80			22.06	6.11	14.53	2.34	6.72
77		26.0	8.05	70.00	2.00	6.70	401.00	7.40		268.0	11.4	200.0			195.0	0.165		0.30	0.90			0.021	4.80			30.23	7.23	14.99	2.06	8.54
78		27.0	8.05	10.00	1.70	3.20	380.00	6.80		216.0	6.6	157.0			149.0	0.148		0.50	1.20			0.070	2.60			21.71	6.02	14.56	2.32	3.74
79		25.0	8.30	160.00	5.80	1.50	315.00	6.40		237.0	10.6	174.0			170.0	0.109		0.40	1.00			0.019	1.40			25.48	6.45	14.55	2.16	6.41
80		27.0	8.40	160.00	20.00	1.00	384.00	4.00		213.0	7.8	156.0			146.0	0.142		0.50	1.00			0.008	1.20			21.58	5.76	14.21	2.14	8.51
81		25.0	8.80	190.00	3.90	2.90	301.00	7.00		217.0	6.0	159.0			148.0	0.149		0.20	0.80			0.002	1.60			22.93	5.96	14.65	2.35	3.83
82		27.0	8.60	140.00	6.00	1.10	310.00	8.60		222.0	7.3	158.0			147.0	0.131		0.40	1.00			0.003	3.70			22.75	5.83	14.04	2.14	9.66
83		30.5	8.60	90.00	1.30	10.30	332.00	9.29		273.0	5.4	139.0			141.0	0.090		0.20	0.50			0.026	3.90			27.44	17.36	128.50	4.60	14.29
84		30.3	7.84	80.00	2.50	16.70	326.00	8.73		253.0	7.3	162.0			161.0	0.080		0.10	0.40			0.033	3.40			25.87	7.92	20.00	2.17	24.64
85		30.8	8.47	100.00	2.50	11.20	317.00	8.21		217.0	7.4	129.0			127.0	0.070		0.10	0.40			0.040	2.00			19.95	6.87	16.00	1.87	15.95
86		30.5	7.25	140.00	5.20	8.70	307.00	8.27		162.0	4.2	128.0			124.0	0.030		0.10	0.40			0.030	2.10			19.65	6.72	15.75	2.08	12.68
87		30.9	8.72	120.00	19.50	2.90	309.00	9.04		185.0	7.5	127.0			121.0	0.060		0.10	0.30			0.019	2.00			14.15	6.68	56.39	2.02	15.35
88		29.9	7.65	140.00	2.10	2.30	309.00	6.77		166.0	3.4	123.0			122.0	0.050		0.20	0.40			0.030	1.40			19.82	6.77	15.51	1.95	17.11
89		31.8	8.55	140.00	7.20	1.60	292.00	8.75		153.0	5.4	119.0			121.0	0.040		0.10	0.40			0.048	1.60			19.00	6.61	15.07	1.90	5.41
90		27.2	8.39	20.00	5.50	23.30	242.60	6.01		120.0	51.8	108.0			84.0	0.204		0.40	1.90			0.023	3.80			13.58	2.80	7.97	1.07	7.70
91		26.0	7.62	20.00	1.10	46.30	196.00	5.44		126.0	87.8	90.0			74.0	0.406		0.50	2.90			0.081	3.40			5.38	0.67	2.54	0.42	1.71
92		27.9	8.82	25.00	0.80	22.20	242.00	7.66		129.0	43.0	95.0			79.0	0.222		0.60	3.20			0.028	1.10			14.86	2.90	8.53	1.43	7.27
93		27.2	8.17	61.00	1.60	6.70	275.00	6.80		140.0	13.2	109.0			96.0	0.130		0.80	3.50			0.020	4.30			15.59	3.67	11.25	1.55	12.83
94		27.4	8.89	62.00	13.00	7.90	251.40	7.31		133.0	18.6	111.0			87.0	0.117		0.50	3.30			0.036	1.80			15.30	3.38	10.27	1.54	17.11
95		27.4	9.02	44.00	0.80	6.60	281.70	8.27		149.0	29.2	117.0			98.0	0.125		0.50	3.60			0.038	2.20			14.32	3.57	11.52	1.28	12.83
96		27.3	8.81	100.00	5.70	2.90	292.30	6.92		145.0	7.6	124.0			100.0	0.123		0.50	2.00			0.025	2.10			14.41	2.95	11.98	1.27	11.54
97		28.1	8.60	63.00	2.00	6.20	298.60	7.10		115.0	10.8	133.0			116.0	0.142		0.42	0.80			0.015	2.80			12.58	1.98	6.78	0.18	12.40
98		28.1	8.90	79.00	2.10	3.80	257.90	8.00		126.0	9.0	111.0			97.0	0.138		0.25	1.90			0.015	3.40			6.05	0.68	3.25	0.25	3.42
99		28.8	8.00	66.00	2.00	3.10	268.60	8.50		110.0	7.6	113.0			110.0	0.127		0.25	1.52			0.015	0.10			12.58	0.58	5.58	0.58	5.99
100		28.7	8.70	79.00	4.00	3.80	246.40	6.90		124.0	8.2	133.0			118.0	0.139		0.35	1.78			0.017	1.30			13.35	1.36	9.85	0.64	11.98
101		29.0	9.20	84.00	18.20	3.90	245.00	9.00		140.0	8.4	111.0			74.0	0.144		0.65	2.88			0.015	2.20			15.33	2.05	6.58	0.98	11.12
102		31.2	8.70	88.00	1.20	3.40	257.30	8.40		136.0	8.0	114.0			92.0	0.151		0.45	3.46			0.017	3.10			9.58	2.05	9.35	0.76	12.40
103		30.8	9.40	72.00	8.00	3.60	237.40	9.70		155.0	9.4	95.0			81.0	0.148		0.68	2.58			0.015	5.30			12.26	1.57	7.84	0.27	18.39
104		26.0	7.30	32.00	9.00	17.00	256.50	1.80		196.0	25.6	115.0			91.0	0.294		0.35	2.87			0.036	2.00			10.61	1.06	6.33	0.58	
105		26.0	7.10	28.00	4.50	19.00	262.80	0.80		194.0	22.4	103.0			86.0	0.361		0.35	2.65			0.041	2.60			9.84	1.11	6.56	0.62	
106		29.0	8.40	80.00	18.00	3.50	149.50	11.20		160.0	2.8	100.0			118.0	0.300						0.020	2.80							29.94
107		27.0	8.00	70.00	20.00	1.50	132.20	8.90		160.0	2.7	97.0			93.0	0.202						0.018	2.60							24.81
108		27.0	8.20	74.00	20.00	1.70	170.40	8.30		164.0	3.1	99.0			90.0	0.194						0.025	2.00							24.38
109	35.0	28.0	7.10				78.00	3.80		150.0	14.7	32.0	8.0			0.010				0.05		0.010	1.90		0.40					

Notes
Ta = Air Temperature (Celsius)
Tw = Water Temperature (Celsius)
Tran = Transparency (centimeter)
Dep = Depth (meter)
Tur = Turbidity (milligram/liter, mg/l)
Con = Conductivity (microhos/centimeter)
DO = Dissolved Oxygen (mg/l)
TS = Total Solid (mg/l)
TDS = Total Dissolved Solid (mg/l)
SS = Suspended Solid (mg/l)
Hard = Total Hardness (mg/l as $CaCO_3$)
Cl = Chloride (mg/l)
Acid = Acidity (mg/l)
Alk = Alkalinity (mg/l)
NO_3-N = Nitrate-Nitrogen (mg/l)
NO_2-N = Nitrite-Nitrogen (mg/l)
Org-N = Organic-Nitrogen (mg/l)
Total N = Total Nitrogen (mg/l)
NH_3-N = Ammonia-Nitrogen (mg/l)
Total P = Total Phosphate (mg/l)
BOD = Biochemical Oxygen Demand (mg/l)
COD = Chemical Oxygen Demand (mg/l)
Oil = Oil & Grease (mg/l)
Ca = Calcium (mg/l)
Mg = Magnesium (mg/l)
Na = Sodium (mg/l)
K = Potassium (mg/l)
Ch-A = Chlorophyll a (mg/m^3 of water)

Table 2C. Phytoplankton data.

No.	Phylum						Total
	Cyanophyta	Chlorophyta	Chrysophyta	Bacillariophyta	Pyrrophyta	Euglenophyta	Phytoplankton
1	10000000	0	0	0	0	0	10000000
2	7310000	738000	0	48000	0	0	8096000
3	3186000	0	0	0	0	10000	3196000
4	46225000	0	0	0	0	45000	46270000
5	234600	0	0	40800	0	0	275400
6	715433	22533	0	140834	0	5633	884433
7	124000	0	0	564200	6200	43400	737800
8	511733	15200	0	35467	491467	20267	1074134
9	828800	0	6400	22400	236800	0	1094400
10	2557334	0	4567	63934	187233	4567	2817635
11	2028167	0	0	286666	207834	7167	2529834
12	618750	282150	24750	14850	0	0	940500
13	272000	135400	2478600	47600	0	0	2933600
14	57000	5000	5000	14500	0	0	81500
15	92000	14000	45000	7000	0	1000	159000
16	2992000	87516000	0	374000	1122000	0	92004000
17	5017200	79160713	13426600	127100	734900	501600	98968113
18	13070	6390	0	80690	0	670	100820
19	49950	0	0	11100	0	0	61050
20	27000	0	0	0	0	0	27000
21	225000	5027500	262500	1267500	97500	72500	6952500
22	45000	0	60000	0	0	0	105000
23	52000	3000	0	0	12000	0	67000
24	36000	27000	0	135000	0	0	198000
25	6240	83200	0	10400	8320	0	108160
26	0	165933	227067	17467	4367	4367	419201
27	42167	0	7667	3833	0	26833	80500
28	6923070	119880	0	1206126	3330	29970	8282376
29	365301	27972	0	13986	43290	0	450549
30	4496	4496	0	98912	0	2248	110152
31	769670	29330	0	54000	178670	0	1031670
32	7032960	2365632	0	713952	21312	49950	10183806
33	10890	333	0	39960	4662	5328	61173
34	29972	500	500	5500	41959	0	78431
35	845600	0	0	11660	401330	0	1258590
36	116000	1178000	0	109000	33000	400000	1836000
37	66000	350000	20000	84000	4000	192000	716000
38	11000	20000	0	72000	0	31000	134000
39	30000	476000	0	66000	56000	18000	646000
40	167000	194000	0	160000	120000	316000	957000
41	722920	2480	0	1240	0	3720	730360
42	40600	4200	0	5600	0	1400	51800
43	1170400	10366400	0	888250	20900	0	12445950
44	0	5100	20400	10200	0	0	35700
45	8080	0	0	0	0	4040	12120
46	0	4507800	3418800	6600	19800	151800	8104800
47	2720	255680	157760	16320	0	0	432480
48	291500	1272000	67500	105670	0	90000	1826670
49	136000	217170	67500	69420	0	89000	579090
50	0	22000	0	4000	6000	0	32000
51	0	20000	0	4000	6000	0	30000
52	2000	179000	0	0	0	0	181000
53	21000	495000	0	7000	54000	0	577000
54	27000	355000	0	4000	19000	0	405000
55	13000	393000	0	14000	4000	0	424000
56	22000	1138000	0	2000	14000	0	1176000

Table 2C. Phytoplankton data. (continued)

No.	Phylum						Total
	Cyanophyta	Chlorophyta	Chrysophyta	Bacillariophyta	Pyrrophyta	Euglenophyta	Phytoplankton
57	2000	235000	0	3000	7000	0	247000
58	6000	258000	0	3000	20000	0	287000
59	6000	290000	0	4000	20000	0	320000
60	7000	336000	0	4000	12000	0	359000
61	11000	755000	0	2000	12000	0	780000
62	74057550	89393650	0	7304100	87850	0	170843150
63	80383700	82232400	0	8131500	55600	20850	170824050
64	96502770	108798300	23400	9465300	737100	0	215526870
65	57215450	29479950	0	1054200	138050	0	87887650
66	50174900	34976850	0	1255000	426700	0	86833450
67	7550850	11459400	0	777450	202350	0	19990050
68	24588750	41769750	0	784350	87150	0	67230000
69	32066200	1373500	0	10029900	6291300	0	49760900
70	6651600	1674400	358800	2226400	1067200	36800	12015200
71	17924850	1674450	36600	10037550	3348900	0	33022350
72	5975200	1155000	0	5759600	292600	0	13182400
73	18610100	1706050	0	11450650	1177100	0	32943900
74	10892650	736600	0	6982300	235800	0	18847350
75	8790650	556600	0	3908300	30250	0	13285800
76	69401500	1303500	663600	14472800	7204800	1106000	94152200
77	61990500	2070750	24750	18372750	4917000	5511000	92886750
78	64245000	982500	232500	9112500	11175000	2557500	88305000
79	89798750	1900450	467650	37421950	4218800	358200	134165800
80	91801650	1627400	834300	40911600	14347900	412000	149934850
81	23674450	448850	19100	44694000	1661700	38200	70536300
82	74087700	1905300	919800	38292150	10643400	43800	125892150
83	81972000	1830600	40500	41188500	71928000	1344600	198304200
84	25786800	5627700	0	30115800	86404500	2129400	150064200
85	57519500	1386900	147400	22686200	13507200	944700	96191900
86	48024500	1028600	0	22302550	9924600	382250	81662500
87	99447900	1916250	10950	70769850	9964500	208050	182317500
88	42253950	1057800	12900	39390150	5430900	116100	88261800
89	71890750	2390650	13700	43463250	4890900	82200	122731450
90	4233600	17883600	0	3259200	0	0	25376400
91	28400	71000	0	149100	0	0	248500
92	2051000	5572000	0	1771000	7000	0	9401000
93	29382500	64502800	0	1518400	36500	0	95440200
94	25042500	65794200	0	11400300	79500	0	102316500
95	23670800	28927200	0	7357600	6800	0	59962400
96	12809500	34976100	0	13830150	41100	0	61656850
97	12735900	609500	0	964600	328600	641300	15279900
98	46929950	1509650	0	1155400	223450	463250	50281700
99	10264750	797050	0	2360750	118750	223250	13764550
100	25423200	989750	0	1856450	2016950	288900	30575250
101	54924800	1170400	0	1758400	627200	1041600	59522400
102	49536000	1346400	0	5623200	129600	871200	57506400
103	46851200	2327600	0	717200	312400	17600	50226000
104	1500400	536800	0	2332000	8800	13200	4391200
105	1017000	373500	0	1260000	18000	144000	2812500
106	34859410	665000	0	3059000	1842050	106400	40531860
107	24224200	623700	0	2502500	3749900	92400	31192700
108	19841250	765900	0	1948250	2880450	83250	25519100
109	148500000	162000000	0	92500000	1500000	0	404500000

Notes Unit = cell/m^3 of water

Table 3C. Zooplankton data.

No.	Phylum								Total	Grand
	Protozoa	Rotifera	Arthropoda	Annelida	Nematoda	Chordata	Mullusca	Coelenterata	Zooplankton	Total Plankton
1	0	2120000	600000	0	0	0	0	0	2720000	12720000
2	0	146000	48000	0	0	0	0	0	194000	8290000
3	100000	100000	30000	0	0	0	0	0	230000	3426000
4	0	45000	2025000	0	0	0	0	0	2070000	48340000
5	40800	23800	13600	0	0	0	0	0	78200	353600
6	78867	1915333	1368900	0	0	0	0	0	3363100	4247533
7	43400	452600	223200	0	0	0	0	0	719200	1457000
8	233067	516799	86134	0	0	0	0	0	836000	1910134
9	3200	0	28800	9600	0	0	0	0	41600	1136000
10	0	0	77633	0	0	0	0	0	77633	2895268
11	0	21500	50167	0	0	0	0	0	71667	2601501
12	34650	54450	257400	0	0	0	0	0	346500	1287000
13	3400	13600	397800	0	0	0	0	0	414800	3348400
14	0	3000	2000	0	0	0	0	0	5000	86500
15	3000	3000	23000	0	0	0	0	0	29000	188000
16	23663	739274	372140	0	0	2493	0	3	1137573	93141573
17	19080	545546	80560	13	0	0	0	0	645199	99613312
18	340	6040	1340	0	0	4020	0	0	11740	112560
19	38850	116550	555000	0	0	0	0	0	710400	771450
20	1063800	54000	664200	0	0	0	0	0	1782000	1809000
21	70000	120000	897500	0	0	0	0	0	1087500	8040000
22	0	17000	138000	0	0	0	0	0	155000	260000
23	3000	37000	36000	0	0	0	0	0	76000	143000
24	49500	202500	310500	0	0	0	0	0	562500	760500
25	60320	31200	18720	0	0	0	0	0	110240	218400
26	4367	34933	30567	4367	0	0	0	0	74234	493435
27	141834	15333	3833	0	0	0	0	0	161000	241500
28	17982	22644	25308	0	0	0	0	0	65934	8348310
29	26640	67932	369297	0	0	0	0	0	463869	914418
30	16736	8992	161856	0	0	0	0	0	187584	297736
31	10000	142000	6660	0	160000	0	0	0	318660	1350330
32	15984	290376	247752	0	0	0	0	0	554112	10737918
33	134	4298	2799	0	0	0	0	0	7231	68404
34	8496	37964	4996	0	0	0	0	0	51456	129887
35	12830	13420	6430	0	0	0	0	0	32680	1291270
36	24000	27000	147000	0	0	0	0	0	198000	2034000
37	6000	16000	255000	0	0	0	0	0	277000	993000
38	0	10000	34000	0	0	0	0	0	44000	178000
39	12000	16000	67000	0	0	0	0	0	95000	741000
40	5000	30000	129000	0	0	0	0	0	164000	1121000
41	0	11160	37200	0	0	0	0	0	48360	778720
42	1400	4200	9800	0	0	0	0	0	15400	67200
43	73150	114950	637450	0	0	0	10450	0	836000	13281950
44	0	25500	326400	0	0	0	0	0	351900	387600
45	0	18180	22220	0	0	0	0	0	40400	52520
46	52800	1914000	600600	0	0	0	0	0	2567400	10672200
47	0	152320	1136960	0	0	0	0	0	1289280	1721760
48	37500	125250	156840	0	0	0	0	0	319590	2146260
49	2500	60670	76750	0	0	0	0	0	139920	719010
50	0	80000	0	0	0	0	0	0	80000	112000
51	0	10000	0	0	0	0	0	0	10000	40000
52	0	0	9000	0	0	0	0	0	9000	190000
53	0	0	50000	0	0	0	0	0	50000	627000
54	0	2000	20000	0	0	0	0	0	22000	427000
55	0	1000	12000	0	0	0	0	0	13000	437000
56	0	0	8000	0	0	0	0	0	8000	1184000

Table 3C. Zooplankton data. (continued)

No.	Phylum								Total	Grand
	Protozoa	Rotifera	Arthropoda	Annelida	Nematoda	Chordata	Mullusca	Coelenterata	Zooplankton	Total Plankton
57	0	1000	22000	0	0	0	0	0	23000	270000
58	0	0	23000	0	0	0	0	0	23000	310000
59	0	1000	20000	0	0	0	0	0	21000	341000
60	0	1000	12000	0	0	0	0	0	13000	372000
61	0	0	4000	0	0	0	0	0	4000	784000
62	665150	3388500	2961800	0	0	37650	0	0	7053100	177896250
63	389200	2745250	854850	0	0	0	0	0	3989300	174813350
64	631800	4902300	1553400	0	0	81900	0	0	7169400	222696270
65	75300	1757000	1807200	0	0	12550	0	0	3652050	91539700
66	112950	1041650	301200	0	0	12550	0	0	1468350	88301800
67	74550	1373850	979800	0	0	10650	0	10650	2449500	22439550
68	62250	759450	410850	0	0	12450	0	0	1245000	68475000
69	214400	1085500	227800	0	0	6700	0	0	1534400	51295300
70	64400	717600	377200	0	0	0	0	0	1159200	13174400
71	256200	713700	201300	0	0	27450	0	0	1198650	34221000
72	7700	277200	130900	0	0	15400	0	0	431200	13613600
73	67050	275650	111750	0	0	14900	7450	0	476800	33420700
74	6550	334050	157200	0	0	0	0	0	497800	19345150
75	0	272250	66550	0	0	0	0	0	338800	13624600
76	268600	703100	624100	0	0	7900	0	0	1603700	95755900
77	544500	668250	288750	0	0	0	0	0	1501500	94388250
78	390000	1147500	382500	0	0	0	0	0	1920000	90225000
79	39800	378100	119400	0	0	0	0	0	537300	134703100
80	41200	484100	82400	0	0	0	0	0	607700	150542550
81	181450	200550	133700	0	0	0	0	0	515700	71052000
82	153300	1850550	470850	0	0	10950	0	0	2485650	128377800
83	340200	696600	340200	0	0	0	0	0	1377000	199681200
84	2129400	1509300	175500	0	0	11700	0	0	3825900	153890100
85	268000	790600	944700	0	0	0	0	0	2003300	98195200
86	229350	340550	180700	0	0	0	0	0	750600	82413100
87	175200	1149750	208050	0	0	0	0	0	1533000	183850500
88	70950	368940	38700	0	0	0	0	0	478590	88740390
89	143850	945300	130150	0	0	0	0	0	1219300	123950750
90	16800	268800	184800	0	0	0	0	0	470400	25846800
91	7100	0	7100	0	0	0	0	0	14200	262700
92	14000	77000	203000	0	0	0	7000	0	301000	9702000
93	73000	292000	211700	0	0	7300	0	0	584000	96024200
94	111300	508800	190800	0	0	55650	0	0	866550	103183050
95	54400	306000	190400	0	0	13600	0	0	564400	60526800
96	47950	328800	424700	0	0	0	0	0	801450	62458300
97	58300	376300	572400	0	0	0	0	0	1007000	16286900
98	38150	182250	114450	0	0	0	0	0	334850	50616550
99	0	275500	536750	0	0	0	0	9500	821750	14586300
100	16050	438700	230050	0	0	0	0	0	684800	31260050
101	16800	218450	134400	0	0	0	0	0	369650	59892050
102	0	216000	388800	0	0	0	0	0	604800	58111200
103	17600	382800	96800	0	0	0	0	0	497200	50723200
104	0	8800	4400	0	0	0	0	0	13200	4404400
105	4500	9000	4500	0	0	0	0	0	18000	2830500
106	139650	445550	53200	0	0	0	0	0	638400	41170260
107	53900	0	0	0	0	0	0	0	53900	31246600
108	22200	0	0	0	0	0	0	0	22200	25541300
109	31500000	157500000	18000000	0	0	0	0	0	207000000	611500000

Notes Unit = cell/m^3 of water
Grand total plankton = total phytoplankton + total zooplankton

Appendix D

Analysis Results of

Relationships between Water Quality and Plankton

Analysis Result of Relationships between Water Quality and Abundance of Plankton in Each Phylum

Descriptive Statistics: Blue-green a, Green algae, Yellow-brown, Diatom, Dinofla

Variable	N	Mean	Median	TrMean	StDev	SE Mean
Blue-gre	109	18983800	2028167	15587708	29703781	2845106
Green al	109	9385149	556600	4980212	25871209	2478012
Yellow-b	109	221161	0	30591	1344902	128818
Diatom	109	6576026	160000	4284558	14966723	1433552
Dinoflag	109	2647294	36500	921136	10945672	1048405
Euglenoi	109	196380	1000	88454	645016	61781
Total Ph	109	38009811	6952500	30014554	62540575	5990301
Protozoa	109	386544	17982	62052	3018187	289090
Rotifer	109	1864727	125250	329284	15063556	1442827
Arthropo	109	447624	133700	226690	1756177	168211
Annelida	109	128.3	0.0	0.0	1006.6	96.4
Nematods	109	1468	0	0	15325	1468
Chordata	109	3173	0	1291	10778	1032
Mullusca	109	228	0	0	1388	133
Coelente	109	185	0	0	1361	130
Total Zo	109	2704077	431200	663368	19787342	1895284
Grand To	109	40713888	8040000	30726010	76056872	7284927

Variable	Minimum	Maximum	Q1	Q3
Blue-gre	0	148500000	38300	25605000
Green al	0	162000000	21000	1865525
Yellow-b	0	13426600	0	11925
Diatom	0	92500000	11380	4765750
Dinoflag	0	86404500	0	559334
Euglenoi	0	5511000	0	86125
Total Ph	12120	404500000	412101	59742400
Protozoa	0	31500000	0	73850
Rotifer	0	157500000	13510	496450
Arthropo	0	18000000	23000	370719
Annelida	0.0	9600.0	0.0	0.0
Nematods	0	160000	0	0
Chordata	0	81900	0	0
Mullusca	0	10450	0	0
Coelente	0	10650	0	0
Total Zo	4000	207000000	59917	1112537
Grand To	40000	611500000	673005	60209425

Descriptive Statistics: Tair, Twater, pH, Trans, Depth, Tur, Con, DO, TS, TDS, SS

Variable	N	N*	Mean	Median	TrMean	StDev
Twater	102	7	28.075	28.000	28.062	2.059
pH	109	0	7.8804	8.0000	7.9537	0.9089
Trans	80	29	111.43	94.00	107.87	79.35
Depth	69	40	5.236	3.000	4.741	5.743
Tur	89	20	13.51	3.80	8.59	27.49
Con	99	10	293.8	242.0	219.1	624.3
DO	109	0	6.934	7.200	7.023	2.132
TS	41	68	127.7	139.0	117.0	108.6
TDS	86	23	173.7	161.0	165.2	95.9
SS	97	12	16.77	7.34	11.29	31.75
Hard	99	10	90.25	109.00	88.39	57.52
Cl	39	70	11.22	2.00	5.63	26.96
Acid	6	103	7.29	2.85	7.29	11.46
Alk	83	26	92.42	100.00	92.60	47.65
Nitrate	92	17	0.2266	0.1300	0.1471	0.4291
Nitrite	3	106	0.0243	0.0300	0.0243	0.0191
Org-N	44	65	0.3307	0.3000	0.3217	0.1742
Total-N	52	57	1.157	0.800	1.077	1.095
NH3-N	12	97	0.02975	0.02000	0.02560	0.03204
Sulfate	49	60	15.40	3.80	9.59	38.23
Total-P	96	13	0.03803	0.02500	0.02981	0.05812
BOD	104	5	2.523	2.000	2.368	1.960
COD	12	97	17.50	9.68	14.46	20.42
Oil&Grea	15	94	2.179	0.800	2.014	2.373
Ca	83	26	24.26	15.33	17.90	41.95
Mg	85	24	5.697	4.576	5.268	4.546
Na	77	32	30.2	11.5	13.3	118.0
K	56	53	2.317	1.846	1.874	2.794
Chlo-A	45	64	13.716	12.830	13.594	6.646

Variable	SE Mean	Minimum	Maximum	Q1	Q3
Twater	0.204	23.000	33.000	27.000	29.225
pH	0.0871	3.0000	9.4000	7.4000	8.4850
Trans	8.87	0.20	290.00	45.50	160.00
Depth	0.691	0.500	20.500	1.900	5.450
Tur	2.91	0.90	166.00	2.40	10.75
Con	62.7	0.1	6200.0	132.2	298.6
DO	0.204	0.200	11.600	6.200	8.310
TS	17.0	10.0	651.0	27.3	177.0
TDS	10.3	0.0	700.0	128.3	206.3
SS	3.22	0.00	214.00	2.90	18.25
Hard	5.78	0.00	317.00	27.56	119.00
Cl	4.32	0.10	120.00	1.10	8.00
Acid	4.68	0.95	30.60	2.02	10.76
Alk	5.23	0.41	195.00	74.00	122.00
Nitrate	0.0447	0.0010	2.6800	0.0400	0.2700
Nitrite	0.0111	0.0030	0.0400	0.0030	0.0400
Org-N	0.0263	0.1000	0.8000	0.2000	0.4425
Total-N	0.152	0.003	3.600	0.355	1.900
NH3-N	0.00925	0.00100	0.10000	0.00100	0.05000
Sulfate	5.46	0.00	255.00	2.21	11.60
Total-P	0.00593	0.00200	0.49000	0.01500	0.04000
BOD	0.192	0.100	9.300	1.048	3.283
COD	5.89	0.00	65.41	7.68	15.38
Oil&Grea	0.613	0.003	6.500	0.400	5.000
Ca	4.60	0.00	346.00	7.88	22.06
Mg	0.493	0.001	24.000	2.970	7.000
Na	13.5	1.3	1025.0	4.6	14.6
K	0.373	0.180	18.100	0.985	2.155
Chlo-A	0.991	1.710	29.940	8.525	18.435

Results for: P2DemandCorre.MTW
Correlations: Blue-green a, Green algae, Yellow-brown, Diatom, Dinoflagella, Eug

	Blue-gre	Green al	Yellow-b	Diatom	Dinoflag	Euglenoi	Total Ph	Protozoa
Twater	0.065	0.061	0.176	0.053	0.161	-0.012	0.101	0.002
	0.514	0.539	0.078	0.599	0.107	0.905	0.312	0.986
pH	0.329	0.090	-0.140	0.164	0.086	0.087	0.246	-0.074
	0.000	0.350	0.146	0.088	0.373	0.371	0.010	0.443
Trans	-0.094	-0.116	0.033	0.072	-0.046	-0.142	-0.093	-0.140
	0.405	0.307	0.770	0.528	0.683	0.209	0.413	0.217
Depth	0.303	-0.029	-0.102	0.235	-0.030	-0.104	0.195	-0.107
	0.011	0.811	0.406	0.052	0.809	0.396	0.109	0.383
Tur	-0.206	-0.092	-0.023	-0.161	-0.040	-0.075	-0.197	-0.048
	0.052	0.391	0.828	0.131	0.708	0.483	0.065	0.653
Con	-0.034	-0.066	-0.062	-0.012	0.009	0.022	-0.046	-0.034
	0.740	0.519	0.540	0.907	0.931	0.826	0.652	0.736
DO	0.280	0.154	-0.036	0.089	0.160	0.105	0.247	-0.127
	0.003	0.109	0.711	0.357	0.096	0.278	0.010	0.189
TS	0.044	-0.289	-0.098	-0.103	0.059	-0.051	-0.010	0.161
	0.785	0.067	0.543	0.521	0.713	0.752	0.949	0.315
TDS	0.057	-0.078	-0.155	0.116	0.179	0.141	0.053	-0.015
	0.600	0.478	0.154	0.289	0.100	0.195	0.629	0.888
SS	-0.158	-0.037	0.008	-0.120	-0.083	-0.075	-0.134	-0.010
	0.123	0.717	0.935	0.241	0.417	0.465	0.190	0.925
Hard	0.378	-0.012	-0.143	0.279	0.243	0.311	0.284	-0.083
	0.000	0.905	0.158	0.005	0.015	0.002	0.004	0.416
Cl	-0.030	-0.003	-0.029	-0.012	-0.024	0.168	-0.015	-0.019
	0.858	0.985	0.862	0.944	0.887	0.308	0.927	0.908
Acid	-0.139	-0.194	-0.225	0.094	-0.188	-0.230	-0.196	0.528
	0.793	0.713	0.668	0.860	0.721	0.661	0.710	0.282
Alk	0.530	-0.021	-0.185	0.473	0.300	0.372	0.452	0.366
	0.000	0.848	0.093	0.000	0.006	0.001	0.000	0.001
Nitrate	-0.111	-0.064	0.045	-0.132	-0.075	-0.076	-0.125	-0.058
	0.291	0.543	0.673	0.209	0.478	0.471	0.234	0.585
Nitrite	0.360	-0.972	0.644	-0.959	-0.965	-0.965	-0.828	-0.975
	0.765	0.151	0.554	0.183	0.168	0.168	0.379	0.142
Org-N	-0.232	-0.041	0.177	-0.348	-0.274	-0.023	-0.319	-0.354
	0.130	0.794	0.251	0.020	0.072	0.882	0.035	0.019
Total-N	-0.197	-0.011	-0.096	-0.240	-0.184	-0.023	-0.221	-0.251
	0.162	0.940	0.497	0.087	0.191	0.873	0.115	0.073
NH3-N	0.206	0.188	-0.276	0.196	0.250	-0.533	0.196	0.195
	0.520	0.559	0.385	0.542	0.433	0.074	0.541	0.543
Sulfate	0.041	-0.054	-0.068	-0.032	-0.004	-0.132	-0.052	-0.036
	0.781	0.712	0.642	0.827	0.978	0.365	0.721	0.808
Total-P	-0.186	-0.151	-0.057	-0.135	-0.044	-0.052	-0.193	-0.054
	0.069	0.142	0.584	0.189	0.668	0.613	0.059	0.600
BOD	0.322	0.279	-0.075	-0.012	0.072	0.103	0.278	-0.004
	0.001	0.004	0.452	0.901	0.466	0.297	0.004	0.971
COD	-0.156	-0.334	-0.270	-0.372	-0.263	-0.330	-0.316	0.553
	0.628	0.289	0.396	0.234	0.408	0.295	0.317	0.062

Oil&Grea	-0.045	-0.214	-0.171	-0.214	-0.357	-0.157	-0.154	-0.211
	0.874	0.443	0.542	0.444	0.191	0.575	0.585	0.451
Ca	-0.076	-0.058	-0.048	-0.046	-0.000	-0.018	-0.077	-0.001
	0.494	0.600	0.667	0.683	1.000	0.875	0.487	0.996
Mg	-0.020	-0.095	-0.083	0.109	0.231	0.044	0.025	0.072
	0.854	0.389	0.450	0.321	0.033	0.691	0.817	0.510
Na	-0.061	-0.046	-0.036	-0.011	0.041	-0.021	-0.046	-0.005
	0.601	0.694	0.757	0.924	0.721	0.856	0.691	0.966
K	-0.069	0.143	0.036	-0.038	0.054	-0.045	0.036	0.024
	0.614	0.292	0.792	0.780	0.692	0.742	0.794	0.861
Chlo-A	-0.029	0.209	-0.298	-0.154	0.169	-0.176	0.085	0.250
	0.851	0.169	0.046	0.313	0.266	0.247	0.577	0.098

	Rotifer	Arthropo	Annelida	Nematods	Chordata	Mullusca	Coelente	Total Zo
Twater	-0.001	0.009	-0.077	-0.125	-0.068	-0.115	0.006	0.000
	0.992	0.928	0.440	0.210	0.494	0.249	0.950	0.999
pH	-0.070	-0.024	-0.029	0.013	0.227	0.060	0.047	-0.066
	0.472	0.808	0.763	0.896	0.018	0.538	0.629	0.494
Trans	-0.160	-0.267	0.305	0.241	-0.048	-0.055	0.019	-0.216
	0.157	0.017	0.006	0.032	0.671	0.628	0.865	0.055
Depth	-0.050	-0.203	-0.026	*	0.075	0.173	-0.071	-0.123
	0.683	0.094	0.830	*	0.539	0.155	0.564	0.313
Tur	-0.012	0.094	-0.060	-0.047	-0.095	-0.006	-0.059	0.013
	0.911	0.381	0.574	0.660	0.377	0.955	0.582	0.903
Con	-0.033	-0.028	-0.014	-0.007	-0.018	-0.017	-0.004	-0.033
	0.749	0.782	0.890	0.942	0.858	0.871	0.969	0.749
DO	-0.125	-0.094	-0.039	0.039	0.331	-0.041	0.074	-0.123
	0.194	0.330	0.690	0.689	0.000	0.672	0.445	0.203
TS	-0.024	0.045	0.036	0.017	*	*	0.000	0.050
	0.882	0.782	0.825	0.918	*	*	1.000	0.758
TDS	-0.025	-0.048	-0.044	-0.044	0.036	-0.009	-0.018	-0.026
	0.820	0.659	0.690	0.687	0.739	0.935	0.872	0.815
SS	-0.005	0.022	-0.066	-0.050	-0.077	0.024	-0.053	-0.003
	0.962	0.832	0.523	0.625	0.455	0.814	0.605	0.974
Hard	-0.092	-0.082	0.015	0.030	0.159	0.053	0.056	-0.090
	0.364	0.421	0.880	0.771	0.116	0.600	0.584	0.376
Cl	-0.021	0.005	-0.032	-0.067	0.663	*	0.000	-0.018
	0.901	0.975	0.848	0.686	0.000	*	1.000	0.912
Acid	-0.205	-0.362	-0.183	*	-0.000	*	*	-0.311
	0.696	0.481	0.728	*	1.000	*	*	0.549
Alk	0.289	0.127	-0.147	0.069	0.163	0.043	0.084	0.293
	0.008	0.254	0.186	0.536	0.142	0.702	0.448	0.007
Nitrate	-0.050	-0.034	-0.014	-0.000	0.002	-0.023	-0.007	-0.050
	0.639	0.750	0.895	1.000	0.982	0.825	0.951	0.639
Nitrite	-0.992	-0.890	*	*	-0.000	*	*	-0.940
	0.080	0.302	*	*	1.000	*	*	0.221
Org-N	-0.407	-0.324	-0.000	*	-0.167	0.145	-0.135	-0.432
	0.006	0.032	1.000	*	0.280	0.347	0.381	0.003
Total-N	-0.379	-0.323	-0.106	*	-0.058	0.139	-0.071	-0.393
	0.006	0.020	0.457	*	0.684	0.326	0.615	0.004

NH3-N	0.199	0.176	0.297	*	-0.000	*	*	0.196
	0.536	0.585	0.348	*	1.000	*	*	0.541
Sulfate	-0.081	-0.169	0.045	-0.027	-0.054	*	-0.020	-0.143
	0.580	0.245	0.756	0.855	0.712	*	0.890	0.326
Total-P	-0.052	-0.080	-0.006	0.039	-0.115	-0.028	-0.065	-0.055
	0.616	0.441	0.956	0.706	0.263	0.787	0.531	0.596
BOD	-0.006	0.126	-0.101	-0.079	0.325	-0.000	0.069	0.006
	0.950	0.203	0.307	0.426	0.001	0.998	0.488	0.952
COD	-0.166	-0.379	-0.000	-0.057	0.000	*	*	-0.254
	0.605	0.225	1.000	0.860	1.000	*	*	0.427
Oil&Grea	-0.211	-0.185	-0.067	*	0.000	*	0.000	-0.209
	0.451	0.509	0.811	*	1.000	*	1.000	0.455
Ca	-0.055	-0.072	0.132	0.030	-0.036	-0.024	-0.026	-0.058
	0.620	0.519	0.235	0.790	0.745	0.832	0.815	0.605
Mg	-0.041	-0.122	0.442	0.173	-0.086	-0.068	-0.102	-0.050
	0.708	0.268	0.000	0.112	0.433	0.539	0.353	0.650
Na	0.034	0.033	-0.025	*	-0.048	-0.027	-0.028	0.030
	0.772	0.775	0.830	*	0.676	0.815	0.809	0.794
K	0.118	0.094	0.038	*	0.017	-0.046	-0.073	0.108
	0.386	0.491	0.780	*	0.899	0.737	0.592	0.427
Chlo-A	0.236	0.068	0.000	*	0.324	0.003	-0.116	0.221
	0.118	0.658	1.000	*	0.030	0.982	0.448	0.145

	Grand To
Twater	0.083
	0.407
pH	0.185
	0.054
Trans	-0.097
	0.394
Depth	0.189
	0.120
Tur	-0.193
	0.070
Con	-0.046
	0.650
DO	0.171
	0.076
TS	-0.005
	0.973
TDS	0.036
	0.742
SS	-0.111
	0.281
Hard	0.209
	0.038
Cl	-0.016
	0.922
Acid	-0.203
	0.699

```
Alk        0.451
           0.000

Nitrate   -0.115
           0.273

Nitrite   -0.844
           0.361

Org-N     -0.325
           0.031

Total-N   -0.228
           0.105

NH3-N      0.196
           0.541

Sulfate   -0.056
           0.704
Total-P   -0.173
           0.092

BOD        0.230
           0.019

COD       -0.322
           0.307

Oil&Grea -0.173
           0.539

Ca        -0.077
           0.486

Mg         0.024
           0.828

Na        -0.045
           0.700

K          0.038
           0.781

Chlo-A     0.090
           0.557

Cell Contents: Pearson correlation
               P-Value

* NOTE * Not enough data in column.

* NOTE * All values in column are identical.
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Analysis Result of Relationships between Water Quality and Number of Plankton in Each Phylum

Descriptive Statistics: Blue-green a, Green algae, Yellow-brown, Diatom, Dinofla

Variable	N	Mean	Median	TrMean	StDev	SE Mean
Blue-gre	109	5.275	4.000	5.152	3.299	0.316
Green al	109	9.321	10.000	9.051	7.014	0.672
Yellow-b	109	0.3303	0.0000	0.2828	0.5453	0.0522
Diatom	109	4.633	4.000	4.343	3.404	0.326
Dinoflag	109	1.2477	1.0000	1.2222	0.8940	0.0856
Euglenoi	109	1.523	1.000	1.323	2.017	0.193
Total Ph	109	22.33	21.00	21.95	13.15	1.26
Protozoa	109	1.890	2.000	1.808	1.641	0.157
Rotifer	109	6.468	6.000	6.212	4.830	0.463
Arthropo	109	3.413	3.000	3.263	2.266	0.217
Annelida	109	0.0275	0.0000	0.0000	0.1644	0.0157
Nematods	109	0.0275	0.0000	0.0000	0.1644	0.0157
Chordata	109	0.0275	0.0000	0.0000	0.1644	0.0157
Mullusca	109	0.1927	0.0000	0.1414	0.4405	0.0422
Coelente	109	0.00917	0.00000	0.00000	0.09578	0.00917
Total Zo	109	12.055	12.000	11.606	7.171	0.687
Grand To	109	34.42	34.00	33.89	17.84	1.71

Variable	Minimum	Maximum	Q1	Q3
Blue-gre	0.000	15.000	3.000	8.000
Green al	0.000	26.000	1.500	14.500
Yellow-b	0.0000	3.0000	0.0000	1.0000
Diatom	0.000	20.000	2.000	6.000
Dinoflag	0.0000	3.0000	0.0000	2.0000
Euglenoi	0.000	8.000	0.000	3.000
Total Ph	1.00	54.00	10.50	32.00
Protozoa	0.000	6.000	0.000	3.000
Rotifer	0.000	21.000	2.000	9.000
Arthropo	0.000	15.000	2.000	4.500
Annelida	0.0000	1.0000	0.0000	0.0000
Nematods	0.0000	1.0000	0.0000	0.0000
Chordata	0.0000	1.0000	0.0000	0.0000
Mullusca	0.0000	2.0000	0.0000	0.0000
Coelente	0.00000	1.00000	0.00000	0.00000
Total Zo	1.000	34.000	6.000	17.000
Grand To	4.00	85.00	17.50	48.00

Descriptive Statistics: Tair, Twater, pH, Trans, Depth, Tur, Con, DO, TS, TDS, SS

Variable	N	N*	Mean	Median	TrMean	StDev
Twater	102	7	28.075	28.000	28.062	2.059
pH	109	0	7.8804	8.0000	7.9537	0.9089
Trans	80	29	111.43	94.00	107.87	79.35
Depth	69	40	5.236	3.000	4.741	5.743
Tur	89	20	13.51	3.80	8.59	27.49
Con	99	10	293.8	242.0	219.1	624.3
DO	109	0	6.934	7.200	7.023	2.132
TS	41	68	127.7	139.0	117.0	108.6
TDS	86	23	173.7	161.0	165.2	95.9
SS	97	12	16.77	7.34	11.29	31.75
Hard	99	10	90.25	109.00	88.39	57.52
Cl	39	70	11.22	2.00	5.63	26.96
Acid	6	103	7.29	2.85	7.29	11.46
Alk	83	26	92.42	100.00	92.60	47.65
Nitrate	92	17	0.2266	0.1300	0.1471	0.4291
Nitrite	3	106	0.0243	0.0300	0.0243	0.0191
Org-N	44	65	0.3307	0.3000	0.3217	0.1742
Total-N	52	57	1.157	0.800	1.077	1.095
NH3-N	12	97	0.02975	0.02000	0.02560	0.03204
Sulfate	49	60	15.40	3.80	9.59	38.23
Total-P	96	13	0.03803	0.02500	0.02981	0.05812
BOD	104	5	2.523	2.000	2.368	1.960
COD	12	97	17.50	9.68	14.46	20.42
Oil&Grea	15	94	2.179	0.800	2.014	2.373
Ca	83	26	24.26	15.33	17.90	41.95
Mg	85	24	5.697	4.576	5.268	4.546
Na	77	32	30.2	11.5	13.3	118.0
K	56	53	2.317	1.846	1.874	2.794
Chlo-A	45	64	13.716	12.830	13.594	6.646

Variable	SE Mean	Minimum	Maximum	Q1	Q3
Twater	0.204	23.000	33.000	27.000	29.225
pH	0.0871	3.0000	9.4000	7.4000	8.4850
Trans	8.87	0.20	290.00	45.50	160.00
Depth	0.691	0.500	20.500	1.900	5.450
Tur	2.91	0.90	166.00	2.40	10.75
Con	62.7	0.1	6200.0	132.2	298.6
DO	0.204	0.200	11.600	6.200	8.310
TS	17.0	10.0	651.0	27.3	177.0
TDS	10.3	0.0	700.0	128.3	206.3
SS	3.22	0.00	214.00	2.90	18.25
Hard	5.78	0.00	317.00	27.56	119.00
Cl	4.32	0.10	120.00	1.10	8.00
Acid	4.68	0.95	30.60	2.02	10.76
Alk	5.23	0.41	195.00	74.00	122.00
Nitrate	0.0447	0.0010	2.6800	0.0400	0.2700
Nitrite	0.0111	0.0030	0.0400	0.0030	0.0400
Org-N	0.0263	0.1000	0.8000	0.2000	0.4425
Total-N	0.152	0.003	3.600	0.355	1.900
NH3-N	0.00925	0.00100	0.10000	0.00100	0.05000
Sulfate	5.46	0.00	255.00	2.21	11.60
Total-P	0.00593	0.00200	0.49000	0.01500	0.04000
BOD	0.192	0.100	9.300	1.048	3.283
COD	5.89	0.00	65.41	7.68	15.38
Oil&Grea	0.613	0.003	6.500	0.400	5.000
Ca	4.60	0.00	346.00	7.88	22.06
Mg	0.493	0.001	24.000	2.970	7.000
Na	13.5	1.3	1025.0	4.6	14.6
K	0.373	0.180	18.100	0.985	2.155
Chlo-A	0.991	1.710	29.940	8.525	18.435

Results for: P2SpCorre.MTW
Correlations: Blue-green a, Green algae, Yellow-brown, Diatom, Dinoflagella, Eug

	Blue-gre	Green al	Yellow-b	Diatom	Dinoflag	Euglenoi	Total Ph	Protozoa
Twater	0.023	-0.114	-0.047	-0.223	-0.049	0.057	-0.108	-0.033
	0.815	0.256	0.640	0.024	0.623	0.570	0.279	0.744
pH	0.502	0.143	-0.095	0.288	0.174	0.096	0.299	0.275
	0.000	0.138	0.324	0.002	0.070	0.320	0.002	0.004
Trans	-0.081	-0.300	0.150	-0.133	0.292	-0.245	-0.222	-0.124
	0.473	0.007	0.185	0.240	0.009	0.028	0.048	0.274
Depth	0.420	0.199	-0.154	0.068	0.290	0.004	0.243	-0.034
	0.000	0.101	0.206	0.576	0.016	0.977	0.045	0.780
Tur	-0.308	-0.303	-0.040	-0.263	-0.467	-0.049	-0.336	-0.217
	0.003	0.004	0.709	0.013	0.000	0.647	0.001	0.041
Con	-0.019	-0.140	-0.037	0.088	-0.058	0.137	-0.037	0.057
	0.855	0.167	0.714	0.388	0.569	0.175	0.715	0.575
DO	0.430	0.344	0.051	0.143	0.343	0.037	0.359	0.137
	0.000	0.000	0.597	0.138	0.000	0.706	0.000	0.155
TS	0.065	-0.495	-0.055	0.100	-0.350	-0.067	-0.298	0.405
	0.686	0.001	0.734	0.532	0.025	0.678	0.059	0.009
TDS	0.021	-0.092	-0.095	0.161	0.058	0.051	0.002	0.108
	0.849	0.402	0.384	0.140	0.598	0.642	0.986	0.322
SS	-0.123	-0.259	-0.007	-0.099	-0.415	-0.079	-0.228	0.034
	0.228	0.010	0.945	0.335	0.000	0.444	0.025	0.740
Hard	0.502	0.107	0.097	0.545	0.142	0.321	0.393	0.427
	0.000	0.290	0.339	0.000	0.160	0.001	0.000	0.000
Cl	0.004	0.426	0.474	0.704	-0.239	0.455	0.597	0.078
	0.979	0.007	0.002	0.000	0.143	0.004	0.000	0.639
Acid	0.211	-0.267	-0.493	0.920	-0.231	-0.294	-0.100	0.772
	0.689	0.608	0.321	0.009	0.660	0.572	0.851	0.072
Alk	0.564	0.190	0.069	0.376	0.166	0.317	0.413	0.509
	0.000	0.086	0.535	0.000	0.135	0.004	0.000	0.000
Nitrate	-0.056	-0.060	0.162	-0.039	-0.347	-0.141	-0.095	0.023
	0.593	0.569	0.124	0.715	0.001	0.181	0.368	0.827
Nitrite	-0.709	-0.980	-0.965	-0.673	-0.965	-0.965	-0.922	-0.709
	0.498	0.127	0.168	0.530	0.168	0.168	0.253	0.498
Org-N	-0.053	0.049	-0.212	-0.058	0.049	-0.040	-0.028	-0.092
	0.732	0.751	0.168	0.710	0.750	0.797	0.857	0.553
Total-N	-0.014	0.039	-0.366	-0.100	0.021	0.029	-0.021	-0.078
	0.921	0.786	0.008	0.481	0.883	0.838	0.884	0.581
NH3-N	0.238	-0.550	-0.184	-0.002	-0.150	-0.427	-0.410	-0.559
	0.457	0.064	0.568	0.995	0.642	0.167	0.186	0.059
Sulfate	0.001	-0.304	-0.073	0.119	-0.111	-0.124	-0.189	0.254
	0.992	0.034	0.619	0.414	0.448	0.396	0.192	0.078
Total-P	-0.166	-0.269	-0.114	-0.244	-0.155	-0.107	-0.271	-0.177
	0.106	0.008	0.270	0.017	0.132	0.300	0.008	0.084
BOD	0.204	0.049	-0.103	0.154	-0.240	0.013	0.100	0.371
	0.038	0.619	0.297	0.119	0.014	0.893	0.313	0.000
COD	-0.165	-0.329	-0.299	-0.146	-0.442	-0.321	-0.356	0.258
	0.608	0.296	0.345	0.651	0.150	0.309	0.257	0.417

Oil&Grea	0.054	-0.174	-0.139	-0.600	-0.515	-0.446	-0.372	-0.387
	0.848	0.536	0.622	0.018	0.049	0.096	0.172	0.154
Ca	-0.066	-0.294	0.066	0.106	-0.201	-0.058	-0.160	0.163
	0.553	0.007	0.555	0.338	0.068	0.605	0.149	0.141
Mg	-0.128	-0.397	0.154	-0.036	-0.047	-0.060	-0.256	0.032
	0.244	0.000	0.160	0.746	0.670	0.585	0.018	0.775
Na	-0.085	-0.215	-0.031	0.015	-0.110	0.092	-0.116	0.009
	0.463	0.060	0.791	0.895	0.343	0.427	0.315	0.941
K	-0.198	-0.290	0.015	-0.105	-0.191	-0.095	-0.269	-0.007
	0.143	0.030	0.915	0.441	0.158	0.484	0.045	0.958
Chlo-A	0.168	0.221	-0.254	-0.228	0.121	-0.224	0.017	0.122
	0.270	0.145	0.092	0.132	0.427	0.139	0.909	0.424

	Rotifer	Arthropo	Annelida	Nematods	Chordata	Mullusca	Coelente	Total Zo
Twater	0.014	0.007	0.087	-0.112	-0.023	-0.164	-0.125	-0.008
	0.890	0.941	0.384	0.261	0.815	0.101	0.210	0.934
pH	0.413	0.053	0.032	0.073	-0.108	0.242	0.013	0.373
	0.000	0.582	0.740	0.450	0.264	0.011	0.896	0.000
Trans	-0.179	-0.172	0.001	-0.059	0.311	-0.043	0.241	-0.196
	0.112	0.128	0.990	0.605	0.005	0.703	0.032	0.081
Depth	0.076	-0.307	-0.112	0.164	-0.074	0.098	-0.000	-0.038
	0.536	0.010	0.358	0.178	0.547	0.424	1.000	0.754
Tur	-0.155	0.036	-0.073	-0.004	-0.073	-0.155	-0.047	-0.160
	0.147	0.736	0.494	0.967	0.496	0.147	0.660	0.134
Con	0.118	-0.105	-0.031	-0.016	-0.041	-0.025	-0.007	0.056
	0.243	0.300	0.759	0.872	0.688	0.807	0.942	0.580
DO	0.369	0.291	0.101	-0.008	-0.058	0.346	0.039	0.394
	0.000	0.002	0.298	0.937	0.548	0.000	0.689	0.000
TS	0.197	-0.084	*	*	0.035	*	0.017	0.169
	0.218	0.601	*	*	0.826	*	0.918	0.290
TDS	0.075	-0.217	0.021	-0.011	-0.108	0.104	-0.044	0.006
	0.495	0.044	0.845	0.921	0.321	0.342	0.687	0.955
SS	-0.044	-0.068	-0.053	0.027	-0.072	-0.124	-0.050	-0.052
	0.670	0.507	0.608	0.792	0.486	0.225	0.625	0.612
Hard	0.428	-0.135	0.015	0.052	-0.075	0.269	0.030	0.358
	0.000	0.183	0.885	0.609	0.461	0.007	0.771	0.000
Cl	0.494	0.402	*	*	-0.032	0.663	-0.067	0.467
	0.001	0.011	*	*	0.848	0.000	0.686	0.003
Acid	0.244	-0.230	*	*	-0.183	0.000	*	0.474
	0.641	0.660	*	*	0.728	1.000	*	0.343
Alk	0.479	-0.166	-0.024	0.040	-0.188	0.219	0.069	0.400
	0.000	0.134	0.828	0.719	0.088	0.047	0.536	0.000
Nitrate	-0.005	-0.114	-0.027	-0.017	-0.049	-0.017	0.000	-0.037
	0.960	0.279	0.802	0.870	0.643	0.870	1.000	0.727
Nitrite	-0.998	-0.945	*	*	*	*	*	-0.995
	0.044	0.212	*	*	*	*	*	0.064
Org-N	-0.409	-0.107	-0.134	0.151	*	-0.099	-0.000	-0.330
	0.006	0.488	0.386	0.327	*	0.525	1.000	0.028
Total-N	-0.231	-0.113	-0.064	0.146	-0.106	-0.009	0.000	-0.202
	0.099	0.424	0.652	0.301	0.457	0.952	1.000	0.151

NH3-N	-0.369	-0.544	*	*	0.297	0.000	0.000	-0.518
	0.238	0.068	*	*	0.348	1.000	1.000	0.084
Sulfate	-0.040	-0.168	-0.020	*	0.000	-0.051	-0.027	-0.037
	0.785	0.250	0.890	*	1.000	0.730	0.855	0.802
Total-P	-0.105	-0.152	-0.072	-0.028	-0.013	-0.152	0.039	-0.170
	0.308	0.141	0.488	0.788	0.898	0.140	0.706	0.098
BOD	0.480	0.190	0.048	-0.011	-0.116	0.309	-0.079	0.483
	0.000	0.054	0.628	0.913	0.241	0.001	0.426	0.000
COD	0.037	-0.297	*	*	*	0.000	-0.057	-0.082
	0.908	0.349	*	*	*	1.000	0.860	0.800
Oil&Grea	-0.459	-0.215	0.000	0.000	-0.067	0.000	*	-0.427
	0.085	0.442	1.000	1.000	0.811	1.000	*	0.112
Ca	-0.024	-0.024	-0.017	-0.024	0.065	-0.056	0.030	0.009
	0.828	0.830	0.880	0.830	0.559	0.613	0.790	0.934
Mg	-0.114	-0.108	-0.017	-0.068	0.259	-0.106	0.173	-0.105
	0.297	0.324	0.881	0.534	0.017	0.333	0.112	0.338
Na	0.077	-0.094	-0.001	-0.027	-0.035	-0.056	0.000	0.020
	0.505	0.415	0.992	0.815	0.765	0.629	1.000	0.862
K	0.109	0.016	0.032	-0.046	0.038	0.090	0.000	0.085
	0.423	0.906	0.818	0.734	0.780	0.508	1.000	0.533
Chlo-A	0.181	-0.010	-0.124	-0.003	*	0.291	0.000	0.170
	0.235	0.949	0.419	0.984	*	0.052	1.000	0.265

	Grand To
Twater	-0.084
	0.400
pH	0.371
	0.000
Trans	-0.251
	0.025
Depth	0.178
	0.143
Tur	-0.314
	0.003
Con	-0.005
	0.963
DO	0.424
	0.000
TS	-0.131
	0.416
TDS	0.004
	0.973
SS	-0.188
	0.065
Hard	0.437
	0.000
Cl	0.615
	0.000
Acid	0.016
	0.975

```
Alk        0.471
           0.000

Nitrate   -0.083
           0.430

Nitrite   -0.961
           0.179

Org-N     -0.218
           0.155

Total-N   -0.111
           0.433

NH3-N     -0.477
           0.117

Sulfate   -0.150
           0.303

Total-P   -0.269
           0.008

BOD        0.274
           0.005

COD       -0.271
           0.394

Oil&Grea -0.426
           0.113

Ca        -0.106
           0.339

Mg        -0.222
           0.041

Na        -0.071
           0.541

K         -0.131
           0.336

Chlo-A     0.116
           0.449

Cell Contents: Pearson correlation
               P-Value

* NOTE * Not enough data in column.

* NOTE * All values in column are identical.
```

Appendix E

Water Quality and Abundance of Plankton Data

for Fittest Model Analysis

Table 1E. Data on water quality and abundance of plankton in phylum Cyanophyta for fittest model analysis.

No.	Blue-green algae	log(Blue-green algae)	Twater	pH	Trans	Depth	Tur	Con	DO	TDS	SS	Hard	Alk	Nitrate	Org-N	Total-N	Total-P	BOD	Ca	Mg	Na	K	Chlo-A
1	74057550	7.86957	28.8	8.78	89	4.0	8.8	227.0	11.60	164	8.00	114	105	0.280	0.20	0.10	0.004	6.8	21.24	4.399	15.34	1.911	11.31
2	96502770	7.98454	28.4	8.84	98	2.2	5.8	263.0	11.10	177	7.00	114	120	0.280	0.10	0.10	0.005	6.6	20.90	4.576	13.90	1.942	23.77
3	57215450	7.75751	28.2	8.70	13.5	4.7	3.1	264.0	10.62	165	4.00	116	115	0.280	0.10	0.10	0.002	7.0	21.19	4.666	14.02	1.848	21.12
4	50174900	7.70049	27.3	8.05	120	19.8	3.2	267.0	8.37	180	4.50	118	120	0.290	0.20	0.10	0.010	5.3	20.97	4.624	14.22	1.920	22.88
5	24588750	7.39074	27.3	8.17	150	13.0	1.8	273.0	7.30	171	10.00	118	110	0.280	0.10	0.10	0.026	7.2	21.51	4.648	14.16	18.100	14.45
6	32066200	7.50605	26.0	8.10	120	5.4	4.6	210.0	7.78	274	2.25	115	114	0.280	0.20	0.60	0.025	2.7	21.67	5.960	13.30	1.844	19.12
7	6651600	6.82293	25.0	8.20	140	2.9	1.9	193.0	7.38	312	2.47	169	177	0.280	0.40	0.80	0.102	2.0	27.34	4.550	13.51	1.603	10.90
8	17924850	7.25346	27.0	7.90	160	3.0	1.5	250.0	9.65	263	3.80	116	134	0.290	0.30	0.70	0.006	3.8	20.65	4.570	12.83	1.798	20.10
9	5975200	6.77635	26.0	8.60	140	4.0	2.0	198.2	8.37	218	2.15	114	130	0.270	0.40	0.80	0.036	2.0	19.61	4.430	12.53	1.761	16.64
10	18610100	7.26975	25.0	8.20	140	20.5	3.2	204.0	9.45	205	2.35	127	130	0.270	0.30	0.70	0.026	2.9	20.95	4.510	12.94	1.870	19.98
11	10892650	7.03713	25.0	8.40	100	5.3	6.6	199.0	9.55	204	3.92	115	120	0.270	0.30	0.70	0.027	2.7	21.25	4.470	12.66	1.800	18.48
12	8790650	6.94402	25.0	8.80	220	3.7	0.9	192.0	8.32	119	1.70	112	130	0.280	0.30	0.60	0.088	0.8	21.00	4.490	12.63	1.778	9.20
13	69401500	7.84137	26.0	8.40	120	1.3	3.1	311.0	7.40	215	8.34	168	159	0.215	0.40	1.00	0.021	3.8	22.06	6.110	14.53	2.340	6.72
14	61990500	7.79233	26.0	8.05	70	2.0	6.7	401.0	7.40	268	11.42	200	195	0.165	0.30	0.90	0.021	4.8	30.23	7.230	14.99	2.060	8.54
15	64245000	7.80784	27.0	8.05	10	1.7	3.2	380.0	6.80	216	6.58	157	149	0.148	0.50	1.20	0.070	2.6	21.71	6.020	14.56	2.320	3.74
16	89798750	7.95327	25.0	8.30	160	5.8	1.5	315.0	6.40	237	10.60	174	170	0.109	0.40	1.00	0.019	1.4	25.48	6.450	14.55	2.160	6.41
17	91801650	7.96285	27.0	8.40	160	20.0	1.0	384.0	4.00	213	7.82	156	146	0.142	0.50	1.00	0.008	1.2	21.58	5.760	14.21	2.140	8.51
18	23674450	7.37428	25.0	8.80	190	3.9	2.9	301.0	7.00	217	6.03	159	148	0.149	0.20	0.80	0.002	1.6	22.93	5.960	14.65	2.350	3.83
19	74087700	7.86975	27.0	8.60	140	6.0	1.1	310.0	8.60	222	7.34	158	147	0.131	0.40	1.00	0.003	3.7	22.75	5.830	14.04	2.140	9.66
20	81972000	7.91367	30.5	8.60	90	1.3	10.3	332.0	9.29	273	5.40	139	141	0.090	0.20	0.50	0.026	3.9	27.44	17.360	128.50	4.600	14.29
21	25786800	7.41140	30.3	7.84	80	2.5	16.7	326.0	8.73	253	7.30	162	161	0.080	0.10	0.40	0.033	3.4	25.87	7.920	20.00	2.170	24.64
22	57519500	7.75982	30.8	8.47	100	2.5	11.2	317.0	8.21	217	7.40	129	127	0.070	0.10	0.40	0.040	2.0	19.95	6.870	16.00	1.870	15.95
23	48024500	7.68146	30.5	7.25	140	5.2	8.7	307.0	8.27	162	4.20	128	124	0.030	0.10	0.40	0.030	2.1	19.65	6.720	15.75	2.080	12.68
24	99447900	7.99760	30.9	8.72	120	19.5	2.9	309.0	9.04	185	7.50	127	121	0.060	0.10	0.30	0.019	2.0	14.15	6.680	56.39	2.020	15.35
25	42253950	7.62587	29.9	7.65	140	2.1	2.3	309.0	6.77	166	3.40	123	122	0.050	0.20	0.40	0.030	1.4	19.82	6.770	15.51	1.950	17.11
26	71890750	7.85667	31.8	8.55	140	7.2	1.6	292.0	8.75	153	5.40	119	121	0.040	0.10	0.40	0.048	1.6	19.00	6.610	15.07	1.900	5.41
27	4233600	6.62671	27.2	8.39	20	5.5	23.3	242.6	6.01	120	51.80	108	84	0.204	0.40	1.90	0.023	3.8	13.58	2.800	7.97	1.070	7.70
28	28400	4.45332	26.0	7.62	20	1.1	46.3	196.0	5.44	126	87.80	90	74	0.406	0.50	2.90	0.081	3.4	5.38	0.670	2.54	0.420	1.71
29	2051000	6.31197	27.9	8.82	25	0.8	22.2	242.0	7.66	129	43.00	95	79	0.222	0.60	3.20	0.028	1.1	14.86	2.900	8.53	1.430	7.27
30	29382500	7.46809	27.2	8.17	61	1.6	6.7	275.0	6.80	140	13.20	109	96	0.130	0.80	3.50	0.02	4.3	15.59	3.670	11.25	1.550	12.83
31	25042500	7.39868	27.4	8.89	62	13.0	7.9	251.4	7.31	133	18.60	111	87	0.117	0.50	3.30	0.036	1.8	15.30	3.380	10.27	1.540	17.11
32	23670800	7.37421	27.4	9.02	44	0.8	6.6	281.7	8.27	149	29.20	117	98	0.125	0.50	3.60	0.038	2.2	14.32	3.570	11.52	1.280	12.83
33	12809500	7.10753	27.3	8.81	100	5.7	2.9	292.3	6.92	145	7.60	124	100	0.123	0.50	2.00	0.025	2.1	14.41	2.950	11.98	1.270	11.54
34	12735900	7.10503	28.1	8.60	63	2.0	6.2	298.6	7.10	115	10.80	133	116	0.142	0.42	0.80	0.015	2.8	12.58	1.980	6.78	0.180	12.40
35	46929950	7.67145	28.1	8.90	79	2.1	3.8	257.9	8.00	126	9.00	111	97	0.138	0.25	1.90	0.015	3.4	6.05	0.680	3.25	0.250	3.42
36	10264750	7.01135	28.8	8.00	66	2.0	3.1	268.6	8.50	110	7.60	113	110	0.127	0.25	1.52	0.015	0.1	12.58	0.580	5.58	0.580	5.99
37	25423200	7.40523	28.7	8.70	79	4.0	3.8	246.4	6.90	124	8.20	133	118	0.139	0.35	1.78	0.017	1.3	13.35	1.360	9.85	0.640	11.98
38	54924800	7.73977	29.0	9.20	84	18.2	3.9	245.0	9.00	140	8.40	111	74	0.144	0.65	2.88	0.015	2.2	15.33	2.050	6.58	0.980	11.12
39	49536000	7.69492	31.2	8.70	88	1.2	3.4	257.3	8.40	136	8.00	114	92	0.151	0.45	3.46	0.017	3.1	9.58	2.050	9.35	0.760	12.40
40	46851200	7.67072	30.8	9.40	72	8.0	3.6	237.4	9.70	155	9.40	95	81	0.148	0.68	2.58	0.015	5.3	12.26	1.570	7.84	0.270	18.39

Notes
Tw = Water Temperature (Celsius)
Tran = Transparency (centimeter)
Depth = Depth of water (meter)
Tur = Turbidity (milligram/liter, mg/l)
Con = Conductivity (microhos/centimeter)

DO = Dissolved Oxygen (mg/l)
TDS = Total Dissolved Solid (mg/l)
SS = Suspended Solid (mg/l)
Hard = Total Hardness (mg/l as $CaCO_3$)
Alk = Alkalinity (mg/l)

NO_3-N = Nitrate-Nitrogen (mg/l)
Org-N = Organic-Nitrogen (mg/l)
Total N = Total Nitrogen (mg/l)
Total P = Total Phosphate (mg/l)
BOD = Biochemical Oxygen Demand (mg/l)

Ca = Calcium (mg/l)
Mg = Magnesium (mg/l)
Na = Sodium (mg/l)
K = Potassium (mg/l)
Ch-A = Chlorophyll a (mg/m^3 of water)

Table 2E. Data on water quality and abundance of plankton in phylum Chlorophyta for fittest model analysis

No.	Green algae	log(G)	Twater	pH	Trans	Depth	Tur	Con	DO	TDS	SS	Hard	Alk	Nitrate	Org-N	Total-N	Total-P	BOD	Ca	Mg	Na	K	Chlo-A
1	89393650	7.95131	28.8	8.78	89	4.0	8.8	227.0	11.60	164	8.00	114	105	0.280	0.20	0.10	0.004	6.8	21.24	4.399	15.34	1.911	11.31
2	82232400	7.91504	28.1	8.56	50	3.1	19.0	244.0	8.99	137	23.00	115	120	0.280	0.30	0.10	0.009	6.4	18.17	3.786	9.04	1.543	16.72
3	108798300	8.03662	28.4	8.84	98	2.2	5.8	263.0	11.10	177	7.00	114	120	0.280	0.10	0.10	0.005	6.6	20.90	4.576	13.90	1.942	23.77
4	29479950	7.46953	28.2	8.70	13.5	4.7	3.1	264.0	10.62	165	4.00	116	115	0.280	0.10	0.10	0.002	7.0	21.19	4.666	14.02	1.848	21.12
5	34976850	7.54378	27.3	8.05	120	19.8	3.2	267.0	8.37	180	4.50	118	120	0.290	0.20	0.10	0.010	5.3	20.97	4.624	14.22	1.920	22.88
6	11459400	7.05916	27.6	8.36	170	3.7	2.6	284.0	7.71	210	3.00	112	125	0.280	0.20	0.10	0.010	6.5	21.53	4.637	14.16	1.872	13.91
7	41769750	7.62086	27.3	8.17	150	13.0	1.8	273.0	7.30	171	10.00	118	110	0.280	0.10	0.10	0.026	7.2	21.51	4.648	14.16	18.100	14.45
8	1373500	6.13783	26.0	8.10	120	5.4	4.6	210.0	7.78	274	2.25	115	114	0.280	0.20	0.60	0.025	2.7	21.67	5.96	13.30	1.844	19.12
9	1674400	6.22386	25.0	8.20	140	2.9	1.9	193.0	7.38	312	2.47	169	177	0.280	0.40	0.80	0.102	2.0	27.34	4.55	13.51	1.603	10.90
10	1674450	6.22387	27.0	7.90	160	3.0	1.5	250.0	9.65	263	3.80	116	134	0.290	0.30	0.70	0.006	3.8	20.65	4.57	12.83	1.798	20.10
11	1155000	6.06258	26.0	8.60	140	4.0	2.0	198.2	8.37	218	2.15	114	130	0.270	0.40	0.80	0.036	2.0	19.61	4.43	12.53	1.761	16.64
12	1706050	6.23199	25.0	8.20	140	20.5	3.2	204.0	9.45	205	2.35	127	130	0.270	0.30	0.70	0.026	2.9	20.95	4.51	12.94	1.870	19.98
13	736600	5.86723	25.0	8.40	100	5.3	6.6	199.0	9.55	204	3.92	115	120	0.270	0.30	0.70	0.027	2.7	21.25	4.47	12.66	1.800	18.48
14	556600	5.74554	25.0	8.80	220	3.7	0.9	192.0	8.32	119	1.70	112	130	0.280	0.30	0.60	0.088	0.8	21.00	4.49	12.63	1.778	9.20
15	1303500	6.11511	26.0	8.40	120	1.3	3.1	311.0	7.40	215	8.34	168	159	0.215	0.40	1.00	0.021	3.8	22.06	6.11	14.53	2.34	6.72
16	2070750	6.31613	26.0	8.05	70	2.0	6.7	401.0	7.40	268	11.42	200	195	0.165	0.30	0.90	0.021	4.8	30.23	7.23	14.99	2.06	8.54
17	982500	5.99233	27.0	8.05	10	1.7	3.2	380.0	6.80	216	6.58	157	149	0.148	0.50	1.20	0.070	2.6	21.71	6.02	14.56	2.32	3.74
18	1900450	6.27886	25.0	8.30	160	5.8	1.5	315.0	6.40	237	10.60	174	170	0.109	0.40	1.00	0.019	1.4	25.48	6.45	14.55	2.16	6.41
19	1627400	6.21149	27.0	8.40	160	20.0	1.0	384.0	4.00	213	7.82	156	146	0.142	0.50	1.00	0.008	1.2	21.58	5.76	14.21	2.14	8.51
20	448850	5.65210	25.0	8.80	190	3.9	2.9	301.0	7.00	217	6.03	159	148	0.149	0.20	0.80	0.002	1.6	22.93	5.96	14.65	2.35	3.83
21	1905300	6.27996	27.0	8.60	140	6.0	1.1	310.0	8.60	222	7.34	158	147	0.131	0.40	1.00	0.003	3.7	22.75	5.83	14.04	2.14	9.66
22	1830600	6.26259	30.5	8.60	90	1.3	10.3	332.0	9.29	273	5.40	139	141	0.090	0.20	0.50	0.026	3.9	27.44	17.36	128.50	4.60	14.29
23	5627700	6.75033	30.3	7.84	80	2.5	16.7	326.0	8.73	253	7.30	162	161	0.080	0.10	0.40	0.033	3.4	25.87	7.92	20.00	2.17	24.64
24	1386900	6.14205	30.8	8.47	100	2.5	11.2	317.0	8.21	217	7.40	129	127	0.070	0.10	0.40	0.040	2.0	19.95	6.87	16.00	1.87	15.95
25	1028600	6.01225	30.5	7.25	140	5.2	8.7	307.0	8.27	162	4.20	128	124	0.030	0.10	0.40	0.030	2.1	19.65	6.72	15.75	2.08	12.68
26	1916250	6.28245	30.9	8.72	120	19.5	2.9	309.0	9.04	185	7.50	127	121	0.060	0.10	0.30	0.019	2.0	14.15	6.68	56.39	2.02	15.35
27	1057800	6.02440	29.9	7.65	140	2.1	2.3	309.0	6.77	166	3.40	123	122	0.050	0.20	0.40	0.030	1.4	19.82	6.77	15.51	1.95	17.11
28	2390650	6.37852	31.8	8.55	140	7.2	1.6	292.0	8.75	153	5.40	119	121	0.040	0.10	0.40	0.048	1.6	19.00	6.61	15.07	1.90	5.41
29	17883600	7.25245	27.2	8.39	20	5.5	23.3	242.6	6.01	120	51.80	108	84	0.204	0.40	1.90	0.023	3.8	13.58	2.80	7.97	1.07	7.70
30	5572000	6.74601	27.9	8.82	25	0.8	22.2	242.0	7.66	129	43.00	95	79	0.222	0.60	3.20	0.028	1.1	14.86	2.90	8.53	1.43	7.27
31	64502800	7.80958	27.2	8.17	61	1.6	6.7	275.0	6.80	140	13.20	109	96	0.130	0.80	3.50	0.020	4.3	15.59	3.67	11.25	1.55	12.83
32	65794200	7.81819	27.4	8.89	62	13.0	7.9	251.4	7.31	133	18.60	111	87	0.117	0.50	3.30	0.036	1.8	15.30	3.38	10.27	1.54	17.11
33	28927200	7.46131	27.4	9.02	44	0.8	6.6	281.7	8.27	149	29.20	117	98	0.125	0.50	3.60	0.038	2.2	14.32	3.57	11.52	1.28	12.83
34	609500	5.78497	28.1	8.60	63	2.0	6.2	298.6	7.10	115	10.80	133	116	0.142	0.42	0.80	0.015	2.8	12.58	1.98	6.78	0.18	12.40
35	1509650	6.17888	28.1	8.90	79	2.1	3.8	257.9	8.00	126	9.00	111	97	0.138	0.25	1.90	0.015	3.4	6.05	0.68	3.25	0.25	3.42
36	797050	5.90149	28.8	8.00	66	2.0	3.1	268.6	8.50	110	7.60	113	110	0.127	0.25	1.52	0.015	0.1	12.58	0.58	5.58	0.58	5.99
37	989750	5.99553	28.7	8.70	79	4.0	3.8	246.4	6.90	124	8.20	133	118	0.139	0.35	1.78	0.017	1.3	13.35	1.36	9.85	0.64	11.98
38	1170400	6.06833	29.0	9.20	84	18.2	3.9	245.0	9.00	140	8.40	111	74	0.144	0.65	2.88	0.015	2.2	15.33	2.05	6.58	0.98	11.12
39	1346400	6.12917	31.2	8.70	88	1.2	3.4	257.3	8.40	136	8.00	114	92	0.151	0.45	3.46	0.017	3.1	9.58	2.05	9.35	0.76	12.40
40	2327600	6.36691	30.8	9.40	72	8.0	3.6	237.4	9.70	155	9.40	95	81	0.148	0.68	2.58	0.015	5.3	12.26	1.57	7.84	0.27	18.39

Notes
Tw = Water Temperature (Celsius)
Tran = Transparency (centimeter)
Depth = Depth of water (meter)
Tur = Turbidity (milligram/liter, mg/l)
Con = Conductivity (microhos/centimeter)
DO = Dissolved Oxygen (mg/l)
TDS = Total Dissolved Solid (mg/l)
SS = Suspended Solid (mg/l)
Hard = Total Hardness (mg/l as $CaCO_3$)
Alk = Alkalinity (mg/l)
NO_3-N = Nitrate-Nitrogen (mg/l)
Org-N = Organic-Nitrogen (mg/l)
Total N = Total Nitrogen (mg/l)
Total P = Total Phosphate (mg/l)
BOD = Biochemical Oxygen Demand (mg/l)
Ca = Calcium (mg/l)
Mg = Magnesium (mg/l)
Na = Sodium (mg/l)
K = Potassium (mg/l)
Ch-A = Chlorophyll a (mg/m^3 of water)

Table 3E. Data on water quality and abundance of plankton in phylum Bacillariophyta for fittest model analysis.

No.	Diatom	Twater	pH	Trans	Depth	Tur	Con	DO	TDS	SS	Hard	Alk	Nitrate	Org-N	Total-N	Total-P	BOD	Ca	Mg	Na	K	Chlo-A
1	7304100	28.8	8.78	89	4.0	8.80	227.0	11.60	164	8.00	114	105	0.280	0.20	0.10	0.004	6.8	21.24	4.399	15.34	1.911	11.31
2	8131500	28.1	8.56	50	3.1	19.00	244.0	8.99	137	23.00	115	120	0.280	0.30	0.10	0.009	6.4	18.17	3.786	9.04	1.543	16.72
3	9465300	28.4	8.84	98	2.2	5.80	263.0	11.10	177	7.00	114	120	0.280	0.10	0.10	0.005	6.6	20.90	4.576	13.90	1.942	23.77
4	1054200	28.2	8.70	13.5	4.7	3.10	264.0	10.62	165	4.00	116	115	0.280	0.10	0.10	0.002	7.0	21.19	4.666	14.02	1.848	21.12
5	1255000	27.3	8.05	120	19.8	3.20	267.0	8.37	180	4.50	118	120	0.290	0.20	0.10	0.010	5.3	20.97	4.624	14.22	1.920	22.88
6	777450	27.6	8.36	170	3.7	2.60	284.0	7.71	210	3.00	112	125	0.280	0.20	0.10	0.010	6.5	21.53	4.637	14.16	1.872	13.91
7	784350	27.3	8.17	150	13.0	1.80	273.0	7.30	171	10.00	118	110	0.280	0.10	0.10	0.026	7.2	21.51	4.648	14.16	18.100	14.45
8	10029900	26.0	8.10	120	5.4	4.60	210.0	7.78	274	2.25	115	114	0.280	0.20	0.60	0.025	2.7	21.67	5.96	13.30	1.844	19.12
9	2226400	25.0	8.20	140	2.9	1.90	193.0	7.38	312	2.47	169	177	0.280	0.40	0.80	0.102	2.0	27.34	4.55	13.51	1.603	10.90
10	10037550	27.0	7.90	160	3.0	1.50	250.0	9.65	263	3.80	116	134	0.290	0.30	0.70	0.006	3.8	20.65	4.57	12.83	1.798	20.10
11	5759600	26.0	8.60	140	4.0	2.00	198.2	8.37	218	2.15	114	130	0.270	0.40	0.80	0.036	2.0	19.61	4.43	12.53	1.761	16.64
12	11450650	25.0	8.20	140	20.5	3.20	204.0	9.45	205	2.35	127	130	0.270	0.30	0.70	0.026	2.9	20.95	4.51	12.94	1.870	19.98
13	6982300	25.0	8.40	100	5.3	6.60	199.0	9.55	204	3.92	115	120	0.270	0.30	0.70	0.027	2.7	21.25	4.47	12.66	1.800	18.48
14	3908300	25.0	8.80	220	3.7	0.90	192.0	8.32	119	1.70	112	130	0.280	0.30	0.60	0.088	0.8	21.00	4.49	12.63	1.778	9.20
15	14472800	26.0	8.40	120	1.3	3.10	311.0	7.40	215	8.34	168	159	0.215	0.40	1.00	0.021	3.8	22.06	6.11	14.53	2.340	6.72
16	18372750	26.0	8.05	70	2.0	6.70	401.0	7.40	268	11.42	200	195	0.165	0.30	0.90	0.021	4.8	30.23	7.23	14.99	2.060	8.54
17	9112500	27.0	8.05	10	1.7	3.20	380.0	6.80	216	6.58	157	149	0.148	0.50	1.20	0.070	2.6	21.71	6.02	14.56	2.320	3.74
18	37421950	25.0	8.30	160	5.8	1.50	315.0	6.40	237	10.60	174	170	0.109	0.40	1.00	0.019	1.4	25.48	6.45	14.55	2.160	6.41
19	40911600	27.0	8.40	160	20.0	1.00	384.0	4.00	213	7.82	156	146	0.142	0.50	1.00	0.008	1.2	21.58	5.76	14.21	2.140	8.51
20	44694000	25.0	8.80	190	3.9	2.90	301.0	7.00	217	6.03	159	148	0.149	0.20	0.80	0.002	1.6	22.93	5.96	14.65	2.350	3.83
21	38292150	27.0	8.60	140	6.0	1.10	310.0	8.60	222	7.34	158	147	0.131	0.40	1.00	0.003	3.7	22.75	5.83	14.04	2.140	9.66
22	41188500	30.5	8.60	90	1.3	10.30	332.0	9.29	273	5.40	139	141	0.090	0.20	0.50	0.026	3.9	27.44	17.36	128.50	4.600	14.29
23	30115800	30.3	7.84	80	2.5	16.70	326.0	8.73	253	7.30	162	161	0.080	0.10	0.40	0.033	3.4	25.87	7.92	20.00	2.170	24.64
24	22686200	30.8	8.47	100	2.5	11.20	317.0	8.21	217	7.40	129	127	0.070	0.10	0.40	0.040	2.0	19.95	6.87	16.00	1.870	15.95
25	22302550	30.5	7.25	140	5.2	8.70	307.0	8.27	162	4.20	128	124	0.030	0.10	0.40	0.030	2.1	19.65	6.72	15.75	2.080	12.68
26	39390150	29.9	7.65	140	2.1	2.30	309.0	6.77	166	3.40	123	122	0.050	0.20	0.40	0.030	1.4	19.82	6.77	15.51	1.950	17.11
27	43463250	31.8	8.55	140	7.2	1.60	292.0	8.75	153	5.40	119	121	0.040	0.10	0.40	0.048	1.6	19.00	6.61	15.07	1.900	5.41
28	3259200	27.2	8.39	20	5.5	23.30	242.6	6.01	120	51.80	108	84	0.204	0.40	1.90	0.023	3.8	13.58	2.80	7.97	1.070	7.70
29	149100	26.0	7.62	20	1.1	46.30	196.0	5.44	126	87.80	90	74	0.406	0.50	2.90	0.081	3.4	5.38	0.67	2.54	0.420	1.71
30	1771000	27.9	8.82	25	0.8	22.20	242.0	7.66	129	43.00	95	79	0.222	0.60	3.20	0.028	1.1	14.86	2.90	8.53	1.430	7.27
31	1518400	27.2	8.17	61	1.6	6.70	275.0	6.80	140	13.20	109	96	0.130	0.80	3.50	0.020	4.3	15.59	3.67	11.25	1.550	12.83
32	11400300	27.4	8.89	62	13.0	7.90	251.4	7.31	133	18.60	111	87	0.117	0.50	3.30	0.036	1.8	15.30	3.38	10.27	1.540	17.11
33	7357600	27.4	9.02	44	0.8	6.60	281.7	8.27	149	29.20	117	98	0.125	0.50	3.60	0.038	2.2	14.32	3.57	11.52	1.280	12.83
34	13830150	27.3	8.81	100	5.7	2.90	292.3	6.92	145	7.60	124	100	0.123	0.50	2.00	0.025	2.1	14.41	2.95	11.98	1.270	11.54
35	964600	28.1	8.60	63	2.0	6.20	298.6	7.10	115	10.80	133	116	0.142	0.42	0.80	0.015	2.8	12.58	1.98	6.78	0.180	12.40
36	1155400	28.1	8.90	79	2.1	3.80	257.9	8.00	126	9.00	111	97	0.138	0.25	1.90	0.015	3.4	6.05	0.68	3.25	0.250	3.42
37	2360750	28.8	8.00	66	2.0	3.10	268.6	8.50	110	7.60	113	110	0.127	0.25	1.52	0.015	0.1	12.58	0.58	5.58	0.580	5.99
38	1856450	28.7	8.70	79	4.0	3.80	246.4	6.90	124	8.20	133	118	0.139	0.35	1.78	0.017	1.3	13.35	1.36	9.85	0.640	11.98
39	1758400	29.0	9.20	84	18.2	3.90	245.0	9.00	140	8.40	111	74	0.144	0.65	2.88	0.015	2.2	15.33	2.05	6.58	0.980	11.12
40	5623200	31.2	8.70	88	1.2	3.40	257.3	8.40	136	8.00	114	92	0.151	0.45	3.46	0.017	3.1	9.58	2.05	9.35	0.760	12.40
41	717200	30.8	9.40	72	8.0	3.60	237.4	9.70	155	9.40	95	81	0.148	0.68	2.58	0.015	5.3	12.26	1.57	7.84	0.270	18.39

Notes
Tw = Water Temperature (Celsius)
Tran = Transparency (centimeter)
Depth = Depth of water (meter)
Tur = Turbidity (milligram/liter, mg/l)
Con = Conductivity (microhos/centimeter)
DO = Dissolved Oxygen (mg/l)
TDS = Total Dissolved Solid (mg/l)
SS = Suspended Solid (mg/l)
Hard = Total Hardness (mg/l as $CaCO_3$)
Alk = Alkalinity (mg/l)
NO_3-N = Nitrate-Nitrogen (mg/l)
Org-N = Organic-Nitrogen (mg/l)
Total N = Total Nitrogen (mg/l)
Total P = Total Phosphate (mg/l)
BOD = Biochemical Oxygen Demand (mg/l)
Ca = Calcium (mg/l)
Mg = Magnesium (mg/l)
Na = Sodium (mg/l)
K = Potassium (mg/l)
Ch-A = Chlorophyll a (mg/m^3 of water)

Table 4E. Data on water quality and abundance of plankton in phylum Chrysophyta for fittest model analysis.

No.	Yellow-brown algae	log(Yellow-brown algae+100)	Twater	pH	Trans	Depth	Tur	Con	DO	TDS	SS	Hard	Alk	Nitrate	Org-N	Total-N	Total-P	BOD	Ca	Mg	Na	K	Chlo-A
1	0	2.00000	28.8	8.78	89	4.0	8.8	227.0	11.60	164	8.00	114	105	0.280	0.20	0.10	0.004	6.8	21.24	4.399	15.34	1.911	11.31
2	0	2.00000	28.1	8.56	50	3.1	19.0	244.0	8.99	137	23.00	115	120	0.280	0.30	0.10	0.009	6.4	18.17	3.786	9.04	1.543	16.72
3	0	2.00000	28.2	8.70	13.5	4.7	3.1	264.0	10.62	165	4.00	116	115	0.280	0.10	0.10	0.002	7.0	21.19	4.666	14.02	1.848	21.12
4	0	2.00000	27.3	8.05	120	19.8	3.2	267.0	8.37	180	4.50	118	120	0.290	0.20	0.10	0.010	5.3	20.97	4.624	14.22	1.920	22.88
5	0	2.00000	27.6	8.36	170	3.7	2.6	284.0	7.71	210	3.00	112	125	0.280	0.20	0.10	0.010	6.5	21.53	4.637	14.16	1.872	13.91
6	0	2.00000	27.3	8.17	150	13.0	1.8	273.0	7.30	171	10.00	118	110	0.280	0.10	0.10	0.026	7.2	21.51	4.648	14.16	18.100	14.45
7	0	2.00000	26.0	8.10	120	5.4	4.6	210.0	7.78	274	2.25	115	114	0.280	0.20	0.60	0.025	2.7	21.67	5.96	13.30	1.844	19.12
8	358800	5.55497	25.0	8.20	140	2.9	1.9	193.0	7.38	312	2.47	169	177	0.280	0.40	0.80	0.102	2.0	27.34	4.55	13.51	1.603	10.90
9	36600	4.56467	27.0	7.90	160	3.0	1.5	250.0	9.65	263	3.80	116	134	0.290	0.30	0.70	0.006	3.8	20.65	4.57	12.83	1.798	20.10
10	0	2.00000	26.0	8.60	140	4.0	2.0	198.2	8.37	218	2.15	114	130	0.270	0.40	0.80	0.036	2.0	19.61	4.43	12.53	1.761	16.64
11	0	2.00000	25.0	8.20	140	20.5	3.2	204.0	9.45	205	2.35	127	130	0.270	0.30	0.70	0.026	2.9	20.95	4.51	12.94	1.870	19.98
12	0	2.00000	25.0	8.40	100	5.3	6.6	199.0	9.55	204	3.92	115	120	0.270	0.30	0.70	0.027	2.7	21.25	4.47	12.66	1.800	18.48
13	0	2.00000	25.0	8.80	220	3.7	0.9	192.0	8.32	119	1.70	112	130	0.280	0.30	0.60	0.088	0.8	21.00	4.49	12.63	1.778	9.20
14	663600	5.82197	26.0	8.40	120	1.3	3.1	311.0	7.40	215	8.34	168	159	0.215	0.40	1.00	0.021	3.8	22.06	6.11	14.53	2.340	6.72
15	24750	4.39533	26.0	8.05	70	2.0	6.7	401.0	7.40	268	11.42	200	195	0.165	0.30	0.90	0.021	4.8	30.23	7.23	14.99	2.060	8.54
16	232500	5.36661	27.0	8.05	10	1.7	3.2	380.0	6.80	216	6.58	157	149	0.148	0.50	1.20	0.070	2.6	21.71	6.02	14.56	2.320	3.74
17	467650	5.67001	25.0	8.30	160	5.8	1.5	315.0	6.40	237	10.60	174	170	0.109	0.40	1.00	0.019	1.4	25.48	6.45	14.55	2.160	6.41
18	834300	5.92137	27.0	8.40	160	20.0	1.0	384.0	4.00	213	7.82	156	146	0.142	0.50	1.00	0.008	1.2	21.58	5.76	14.21	2.140	8.51
19	19100	4.28330	25.0	8.80	190	3.9	2.9	301.0	7.00	217	6.03	159	148	0.149	0.20	0.80	0.002	1.6	22.93	5.96	14.65	2.350	3.83
20	919800	5.96374	27.0	8.60	140	6.0	1.1	310.0	8.60	222	7.34	158	147	0.131	0.40	1.00	0.003	3.7	22.75	5.83	14.04	2.140	9.66
21	40500	4.60853	30.5	8.60	90	1.3	10.3	332.0	9.29	273	5.40	139	141	0.090	0.20	0.50	0.026	3.9	27.44	17.36	128.50	4.600	14.29
22	0	2.00000	30.3	7.84	80	2.5	16.7	326.0	8.73	253	7.30	162	161	0.080	0.10	0.40	0.033	3.4	25.87	7.92	20.00	2.170	24.64
23	147400	5.16879	30.8	8.47	100	2.5	11.2	317.0	8.21	217	7.40	129	127	0.070	0.10	0.40	0.040	2.0	19.95	6.87	16.00	1.870	15.95
24	0	2.00000	30.5	7.25	140	5.2	8.7	307.0	8.27	162	4.20	128	124	0.030	0.10	0.40	0.030	2.1	19.65	6.72	15.75	2.080	12.68
25	10950	4.04336	30.9	8.72	120	19.5	2.9	309.0	9.04	185	7.50	127	121	0.060	0.10	0.30	0.019	2.0	14.15	6.68	56.39	2.020	15.35
26	12900	4.11394	29.9	7.65	140	2.1	2.3	309.0	6.77	166	3.40	123	122	0.050	0.20	0.40	0.030	1.4	19.82	6.77	15.51	1.950	17.11
27	13700	4.13988	31.8	8.55	140	7.2	1.6	292.0	8.75	153	5.40	119	121	0.040	0.10	0.40	0.048	1.6	19.00	6.61	15.07	1.900	5.41
28	0	2.00000	27.2	8.39	20	5.5	23.3	242.6	6.01	120	51.80	108	84	0.204	0.40	1.90	0.023	3.8	13.58	2.8	7.97	1.070	7.70
29	0	2.00000	26.0	7.62	20	1.1	46.3	196.0	5.44	126	87.80	90	74	0.406	0.50	2.90	0.081	3.4	5.38	0.67	2.54	0.420	1.71
30	0	2.00000	27.9	8.82	25	0.8	22.2	242.0	7.66	129	43.00	95	79	0.222	0.60	3.20	0.028	1.1	14.86	2.9	8.53	1.430	7.27
31	0	2.00000	27.2	8.17	61	1.6	6.7	275.0	6.80	140	13.20	109	96	0.130	0.80	3.50	0.020	4.3	15.59	3.67	11.25	1.550	12.83
32	0	2.00000	27.4	8.89	62	13.0	7.9	251.4	7.31	133	18.60	111	87	0.117	0.50	3.30	0.036	1.8	15.30	3.38	10.27	1.540	17.11
33	0	2.00000	27.4	9.02	44	0.8	6.6	281.7	8.27	149	29.20	117	98	0.125	0.50	3.60	0.038	2.2	14.32	3.57	11.52	1.280	12.83
34	0	2.00000	27.3	8.81	100	5.7	2.9	292.3	6.92	145	7.60	124	100	0.123	0.50	2.00	0.025	2.1	14.41	2.95	11.98	1.270	11.54
35	0	2.00000	28.1	8.60	63	2.0	6.2	298.6	7.10	115	10.80	133	116	0.142	0.42	0.80	0.015	2.8	12.58	1.98	6.78	0.180	12.40
36	0	2.00000	28.1	8.90	79	2.1	3.8	257.9	8.00	126	9.00	111	97	0.138	0.25	1.90	0.015	3.4	6.05	0.68	3.25	0.250	3.42
37	0	2.00000	28.8	8.00	66	2.0	3.1	268.6	8.50	110	7.60	113	110	0.127	0.25	1.52	0.015	0.1	12.58	0.58	5.58	0.580	5.99
38	0	2.00000	28.7	8.70	79	4.0	3.8	246.4	6.90	124	8.20	133	118	0.139	0.35	1.78	0.017	1.3	13.35	1.36	9.85	0.640	11.98
39	0	2.00000	29.0	9.20	84	18.2	3.9	245.0	9.00	140	8.40	111	74	0.144	0.65	2.88	0.015	2.2	15.33	2.05	6.58	0.980	11.12
40	0	2.00000	31.2	8.70	88	1.2	3.4	257.3	8.40	136	8.00	114	92	0.151	0.45	3.46	0.017	3.1	9.58	2.05	9.35	0.760	12.40
41	0	2.00000	30.8	9.40	72	8.0	3.6	237.4	9.70	155	9.40	95	81	0.148	0.68	2.58	0.015	5.3	12.26	1.57	7.84	0.270	18.39

Notes
Tw = Water Temperature (Celsius)
Tran = Transparency (centimeter)
Depth = Depth of water (meter)
Tur = Turbidity (milligram/liter, mg/l)
Con = Conductivity (microhos/centimeter)
DO = Dissolved Oxygen (mg/l)
TDS = Total Dissolved Solid (mg/l)
SS = Suspended Solid (mg/l)
Hard = Total Hardness (mg/l as $CaCO_3$)
Alk = Alkalinity (mg/l)
NO_3-N = Nitrate-Nitrogen (mg/l)
Org-N = Organic-Nitrogen (mg/l)
Total N = Total Nitrogen (mg/l)
Total P = Total Phosphate (mg/l)
BOD = Biochemical Oxygen Demand (mg/l)
Ca = Calcium (mg/l)
Mg = Magnesium (mg/l)
Na = Sodium (mg/l)
K = Potassium (mg/l)
Ch-A = Chlorophyll a (mg/m^3 of water)

Table 5E. Data on water quality and abundance of plankton in phylum Pyrrophyta for fittest model analysis.

No.	Dinoflagellate	ln(Dinoflagellate+100)	Twater	pH	Trans	Depth	Tur	Con	DO	TDS	SS	Hard	Alk	Nitrate	Org-N	Total-N	Total-P	BOD	Ca	Mg	Na	K	Chlo-A
1	87850	11.38	28.8	8.78	89	4.0	8.8	227.0	11.60	164	8.00	114	105	0.280	0.20	0.10	0.004	6.8	21.24	4.399	15.34	1.911	11.31
2	55600	10.93	28.1	8.56	50	3.1	19.0	244.0	8.99	137	23.00	115	120	0.280	0.30	0.10	0.009	6.4	18.17	3.786	9.04	1.543	16.72
3	737100	13.51	28.4	8.84	98	2.2	5.8	263.0	11.10	177	7.00	114	120	0.280	0.10	0.10	0.005	6.6	20.90	4.576	13.90	1.942	23.77
4	138050	11.84	28.2	8.70	13.5	4.7	3.1	264.0	10.62	165	4.00	116	115	0.280	0.10	0.10	0.002	7.0	21.19	4.666	14.02	1.848	21.12
5	426700	12.96	27.3	8.05	120	19.8	3.2	267.0	8.37	180	4.50	118	120	0.290	0.20	0.10	0.010	5.3	20.97	4.624	14.22	1.920	22.88
6	202350	12.22	27.6	8.36	170	3.7	2.6	284.0	7.71	210	3.00	112	125	0.280	0.20	0.10	0.010	6.5	21.53	4.637	14.16	1.872	13.91
7	87150	11.38	27.3	8.17	150	13.0	1.8	273.0	7.30	171	10.00	118	110	0.280	0.10	0.10	0.026	7.2	21.51	4.648	14.16	18.100	14.45
8	6291300	15.65	26.0	8.10	120	5.4	4.6	210.0	7.78	274	2.25	115	114	0.280	0.20	0.60	0.025	2.7	21.67	5.96	13.30	1.844	19.12
9	1067200	13.88	25.0	8.20	140	2.9	1.9	193.0	7.38	312	2.47	169	177	0.280	0.40	0.80	0.102	2.0	27.34	4.55	13.51	1.603	10.90
10	3348900	15.02	27.0	7.90	160	3.0	1.5	250.0	9.65	263	3.80	116	134	0.290	0.30	0.70	0.006	3.8	20.65	4.57	12.83	1.798	20.10
11	292600	12.59	26.0	8.60	140	4.0	2.0	198.2	8.37	218	2.15	114	130	0.270	0.40	0.80	0.036	2.0	19.61	4.43	12.53	1.761	16.64
12	1177100	13.98	25.0	8.20	140	20.5	3.2	204.0	9.45	205	2.35	127	130	0.270	0.30	0.70	0.026	2.9	20.95	4.51	12.94	1.870	19.98
13	235800	12.37	25.0	8.40	100	5.3	6.6	199.0	9.55	204	3.92	115	120	0.270	0.30	0.70	0.027	2.7	21.25	4.47	12.66	1.800	18.48
14	30250	10.32	25.0	8.80	220	3.7	0.9	192.0	8.32	119	1.70	112	130	0.280	0.30	0.60	0.088	0.8	21.00	4.49	12.63	1.778	9.20
15	7204800	15.79	26.0	8.40	120	1.3	3.1	311.0	7.40	215	8.34	168	159	0.215	0.40	1.00	0.021	3.8	22.06	6.11	14.53	2.340	6.72
16	4917000	15.41	26.0	8.05	70	2.0	6.7	401.0	7.40	268	11.42	200	195	0.165	0.30	0.90	0.021	4.8	30.23	7.23	14.99	2.060	8.54
17	11175000	16.23	27.0	8.05	10	1.7	3.2	380.0	6.80	216	6.58	157	149	0.148	0.50	1.20	0.070	2.6	21.71	6.02	14.56	2.320	3.74
18	4218800	15.26	25.0	8.30	160	5.8	1.5	315.0	6.40	237	10.60	174	170	0.109	0.40	1.00	0.019	1.4	25.48	6.45	14.55	2.160	6.41
19	14347900	16.48	27.0	8.40	160	20.0	1.0	384.0	4.00	213	7.82	156	146	0.142	0.50	1.00	0.008	1.2	21.58	5.76	14.21	2.140	8.51
20	1661700	14.32	25.0	8.80	190	3.9	2.9	301.0	7.00	217	6.03	159	148	0.149	0.20	0.80	0.002	1.6	22.93	5.96	14.65	2.350	3.83
21	10643400	16.18	27.0	8.60	140	6.0	1.1	310.0	8.60	222	7.34	158	147	0.131	0.40	1.00	0.003	3.7	22.75	5.83	14.04	2.140	9.66
22	71928000	18.09	30.5	8.60	90	1.3	10.3	332.0	9.29	273	5.40	139	141	0.090	0.20	0.50	0.026	3.9	27.44	17.36	128.50	4.600	14.29
23	86404500	18.27	30.3	7.84	80	2.5	16.7	326.0	8.73	253	7.30	162	161	0.080	0.10	0.40	0.033	3.4	25.87	7.92	20.00	2.170	24.64
24	13507200	16.42	30.8	8.47	100	2.5	11.2	317.0	8.21	217	7.40	129	127	0.070	0.10	0.40	0.040	2.0	19.95	6.87	16.00	1.870	15.95
25	9924600	16.11	30.5	7.25	140	5.2	8.7	307.0	8.27	162	4.20	128	124	0.030	0.10	0.40	0.030	2.1	19.65	6.72	15.75	2.080	12.68
26	9964500	16.11	30.9	8.72	120	19.5	2.9	309.0	9.04	185	7.50	127	121	0.060	0.10	0.30	0.019	2.0	14.15	6.68	56.39	2.020	15.35
27	5430900	15.51	29.9	7.65	140	2.1	2.3	309.0	6.77	166	3.40	123	122	0.050	0.20	0.40	0.030	1.4	19.82	6.77	15.51	1.950	17.11
28	4890900	15.40	31.8	8.55	140	7.2	1.6	292.0	8.75	153	5.40	119	121	0.040	0.10	0.40	0.048	1.6	19.00	6.61	15.07	1.900	5.41
29	0	4.61	27.2	8.39	20	5.5	23.3	242.6	6.01	120	51.80	108	84	0.204	0.40	1.90	0.023	3.8	13.58	2.80	7.97	1.070	7.70
30	0	4.61	26.0	7.62	20	1.1	46.3	196.0	5.44	126	87.80	90	74	0.406	0.50	2.90	0.081	3.4	5.38	0.67	2.54	0.420	1.71
31	7000	8.87	27.9	8.82	25	0.8	22.2	242.0	7.66	129	43.00	95	79	0.222	0.60	3.20	0.028	1.1	14.86	2.90	8.53	1.430	7.27
32	36500	10.51	27.2	8.17	61	1.6	6.7	275.0	6.80	140	13.20	109	96	0.130	0.80	3.50	0.020	4.3	15.59	3.67	11.25	1.550	12.83
33	79500	11.28	27.4	8.89	62	13.0	7.9	251.4	7.31	133	18.60	111	87	0.117	0.50	3.30	0.036	1.8	15.30	3.38	10.27	1.540	17.11
34	6800	8.84	27.4	9.02	44	0.8	6.6	281.7	8.27	149	29.20	117	98	0.125	0.50	3.60	0.038	2.2	14.32	3.57	11.52	1.280	12.83
35	41100	10.63	27.3	8.81	100	5.7	2.9	292.3	6.92	145	7.60	124	100	0.123	0.50	2.00	0.025	2.1	14.41	2.95	11.98	1.270	11.54
36	328600	12.70	28.1	8.60	63	2.0	6.2	298.6	7.10	115	10.80	133	116	0.142	0.42	0.80	0.015	2.8	12.58	1.98	6.78	0.180	12.40
37	223450	12.32	28.1	8.90	79	2.1	3.8	257.9	8.00	126	9.00	111	97	0.138	0.25	1.90	0.015	3.4	6.05	0.68	3.25	0.250	3.42
38	118750	11.69	28.8	8.00	66	2.0	3.1	268.6	8.50	110	7.60	113	110	0.127	0.25	1.52	0.015	0.1	12.58	0.58	5.58	0.580	5.99
39	2016950	14.52	28.7	8.70	79	4.0	3.8	246.4	6.90	124	8.20	133	118	0.139	0.35	1.78	0.017	1.3	13.35	1.36	9.85	0.640	11.98
40	627200	13.35	29.0	9.20	84	18.2	3.9	245.0	9.00	140	8.40	111	74	0.144	0.65	2.88	0.015	2.2	15.33	2.05	6.58	0.980	11.12
41	129600	11.77	31.2	8.70	88	1.2	3.4	257.3	8.40	136	8.00	114	92	0.151	0.45	3.46	0.017	3.1	9.58	2.05	9.35	0.760	12.40
42	312400	12.65	30.8	9.40	72	8.0	3.6	237.4	9.70	155	9.40	95	81	0.148	0.68	2.58	0.015	5.3	12.26	1.57	7.84	0.270	18.39

<u>Notes</u>
Tw = Water Temperature (Celsius)
Tran = Transparency (centimeter)
Depth = Depth of water (meter)
Tur = Turbidity (milligram/liter, mg/l)
Con = Conductivity (microhos/centimeter)

DO = Dissolved Oxygen (mg/l)
TDS = Total Dissolved Solid (mg/l)
SS = Suspended Solid (mg/l)
Hard = Total Hardness (mg/l as $CaCO_3$)
Alk = Alkalinity (mg/l)

NO_3-N = Nitrate-Nitrogen (mg/l)
Org-N = Organic-Nitrogen (mg/l)
Total N = Total Nitrogen (mg/l)
Total P = Total Phosphate (mg/l)
BOD = Biochemical Oxygen Demand (mg/l)

Ca = Calcium (mg/l)
Mg = Magnesium (mg/l)
Na = Sodium (mg/l)
K = Potassium (mg/l)
Ch-A = Chlorophyll a (mg/m^3 of water)

Table 6E. Data on water quality and abundance of plankton in phylum Euglenophyta for fittest model analysis.

No.	Euglenoid	log(Euglenoid+100)	Twater	pH	Trans	Depth	Tur	Con	DO	TDS	SS	Hard	Alk	Nitrate	Org-N	Total-N	Total-P	BOD	Ca	Mg	Na	K	Chlo-A
1	0	2.00000	28.8	8.78	89	4.0	8.8	227.0	11.60	164	8.00	114	105	0.280	0.20	0.10	0.004	6.8	21.24	4.399	15.34	1.911	11.31
2	20850	4.32118	28.1	8.56	50	3.1	19.0	244.0	8.99	137	23.00	115	120	0.280	0.30	0.10	0.009	6.4	18.17	3.786	9.04	1.543	16.72
3	0	2.00000	28.4	8.84	98	2.2	5.8	263.0	11.10	177	7.00	114	120	0.280	0.10	0.10	0.005	6.6	20.90	4.576	13.90	1.942	23.77
4	0	2.00000	28.2	8.70	13.5	4.7	3.1	264.0	10.62	165	4.00	116	115	0.280	0.10	0.10	0.002	7.0	21.19	4.666	14.02	1.848	21.12
5	0	2.00000	27.3	8.05	120	19.8	3.2	267.0	8.37	180	4.50	118	120	0.290	0.20	0.10	0.010	5.3	20.97	4.624	14.22	1.920	22.88
6	0	2.00000	27.6	8.36	170	3.7	2.6	284.0	7.71	210	3.00	112	125	0.280	0.20	0.10	0.010	6.5	21.53	4.637	14.16	1.872	13.91
7	0	2.00000	27.3	8.17	150	13.0	1.8	273.0	7.30	171	10.00	118	110	0.280	0.10	0.10	0.026	7.2	21.51	4.648	14.16	18.100	14.45
8	0	2.00000	26.0	8.10	120	5.4	4.6	210.0	7.78	274	2.25	115	114	0.280	0.20	0.60	0.025	2.7	21.67	5.96	13.30	1.844	19.12
9	36800	4.56703	25.0	8.20	140	2.9	1.9	193.0	7.38	312	2.47	169	177	0.280	0.40	0.80	0.102	2.0	27.34	4.55	13.51	1.603	10.90
10	0	2.00000	27.0	7.90	160	3.0	1.5	250.0	9.65	263	3.80	116	134	0.290	0.30	0.70	0.006	3.8	20.65	4.57	12.83	1.798	20.10
11	0	2.00000	26.0	8.60	140	4.0	2.0	198.2	8.37	218	2.15	114	130	0.270	0.40	0.80	0.036	2.0	19.61	4.43	12.53	1.761	16.64
12	0	2.00000	25.0	8.20	140	20.5	3.2	204.0	9.45	205	2.35	127	130	0.270	0.30	0.70	0.026	2.9	20.95	4.51	12.94	1.870	19.98
13	0	2.00000	25.0	8.40	100	5.3	6.6	199.0	9.55	204	3.92	115	120	0.270	0.30	0.70	0.027	2.7	21.25	4.47	12.66	1.800	18.48
14	0	2.00000	25.0	8.80	220	3.7	0.9	192.0	8.32	119	1.70	112	130	0.280	0.30	0.60	0.088	0.8	21.00	4.49	12.63	1.778	9.20
15	1106000	6.04379	26.0	8.40	120	1.3	3.1	311.0	7.40	215	8.34	168	159	0.215	0.40	1.00	0.021	3.8	22.06	6.11	14.53	2.340	6.72
16	5511000	6.74124	26.0	8.05	70	2.0	6.7	401.0	7.40	268	11.42	200	195	0.165	0.30	0.90	0.021	4.8	30.23	7.23	14.99	2.060	8.54
17	2557500	6.40783	27.0	8.05	10	1.7	3.2	380.0	6.80	216	6.58	157	149	0.148	0.50	1.20	0.070	2.6	21.71	6.02	14.56	2.320	3.74
18	358200	5.55425	25.0	8.30	160	5.8	1.5	315.0	6.40	237	10.60	174	170	0.109	0.40	1.00	0.019	1.4	25.48	6.45	14.55	2.160	6.41
19	412000	5.61500	27.0	8.40	160	20.0	1.0	384.0	4.00	213	7.82	156	146	0.142	0.50	1.00	0.008	1.2	21.58	5.76	14.21	2.140	8.51
20	38200	4.58320	25.0	8.80	190	3.9	2.9	301.0	7.00	217	6.03	159	148	0.149	0.20	0.80	0.002	1.6	22.93	5.96	14.65	2.350	3.83
21	43800	4.64246	27.0	8.60	140	6.0	1.1	310.0	8.60	222	7.34	158	147	0.131	0.40	1.00	0.003	3.7	22.75	5.83	14.04	2.140	9.66
22	1344600	6.12863	30.5	8.60	90	1.3	10.3	332.0	9.29	273	5.40	139	141	0.090	0.20	0.50	0.026	3.9	27.44	17.36	128.50	4.600	14.29
23	2129400	6.32828	30.3	7.84	80	2.5	16.7	326.0	8.73	253	7.30	162	161	0.080	0.10	0.40	0.033	3.4	25.87	7.92	20.00	2.170	24.64
24	944700	5.97534	30.8	8.47	100	2.5	11.2	317.0	8.21	217	7.40	129	127	0.070	0.10	0.40	0.040	2.0	19.95	6.87	16.00	1.870	15.95
25	382250	5.58246	30.5	7.25	140	5.2	8.7	307.0	8.27	162	4.20	128	124	0.030	0.10	0.40	0.030	2.1	19.65	6.72	15.75	2.080	12.68
26	208050	5.31838	30.9	8.72	120	19.5	2.9	309.0	9.04	185	7.50	127	121	0.060	0.10	0.30	0.019	2.0	14.15	6.68	56.39	2.020	15.35
27	116100	5.06521	29.9	7.65	140	2.1	2.3	309.0	6.77	166	3.40	123	122	0.050	0.20	0.40	0.030	1.4	19.82	6.77	15.51	1.950	17.11
28	82200	4.91540	31.8	8.55	140	7.2	1.6	292.0	8.75	153	5.40	119	121	0.040	0.10	0.40	0.048	1.6	19.00	6.61	15.07	1.900	5.41
29	0	2.00000	27.2	8.39	20	5.5	23.3	242.6	6.01	120	51.80	108	84	0.204	0.40	1.90	0.023	3.8	13.58	2.8	7.97	1.070	7.70
30	0	2.00000	26.0	7.62	20	1.1	46.3	196.0	5.44	126	87.80	90	74	0.406	0.50	2.90	0.081	3.4	5.38	0.67	2.54	0.420	1.71
31	0	2.00000	27.9	8.82	25	0.8	22.2	242.0	7.66	129	43.00	95	79	0.222	0.60	3.20	0.028	1.1	14.86	2.9	8.53	1.430	7.27
32	0	2.00000	27.2	8.17	61	1.6	6.7	275.0	6.80	140	13.20	109	96	0.130	0.80	3.50	0.020	4.3	15.59	3.67	11.25	1.550	12.83
33	0	2.00000	27.4	8.89	62	13.0	7.9	251.4	7.31	133	18.60	111	87	0.117	0.50	3.30	0.036	1.8	15.30	3.38	10.27	1.540	17.11
34	0	2.00000	27.4	9.02	44	0.8	6.6	281.7	8.27	149	29.20	117	98	0.125	0.50	3.60	0.038	2.2	14.32	3.57	11.52	1.280	12.83
35	0	2.00000	27.3	8.81	100	5.7	2.9	292.3	6.92	145	7.60	124	100	0.123	0.50	2.00	0.025	2.1	14.41	2.95	11.98	1.270	11.54
36	641300	5.80713	28.1	8.60	63	2.0	6.2	298.6	7.10	115	10.80	133	116	0.142	0.42	0.80	0.015	2.8	12.58	1.98	6.78	0.180	12.40
37	463250	5.66591	28.1	8.90	79	2.1	3.8	257.9	8.00	126	9.00	111	97	0.138	0.25	1.90	0.015	3.4	6.05	0.68	3.25	0.250	3.42
38	223250	5.34899	28.8	8.00	66	2.0	3.1	268.6	8.50	110	7.60	113	110	0.127	0.25	1.52	0.015	0.1	12.58	0.58	5.58	0.580	5.99
39	288900	5.4609	28.7	8.70	79	4.0	3.8	246.4	6.90	124	8.20	133	118	0.139	0.35	1.78	0.017	1.3	13.35	1.36	9.85	0.640	11.98
40	1041600	6.01774	29.0	9.20	84	18.2	3.9	245.0	9.00	140	8.40	111	74	0.144	0.65	2.88	0.015	2.2	15.33	2.05	6.58	0.980	11.12
41	871200	5.94017	31.2	8.70	88	1.2	3.4	257.3	8.40	136	8.00	114	92	0.151	0.45	3.46	0.017	3.1	9.58	2.05	9.35	0.760	12.40
42	17600	4.24797	30.8	9.40	72	8.0	3.6	237.4	9.70	155	9.40	95	81	0.148	0.68	2.58	0.015	5.3	12.26	1.57	7.84	0.270	18.39

Notes
Tw = Water Temperature (Celsius)
Tran = Transparency (centimeter)
Depth = Depth of water (meter)
Tur = Turbidity (milligram/liter, mg/l)
Con = Conductivity (microhos/centimeter)
DO = Dissolved Oxygen (mg/l)
TDS = Total Dissolved Solid (mg/l)
SS = Suspended Solid (mg/l)
Hard = Total Hardness (mg/l as $CaCO_3$)
Alk = Alkalinity (mg/l)
NO_3-N = Nitrate-Nitrogen (mg/l)
Org-N = Organic-Nitrogen (mg/l)
Total N = Total Nitrogen (mg/l)
Total P = Total Phosphate (mg/l)
BOD = Biochemical Oxygen Demand (mg/l)
Ca = Calcium (mg/l)
Mg = Magnesium (mg/l)
Na = Sodium (mg/l)
K = Potassium (mg/l)
Ch-A = Chlorophyll a (mg/m^3 of water)

Table 7E. Data on water quality and abundance of plankton in phylum Protozoa for fittest model analysis.

No.	Protozoa	Twater	pH	Trans	Depth	Tur	Con	DO	TDS	SS	Hard	Alk	Nitrate	Org-N	Total-N	Total-P	BOD	Ca	Mg	Na	K	Chlo-A
1	389200	28.1	8.56	50	3.1	19.0	244.0	8.99	137	23.00	115	120	0.280	0.30	0.10	0.009	6.4	18.17	3.786	9.04	1.543	16.72
2	631800	28.4	8.84	98	2.2	5.8	263.0	11.10	177	7.00	114	120	0.280	0.10	0.10	0.005	6.6	20.90	4.576	13.90	1.942	23.77
3	112950	27.3	8.05	120	19.8	3.2	267.0	8.37	180	4.50	118	120	0.290	0.20	0.10	0.010	5.3	20.97	4.624	14.22	1.920	22.88
4	74550	27.6	8.36	170	3.7	2.6	284.0	7.71	210	3.00	112	125	0.280	0.20	0.10	0.010	6.5	21.53	4.637	14.16	1.872	13.91
5	62250	27.3	8.17	150	13.0	1.8	273.0	7.30	171	10.00	118	110	0.280	0.10	0.10	0.026	7.2	21.51	4.648	14.16	18.100	14.45
6	214400	26.0	8.10	120	5.4	4.6	210.0	7.78	274	2.25	115	114	0.280	0.20	0.60	0.025	2.7	21.67	5.96	13.30	1.844	19.12
7	64400	25.0	8.20	140	2.9	1.9	193.0	7.38	312	2.47	169	177	0.280	0.40	0.80	0.102	2.0	27.34	4.55	13.51	1.603	10.90
8	256200	27.0	7.90	160	3.0	1.5	250.0	9.65	263	3.80	116	134	0.290	0.30	0.70	0.006	3.8	20.65	4.57	12.83	1.798	20.10
9	7700	26.0	8.60	140	4.0	2.0	198.2	8.37	218	2.15	114	130	0.270	0.40	0.80	0.036	2.0	19.61	4.43	12.53	1.761	16.64
10	67050	25.0	8.20	140	20.5	3.2	204.0	9.45	205	2.35	127	130	0.270	0.30	0.70	0.026	2.9	20.95	4.51	12.94	1.870	19.98
11	6550	25.0	8.40	100	5.3	6.6	199.0	9.55	204	3.92	115	120	0.270	0.30	0.70	0.027	2.7	21.25	4.47	12.66	1.800	18.48
12	268600	26.0	8.40	120	1.3	3.1	311.0	7.40	215	8.34	168	159	0.215	0.40	1.00	0.021	3.8	22.06	6.11	14.53	2.340	6.72
13	544500	26.0	8.05	70	2.0	6.7	401.0	7.40	268	11.42	200	195	0.165	0.30	0.90	0.021	4.8	30.23	7.23	14.99	2.060	8.54
14	390000	27.0	8.05	10	1.7	3.2	380.0	6.80	216	6.58	157	149	0.148	0.50	1.20	0.070	2.6	21.71	6.02	14.56	2.320	3.74
15	39800	25.0	8.30	160	5.8	1.5	315.0	6.40	237	10.60	174	170	0.109	0.40	1.00	0.019	1.4	25.48	6.45	14.55	2.160	6.41
16	41200	27.0	8.40	160	20.0	1.0	384.0	4.00	213	7.82	156	146	0.142	0.50	1.00	0.008	1.2	21.58	5.76	14.21	2.140	8.51
17	181450	25.0	8.80	190	3.9	2.9	301.0	7.00	217	6.03	159	148	0.149	0.20	0.80	0.002	1.6	22.93	5.96	14.65	2.350	3.83
18	153300	27.0	8.60	140	6.0	1.1	310.0	8.60	222	7.34	158	147	0.131	0.40	1.00	0.003	3.7	22.75	5.83	14.04	2.140	9.66
19	340200	30.5	8.60	90	1.3	10.3	332.0	9.29	273	5.40	139	141	0.090	0.20	0.50	0.026	3.9	27.44	17.36	128.50	4.600	14.29
20	268000	30.8	8.47	100	2.5	11.2	317.0	8.21	217	7.40	129	127	0.070	0.10	0.40	0.040	2.0	19.95	6.87	16.00	1.870	15.95
21	229350	30.5	7.25	140	5.2	8.7	307.0	8.27	162	4.20	128	124	0.030	0.10	0.40	0.030	2.1	19.65	6.72	15.75	2.080	12.68
22	175200	30.9	8.72	120	19.5	2.9	309.0	9.04	185	7.50	127	121	0.060	0.10	0.30	0.019	2.0	14.15	6.68	56.39	2.020	15.35
23	70950	29.9	7.65	140	2.1	2.3	309.0	6.77	166	3.40	123	122	0.050	0.20	0.40	0.030	1.4	19.82	6.77	15.51	1.950	17.11
24	143850	31.8	8.55	140	7.2	1.6	292.0	8.75	153	5.40	119	121	0.040	0.10	0.40	0.048	1.6	19.00	6.61	15.07	1.900	5.41
25	16800	27.2	8.39	20	5.5	23.3	242.6	6.01	120	51.80	108	84	0.204	0.40	1.90	0.023	3.8	13.58	2.80	7.97	1.070	7.70
26	7100	26.0	7.62	20	1.1	46.3	196.0	5.44	126	87.80	90	74	0.406	0.50	2.90	0.081	3.4	5.38	0.67	2.54	0.420	1.71
27	14000	27.9	8.82	25	0.8	22.2	242.0	7.66	129	43.00	95	79	0.222	0.60	3.20	0.028	1.1	14.86	2.90	8.53	1.430	7.27
28	73000	27.2	8.17	61	1.6	6.7	275.0	6.80	140	13.20	109	96	0.130	0.80	3.50	0.020	4.3	15.59	3.67	11.25	1.550	12.83
29	111300	27.4	8.89	62	13.0	7.9	251.4	7.31	133	18.60	111	87	0.117	0.50	3.30	0.036	1.8	15.30	3.38	10.27	1.540	17.11
30	54400	27.4	9.02	44	0.8	6.6	281.7	8.27	149	29.20	117	98	0.125	0.50	3.60	0.038	2.2	14.32	3.57	11.52	1.280	12.83
31	47950	27.3	8.81	100	5.7	2.9	292.3	6.92	145	7.60	124	100	0.123	0.50	2.00	0.025	2.1	14.41	2.95	11.98	1.270	11.54
32	58300	28.1	8.60	63	2.0	6.2	298.6	7.10	115	10.80	133	116	0.142	0.42	0.80	0.015	2.8	12.58	1.98	6.78	0.180	12.40
33	38150	28.1	8.90	79	2.1	3.8	257.9	8.00	126	9.00	111	97	0.138	0.25	1.90	0.015	3.4	6.05	0.68	3.25	0.250	3.42
34	16050	28.7	8.70	79	4.0	3.8	246.4	6.90	124	8.20	133	118	0.139	0.35	1.78	0.017	1.3	13.35	1.36	9.85	0.640	11.98
35	16800	29.0	9.20	84	18.2	3.9	245.0	9.00	140	8.40	111	74	0.144	0.65	2.88	0.015	2.2	15.33	2.05	6.58	0.980	11.12
36	17600	30.8	9.40	72	8.0	3.6	237.4	9.70	155	9.40	95	81	0.148	0.68	2.58	0.015	5.3	12.26	1.57	7.84	0.270	18.39

Notes
Tw = Water Temperature (Celsius)
Tran = Transparency (centimeter)
Depth = Depth of water (meter)
Tur = Turbidity (milligram/liter, mg/l)
Con = Conductivity (microhos/centimeter)
DO = Dissolved Oxygen (mg/l)
TDS = Total Dissolved Solid (mg/l)
SS = Suspended Solid (mg/l)
Hard = Total Hardness (mg/l as $CaCO_3$)
Alk = Alkalinity (mg/l)
NO_3-N = Nitrate-Nitrogen (mg/l)
Org-N = Organic-Nitrogen (mg/l)
Total N = Total Nitrogen (mg/l)
Total P = Total Phosphate (mg/l)
BOD = Biochemical Oxygen Demand (mg/l)
Ca = Calcium (mg/l)
Mg = Magnesium (mg/l)
Na = Sodium (mg/l)
K = Potassium (mg/l)
Ch-A = Chlorophyll a (mg/m^3 of water)

Table 8E. Data on water quality and abundance of plankton in phylum Rotifera for fittest model analysis.

No.	Rotifer	ln (Rotifer)	Twater	pH	Trans	Depth	Tur	Con	DO	TDS	SS	Hard	Alk	Nitrate	Org-N	Total-N	Total-P	BOD	Ca	Mg	Na	K	Chlo-A
1	3388500	15.0359	28.8	8.78	89	4.0	8.8	227.0	11.60	164	8.00	114	105	0.280	0.20	0.10	0.004	6.8	21.24	4.399	15.34	1.911	11.31
2	2745250	14.8254	28.1	8.56	50	3.1	19.0	244.0	8.99	137	23.00	115	120	0.280	0.30	0.10	0.009	6.4	18.17	3.786	9.04	1.543	16.72
3	4902300	15.4052	28.4	8.84	98	2.2	5.8	263.0	11.10	177	7.00	114	120	0.280	0.10	0.10	0.005	6.6	20.90	4.576	13.90	1.942	23.77
4	1757000	14.3791	28.2	8.70	13.5	4.7	3.1	264.0	10.62	165	4.00	116	115	0.280	0.10	0.10	0.002	7.0	21.19	4.666	14.02	1.848	21.12
5	1041650	13.8563	27.3	8.05	120	19.8	3.2	267.0	8.37	180	4.50	118	120	0.290	0.20	0.10	0.010	5.3	20.97	4.624	14.22	1.920	22.88
6	1373850	14.1331	27.6	8.36	170	3.7	2.6	284.0	7.71	210	3.00	112	125	0.280	0.20	0.10	0.010	6.5	21.53	4.637	14.16	1.872	13.91
7	759450	13.5403	27.3	8.17	150	13.0	1.8	273.0	7.30	171	10.00	118	110	0.280	0.10	0.10	0.026	7.2	21.51	4.648	14.16	18.100	14.45
8	1085500	13.8976	26.0	8.10	120	5.4	4.6	210.0	7.78	274	2.25	115	114	0.280	0.20	0.60	0.025	2.7	21.67	5.96	13.30	1.844	19.12
9	717600	13.4837	25.0	8.20	140	2.9	1.9	193.0	7.38	312	2.47	169	177	0.280	0.40	0.80	0.102	2.0	27.34	4.55	13.51	1.603	10.90
10	713700	13.4782	27.0	7.90	160	3.0	1.5	250.0	9.65	263	3.80	116	134	0.290	0.30	0.70	0.006	3.8	20.65	4.57	12.83	1.798	20.10
11	277200	12.5325	26.0	8.60	140	4.0	2.0	198.2	8.37	218	2.15	114	130	0.270	0.40	0.80	0.036	2.0	19.61	4.43	12.53	1.761	16.64
12	275650	12.5269	25.0	8.20	140	20.5	3.2	204.0	9.45	205	2.35	127	130	0.270	0.30	0.70	0.026	2.9	20.95	4.51	12.94	1.870	19.98
13	334050	12.719	25.0	8.40	100	5.3	6.6	199.0	9.55	204	3.92	115	120	0.270	0.30	0.70	0.027	2.7	21.25	4.47	12.66	1.800	18.48
14	272250	12.5145	25.0	8.80	220	3.7	0.9	192.0	8.32	119	1.70	112	130	0.280	0.30	0.60	0.088	0.8	21.00	4.49	12.63	1.778	9.20
15	703100	13.4633	26.0	8.40	120	1.3	3.1	311.0	7.40	215	8.34	168	159	0.215	0.40	1.00	0.021	3.8	22.06	6.11	14.53	2.340	6.72
16	668250	13.4124	26.0	8.05	70	2.0	6.7	401.0	7.40	268	11.42	200	195	0.165	0.30	0.90	0.021	4.8	30.23	7.23	14.99	2.060	8.54
17	1147500	13.9531	27.0	8.05	10	1.7	3.2	380.0	6.80	216	6.58	157	149	0.148	0.50	1.20	0.070	2.6	21.71	6.02	14.56	2.320	3.74
18	378100	12.8429	25.0	8.30	160	5.8	1.5	315.0	6.40	237	10.60	174	170	0.109	0.40	1.00	0.019	1.4	25.48	6.45	14.55	2.160	6.41
19	484100	13.09	27.0	8.40	160	20.0	1.0	384.0	4.00	213	7.82	156	146	0.142	0.50	1.00	0.008	1.2	21.58	5.76	14.21	2.140	8.51
20	200550	12.2088	25.0	8.80	190	3.9	2.9	301.0	7.00	217	6.03	159	148	0.149	0.20	0.80	0.002	1.6	22.93	5.96	14.65	2.350	3.83
21	1850550	14.431	27.0	8.60	140	6.0	1.1	310.0	8.60	222	7.34	158	147	0.131	0.40	1.00	0.003	3.7	22.75	5.83	14.04	2.140	9.66
22	696600	13.454	30.5	8.60	90	1.3	10.3	332.0	9.29	273	5.40	139	141	0.090	0.20	0.50	0.026	3.9	27.44	17.36	128.50	4.600	14.29
23	1509300	14.2272	30.3	7.84	80	2.5	16.7	326.0	8.73	253	7.30	162	161	0.080	0.10	0.40	0.033	3.4	25.87	7.92	20.00	2.170	24.64
24	790600	13.5805	30.8	8.47	100	2.5	11.2	317.0	8.21	217	7.40	129	127	0.070	0.10	0.40	0.040	2.0	19.95	6.87	16.00	1.870	15.95
25	340550	12.7383	30.5	7.25	140	5.2	8.7	307.0	8.27	162	4.20	128	124	0.030	0.10	0.40	0.030	2.1	19.65	6.72	15.75	2.080	12.68
26	1149750	13.9551	30.9	8.72	120	19.5	2.9	309.0	9.04	185	7.50	127	121	0.060	0.10	0.30	0.019	2.0	14.15	6.68	56.39	2.020	15.35
27	368940	12.8184	29.9	7.65	140	2.1	2.3	309.0	6.77	166	3.40	123	122	0.050	0.20	0.40	0.030	1.4	19.82	6.77	15.51	1.950	17.11
28	945300	13.7593	31.8	8.55	140	7.2	1.6	292.0	8.75	153	5.40	119	121	0.040	0.10	0.40	0.048	1.6	19.00	6.61	15.07	1.900	5.41
29	268800	12.5017	27.2	8.39	20	5.5	23.3	242.6	6.01	120	51.80	108	84	0.204	0.40	1.90	0.023	3.8	13.58	2.8	7.97	1.070	7.70
30	77000	11.2516	27.9	8.82	25	0.8	22.2	242.0	7.66	129	43.00	95	79	0.222	0.60	3.20	0.028	1.1	14.86	2.9	8.53	1.430	7.27
31	292000	12.5845	27.2	8.17	61	1.6	6.7	275.0	6.80	140	13.20	109	96	0.130	0.80	3.50	0.020	4.3	15.59	3.67	11.25	1.550	12.83
32	306000	12.6313	27.4	9.02	44	0.8	6.6	281.7	8.27	149	29.20	117	98	0.125	0.50	3.60	0.038	2.2	14.32	3.57	11.52	1.280	12.83
33	328800	12.7032	27.3	8.81	100	5.7	2.9	292.3	6.92	145	7.60	124	100	0.123	0.50	2.00	0.025	2.1	14.41	2.95	11.98	1.270	11.54
34	376300	12.8381	28.1	8.60	63	2.0	6.2	298.6	7.10	115	10.80	133	116	0.142	0.42	0.80	0.015	2.8	12.58	1.98	6.78	0.180	12.40
35	182250	12.1131	28.1	8.90	79	2.1	3.8	257.9	8.00	126	9.00	111	97	0.138	0.25	1.90	0.015	3.4	6.05	0.68	3.25	0.250	3.42
36	275500	12.5263	28.8	8.00	66	2.0	3.1	268.6	8.50	110	7.60	113	110	0.127	0.25	1.52	0.015	0.1	12.58	0.58	5.58	0.580	5.99
37	438700	12.9916	28.7	8.70	79	4.0	3.8	246.4	6.90	124	8.20	133	118	0.139	0.35	1.78	0.017	1.3	13.35	1.36	9.85	0.640	11.98
38	218450	12.2943	29.0	9.20	84	18.2	3.9	245.0	9.00	140	8.40	111	74	0.144	0.65	2.88	0.015	2.2	15.33	2.05	6.58	0.980	11.12
39	216000	12.283	31.2	8.70	88	1.2	3.4	257.3	8.40	136	8.00	114	92	0.151	0.45	3.46	0.017	3.1	9.58	2.05	9.35	0.760	12.40
40	382800	12.8553	30.8	9.40	72	8.0	3.6	237.4	9.70	155	9.40	95	81	0.148	0.68	2.58	0.015	5.3	12.26	1.57	7.84	0.270	18.39

Notes
Tw = Water Temperature (Celsius)
Tran = Transparency (centimeter)
Depth = Depth of water (meter)
Tur = Turbidity (milligram/liter, mg/l)
Con = Conductivity (microhos/centimeter)
DO = Dissolved Oxygen (mg/l)
TDS = Total Dissolved Solid (mg/l)
SS = Suspended Solid (mg/l)
Hard = Total Hardness (mg/l as $CaCO_3$)
Alk = Alkalinity (mg/l)
NO_3-N = Nitrate-Nitrogen (mg/l)
Org-N = Organic-Nitrogen (mg/l)
Total N = Total Nitrogen (mg/l)
Total P = Total Phosphate (mg/l)
BOD = Biochemical Oxygen Demand (mg/l)
Ca = Calcium (mg/l)
Mg = Magnesium (mg/l)
Na = Sodium (mg/l)
K = Potassium (mg/l)
Ch-A = Chlorophyll a (mg/m^3 of water)

Table 9E. Data on water quality and abundance of plankton in phylum Arthropoda for fittest model analysis.

No.	Arthropoda	ln(Arthropoda)	Twater	pH	Trans	Depth	Tur	Con	DO	TDS	SS	Hard	Alk	Nitrate	Org-N	Total-N	Total-P	BOD	Ca	Mg	Na	K	Chlo-A
1	2961800	14.9013	28.8	8.78	89	4.0	8.8	227.0	11.60	164	8.00	114	105	0.280	0.20	0.20	0.004	6.8	21.24	4.399	15.34	1.911	11.31
2	854850	13.6587	28.1	8.56	50	3.1	19.0	244.0	8.99	137	23.00	115	120	0.280	0.30	0.30	0.009	6.4	18.17	3.786	9.04	1.543	16.72
3	1553400	14.2560	28.4	8.84	98	2.2	5.8	263.0	11.10	177	7.00	114	120	0.280	0.10	0.10	0.005	6.6	20.90	4.576	13.90	1.942	23.77
4	1807200	14.4073	28.2	8.70	13.5	4.7	3.1	264.0	10.62	165	4.00	116	115	0.280	0.10	0.10	0.002	7.0	21.19	4.666	14.02	1.848	21.12
5	301200	12.6155	27.3	8.05	120	19.8	3.2	267.0	8.37	180	4.50	118	120	0.290	0.20	0.20	0.010	5.3	20.97	4.624	14.22	1.920	22.88
6	979800	13.7951	27.6	8.36	170	3.7	2.6	284.0	7.71	210	3.00	112	125	0.280	0.20	0.20	0.010	6.5	21.53	4.637	14.16	1.872	13.91
7	410850	12.9260	27.3	8.17	150	13.0	1.8	273.0	7.30	171	10.00	118	110	0.280	0.10	0.10	0.026	7.2	21.51	4.648	14.16	18.100	14.45
8	227800	12.3362	26.0	8.10	120	5.4	4.6	210.0	7.78	274	2.25	115	114	0.280	0.20	0.20	0.025	2.7	21.67	5.96	13.30	1.844	19.12
9	377200	12.8405	25.0	8.20	140	2.9	1.9	193.0	7.38	312	2.47	169	177	0.280	0.40	0.40	0.102	2.0	27.34	4.55	13.51	1.603	10.90
10	201300	12.2126	27.0	7.90	160	3.0	1.5	250.0	9.65	263	3.80	116	134	0.290	0.30	0.30	0.006	3.8	20.65	4.57	12.83	1.798	20.10
11	130900	11.7822	26.0	8.60	140	4.0	2.0	198.2	8.37	218	2.15	114	130	0.270	0.40	0.40	0.036	2.0	19.61	4.43	12.53	1.761	16.64
12	111750	11.6240	25.0	8.20	140	20.5	3.2	204.0	9.45	205	2.35	127	130	0.270	0.30	0.30	0.026	2.9	20.95	4.51	12.94	1.870	19.98
13	157200	11.9653	25.0	8.40	100	5.3	6.6	199.0	9.55	204	3.92	115	120	0.270	0.30	0.30	0.027	2.7	21.25	4.47	12.66	1.800	18.48
14	66550	11.1057	25.0	8.80	220	3.7	0.9	192.0	8.32	119	1.70	112	130	0.280	0.30	0.30	0.088	0.8	21.00	4.49	12.63	1.778	9.20
15	624100	13.3441	26.0	8.40	120	1.3	3.1	311.0	7.40	215	8.34	168	159	0.215	0.40	0.40	0.021	3.8	22.06	6.11	14.53	2.340	6.72
16	288750	12.5733	26.0	8.05	70	2.0	6.7	401.0	7.40	268	11.42	200	195	0.165	0.30	0.30	0.021	4.8	30.23	7.23	14.99	2.060	8.54
17	382500	12.8545	27.0	8.05	10	1.7	3.2	380.0	6.80	216	6.58	157	149	0.148	0.50	0.50	0.070	2.6	21.71	6.02	14.56	2.320	3.74
18	119400	11.6902	25.0	8.30	160	5.8	1.5	315.0	6.40	237	10.60	174	170	0.109	0.40	0.40	0.019	1.4	25.48	6.45	14.55	2.160	6.41
19	82400	11.3193	27.0	8.40	160	20.0	1.0	384.0	4.00	213	7.82	156	146	0.142	0.50	0.50	0.008	1.2	21.58	5.76	14.21	2.140	8.51
20	133700	11.8034	25.0	8.80	190	3.9	2.9	301.0	7.00	217	6.03	159	148	0.149	0.20	0.20	0.002	1.6	22.93	5.96	14.65	2.350	3.83
21	470850	13.0623	27.0	8.60	140	6.0	1.1	310.0	8.60	222	7.34	158	147	0.131	0.40	0.40	0.003	3.7	22.75	5.83	14.04	2.140	9.66
22	340200	12.7373	30.5	8.60	90	1.3	10.3	332.0	9.29	273	5.40	139	141	0.090	0.20	0.20	0.026	3.9	27.44	17.36	128.50	4.600	14.29
23	175500	12.0754	30.3	7.84	80	2.5	16.7	326.0	8.73	253	7.30	162	161	0.080	0.10	0.10	0.033	3.4	25.87	7.92	20.00	2.170	24.64
24	944700	13.7586	30.8	8.47	100	2.5	11.2	317.0	8.21	217	7.40	129	127	0.070	0.10	0.10	0.040	2.0	19.95	6.87	16.00	1.870	15.95
25	180700	12.1046	30.5	7.25	140	5.2	8.7	307.0	8.27	162	4.20	128	124	0.030	0.10	0.10	0.030	2.1	19.65	6.72	15.75	2.080	12.68
26	208050	12.2455	30.9	8.72	120	19.5	2.9	309.0	9.04	185	7.50	127	121	0.060	0.10	0.10	0.019	2.0	14.15	6.68	56.39	2.020	15.35
27	130150	11.7764	31.8	8.55	140	7.2	1.6	292.0	8.75	153	5.40	119	121	0.040	0.10	0.10	0.048	1.6	19.00	6.61	15.07	1.900	5.41
28	184800	12.1270	27.2	8.39	20	5.5	23.3	242.6	6.01	120	51.80	108	84	0.204	0.40	0.40	0.023	3.8	13.58	2.80	7.97	1.070	7.70
29	7100	8.8679	26.0	7.62	20	1.1	46.3	196.0	5.44	126	87.80	90	74	0.406	0.50	0.50	0.081	3.4	5.38	0.67	2.54	0.420	1.71
30	203000	12.2210	27.9	8.82	25	0.8	22.2	242.0	7.66	129	43.00	95	79	0.222	0.60	0.60	0.028	1.1	14.86	2.90	8.53	1.430	7.27
31	211700	12.2629	27.2	8.17	61	1.6	6.7	275.0	6.80	140	13.20	109	96	0.130	0.80	0.80	0.020	4.3	15.59	3.67	11.25	1.550	12.83
32	190800	12.1590	27.4	8.89	62	13.0	7.9	251.4	7.31	133	18.60	111	87	0.117	0.50	0.50	0.036	1.8	15.30	3.38	10.27	1.540	17.11
33	190400	12.1569	27.4	9.02	44	0.8	6.6	281.7	8.27	149	29.20	117	98	0.125	0.50	0.50	0.038	2.2	14.32	3.57	11.52	1.280	12.83
34	424700	12.9591	27.3	8.81	100	5.7	2.9	292.3	6.92	145	7.60	124	100	0.123	0.50	0.50	0.025	2.1	14.41	2.95	11.98	1.270	11.54
35	572400	13.2576	28.1	8.60	63	2.0	6.2	298.6	7.10	115	10.80	133	116	0.142	0.42	0.42	0.015	2.8	12.58	1.98	6.78	0.180	12.40
36	114450	11.6479	28.1	8.90	79	2.1	3.8	257.9	8.00	126	9.00	111	97	0.138	0.25	0.25	0.015	3.4	6.05	0.68	3.25	0.250	3.42
37	536750	13.1933	28.8	8.00	66	2.0	3.1	268.6	8.50	110	7.60	113	110	0.127	0.25	0.25	0.015	0.1	12.58	0.58	5.58	0.580	5.99
38	230050	12.3461	28.7	8.70	79	4.0	3.8	246.4	6.90	124	8.20	133	118	0.139	0.35	0.35	0.017	1.3	13.35	1.36	9.85	0.640	11.98
39	134400	11.8086	29.0	9.20	84	18.2	3.9	245.0	9.00	140	8.40	111	74	0.144	0.65	0.65	0.015	2.2	15.33	2.05	6.58	0.980	11.12
40	388800	12.8708	31.2	8.70	88	1.2	3.4	257.3	8.40	136	8.00	114	92	0.151	0.45	0.45	0.017	3.1	9.58	2.05	9.35	0.760	12.40

Notes
Tw = Water Temperature (Celsius)
Tran = Transparency (centimeter)
Depth = Depth of water (meter)
Tur = Turbidity (milligram/liter, mg/l)
Con = Conductivity (microhos/centimeter)

DO = Dissolved Oxygen (mg/l)
TDS = Total Dissolved Solid (mg/l)
SS = Suspended Solid (mg/l)
Hard = Total Hardness (mg/l as $CaCO_3$)
Alk = Alkalinity (mg/l)

NO_3-N = Nitrate-Nitrogen (mg/l)
Org-N = Organic-Nitrogen (mg/l)
Total N = Total Nitrogen (mg/l)
Total P = Total Phosphate (mg/l)
BOD = Biochemical Oxygen Demand (mg/l)

Ca = Calcium (mg/l)
Mg = Magnesium (mg/l)
Na = Sodium (mg/l)
K = Potassium (mg/l)
Ch-A = Chlorophyll a (mg/m^3 of water)

Table 10E. Data on water quality and abundance of plankton in phylum Chordata for fittest model analysis.

No.	Chordata	log(Chordata +100)	Twater	pH	Trans	Depth	Tur	Con	DO	TDS	SS	Hard	Alk	Nitrate	Org-N	Total-N	Total-P	BOD	Ca	Mg	Na	K	Chlo-A
1	37650	4.57692	28.8	8.78	89	4.0	8.8	227.0	11.60	164	8.00	114	105	0.280	0.20	0.10	0.004	6.8	21.24	4.399	15.34	1.911	11.31
2	81900	4.91381	28.4	8.84	98	2.2	5.8	263.0	11.10	177	7.00	114	120	0.280	0.10	0.10	0.005	6.6	20.90	4.576	13.90	1.942	23.77
3	12550	4.10209	28.2	8.70	13.5	4.7	3.1	264.0	10.62	165	4.00	116	115	0.280	0.10	0.10	0.002	7.0	21.19	4.666	14.02	1.848	21.12
4	12550	4.10209	27.3	8.05	120	19.8	3.2	267.0	8.37	180	4.50	118	120	0.290	0.20	0.10	0.010	5.3	20.97	4.624	14.22	1.920	22.88
5	10650	4.03141	27.6	8.36	170	3.7	2.6	284.0	7.71	210	3.00	112	125	0.280	0.20	0.10	0.010	6.5	21.53	4.637	14.16	1.872	13.91
6	12450	4.09864	27.3	8.17	150	13.0	1.8	273.0	7.30	171	10.00	118	110	0.280	0.10	0.10	0.026	7.2	21.51	4.648	14.16	18.100	14.45
7	6700	3.83251	26.0	8.10	120	5.4	4.6	210.0	7.78	274	2.25	115	114	0.280	0.20	0.60	0.025	2.7	21.67	5.96	13.30	1.844	19.12
8	0	2.00000	25.0	8.20	140	2.9	1.9	193.0	7.38	312	2.47	169	177	0.280	0.40	0.80	0.102	2.0	27.34	4.55	13.51	1.603	10.90
9	27450	4.44012	27.0	7.90	160	3.0	1.5	250.0	9.65	263	3.80	116	134	0.290	0.30	0.70	0.006	3.8	20.65	4.57	12.83	1.798	20.10
10	15400	4.19033	26.0	8.60	140	4.0	2.0	198.2	8.37	218	2.15	114	130	0.270	0.40	0.80	0.036	2.0	19.61	4.43	12.53	1.761	16.64
11	14900	4.17609	25.0	8.20	140	20.5	3.2	204.0	9.45	205	2.35	127	130	0.270	0.30	0.70	0.026	2.9	20.95	4.51	12.94	1.870	19.98
12	0	2.00000	25.0	8.80	220	3.7	0.9	192.0	8.32	119	1.70	112	130	0.280	0.30	0.60	0.088	0.8	21.00	4.49	12.63	1.778	9.20
13	7900	3.90309	26.0	8.40	120	1.3	3.1	311.0	7.40	215	8.34	168	159	0.215	0.40	1.00	0.021	3.8	22.06	6.11	14.53	2.340	6.72
14	0	2.00000	26.0	8.05	70	2.0	6.7	401.0	7.40	268	11.42	200	195	0.165	0.30	0.90	0.021	4.8	30.23	7.23	14.99	2.060	8.54
15	0	2.00000	27.0	8.05	10	1.7	3.2	380.0	6.80	216	6.58	157	149	0.148	0.50	1.20	0.070	2.6	21.71	6.02	14.56	2.320	3.74
16	0	2.00000	25.0	8.30	160	5.8	1.5	315.0	6.40	237	10.60	174	170	0.109	0.40	1.00	0.019	1.4	25.48	6.45	14.55	2.160	6.41
17	0	2.00000	27.0	8.40	160	20.0	1.0	384.0	4.00	213	7.82	156	146	0.142	0.50	1.00	0.008	1.2	21.58	5.76	14.21	2.140	8.51
18	0	2.00000	25.0	8.80	190	3.9	2.9	301.0	7.00	217	6.03	159	148	0.149	0.20	0.80	0.002	1.6	22.93	5.96	14.65	2.350	3.83
19	10950	4.04336	27.0	8.60	140	6.0	1.1	310.0	8.60	222	7.34	158	147	0.131	0.40	1.00	0.003	3.7	22.75	5.83	14.04	2.140	9.66
20	0	2.00000	30.5	8.60	90	1.3	10.3	332.0	9.29	273	5.40	139	141	0.090	0.20	0.50	0.026	3.9	27.44	17.36	128.50	4.600	14.29
21	11700	4.07188	30.3	7.84	80	2.5	16.7	326.0	8.73	253	7.30	162	161	0.080	0.10	0.40	0.033	3.4	25.87	7.92	20.00	2.170	24.64
22	0	2.00000	30.8	8.47	100	2.5	11.2	317.0	8.21	217	7.40	129	127	0.070	0.10	0.40	0.040	2.0	19.95	6.87	16.00	1.870	15.95
23	0	2.00000	30.5	7.25	140	5.2	8.7	307.0	8.27	162	4.20	128	124	0.030	0.10	0.40	0.030	2.1	19.65	6.72	15.75	2.080	12.68
24	0	2.00000	30.9	8.72	120	19.5	2.9	309.0	9.04	185	7.50	127	121	0.060	0.10	0.30	0.019	2.0	14.15	6.68	56.39	2.020	15.35
25	0	2.00000	29.9	7.65	140	2.1	2.3	309.0	6.77	166	3.40	123	122	0.050	0.20	0.40	0.030	1.4	19.82	6.77	15.51	1.950	17.11
26	0	2.00000	31.8	8.55	140	7.2	1.6	292.0	8.75	153	5.40	119	121	0.040	0.10	0.40	0.048	1.6	19.00	6.61	15.07	1.900	5.41
27	0	2.00000	27.2	8.39	20	5.5	23.3	242.6	6.01	120	51.80	108	84	0.204	0.40	1.90	0.023	3.8	13.58	2.80	7.97	1.070	7.70
28	0	2.00000	26.0	7.62	20	1.1	46.3	196.0	5.44	126	87.80	90	74	0.406	0.50	2.90	0.081	3.4	5.38	0.67	2.54	0.420	1.71
29	0	2.00000	27.9	8.82	25	0.8	22.2	242.0	7.66	129	43.00	95	79	0.222	0.60	3.20	0.028	1.1	14.86	2.90	8.53	1.430	7.27
30	7300	3.86923	27.2	8.17	61	1.6	6.7	275.0	6.80	140	13.20	109	96	0.130	0.80	3.50	0.020	4.3	15.59	3.67	11.25	1.550	12.83
32	0	2.00000	27.3	8.81	100	5.7	2.9	292.3	6.92	145	7.60	124	100	0.123	0.50	2.00	0.025	2.1	14.41	2.95	11.98	1.270	11.54
33	0	2.00000	28.1	8.60	63	2.0	6.2	298.6	7.10	115	10.80	133	116	0.142	0.42	0.80	0.015	2.8	12.58	1.98	6.78	0.180	12.40
34	0	2.00000	28.1	8.90	79	2.1	3.8	257.9	8.00	126	9.00	111	97	0.138	0.25	1.90	0.015	3.4	6.05	0.68	3.25	0.250	3.42
35	0	2.00000	28.8	8.00	66	2.0	3.1	268.6	8.50	110	7.60	113	110	0.127	0.25	1.52	0.015	0.1	12.58	0.58	5.58	0.580	5.99
36	0	2.00000	28.7	8.70	79	4.0	3.8	246.4	6.90	124	8.20	133	118	0.139	0.35	1.78	0.017	1.3	13.35	1.36	9.85	0.640	11.98
37	0	2.00000	29.0	9.20	84	18.2	3.9	245.0	9.00	140	8.40	111	74	0.144	0.65	2.88	0.015	2.2	15.33	2.05	6.58	0.980	11.12
38	0	2.00000	31.2	8.70	88	1.2	3.4	257.3	8.40	136	8.00	114	92	0.151	0.45	3.46	0.017	3.1	9.58	2.05	9.35	0.760	12.40

Notes

Tw = Water Temperature (Celsius)
Tran = Transparency (centimeter)
Depth = Depth of water (meter)
Tur = Turbidity (milligram/liter, mg/l)
Con = Conductivity (microhos/centimeter)

DO = Dissolved Oxygen (mg/l)
TDS = Total Dissolved Solid (mg/l)
SS = Suspended Solid (mg/l)
Hard = Total Hardness (mg/l as $CaCO_3$)
Alk = Alkalinity (mg/l)

NO_3-N = Nitrate-Nitrogen (mg/l)
Org-N = Organic-Nitrogen (mg/l)
Total N = Total Nitrogen (mg/l)
Total P = Total Phosphate (mg/l)
BOD = Biochemical Oxygen Demand (mg/l)

Ca = Calcium (mg/l)
Mg = Magnesium (mg/l)
Na = Sodium (mg/l)
K = Potassium (mg/l)
Ch-A = Chlorophyll a (mg/m^3 of water)

Table 11E. Data on water quality and abundance of total phytoplankton for fittest model analysis.

No.	Total phytoplankton	log (Total phytoplankton)	Twater	pH	Trans	Depth	Tur	Con	DO	TDS	SS	Hard	Alk	Nitrate	Org-N	Total-N	Total-P	BOD	Ca	Mg	Na	K	Chlo-A
1	170843150	8.23260	28.8	8.78	89	4.0	8.8	227.0	11.60	164	8.00	114	105	0.280	0.20	0.10	0.004	6.8	21.24	4.399	15.34	1.911	11.31
2	215526870	8.33350	28.4	8.84	98	2.2	5.8	263.0	11.10	177	7.00	114	120	0.280	0.10	0.10	0.005	6.6	20.90	4.576	13.90	1.942	23.77
3	87887650	7.94393	28.2	8.70	13.5	4.7	3.1	264.0	10.62	165	4.00	116	115	0.280	0.10	0.10	0.002	7.0	21.19	4.666	14.02	1.848	21.12
4	86833450	7.93869	27.3	8.05	120	19.8	3.2	267.0	8.37	180	4.50	118	120	0.290	0.20	0.10	0.010	5.3	20.97	4.624	14.22	1.920	22.88
5	67230000	7.82756	27.3	8.17	150	13.0	1.8	273.0	7.30	171	10.00	118	110	0.280	0.10	0.10	0.026	7.2	21.51	4.648	14.16	18.100	14.45
6	49760900	7.69689	26.0	8.10	120	5.4	4.6	210.0	7.78	274	2.25	115	114	0.280	0.20	0.60	0.025	2.7	21.67	5.96	13.30	1.844	19.12
7	12015200	7.07973	25.0	8.20	140	2.9	1.9	193.0	7.38	312	2.47	169	177	0.280	0.40	0.80	0.102	2.0	27.34	4.55	13.51	1.603	10.90
8	33022350	7.51881	27.0	7.90	160	3.0	1.5	250.0	9.65	263	3.80	116	134	0.290	0.30	0.70	0.006	3.8	20.65	4.57	12.83	1.798	20.10
9	13182400	7.11999	26.0	8.60	140	4.0	2.0	198.2	8.37	218	2.15	114	130	0.270	0.40	0.80	0.036	2.0	19.61	4.43	12.53	1.761	16.64
10	32943900	7.51778	25.0	8.20	140	20.5	3.2	204.0	9.45	205	2.35	127	130	0.270	0.30	0.70	0.026	2.9	20.95	4.51	12.94	1.870	19.98
11	18847350	7.27525	25.0	8.40	100	5.3	6.6	199.0	9.55	204	3.92	115	120	0.270	0.30	0.70	0.027	2.7	21.25	4.47	12.66	1.800	18.48
12	13285800	7.12339	25.0	8.80	220	3.7	0.9	192.0	8.32	119	1.70	112	130	0.280	0.30	0.60	0.088	0.8	21.00	4.49	12.63	1.778	9.20
13	94152200	7.97383	26.0	8.40	120	1.3	3.1	311.0	7.40	215	8.34	168	159	0.215	0.40	1.00	0.021	3.8	22.06	6.11	14.53	2.340	6.72
14	92886750	7.96795	26.0	8.05	70	2.0	6.7	401.0	7.40	268	11.42	200	195	0.165	0.30	0.90	0.021	4.8	30.23	7.23	14.99	2.060	8.54
15	88305000	7.94599	27.0	8.05	10	1.7	3.2	380.0	6.80	216	6.58	157	149	0.148	0.50	1.20	0.070	2.6	21.71	6.02	14.56	2.320	3.74
16	134165800	8.12764	25.0	8.30	160	5.8	1.5	315.0	6.40	237	10.60	174	170	0.109	0.40	1.00	0.019	1.4	25.48	6.45	14.55	2.160	6.41
17	149934850	8.17590	27.0	8.40	160	20.0	1.0	384.0	4.00	213	7.82	156	146	0.142	0.50	1.00	0.008	1.2	21.58	5.76	14.21	2.140	8.51
18	70536300	7.84841	25.0	8.80	190	3.9	2.9	301.0	7.00	217	6.03	159	148	0.149	0.20	0.80	0.002	1.6	22.93	5.96	14.65	2.350	3.83
19	125892150	8.10000	27.0	8.60	140	6.0	1.1	310.0	8.60	222	7.34	158	147	0.131	0.40	1.00	0.003	3.7	22.75	5.83	14.04	2.140	9.66
20	198304200	8.29733	30.5	8.60	90	1.3	10.3	332.0	9.29	273	5.40	139	141	0.090	0.20	0.50	0.026	3.9	27.44	17.36	128.50	4.600	14.29
21	150064200	8.17628	30.3	7.84	80	2.5	16.7	326.0	8.73	253	7.30	162	161	0.080	0.10	0.40	0.033	3.4	25.87	7.92	20.00	2.170	24.64
22	96191900	7.98314	30.8	8.47	100	2.5	11.2	317.0	8.21	217	7.40	129	127	0.070	0.10	0.40	0.040	2.0	19.95	6.87	16.00	1.870	15.95
23	81662500	7.91202	30.5	7.25	140	5.2	8.7	307.0	8.27	162	4.20	128	124	0.030	0.10	0.40	0.030	2.1	19.65	6.72	15.75	2.080	12.68
24	182317500	8.26083	30.9	8.72	120	19.5	2.9	309.0	9.04	185	7.50	127	121	0.060	0.10	0.30	0.019	2.0	14.15	6.68	56.39	2.020	15.35
25	88261800	7.94577	29.9	7.65	140	2.1	2.3	309.0	6.77	166	3.40	123	122	0.050	0.20	0.40	0.030	1.4	19.82	6.77	15.51	1.950	17.11
26	122731450	8.08896	31.8	8.55	140	7.2	1.6	292.0	8.75	153	5.40	119	121	0.040	0.10	0.40	0.048	1.6	19.00	6.61	15.07	1.900	5.41
27	25376400	7.40443	27.2	8.39	20	5.5	23.3	242.6	6.01	120	51.80	108	84	0.204	0.40	1.90	0.023	3.8	13.58	2.80	7.97	1.070	7.70
28	248500	5.39533	26.0	7.62	20	1.1	46.3	196.0	5.44	126	87.80	90	74	0.406	0.50	2.90	0.081	3.4	5.38	0.67	2.54	0.420	1.71
29	9401000	6.97317	27.9	8.82	25	0.8	22.2	242.0	7.66	129	43.00	95	79	0.222	0.60	3.20	0.028	1.1	14.86	2.90	8.53	1.430	7.27
30	95440200	7.97973	27.2	8.17	61	1.6	6.7	275.0	6.80	140	13.20	109	96	0.130	0.80	3.50	0.020	4.3	15.59	3.67	11.25	1.550	12.83
31	102316500	8.00995	27.4	8.89	62	13.0	7.9	251.4	7.31	133	18.60	111	87	0.117	0.50	3.30	0.036	1.8	15.30	3.38	10.27	1.540	17.11
32	59962400	7.77788	27.4	9.02	44	0.8	6.6	281.7	8.27	149	29.20	117	98	0.125	0.50	3.60	0.038	2.2	14.32	3.57	11.52	1.280	12.83
33	61656850	7.78998	27.3	8.81	100	5.7	2.9	292.3	6.92	145	7.60	124	100	0.123	0.50	2.00	0.025	2.1	14.41	2.95	11.98	1.270	11.54
34	15279900	7.18412	28.1	8.60	63	2.0	6.2	298.6	7.10	115	10.80	133	116	0.142	0.42	0.80	0.015	2.8	12.58	1.98	6.78	0.180	12.40
35	50281700	7.70141	28.1	8.90	79	2.1	3.8	257.9	8.00	126	9.00	111	97	0.138	0.25	1.90	0.015	3.4	6.05	0.68	3.25	0.250	3.42
36	13764550	7.13876	28.8	8.00	66	2.0	3.1	268.6	8.50	110	7.60	113	110	0.127	0.25	1.52	0.015	0.1	12.58	0.58	5.58	0.580	5.99
37	30575250	7.48537	28.7	8.70	79	4.0	3.8	246.4	6.90	124	8.20	133	118	0.139	0.35	1.78	0.017	1.3	13.35	1.36	9.85	0.640	11.98
38	59522400	7.77468	29.0	9.20	84	18.2	3.9	245.0	9.00	140	8.40	111	74	0.144	0.65	2.88	0.015	2.2	15.33	2.05	6.58	0.980	11.12
39	57506400	7.75972	31.2	8.70	88	1.2	3.4	257.3	8.40	136	8.00	114	92	0.151	0.45	3.46	0.017	3.1	9.58	2.05	9.35	0.760	12.40
40	50226000	7.70093	30.8	9.40	72	8.0	3.6	237.4	9.70	155	9.40	95	81	0.148	0.68	2.58	0.015	5.3	12.26	1.57	7.84	0.270	18.39

<u>Notes</u>

Tw = Water Temperature (Celsius)
Tran = Transparency (centimeter)
Depth = Depth of water (meter)
Tur = Turbidity (milligram/liter, mg/l)
Con = Conductivity (microhos/centimeter)

DO = Dissolved Oxygen (mg/l)
TDS = Total Dissolved Solid (mg/l)
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Hard = Total Hardness (mg/l as $CaCO_3$)
Alk = Alkalinity (mg/l)

NO_3-N = Nitrate-Nitrogen (mg/l)
Org-N = Organic-Nitrogen (mg/l)
Total N = Total Nitrogen (mg/l)
Total P = Total Phosphate (mg/l)
BOD = Biochemical Oxygen Demand (mg/l)

Ca = Calcium (mg/l)
Mg = Magnesium (mg/l)
Na = Sodium (mg/l)
K = Potassium (mg/l)
Ch-A = Chlorophyll a (mg/m^3 of water)

Table 12E. Data on water quality and abundance of total zooplankton for fittest model analysis.

No.	Total zooplankton	log (Total zooplankton)	Twater	pH	Trans	Depth	Tur	Con	DO	TDS	SS	Hard	Alk	Nitrate	Org-N	Total-N	Total-P	BOD	Ca	Mg	Na	K	Chlo-A
1	7053100	6.84838	28.8	8.78	89	4.0	8.8	227.0	11.60	164	8.00	114	105	0.280	0.20	0.10	0.004	6.8	21.24	4.399	15.34	1.911	11.31
2	3989300	6.60090	28.1	8.56	50	3.1	19.0	244.0	8.99	137	23.00	115	120	0.280	0.30	0.10	0.009	6.4	18.17	3.786	9.04	1.543	16.72
3	7169400	6.85548	28.4	8.84	98	2.2	5.8	263.0	11.10	177	7.00	114	120	0.280	0.10	0.10	0.005	6.6	20.90	4.576	13.90	1.942	23.77
4	3652050	6.56254	28.2	8.70	13.5	4.7	3.1	264.0	10.62	165	4.00	116	115	0.280	0.10	0.10	0.002	7.0	21.19	4.666	14.02	1.848	21.12
5	1468350	6.16683	27.3	8.05	120	19.8	3.2	267.0	8.37	180	4.50	118	120	0.290	0.20	0.10	0.010	5.3	20.97	4.624	14.22	1.920	22.88
6	2449500	6.38908	27.6	8.36	170	3.7	2.6	284.0	7.71	210	3.00	112	125	0.280	0.20	0.10	0.010	6.5	21.53	4.637	14.16	1.872	13.91
7	1245000	6.09517	27.3	8.17	150	13.0	1.8	273.0	7.30	171	10.00	118	110	0.280	0.10	0.10	0.026	7.2	21.51	4.648	14.16	18.100	14.45
8	1534400	6.18594	26.0	8.10	120	5.4	4.6	210.0	7.78	274	2.25	115	114	0.280	0.20	0.60	0.025	2.7	21.67	5.96	13.30	1.844	19.12
9	1159200	6.06416	25.0	8.20	140	2.9	1.9	193.0	7.38	312	2.47	169	177	0.280	0.40	0.80	0.102	2.0	27.34	4.55	13.51	1.603	10.90
10	1198650	6.07869	27.0	7.90	160	3.0	1.5	250.0	9.65	263	3.80	116	134	0.290	0.30	0.70	0.006	3.8	20.65	4.57	12.83	1.798	20.10
11	431200	5.63468	26.0	8.60	140	4.0	2.0	198.2	8.37	218	2.15	114	130	0.270	0.40	0.80	0.036	2.0	19.61	4.43	12.53	1.761	16.64
12	476800	5.67834	25.0	8.20	140	20.5	3.2	204.0	9.45	205	2.35	127	130	0.270	0.30	0.70	0.026	2.9	20.95	4.51	12.94	1.870	19.98
13	497800	5.69705	25.0	8.40	100	5.3	6.6	199.0	9.55	204	3.92	115	120	0.270	0.30	0.70	0.027	2.7	21.25	4.47	12.66	1.800	18.48
14	338800	5.52994	25.0	8.80	220	3.7	0.9	192.0	8.32	119	1.70	112	130	0.280	0.30	0.60	0.088	0.8	21.00	4.49	12.63	1.778	9.20
15	1603700	6.20512	26.0	8.40	120	1.3	3.1	311.0	7.40	215	8.34	168	159	0.215	0.40	1.00	0.021	3.8	22.06	6.11	14.53	2.340	6.72
16	1501500	6.17653	26.0	8.05	70	2.0	6.7	401.0	7.40	268	11.42	200	195	0.165	0.30	0.90	0.021	4.8	30.23	7.23	14.99	2.060	8.54
17	1920000	6.28330	27.0	8.05	10	1.7	3.2	380.0	6.80	216	6.58	157	149	0.148	0.50	1.20	0.070	2.6	21.71	6.02	14.56	2.320	3.74
18	537300	5.73022	25.0	8.30	160	5.8	1.5	315.0	6.40	237	10.60	174	170	0.109	0.40	1.00	0.019	1.4	25.48	6.45	14.55	2.160	6.41
19	607700	5.78369	27.0	8.40	160	20.0	1.0	384.0	4.00	213	7.82	156	146	0.142	0.50	1.00	0.008	1.2	21.58	5.76	14.21	2.140	8.51
20	515700	5.71240	25.0	8.80	190	3.9	2.9	301.0	7.00	217	6.03	159	148	0.149	0.20	0.80	0.002	1.6	22.93	5.96	14.65	2.350	3.83
21	2485650	6.39544	27.0	8.60	140	6.0	1.1	310.0	8.60	222	7.34	158	147	0.131	0.40	1.00	0.003	3.7	22.75	5.83	14.04	2.140	9.66
22	1377000	6.13893	30.5	8.60	90	1.3	10.3	332.0	9.29	273	5.40	139	141	0.090	0.20	0.50	0.026	3.9	27.44	17.36	128.50	4.600	14.29
23	3825900	6.58273	30.3	7.84	80	2.5	16.7	326.0	8.73	253	7.30	162	161	0.080	0.10	0.40	0.033	3.4	25.87	7.92	20.00	2.170	24.64
24	2003300	6.30175	30.8	8.47	100	2.5	11.2	317.0	8.21	217	7.40	129	127	0.070	0.10	0.40	0.040	2.0	19.95	6.87	16.00	1.870	15.95
25	750600	5.87541	30.5	7.25	140	5.2	8.7	307.0	8.27	162	4.20	128	124	0.030	0.10	0.40	0.030	2.1	19.65	6.72	15.75	2.080	12.68
26	1533000	6.18554	30.9	8.72	120	19.5	2.9	309.0	9.04	185	7.50	127	121	0.060	0.10	0.30	0.019	2.0	14.15	6.68	56.39	2.020	15.35
27	478590	5.67996	29.9	7.65	140	2.1	2.3	309.0	6.77	166	3.40	123	122	0.050	0.20	0.40	0.030	1.4	19.82	6.77	15.51	1.950	17.11
28	1219300	6.08611	31.8	8.55	140	7.2	1.6	292.0	8.75	153	5.40	119	121	0.040	0.10	0.40	0.048	1.6	19.00	6.61	15.07	1.900	5.41
29	470400	5.67247	27.2	8.39	20	5.5	23.3	242.6	6.01	120	51.80	108	84	0.204	0.40	1.90	0.023	3.8	13.58	2.80	7.97	1.070	7.70
30	14200	4.15229	26.0	7.62	20	1.1	46.3	196.0	5.44	126	87.80	90	74	0.406	0.50	2.90	0.081	3.4	5.38	0.67	2.54	0.420	1.71
31	301000	5.47857	27.9	8.82	25	0.8	22.2	242.0	7.66	129	43.00	95	79	0.222	0.60	3.20	0.028	1.1	14.86	2.90	8.53	1.430	7.27
32	584000	5.76641	27.2	8.17	61	1.6	6.7	275.0	6.80	140	13.20	109	96	0.130	0.80	3.50	0.020	4.3	15.59	3.67	11.25	1.550	12.83
33	866550	5.93779	27.4	8.89	62	13.0	7.9	251.4	7.31	133	18.60	111	87	0.117	0.50	3.30	0.036	1.8	15.30	3.38	10.27	1.540	17.11
34	564400	5.75159	27.4	9.02	44	0.8	6.6	281.7	8.27	149	29.20	117	98	0.125	0.50	3.60	0.038	2.2	14.32	3.57	11.52	1.280	12.83
35	801450	5.90388	27.3	8.81	100	5.7	2.9	292.3	6.92	145	7.60	124	100	0.123	0.50	2.00	0.025	2.1	14.41	2.95	11.98	1.270	11.54
36	1007000	6.00303	28.1	8.60	63	2.0	6.2	298.6	7.10	115	10.80	133	116	0.142	0.42	0.80	0.015	2.8	12.58	1.98	6.78	0.180	12.40
37	334850	5.52485	28.1	8.90	79	2.1	3.8	257.9	8.00	126	9.00	111	97	0.138	0.25	1.90	0.015	3.4	6.05	0.68	3.25	0.250	3.42
38	821750	5.91474	28.8	8.00	66	2.0	3.1	268.6	8.50	110	7.60	113	110	0.127	0.25	1.52	0.015	0.1	12.58	0.58	5.58	0.580	5.99
39	684800	5.83556	28.7	8.70	79	4.0	3.8	246.4	6.90	124	8.20	133	118	0.139	0.35	1.78	0.017	1.3	13.35	1.36	9.85	0.640	11.98
40	369650	5.56779	29.0	9.20	84	18.2	3.9	245.0	9.00	140	8.40	111	74	0.144	0.65	2.88	0.015	2.2	15.33	2.05	6.58	0.980	11.12
41	604800	5.78161	31.2	8.70	88	1.2	3.4	257.3	8.40	136	8.00	114	92	0.151	0.45	3.46	0.017	3.1	9.58	2.05	9.35	0.760	12.40
42	497200	5.69653	30.8	9.40	72	8.0	3.6	237.4	9.70	155	9.40	95	81	0.148	0.68	2.58	0.015	5.3	12.26	1.57	7.84	0.270	18.39

Notes

Tw = Water Temperature (Celsius)
Tran = Transparency (centimeter)
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Tur = Turbidity (milligram/liter, mg/l)
Con = Conductivity (microhos/centimeter)

DO = Dissolved Oxygen (mg/l)
TDS = Total Dissolved Solid (mg/l)
SS = Suspended Solid (mg/l)
Hard = Total Hardness (mg/l as $CaCO_3$)
Alk = Alkalinity (mg/l)

NO_3-N = Nitrate-Nitrogen (mg/l)
Org-N = Organic-Nitrogen (mg/l)
Total N = Total Nitrogen (mg/l)
Total P = Total Phosphate (mg/l)
BOD = Biochemical Oxygen Demand (mg/l)

Ca = Calcium (mg/l)
Mg = Magnesium (mg/l)
Na = Sodium (mg/l)
K = Potassium (mg/l)
Ch-A = Chlorophyll a (mg/m^3 of water)

Table 13E. Data on water quality and abundance of grand total plankton for fittest model analysis.

No.	Grand total plankton	log (Grand total plankton)	Twater	pH	Trans	Depth	Tur	Con	DO	TDS	SS	Hard	Alk	Nitrate	Org-N	Total-N	Total-P	BOD	Ca	Mg	Na	K	Chlo-A
1	177896250	8.25017	28.80	8.78	89	4.0	8.8	227.0	11.60	164	8.00	114	105	0.280	0.20	0.10	0.004	6.8	21.24	4.399	15.34	1.911	11.31
2	174813350	8.24257	28.10	8.56	50	3.1	19.0	244.0	8.99	137	23.00	115	120	0.280	0.30	0.10	0.009	6.4	18.17	3.786	9.04	1.543	16.72
3	222696270	8.34771	28.40	8.84	98	2.2	5.8	263.0	11.10	177	7.00	114	120	0.280	0.10	0.10	0.005	6.6	20.90	4.576	13.90	1.942	23.77
4	91539700	7.96161	28.20	8.70	13.5	4.7	3.1	264.0	10.62	165	4.00	116	115	0.280	0.10	0.10	0.002	7.0	21.19	4.666	14.02	1.848	21.12
5	88301800	7.94597	27.30	8.05	120	19.8	3.2	267.0	8.37	180	4.50	118	120	0.290	0.20	0.10	0.010	5.3	20.97	4.624	14.22	1.920	22.88
6	22439550	7.35101	27.60	8.36	170	3.7	2.6	284.0	7.71	210	3.00	112	125	0.280	0.20	0.10	0.010	6.5	21.53	4.637	14.16	1.872	13.91
7	68475000	7.83553	27.30	8.17	150	13.0	1.8	273.0	7.30	171	10.00	118	110	0.280	0.10	0.10	0.026	7.2	21.51	4.648	14.16	18.100	14.45
8	51295300	7.71008	26.00	8.10	120	5.4	4.6	210.0	7.78	274	2.25	115	114	0.280	0.20	0.60	0.025	2.7	21.67	5.96	13.30	1.844	19.12
9	13174400	7.11973	25.00	8.20	140	2.9	1.9	193.0	7.38	312	2.47	169	177	0.280	0.40	0.80	0.102	2.0	27.34	4.55	13.51	1.603	10.90
10	34221000	7.53429	27.00	7.90	160	3.0	1.5	250.0	9.65	263	3.80	116	134	0.290	0.30	0.70	0.006	3.8	20.65	4.57	12.83	1.798	20.10
11	13613600	7.13397	26.00	8.60	140	4.0	2.0	198.2	8.37	218	2.15	114	130	0.270	0.40	0.80	0.036	2.0	19.61	4.43	12.53	1.761	16.64
12	33420700	7.52402	25.00	8.20	140	20.5	3.2	204.0	9.45	205	2.35	127	130	0.270	0.30	0.70	0.026	2.9	20.95	4.51	12.94	1.870	19.98
13	19345150	7.28657	25.00	8.40	100	5.3	6.6	199.0	9.55	204	3.92	115	120	0.270	0.30	0.70	0.027	2.7	21.25	4.47	12.66	1.800	18.48
14	13624600	7.13432	25.00	8.80	220	3.7	0.9	192.0	8.32	119	1.70	112	130	0.280	0.30	0.60	0.088	0.8	21.00	4.49	12.63	1.778	9.20
15	95755900	7.98117	26.00	8.40	120	1.3	3.1	311.0	7.40	215	8.34	168	159	0.215	0.40	1.00	0.021	3.8	22.06	6.11	14.53	2.340	6.72
16	94388250	7.97492	26.00	8.05	70	2.0	6.7	401.0	7.40	268	11.42	200	195	0.165	0.30	0.90	0.021	4.8	30.23	7.23	14.99	2.060	8.54
17	90225000	7.95533	27.00	8.05	10	1.7	3.2	380.0	6.80	216	6.58	157	149	0.148	0.50	1.20	0.070	2.6	21.71	6.02	14.56	2.320	3.74
18	134703100	8.12938	25.00	8.30	160	5.8	1.5	315.0	6.40	237	10.60	174	170	0.109	0.40	1.00	0.019	1.4	25.48	6.45	14.55	2.160	6.41
19	150542550	8.17766	27.00	8.40	160	20.0	1.0	384.0	4.00	213	7.82	156	146	0.142	0.50	1.00	0.008	1.2	21.58	5.76	14.21	2.140	8.51
20	71052000	7.85158	25.00	8.80	190	3.9	2.9	301.0	7.00	217	6.03	159	148	0.149	0.20	0.80	0.002	1.6	22.93	5.96	14.65	2.350	3.83
21	128377800	8.10849	27.00	8.60	140	6.0	1.1	310.0	8.60	222	7.34	158	147	0.131	0.40	1.00	0.003	3.7	22.75	5.83	14.04	2.140	9.66
22	199681200	8.30034	30.50	8.60	90	1.3	10.3	332.0	9.29	273	5.40	139	141	0.090	0.20	0.50	0.026	3.9	27.44	17.36	128.50	4.600	14.29
23	153890100	8.18721	30.30	7.84	80	2.5	16.7	326.0	8.73	253	7.30	162	161	0.080	0.10	0.40	0.033	3.4	25.87	7.92	20.00	2.170	24.64
24	98195200	7.99209	30.80	8.47	100	2.5	11.2	317.0	8.21	217	7.40	129	127	0.070	0.10	0.40	0.040	2.0	19.95	6.87	16.00	1.870	15.95
25	82413100	7.91600	30.50	7.25	140	5.2	8.7	307.0	8.27	162	4.20	128	124	0.030	0.10	0.40	0.030	2.1	19.65	6.72	15.75	2.080	12.68
26	183850500	8.26446	30.90	8.72	120	19.5	2.9	309.0	9.04	185	7.50	127	121	0.060	0.10	0.30	0.019	2.0	14.15	6.68	56.39	2.020	15.35
27	88740390	7.94812	29.90	7.65	140	2.1	2.3	309.0	6.77	166	3.40	123	122	0.050	0.20	0.40	0.030	1.4	19.82	6.77	15.51	1.950	17.11
28	123950750	8.09325	31.80	8.55	140	7.2	1.6	292.0	8.75	153	5.40	119	121	0.040	0.10	0.40	0.048	1.6	19.00	6.61	15.07	1.900	5.41
29	25846800	7.41241	27.20	8.39	20	5.5	23.3	242.6	6.01	120	51.80	108	84	0.204	0.40	1.90	0.023	3.8	13.58	2.80	7.97	1.070	7.70
30	262700	5.41946	26.00	7.62	20	1.1	46.3	196.0	5.44	126	87.80	90	74	0.406	0.50	2.90	0.081	3.4	5.38	0.67	2.54	0.420	1.71
31	9702000	6.98686	27.90	8.82	25	0.8	22.2	242.0	7.66	129	43.00	95	79	0.222	0.60	3.20	0.028	1.1	14.86	2.90	8.53	1.430	7.27
32	96024200	7.98238	27.20	8.17	61	1.6	6.7	275.0	6.80	140	13.20	109	96	0.130	0.80	3.50	0.020	4.3	15.59	3.67	11.25	1.550	12.83
33	103183050	8.01361	27.40	8.89	62	13.0	7.9	251.4	7.31	133	18.60	111	87	0.117	0.50	3.30	0.036	1.8	15.30	3.38	10.27	1.540	17.11
34	60526800	7.78195	27.40	9.02	44	0.8	6.6	281.7	8.27	149	29.20	117	98	0.125	0.50	3.60	0.038	2.2	14.32	3.57	11.52	1.280	12.83
35	62458300	7.79559	27.30	8.81	100	5.7	2.9	292.3	6.92	145	7.60	124	100	0.123	0.50	2.00	0.025	2.1	14.41	2.95	11.98	1.270	11.54
36	16286900	7.21184	28.10	8.60	63	2.0	6.2	298.6	7.10	115	10.80	133	116	0.142	0.42	0.80	0.015	2.8	12.58	1.98	6.78	0.180	12.40
37	50616550	7.70429	28.10	8.90	79	2.1	3.8	257.9	8.00	126	9.00	111	97	0.138	0.25	1.90	0.015	3.4	6.05	0.68	3.25	0.250	3.42
38	14586300	7.16395	28.80	8.00	66	2.0	3.1	268.6	8.50	110	7.60	113	110	0.127	0.25	1.52	0.015	0.1	12.58	0.58	5.58	0.580	5.99
39	31260050	7.49499	28.70	8.70	79	4.0	3.8	246.4	6.90	124	8.20	133	118	0.139	0.35	1.78	0.017	1.3	13.35	1.36	9.85	0.640	11.98
40	59892050	7.77737	29.00	9.20	84	18.2	3.9	245.0	9.00	140	8.40	111	74	0.144	0.65	2.88	0.015	2.2	15.33	2.05	6.58	0.980	11.12
41	58111200	7.76426	31.20	8.70	88	1.2	3.4	257.3	8.40	136	8.00	114	92	0.151	0.45	3.46	0.017	3.1	9.58	2.05	9.35	0.760	12.40
42	50723200	7.70521	30.80	9.40	72	8.0	3.6	237.4	9.70	155	9.40	95	81	0.148	0.68	2.58	0.015	5.3	12.26	1.57	7.84	0.270	18.39

Notes

Tw = Water Temperature (Celsius)
Tran = Transparency (centimeter)
Depth = Depth of water (meter)
Tur = Turbidity (milligram/liter, mg/l)
Con = Conductivity (microhos/centimeter)

DO = Dissolved Oxygen (mg/l)
TDS = Total Dissolved Solid (mg/l)
SS = Suspended Solid (mg/l)
Hard = Total Hardness (mg/l as $CaCO_3$)
Alk = Alkalinity (mg/l)

NO_3-N = Nitrate-Nitrogen (mg/l)
Org-N = Organic-Nitrogen (mg/l)
Total N = Total Nitrogen (mg/l)
Total P = Total Phosphate (mg/l)
BOD = Biochemical Oxygen Demand (mg/l)

Ca = Calcium (mg/l)
Mg = Magnesium (mg/l)
Na = Sodium (mg/l)
K = Potassium (mg/l)
Ch-A = Chlorophyll a (mg/m^3 of water)

Appendix F

Manual of Water Quality and Plankton Information Database

and

Water Quality and Plankton Information Database

Manual

Water Quality & Plankton Information Database

As part of

Analysis of Relationships between

Water Quality and Plankton of Reservoirs in Thailand

Prepared by

Mr. Puripat Wongpipattananon

February 7, 2004

Content

1. Glossary

Database	:	a file storing data on water quality related information
Tables	:	Sources for raw data input on each subject. This is a place where data is stored.
Relationship	:	An indication of how each table is related with other.
Queries	:	A question you would like the database to answer by selecting the field you would like to see and the data will display following the selected fields.
Forms	:	A place to enter data to the table/database
Reports	:	Presentation of the database in different format and structure.
Switchboard	:	A menu board or a short cut menu to a group of selected forms, reports, or queries.
Fields	:	a smallest unit to enter data to a table or a form
Multi-Page Form	:	A form page that contains other forms so data can be entered from one place
Parameter Query	:	A datasheet which displays an answer to a particular query. When the query is called, a text box will pop up to ask for a particular name. Enter the name you would like to see the details; if there is information related, the datasheet will display those data. If not, there will be no information presenting. Note that spelling and space for a particular name on a question has to be exactly correct the same as what input in database.

2. Contents of Database

(List of Tables, Forms, Queries and Reports)

2.1 List of Tables

- **Station Info :** A table contains data on stations those data are collected. Fields listed in this table are;
  - **Station No:** This is a primary key of the table, Data input need to be unique. Range of digit number can be from 1 to 10.
  - **Station Name:** Name of the station where water quality data are collected. Information can be typed in upto 255 characters.
  - **Location1 (Sub-District):** A sub-district address of a station (Tambon). Range of information is from 1- 255 characters.
  - **Location2 (District):** A district address of a station (Amphoe and King Amphoe). Range of information is from 1- 255 characters.
  - **Location3 (Province):** A province address of a station. Range of information is from 1- 255 characters.
  - **LocationPic:** A picture of the station.
- **Data Sources:** A table which contains data on source of information. Sources of information could be from a primary source where the data is firstly collected or a secondary source where the data is compiled from other reports. Fields listed in this table are;
  - **Data Source No:** A primary key of Data Source Table. Data input needs to be unique and range of input is range from 1 to 255 characters.

- **Source Type:** Type of Data Source. Select from a list of either primary or secondary.
- **Source Name:** Name of the data source. It could be a report name for secondary data or a source of sample for primary data.
- **Source Date:** Date of Data Source. This field can be report date for secondary data or date of data collecting for secondary data.
- **Owner:** A name of a person or a department owns the report or a person or a department who collects data.
- **Sample Date:** Date of data collecting.

- **Species:** A table listing all the information regarding the plankton found in each water data set info at each station. Fields listed in this table are;
  - **Plankton No**: a primary key of the table, Data input needs to be unique. Range of digit number can be from 1 to 10.
  - **Phylum:** a phylum name of plankton.
  - **Genus:** a field indicating a genus of plankton.
  - **Species:** a field indicating species name.
  - **Gender:** a field indicating name follow to International Code of Botanical Nomenclature (ICBN) and International Code of Zoological Nomenclature (ICZN).
  - **Species Quality:** abundance of plankton species.
  - **Station No.:** a foreign key to link plankton table with Station table.
  - **Data Source No.:** a foreign key to link this plankton table with Data Source.
  - **Picture Main:** a main picture of plankton

- **Picture B:** another picture of plankton

❖ **Water Data Set Info:**

- **Water Data Set No.:** A primary key of the table. Data input has to be unique. Range of data is from 1 to 10.
- **Date:** date of data input.
- **Station No:** a foreign key to link Station table with Water Data Set Info table.
- **Data Source No:** a foreign key to link Data Source table with Water Data Set Info table.

❖ **Water Quality:** data related to the 3 characteristics of water quality, physical, chemical, and biological. Fields listed in this table are;

Physical Properties;

- Tair = Air temperature in Celsius
- Twater = Water temperature in Celsius
- Trans = Transparency in centimeter
- Depth = Depth of water source in meter

Biological Properties;

- Chlo-A = Chlorophyll a in milligram per cubic meter

Chemical Properties;

- pH = pH
- Tur = Turbidity in milligram per liter (mg/l)
- Con = Conductivity in microhos per centimeter
- DO = Dissolved oxygen in mg/l
- TS = Total solid in mg/l

- TDS = Total dissolved solid in mg/l
- SS = Suspended solid in mg/l
- Hard = Total hardness in mg/l as calcium carbonate
- Cl = Chloride in mg/l
- Acid = Acidity in mg/l
- Alk = Alkalinity in mg/l
- NO_3-N = Nitrate-nitrogen in mg/l
- NO_2-N = Nitrite-nitrogen in mg/l
- Org-N = Organic nitrogenin mg/l
- Total-N = Total nitrogen in mg/l
- NH_3-N = Ammonia-nitrogen- in mg/l
- Sulfate = Sulfate in mg/l
- Total-P = Total phosphate in mg/l
- BOD = Biochemical oxygen demand in mg/l
- COD = Chemical oxygen demand in mg/l
- Oil = Oil & grease in mg/l
- Ca = Calcium in mg/l
- Mg = Magnesium in mg/l
- Na = Sodium in mg/l
- K = Potassium in mg/l

2.2 List of Forms

- **Stations:** A form which contains fields related to stations. This is a place where data will be passed to Stations Info table.

- **Data Sources:** A form which contains fields related to source of data. This is where data will be passed to Data Sources table.
- **Water Data Set Info:** A multi-page form that data can be entered to water quality form and plankton form.
  - **Water Quality**: A form which contains fields related to water quality data that will be passed to water quality table.
  - **Plankton**: A form which contains fields related to plankton data that will be passed to plankton species table.

2.3 List of Queries

- **Bio Properties Data**: Data displaying an answer to a question on Data Set, Data Source, Stations, and Bio Characteristics.
- **Chemi Properties Data**: Data displaying an answer to a question on Data Set, Data Source, Stations, and Chemical Characteristics.
- **Physical Properties Data**: Data displaying an answer to a question on Data Set, Data Source, Stations, and Physical Characteristics.
- **Data Sources Query**: a parameter query where a datasheet will display and answer responding to a specific Data Source you would like to see its information.
- **Station Query**: a parameter query where a datasheet will display and answer responding to a specific station you would like to see its information.

2.4 List of Reports

- **Bio Properties Data**: a report on Biological Characteristics Data and its related information.

- **Chemi Properties Data**: a report on Chemical Characteristics Data and its related information.
- **Physical Properties Data**: a report on Physical Characteristics Data and its related information.
- **Data Sources Query**: a report on Data Source related information.
- **Station Query:** a report on station related information.

3. Steps to Use Database for Data Input

To enter data

3.1 When open database, the program will kick off with a main switchboard listing" *Single Form*", *Query Pages*", "*Report Pages*", and "*Exit Database*". Select **Single Form** to enter data into each form.

3.2 Under Single Form, select "**Stations**" to enter information regarding station details.

(1) To add a record, click on " *Add Record*".

(2) Enter data starting from "*Station No.*" using 1 to 10 digits. The data entering here cannot be repeated in this same form but can be used in other forms.

(3) The next field is "*Station Name*". Data range is from 1 to 255 characters.

(4) Following is "*Location1 (Sub-District)*". Enter data regarding a Sub-District or Tambon of a station locating. Data range is from 1 to 255 characters; and a field "*Location2 (District)*". Enter data regarding a district or Amphoe or King Amphoe of a station locating. Data range is from 1 to 255 characters. The last field is "*Location3 (Province)*". Enter data regarding a Province of a station locating. Data range is from 1 to 255 characters. If a picture of a station is available, you can enter its photo into the very last field of this form called "LocationPic"

(5) To go to the next form, click on "*Go To Datasource*" button below the station address.

Note:

- *To ensure data is entered in sequence, notice a record number at the bottom. Usually, the number of record and the Station No. sequence is in the same order.*
- *To go from one field to the next field, we can use tab button, enter after finish one field, or click on the next field.*

3.3 Under **Data Source** Form;

(1) Click on "*Add Record*" button to enter a new set of data on data source.

(2) Tab or click on "*Source Type*" to select Type of data from a drop down menu that contains a list of "Primary " or "Secondary".

(3) Tab or click on " *Source Name*" to enter the name of data source. It could be a report name for secondary or a place name where sample is collected for primary data.

(4) Tab or click to enter data on "*Source Date*". It could be a report name or the date of collecting sample. If you have data available only for month and year, enter month and year. Then you will find that the field will automatically generate the first date of that month which is acceptable for this database.

(5) Tab or click to enter data on " *Owner*". Data entering here is a name of the owner of the report in case of a secondary data.

(6) Tab or click on "*Sample Date*" to enter data on date of collecting sample if the data source is primary.

(7) Select "*Go To Water Data Set*" to open "*Water Data Set*" form.

Note: *Date format using a medium date format and the year base on A.D. system (i.e. 2004)*

3.4 Under **Water Data Set** Form;

(1) Click on "*Add Record*" to start enter data on Water Quality and Plankton.

(2) First is to enter data on "*Water Data Set No*". Data can be text or number ranging from 1 – 10 digits.

(3) Tab or click to fill in the "*Date*" entering this data set.

(4) Tab or click on "*Station No.*" and "*Data Source No.*" to input the *Station No*. and *Data Source No*. of the water data set. These two numbers must be one of the numbers already entered in the Stations Form and Data Source Form.

3.4.1 Plankton Form Page

(a) Select "Plankton" Tab to start entering information on planktons.

(b) Enter data on "*Plankton No.*". Data can be text or number range from 1 – 10 digits. It is recommended that the number/text entering here should be related to the Water Data Set No. on the top of this page. *This will both help match up the plankton data set with the water data set and help sequencing data and avoid duplicating number. For instance, If Water Data Set No. is 0001, then Plankton No. should be 0001-001 for the first plankton found and 0001-002 for the second plankton found.*

(c) Tab or click to enter the "*Genus* " which is a name of plankton's genus.

(d) Tab or click to enter the "*Species* " which is a name of plankton's species.

(e) Tab or click to enter the "*Gender* " which is a name follow to ICBN and ICZN.

(f) Tab or click on "*Phylum*" field and choose a phylum name on the list for drop down menu. If the name list does not match what we have on the list, a new name can be typed straight to this field.

(g) Select "*Station No.*" and " *Data Source No.*" to enter data which will be the same as presented on the top part of this water data set main form.

(h) Click on " *Picture Main*" if there is a picture of plankton to add. A further step if adding a picture is to select "insert" on the menu bar. Select "Object", then click on "create from file" and browse to choose the file storing the picture of plankton.

(i) If there is more picture of this same plankton, repeat the same steps as stated under the previous step (step g.).

(j) If there is more record on Plankton, click on "Add Plankton Record" and repeat from step "b to g".

3.4.2 Water Quality Form Page

(a) Click on "Water Quality" Tab to begin entering data on water quality

(b) Click on "*Water Quality No.*". Data can be text or number ranging from 1 – 10 digits. It is recommend that the number/text entering here should be related to the Water Data Set No. on the top of this page. *This will both help match up the plankton data set with the water data set and help sequencing data and avoid duplicating number. For instance, If Water Data Set No. is 0001, then Plankton No. should be 0001-001 for the first plankton found and 0001-002 for the second plankton found.*

(c) Select "*Station No.*" and " *Data Source No.*" to enter data which will be the same as presented on the top part of this water data set main form. However, "*Water Data Set No.*" will be generated automatically. Enter data on each characteristic through each field. If the data is not available for any field, it can be skipped to next data available field.

(d) If there is more data on water quality, repeat from step "b to d".

Note: *Scroll up or down on the right to move up and down for the page. If there is no data available for some fields, please leave it blank by using tab button to skip to the next data available field.*

4. Steps to Print a Report

Step 1: Select on a report you would like to print out.

Step 2: If you are satisfied with the preview shown, on a menu bar, click on “File” and “Print” or simply select “ Printer” icon to print it out.

5. Maintain Database

- Ensure a proper size of the computer storing the file.
- Do not change any format of any field especially in a table and a form.
- However, If there is need for changes, it is recommended that a back up copy is available.
- Pictures for the database should be stored in the same drive as the database stored.

Water Quality and Plankton Information Database

Curriculum Vitae

Mr. Puripat Wongpipattananon was born on July 8, 1971, in Trang Province, in the southern region of Thailand. After the primary school at Songkhla Wattana School and the secondary school at Wachiranukul School, Songkhla Province, studied the undergraduate program in Biotechnology at Rangsit University, Pathum Thani Province and continued the Master degree in Environmental Science, Kasetsart University and worked as research assistant for Environmental Impact Assessment (EIA) report at Interdisciplinary Program of Environmental Science, Kasetsart University. After graduated in 1996, Mr. Puripat Wongpipattananon started working as Environmental Scientist at TEAM Consulting Engineering and Management Co., Ltd. Bangkok. He pursued the Ph.D. program in Environmental Biology at Suranaree University of Technology, in the Second Trimester of 1999. Up to the present time, he still works as a Environmental Scientist at TEAM Consulting Engineering and Management Co., Ltd. Bangkok.