STUDY ON THE PHYSICO-CHEMICAL CHARACTERISTICS OF NEGOMBO LAGOON

By

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This is submitted in partial fulfillment of the requirements for the degree of Bachelor of Science (Natural Resources) of the Faculty of Applied Sciences, Sabaragamuwa University of Sri Lanka, Buttala, Sri Lanka.

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December 2000

DECLARATION

The work is described in this thesis was carried out by me at the Faculty of Applied Sciences under the supervision of Mr. Hemantha Dassanayake and Dr.R. Chandrajith. A report on this has not been submitted to any other University for another degree.

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AFFECTIONATELY DEDICATED

TO

MY PARENTS, BROTHER, SISTER AND

TEACHERS

Acknowledgement

I would like to extend my sincere thanks to my external Supervisor Mr. Hemantha Dassanayake, Head, Environmental Studies Division, National Aquatic Resources Research and Development Agency for his constant support and guidance throughout this study. I am grateful to the staff of Environmental Studies Division, NARA, who encouraged me constantly and helped me.

I also wish to thank Dr. K.K.D.S.Ranaweera, Dean, Faculty of Applied Sciences, Mr. Jagath Wansapala, Head, Department of Natural Resources, Mr. K.P.L. Nishantha, course Co-ordinater of B.Sc. Degree programme in Natural Resources and the staff of the faculty of Applied Sciences, University of Sabaragamuwa, Sri Lanka for providing their guidance to complete this report. It is my grate pleasure to thank Dr. R. Chandrajith, the internal supervisor, for providing me with guidance, advice and the encouragement to complete this report successfully.

I express my special thank to my dearest friends for their kind support given to me at all times to complete this report successfully. Also my special thank go to my ever loving parents, brother and sister for encouraging me throughout this work.

Finally, I am grateful to thank National Aquatic Resources Research and Development Agency for providing facilities to my research project of the B.Sc Degree Programme.

ABSTRACT

Negombo lagoon is a semi- enclosed water body situated in Western province. Several canals bring polluted water to the Negombo lagoon. Treated and untreated effluents discharge to the lagoon and canals directly or indirectly.

The main objective of this report is to study on the physico-chemical properties, information regarding pollution and suggestion of important mitigatory measures.

NARA already selected site selections of Dandugam Oya, Ja-Ela and Negombo lagoon. There were three field visits for studied period. In the month of July, concentrations of nutrients were relatively high. There was salinity variation in the entire lagoon. But, salinity could not seen in Dandugam Oya and Ja-Ela during the studied period. pH in the Dandugam Oya and Ja-Ela was somewhat low but in the Negombo lagoon, it has somewhat alkaline condition. Thus, physical and chemical parameters in those locations do not effect significantly to their ecosystems.

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CHAPTER 1

INTRODUCTION

Negombo Lagoon, a brackish water body is situated at Latitude 7° 11'N, Longitude 79°50' E. It is 14.1 km long and has the surface extent of 3170 ha. The lagoon receives freshwater from two rivers, Dandugam Oya and Ja-Ela, which open to the southern end of the lagoon. The Lagoon opens to the sea at its northern end (appendix I and appendix II)

Negombo Lagoon is one of the important ecosystems in Sri Lanka. Since the lagoon gives shelter to nursery grounds for many marine finfish and shellfish that are supporting a commercial coastal fishery. Pinto and Punchihewa (1996) has estimated the extent of sea grass bed area in the lagoon as 900 ha. The sea grass beds and mangrove areas in the periphery of the lagoon provide food and shelter for about 109 finfish species (Pinto and Punchihewa. 1996) and six commercially important shellfish species (Siddeek and Jayasinghe, 1985; Costa, 1979). Sanders *et al.* (2000) have identified fourteen species of shrimps in the Lagoon along with the above six commercial species. In 1997 the lagoon produced 617 tons of shrimps and 1044 tons of other fishes. They have also estimated a catch of 617 t of shrimps and 1044 tons of others (mostly fish) from the Negombo Lagoon in 1997.

However the, deterioration of the lagoon conditions has been reported in the recent years. Pollution from the land sources, siltation due to deforestation in the upper reaches, reduced water exchange due to unplanned planting of mangroves in the area near the mouth of the lagoon, destruction of mangrove areas around the lagoon have contributed vastly to the deterioration of water quality in the lagoon. The maritime sources of pollutants in the lagoon include spent oil, fuel oil and bilge water discharges from fishing boats, disposal of fish offal etc. As a result, the fauna in the lagoon faces stressful conditions. Occurrence of algal blooms in the lagoon has been reported from time to time indicating that the load of nutrient input to the lagoon is increasing.

The Dutch Canal constructed along the eastern boundary of the Muturajawela marsh links the Negombo lagoon and the Kelani River.The Hamilton Canal was constructed along the Western margin of the Muturajawela marsh connecting the Kelani River and the Negombo lagoon. Several canals bring polluted water to the Negombo lagoon. Furthermore, the treated effluent from the Katunayake Export Processing Zone is discharged in to the

Dandugam Oya and untreated effluent from the Ekala Industrial Zone discharge to Ja-Ela, which finally flows in to the lagoon. These industrial effluents contain pollutants such as organic matter, textile dyes and heavy metals.

Occurrence of algal blooms in water bodies is a common phenomenon and is generally considered a nuisance. Algal blooms usually indicate eutrophication of the water body. They are mostly occurring in freshwater lakes rather than in brackish water and are related to the nutrient input to the water body. However, the algal mats may play a crucial role in the system at keeping nutrient levels lower in the water column than potentially possible. The mats effect the cycling of nutrients within the water column and out of the sediments; therefore, it is important to understand their role in nutrient cycling.

Due to the algal mats intercepting potential nutrients reaching the water column, the algal mats are considered as a control on nuisance phytoplankton blooms but nuisance blooms of macro algae have depleted eelgrass and soft shell clam populations (Tsie, 1997). As such it is important to determine which bloom is less damaging to the ecosystem. Moreover, the algal mats also provide protection for marine organisms, which could increase biodiversity in the system. Algal mats may also play an important role for the benthic organisms that also need the same nutrients as the algae and other marine organisms. In this context it is decided to find out the current situation in the Negombo Lagoon ecosystem with regard to the occurrence of filamentous algae. Occurrence of algal blooms in the lagoon has been reported from time to time indicating an increase input of nutrient into the lagoon.

OBJECTIVES

The main objectives of the research was to

- ✓ Study the physico-chemical properties of Negombo Lagoon, Dandugam Oya and Ja-Ela.

The co-objectives were as follows:

- ✓ Studying variation of physico-chemical characteristics of Negombo Lagoon, Dandugam Oya and Ja-Ela.
- ✓ Indicate pollution level of the water bodies.
- ✓ Identify the sources of pollution and to suggest implementing mitigatory measures.

CHAPTER 2

LITERETURE REVIEW ON THE WATER QUALITY STATUS OF SOME WATER BODIES IN SRI LANKA

Since the water related problems in the country have already been identified as prevalence of water born diseases, eutrophication, salinization, water logging and siltation, decreases of biodiversity and reduce of natural scenery, much attention has already given on the water quality of rivers, canals, lakes and lagoons. Kelani River, Hamilton canal and Kandy Meda Ela are some of water streams and there is high potential for pollution of water in them (Silva, E.I.L., 1996).

Kelani River

The Kelani River is the second largest watershed in Sri Lanka. It is 144.3km long and the basin consists of an area of 2278km^2 from sea level to an elevation exceeding 1500m. Pollution aspects of the river are as follows.

- Discharge heavy loads of industrial pollutants - There are twenty-three major industries such as petroleum refinery, textile factories, tanneries and breweries etc; in the watershed. Twenty of them directly discharge their effluents and other waste into the Kelani River and its tributaries. (Silva, E.I.L., 1996)

- Discharge domestic sewage and organic waste directly into the river. - This results 400 ppm of COD in 1.0 ml, 25 ppm total nitrogen and 18500 coliform per 100 ml. (Silva, E.I.L., 1996)

- Extraction of water at Ambatale for domestic and industrial uses of the metroplitan. - This will be a significant effect on salt-water intrusion during the dry season.

- Extensive exploitation of sand from the river beds also a cause for the salt-water intrusion.

Hamilton Canal

Hamilton canal is an artificial watercourse, which connects two brackish water bodies viz.; the Kelani estuary and Negombo lagoon. It is 14.7 km long, 1.6 to 1.8m wide and depth ranges between 1.50 m and 1.25 m. Hamilton canal is susceptible to non –point pollution sources, and they are as following. (Silva, E.I.L., 1996)

- Tidal fluctuation, this would certainly be one of the determinants of the physico-chemical properties of the canals' water (eg. pH, salinity, DO, etc)

- Possibility of pollution with organic residues (eg. pesticides)

There are only a few organisms whose present specially indicates that the water is polluted. For an example, presence of cloakroom bacteria indicates fecal contamination. Although several organisms are known frequently to be associated with polluting conditions They also occur widely in environments which are not polluted, for an example tubificid worms, sewage fungus (*Shaerotilus notans)*

Algae, macrophytes, protozoa bacteria, macrovertebrates and fish are some of the biological indicators, which can be used to detect the water pollution. Most polluted sites will not bear macrophytes (Haslam, 1990) and when conditions improve so that tolerant species can occur.

Negombo Lagoon

Several development projects have been taken place in the vicinity of the lagoon during the last two decades. The establishment of the Ekala industrial city and the Katunayake free trade zone may have direct or indirect impacts on the water quality of the Negombo lagoon .In October 1990 and unusual mortality of fish was observed in the Ja-Ela, an artificial canal constructed for flood control at the down stream of the Attanagalu Oya. (Silva, E.I.L., 1996)

The climatic and weather conditions of the area are mainly control by the South –West monsoon but it receives a considerable amount of rain throughout the year. The hydrographic studies conduct by the NARA in 1992 showed that evaporation exceeds rainfall only between January and March. The daily minimum and maximum air temperature ranges from 19°C to 35 °C and the highest daily fluctuation in temperature occurs from December to February (Silva, 1981; NARA, 1992)

Seventeen industries in generating industrial effluents in the Ekala Industrial Processing Factories discharge partially treated or untreated effluents into the fresh water in flow of the Negombo lagoon directly or indirectly (Edirisinghe; 1993). These industries comprise of a tannery, several textile-processing units and some other factories such as chemical processing, battery manufacturing, distillery and fiber mill. In addition, Central Sewage Treatment Plant of the Katunayake Export Processing Zone treats the effluents of seventy six industries, which are also located in the vicinity of the lagoon. It has been reported that the effluents discharged from all these industries except from the Katunayake Export Processing Zone is not within the relevant Central Environmental tolerance limit specified for effluent discharged into surface water.

Report on Dynamics of some physical oceanographic characteristics of the Negombo lagoon, 1992 by Oceanographic Division, NARA (Wikramarathne, et. al.1992) indicated that changes in surface and bottom salinity with time. Annual variation of salinity at Negombo lagoon exhibits a maximum in March (31 ppt) and a minimum in June (2.21 ppt). The results of the studies carried out from 1969 to 1991 (Samarakoon and Raphael, 1970; Silva, 1981; NARA, 1988; NARA, 1992) were diagnosed to analyze the spatial, seasonal and diurnal pattern of the physico-chemical properties of the Negombo lagoon.

CHAPTER 3

MATERIAL AND METHODS

3.1 Water sampling

Water samplings were carried out on July to September 2000 and sampling sites were already selected by NARA. Twenty sampling sites were selected from Dandugam Oya, Ja-Ela and Negombo lagoon and in which six sites from Negombo lagoon, five sites from Ja-Ela and nine sites from Dandugam Oya. Water samples were taken using a plastic beaker and transferred in to precleaned polythene bottles. Travelling around the area by a small motorboat. Temperature, pH, salinity, Dissolved oxygen, Turbidity, Total dissolved solids and electrical conductivity were measured *insitu.*

Three field visits were made to collect water samples as monthly basis. Water samples were collected for analysing the nutrients and another sample for analysing chlorophyll a concentration of water for each location. After taking water sample for analysing chlorophyll a, immediately fixed with powdered $MgCO_3$.

For the purpose of determining the levels of pollutants in the lagoon, water samples were collected and analysed for important Physico-Chemical parameters. The following parameters of Physical and chemical components were analysed by following methods.

3.2 Preservation of water samples

The water samples were filtered and at 4^0 C and transport to lab. The samples for nutrients were kept deep-frozen and analysis performed in following day. For analysing ammonia most reliable results were obtained from fresh samples. Also water samples for chlorophyll - a testing samples at 4^0 C.

3.3 DETERMINATION OF PHYSICAL AND CHEMICAL PARAMETES

The methods given APHA (1999) and Stirling (1985) were used for the determination of water quality parameters.

3.3.1 Temperature

Temperature needs *insitu* measurement. It was calibrated in Celsius. Any chemicals and reagents did not use. Readings were taken from the instrument directly.

3.3.2 Turbidity NTU (Nephelometric Turbidity Unit)

Suspended matter such as clay, silt, finely divided organic and inorganic matter, soluble coloured organic compounds and planktons and other microscopic organisms causes turbidity in water. The standard method for determination of turbidity has been based on the turbid meter, However, turbidity values that can be measured directly. After immersed into the sample. Instrument was calibrated by using appropriate calibration standards.

3.3.3 Electrical Conductivity

Electrical conductivity was measured at the sampling stations with the help of a Conductor meter by dipping the sensitive probe in the water sample. Instrument was calibrated with KCl (0.01) solution before use.

3.3.4 Total Dissolved solids

Total dissolved solids were measured at the sampling stations with the help of a portable electrical conductometer by dipping the sensitive probe in the water sample.

3.3.5 pH

pH is a measure of H^+ ion activity when a pH electrode is immersed in a water sample at a sampling station. pH of the water was measured by using portable pH meter. For calibration of instrument pH 7, pH 4 and pH 9 buffer solutions were used.

3.3.6 Salinity

Salinity of a water sample was measured with a help of portable salinometer at a sampling station.

3.3.7 Dissolved oxygen

Dissolved oxygen was measured by using portable DO meter at sampling stations.

3.3.8. Ammonia

Phenol – hypochlorite method was used to determine ammonia for water samples.

Special apparatus and equipments

i. Spectrophotometer
For using the 640nm, providing a light path of 1 cm.

ii. Graduated pipette

iii. Erlenmeyer flasks

Special Reagents

i. Phenol solution

20.00 g of phenol was dissolved in 200 ml of 95 % v/v ethyl alcohol

ii. Sodium nitroprusside solution.

1.0 g of sodium nitroprusside was dissolved in 200 ml of distilled water and stored in an amber bottle on the refrigerator. The solution was stable at least one month.

iii. Alkaline Reagent

100.0 g of sodium citrate and 5.0 g of sodium hydroxide were dissolved in 500.0ml of distilled water.

iv. Sodium hypochlorite

Commercial bleach solution

v. oxidising solution

100.0 ml of alkaline reagent and 25ml of sodium hypochlorite were mixed together. This solution should be made up fresh before use and was stable for less than one day.

Experimental Procedure

2.00 ml of phenol as pipette out and it was added into 10.0ml water sample. Swirling mixed it and then 2.0 ml of sodium nitroprusside solution and 5.0ml of oxidising solution were added in to the sample. Top of the flasks were covered and kept the sample out from direct sunlight. About one hour at room temperature the absorbance was read at 6.00 nm by using UV/ visible spectrophotometer.

3.3.9 Nitrite nitrogen

Nitrite is an intermediate product in the nitrification of ammonia to nitrite. It is toxic to fish and therefore is important for aquaculture.

Special apparatus and equipments.

i. Spectrophotometer
   For used at 543 nm.

ii. Graduated pipettes

iii. 25 ml Erlenmeyer flasks

Special Reagents

i. Sulfanilamide solution

5.0 of sulfanilamide were dissolved in a mixture of 50 ml concentrated HCl acid and about 300 ml of distilled water. Above solution was diluted to 500 ml using distilled water. The solution was stable for many months.

ii. N- (1 – naphthyl)- ethylenediamine dihydrochloride (NED) solution

0.50 of the dihydrochloride was dissolved in 500 ml of distilled water. Solution was stirred in a dark bottle in a refrigerator. It was stable for one month.

Experimental procedure

0.2ml of sulfanilamide solution was pipetted out and added in to the each 10 ml samples. Above each samples were mixed and allowed the reagent to react for more than 2 minutes but less than 10 minuets to assure a complete reaction.

0.2 ml of NED regent was added to the each samples and mixed immediately. . Between 10 minutes and 2 hrs afterwards, extinction of the solution was measured using spectrophotometer in 1 mm cuvette at a wavelength of 543nm.

3.3.10 Nitrate nitrogen

The following procedure was based on methods Morris and Riley with some modifications suggested by Grasshoff and wood *et al.* Nitrate in water is reduced almost quantitatively to nitrite when a sample is run through a column containing cadmium filings coated with metallic copper.

Special apparatus and equipments

i. Cadmium / copper reduction column

ii. Spectrophotometer

iii. 10 me and 1 ml graduated pipettes

iv. Erlenmeyer flasks.

Special Reagents

i. Concentrated Ammonium chloride EDTA solution.

13.0 g and 1- 7 g of disodium ethylene diamine teakettle was dissolved in 500 ml of distilled water pH was adjusted to 8.5 with conc. NH_4OH and dilute to 1 litre. .

ii. Dilute NH_4Cl - EDTA solution

Of NH_4Cl - EDTA solution was diluted to 500 ml with distilled water.

iii. Sulphanilamide solution

Previous method was used

Iv. N–(1-naphthyl) ethylenediamine dihydrochloride (NED) solution

Which used to determine N-NO_2

Experimental Procedure

2. 0 ml of NH_4Cl solution was added to the 50 ml water sample in the Erlenmeyer flask. Solution was mixed and poured in to the top of the column and allowed it to pass through Then Erlenmeyer flask was placed under the collection tube. About 40 ml of the sample was allowed to pass through the column and discarded remained 10 ml sample was taken for analysing.

Then followed same procedure for analysing nitrite.

3.3.10 Total soluble phosphate

Organisms required Nitrogen and phosphorous in small quantities of in order to grow and function. However, excessive quantities of these nutrients can result in excessive growth and productivity.

Special apparatus and equipment

i. 50 ml graduated beakers

ii. Graduated pipettes

iii. Measuring cylinder

iv. Spectrophotometer

Special reagents

i. 1.8 M sulphuric acid solution

100 ml of concentrated (18m) sulphuric solution and 500 ml distilled water were mixed and diluted to 1 litre.

ii. Sulphuric acid Antimony solution

53.3 ml concentrated sulphuric acid with 500 ml distilled water were mixed and cooled. 0.748g of K (SbO) $C_4H_4O_6$. ½ H_2O (Potassium Antimonyl Tartarate) was dissolved in the H_2SO_4 solution and diluted to 1 litre with distilled water. Then stored in refrigerator.

iii. Molibdate solution

10.839 g of sodium molibdate was dissolved in 500 ml distilled water and diluted to 1 litre with distilled water. Then it was stored in refrigerator.

iv. Ascorbic Acid

v. Mixed reagent

25 ml of sulphuric antimony solution, 25 l of molibdate solution, 10 ml of 1.8 m sulphuric acid solution and 0.2 g ascorbic acid were mixed together and diluted to 100 ml with distilled water. This solution should be prepared each day.

Experimental Procedure

25 .0 ml from each water sample were taken into 50 ml beakers. Then 5.0 ml of mixed reagent was added and allowed 15 minutes for colour development. Then measured the absorbance of samples against the reagent blank at 882 nm in 1 cm glass cuvette. The colour was stable for 2 hours.

3.3.11 Concentration of chlorophyll-a

Chlorophyll-a is essential to photosynthesis and is resent in all plants. Planktonic algal contain 1 to 2 % chlorophyll-a dry weight Hadrian P. Stirling method was used to analysis chlorophyll-a concentration. The weight per unit volume or biomass of phytoplankton in given water is a good indicator of its primary productivity

Special apparatus and equipments

i. Filter equipment designed to hold 47 – mm diameter synthetic membrane filter.

ii. Centrifuge tubes

iii. Membrane filter papers

iv. Centrifuger

v. Spectrophotometer

vi. Volumetric flask

Special Reagents

i. 90 % acetone solution

100 ml of distilled water was pipette out in to a volumetric flask and made up to litre with A-R grade acetone. Solution was stored in a dark glass bottle.

ii. Magnesium carbonate suspension

1.0 g of A R grade finely powdered magnesium carbonate was added to 100 ml distilled water. The power was suspended by vigorous shaking immediately before use.

Experimental procedure

Water sample bottle was shake well and 300.0 ml of water volume was filtered through a 4.5 cm membrane filter paper. After filtered the sample, filter paper was transferred carefully to the centrifuge tubes with 10 ml of 90 % acetone solution. Those tubes were left for 24 hours at 4^0C in dark environment. After 24 hours period, tubes were centrifuged 10 minutes. After that the supernatant was transferred in to 1 cm path length spectrophotometer cuvette and measured the absorbance at the following wavelengths.

Wave lengths 750 nm, 665 nm, 664 nm, 647 nm, 630 nm.
Then amount of chlorophyll -a was calculated by the equation.

Calculation

$$\text{Chlorophyll a, } \mu g l^{-1} = 11.85\, A_{664} - 1.54\, A_{647} - 0.08\, A_{630} \times \frac{V_2}{V_1 \times L}$$

Where, A_{630}, A_{647} and A_{664} are the corrected absorbances at 630, 647 and 664 nm, respectively, V_1 is the volume of water sample filtered in litres

V_2 ml is the final volume of acetone extract

L is the path length of the spectrophotometer cuvette in cm.

CHAPTER 4

RESULTS AND DISCUSSION

Water sampling was started on July to September 2000.

Temperature

The lagoon water is characterised by moderate temperature with values ranging from 28.3 ^{0}C to 30°C for July and it was ranging from 27.5^{0}C to 28.8ºC during August. The mean temperature of Negombo lagoon was 28.9°C in the month of July and for month of August it was 28.0^{0}C . The temperature of the NG4 (Hamilton canal mouth) was relatively higher than other stations (30°C). Temperatures in each location of Negombo lagoon are given in table 4.1. and figure 4.1.

The mean temperature of Dandugam Oya was ranging from 27.2^0 C to 29.3 ^{0}C . The highest temperature was recorded during the month of July and August .For July it was 29.3 ^{0}C and for August it was 29.2^{0}C respectively. The relatively low temperature was recorded in Dandugam Oya for September .The lower temperature is probably due to the heavy rain Which causes turbulence; intern results in the mixing of the surface water and bottom waters. Temperature in Dandugam Oya is given in table 4.2 and figure 4.2.

The highest mean temperature was attained by July when considering the Ja-Ela. It was 30 .5°C. For August and September it was 29.06^{0}C and 27.6^{0}C respectively. There was little variations of mean temperature in each location could be identified. During month of July the highest temperature (30.7°C) was attained by J3 (domestic area) and also for August it was 29.3°C in domestic area. The temperatures in Ja- Ela are given in table 4.3 and figure 4.3.

In general, the rates of chemical reaction decrease with decreasing temperature. The relative concentrations of reaction sand products in chemical equilibria can also change with temperature.

Electrical conductivity

Electrical conductivity of the each station is given in table 5. The electrical conductivity of water is a measure of the ions present in the water, their mobility, valence and temperature.

Mean conductivity of Negombo lagoon was rather high during the period at all six stations. This is due to seawater intrusion to the lagoon through its inlet during the high tides. The mean electrical conductivity in lagoon water was 25.7 ms in the month of July. In August, it was dropped to 19.3ms. The maximum electrical conductivity was recorded in NG1 (mouth of the lagoon) during July and August (40.8 ms and 40.4 ms respectively) because it is the place where seawater enters the lagoon. Also NG_3 (close to Blue lagoon Hotel) was shown rather high conductivity probably due to the sewage from the town, or due to contaminants from connecting rivers and canals. The monthly variation of electrical conductivity during the study does not show any significant difference ($T_{calculated}=0.76<T_{tabulated}=2.23$). Electrical conductivity in each location of Negombo lagoon are given in table 4.4 and figure 4.4.

Maximum mean conductivity was recorded in Dandugam Oya in the month of July. (1.88 ms) The mean conductivities of other months were relatively low. The lowest values were recorded in September. Electrical conductivity of each location in Dandugam Oya is given in table 4.5 and figure 4.5.

When considering conductivity of Ja- Ela, the maximum conductivity was recorded at J1 (Ja-Ela, Dandugam Oya junction) during the period of July and August (3.84ms and 0.475ms respectively). Because due to the concentration of ions were rather high in both streams and conductivity was high at where the point they connect together. The mean highest conductivity was noted in the July and it was decreased in the August conductivity is, however, the indication of solubility of electrolytes and thus effects biological productivity. Probably, electrical conductivity was rather high at where the point, Dandugam Oya and Ja-Ela connect together. The mean highest conductivity in Ja-Ela was noted in the July and it was decreased in the August. The table 4.6 and figure 4.6. are shown, mean conductivity in each location.

Turbidity

Turbidity is an important consideration in natural waters from the point of view of aesthetics and light penetration. Turbidity in water caused by suspended matter such as clay, silt, finely divided organic and inorganic matter, soluble coloured organic compounds and plankton and other macroscopic organisms. Turbidity is mainly depend on the tidal action i.e. where there is strong tidal flow turbulence over the rough bottom, will keep water well mixed.

The maximum turbidity values were observed during the month of August in Dandugam Oya (20.5 NTU). The mean turbidity of Dandugam Oya was 17.23 NTU. In August and mean turbidity was 13.76 NTU in September .The minimum values was observed in D2 (Behind proposed hotel) in August D5 (Behind the temple) and D6 (Behind the distillery) were shown rather high value in August (20.5, 20.0 NTU). Also D8 (effluent releasing point) and D9 (upstream effluent releasing point) were noted high value in September 15.0 and 15.2 NTU) Turbidity in Dandugam Oya is given in table 4.7and figure 4.7.

Maximum turbidity of 23.4 NTU was observed in Ja- Ela during the month of August Seasonal and spatial distribution of turbidity are directly associated with the fresh water inflow and the annual rainfall pattern in Negombo lagoon. In general, the maximum turbidity was encountered in areas with high concentrations of suspended matters and corresponding to areas with relatively low Turbidity of Ja-Ela are shown in table 4.8 and figure 4.8.

Dissolved Oxygen (DO)

The mean dissolved oxygen (DO) content of Negombo lagoon water is presented in table 4.9 and figure 4.9 shows how the dissolved oxygen varied at different sampling site. The solubility of oxygen in water depends on atmospheric pressure, temperature and the salt content in the water and also depends on physical chemical and biochemical activities in water. Concentration of dissolved oxygen for the Negombo lagoon water varied from 2.92 mgO_2l^{-1} to $5.6mgO_2l^{-1}$ in the July. The mean dissolved oxygen of Negombo lagoon was 4.24 mgO_2l^{-1} in July and for August it was $3.7mgO_2l^{-1}$. Near the Air Port Garden hotel and the lagoon mouth were shown relatively high values of DO during the period of July and August. pH is affecting the dissolve of atmospheric Oxygen in water. Location near the Air Port Garden hotel was having high pH; therefore DO content was relatively low in Air Port Garden. The variation of DO content in each location was.negligible. The DO concentration of Lagoon water was higher than other locations. Depletion of DO in water creates anaerobic condition and it leads to microbial reduction of nitrates to nitrite and sulphate to sulphite. Therefore, it may change the chemical composition of the water and creates a bad odour.

The average of 2.60mgO_2l^{-1} of DO concentration was recorded in Dandugam Oya. The concentration of DO was not significantly varied in each locations of Dandugam Oya. The sampling site D4 (Dandugam Oya Bridge) was recorded high concentration of DO at the location compare with others. High DO concentration results in an increased pH value. Table 4.10 and figure 4.10 show concentration of DO in Dandugam Oya.

Mean DO concentration was relatively high in Dandugam Oya during the moth of July (1.98mgO_2l^{-1}). When considering the August, the relatively high concentrations of DO were recorded in Dandugam Oya Bridge, Behind the Temple and Behind the Distillery (4.3mgO_2l^{-1}, 4.05mgO_2l^{-1} and 3.40mgO_2l^{-1}) respectively. It may be due to relatively high temperature. The mean DO concentration was dropped to 1.85 and 1.93mgO_2l^{-1} in Dandugam Oya in the month of September. Concentration of DO in Dandugam Oya is given in table 4.11and figure 4.11.

Maximum mean concentration of DO was attained by month of July and it was 3.55mgl^{-1} in Ja-Ela. There was no significance variation of mean DO concentration during the three month period at each location. Concentration of DO in Ja-Ela is shown in table 4.12 and figure 4.12.

Salinity

The presence of mean salinity values of each stations are given in the table 4.13 and figure 4.13. The diurnal changes in salinity is directly associated with the tidal rhythm which also changes the pH and the DO. There were no uniform patterns of salinity variation in the entire lagoon. The salinity of NG_1 or lagoon mouth was very high during the July and August because enter the saltwater intrusion. The salinity is considerably diluted by the sources of fresh water (i.e. inflow from the Dandugam Oya, Muthurajawela marsh and precipitation). The maximum salinity values were recorded during July and August. The mean salinity of the lagoon were 15.72 ppt and 14.95 ppt during the both months respectively .The minimum salinity was recorded in NG_2 (town canal Opening). The salinity of the lagoon was ranging from 5.3 ppt to 26.2 ppt in July and 4.1 to 25.9 ppt in August. 5.3 ppt was the lowest value that was recorded in Dandugam Oya mouth during the July. The salinity varying from 25 ppt to 29 ppt at the mouth and 5 to 10 ppt at the head of the estuary.

The salinity of Dandugam Oya and Ja – Ela were much lower than Negombo lagoon. The maximum mean salinity was observed in Dandugam Oya during the month of July. The maximum of salinity (1.7 and 1.02 ppt) were noted in D_1 (Dutch canal mouth) and D_2 (Behind proposed hotel) for same month. Relatively high salinity was recorded in July may be due to the evaporation in Dandugam Oya. Salinity in Dandugam Oya is given in table 4.14 and figure 4.14. There were no salinity recorded in Dandugam Oya or Ja-Ela during the period of September may be due to the heavy rain Therefore, there was no salinity variation in both fresh water bodies. The salinity was not recorded in Dandugam Oya and Ja-Ela during the month of September.Salinity in Ja-Ela are given in table 4.15 and 4.15.

pH

The pH is the H^+ ion activity, which was measured using a calibrated pH meter. The pH value of the Negombo lagoon was fluctuated between 6.75 and 8.10. The mean pH of the lagoon was 7.70. It was recorded in month of July. For August it was 7.5 .The maximum, pH was recorded in the NG1 (sea mouth), because of buffering capacity in seawater. In general, pH of the lagoon is above 7. It may be due to the saltwater intrusion. The lagoon water was alkaline during the studied period. However, the pH increased towards the sea mouth and highest recorded pH was 8.1, at the lagoon mouth in July. The lowest pH values were recorded in NG5 (Dandugam Oya mouth) during the August. This is mainly due to the fresh water inflow from Dandugam Oya. The pH values of Negombo lagoon are given in table 4.16 and 4.16.

The pH of Dandugam Oya was ranging from 6.51 to 6.83 for July and it was ranging from 5.93 to 6.36 for August. In July mean pH of 6.62 was recorded in the Dandugam Oya. It was slightly acidic during the month for August (5.98). This low pH may affect to the aquatic organism in Dandugam Oya in 95% significant level ($T_{calculated}$=5.77>$T_{tabulated}$=1.77). The accumulation of domestic waste matter may be contributed to the acidity. Mean pH values in each location of Dandugam Oya are given in table 4.17 and figure. 4.17.

pH values of Ja-Ela are given in table 4.18 and figure 4.18. The pH of Ja -Ela is ranging from 6.40 to 6.90 for July and from 5.99 to 6.66 in the August. The mean pH of Ja-Ela was 6.73 and 6.15 during the July and August respectively. The mean variation of pH did not show among any significance the stations. But pH was never too low or too high to threaten the aquatic life.

Total Dissolved Solids

Electrical conductivity is closely related to the amount of total dissolved solids of a water body and is also used as an index of salt content of water. Total dissolved solids of a water sample represent dissolved organic matters, dissolved inorganic substances excepting gases and suspended inorganic substances.

Maximum mean value of TDS was observed during the month of July (10270ms/l) in Negombo lagoon. The highest concentration of TDS was presented in the location at near Air Port Garden (13500ms/l) during the same month. In August it was 17700ms/l. The minimum value was shown in Hamilton canal mouth (3960ms/l) during month of August. The mean concentration of TDS was somewhat higher in the month of July (10270ms/l). There was no significant effect to the lagoon by TDS. When Total dissolved ion concentration high, the salinity also high. Total dissolved solids in Negombo lagoon are indicated in table 4.19 and figure 4.19.

When considering the Dandugam Oya, the highest mean concentration of TDS was recorded during month of July (925.6ms/l). The highest TDS value was recorded in Dutch canal Mouth during the studied period (1700, 135 and 35ms/l). The minimum content of TDS was recorded in Kottela junction (34ms/l) in month of September. Behind proposed hotel (D2) also shown relatively high content of TDS during the period. The mean variation of TDS was lower in each location and it was recorded in the month of September and highest mean variation of TDS in each location was 331.8 during the month of July. This may be due to the salinity. Total dissolved solids values of Dandugam Oya are given in table 4.20 and figure 4.20.

Maximum TDS (1950ms/l) was recorded in Ja-Ela - Dandugam Oya junction during the period of July. Because it due to the mixing of Ja-Ela and Dandugam Oya in the point. Both streams brought large amount of domestic wastes and industrial effluents. Therefore, TDS was also high. The TDS concentration was decreased regularly towards the Ja-Ela Bridge during the three month period. The maximum mean TDS was attained by July (841.8). The minimum value was recorded in the month of September (31.8ms/l) may be due to the flushing during heavy rain. Table 4.21 and figure 4.21. are shown total dissolved solids in Ja-Ela.

Nitrate nitrogen

Organisms require nitrogen in small quantities in order to grow and function. However, excessive quantities of this nutrient can result in excessive growth and productivity leads to undesirable phenomenon such as eutrophication. The growths of algal bloom in the water body occur nuisance conditions. Concentrations of nutrients in water body are therefore important indicators of the water body.

The maximum concentration of nitrate was recorded at the Town Canal Opening. It was $0.52mgl^{-1}$in month of July. The mean concentration of nitrate in Negombo lagoon was $0.18mgl^{-1}$ in the month of July and $0.37mgl^{-1}$ was recorded in the month of August. Therefore, mean nitrate concentration in July is higher than the nitrate concentration in August. Nitrate concentration was rise to significant level in the Negombo lagoon (T=-2.16 in 95% confidence level). Nitrate concentration of Negombo lagoon is given in table 4.22 and figure 4.22.

When considering Dandugam Oya, the maximum value of nitrate was $0.92mgl^{-1}$ detected during the month of July. Concentrations of nitrate also lower in September probably due to heavy rain. Concentration of nitrate in Dandugam Oya is given in table 4.23 and figure 4.23.

The nitrate concentration of Ja-Ela was rather lower than that of Dandugam Oya in the month of July. But in September, it was relatively high. The highest mean nitrate concentration was recorded ($0.46mgl^{-1}$) in month of August. The maximum concentration of nitrate was recorded in J4 (Nugape Bridge) in month of August ($1.88mgl^{-1}$). Table 4.24 and figure 4.24 are shown nitrate concentration of Ja-Ela.

Total soluble phosphate

The mean concentration of phosphate in July was $0.35mgl^{-1}$. This is relatively higher than mean phosphate concentration in August. Because it may be due to presence of phosphate based wastes discharged from domestic sewage and agricultural and runoff in which may enhance aquatic pollution. Seventeen industries generating industrial effluents in the Ekala industrial processing factories discharged partially treated or untreated effluent in the fresh water inflow of the Negombo lagoon directly or indirectly. The mean concentration of phosphate in August was $0.0137mgl^{-1}$. But this level is not effect significantly to the aquatic ecosystem. Concentration of phosphate in Negombo lagoon is given in table 4.25 and figure 4.25.

The relatively high concentration of phosphate (0.12mgl^{-1}) detected in the water samples obtained from Dandugam Oya in the month of July. The minimum phosphate content was recorded in September. It was observed that *Eichornia pescaprae* were spread in the Dandugam Oya particularly close to D7 (down stream of the effluent releasing point) during the month of August and September, Probably due to the high concentration of the nutrients. Concentration of phosphate in Dandugam Oya is given in table 4.26 and figure 4.26.

.Mean concentration of phosphate was relatively low in Ja-Ela when compare the Dandugam Oya during the observed period. Table 4.27 and figure 4.27 are given concentration of phosphate in Ja-Ela.

Nitrite nitrogen

The mean highest concentration of nitrite obtained in the month of August (0.02mgl^{-1}) in the Negombo lagoon. So, nitrite concentration was low in both months. Thus, there was no toxic condition in the lagoon at 95% confidence level. ($T_{calculated}$= -5.26<$T_{tabulated}$2.228). Nitrite concentration of each location in Negombo lagoon is given in table 4.28 and figure 4.28.

The mean concentration of nitrite was very low in Ja-Ela and Dandugam Oya during the three month period. The very high variation of nitrite concentration did not recorded in each location. In the month of September, the concentration of nitrite was very low due to the seasonal rain. Nitrite content of 0.019mgl^{-1} was recorded in Dandugam Oya in July. Maximum concentration of 0.03mgl-1 was recorded in D2 (Behind proposed hotel) in the August. The mean concentration of nitrite in the Ja-Ela was 0.0043mgl^{-1} in July. The relatively low nitrite concentrations were recorded in the month of September. Table 4.29 and figure 4.29 are shown concentration of nitrite in Dandugam Oya.

Ammonial nitrogen

The mean NH_4-N concentration of studied period is given in table 4.30 and figure 4.30. Ammonia is also providing nitrogen requirement for the aquatic plants. The maximum means concentration of ammonia in the Negombo lagoon was 0.322mgl^{-1} within the study period.

The highest concentration was recorded at the Town Canal Opening in the month of July ($0.594mgl^{-1}$). The minimum mean concentration of ammonia in Negombo lagoon was recorded at NG3 (Blue Lagoon Hotel) during the studied period ($0.072mgl^{-1}$).

When In Dandugam Oya, the mean ammonia concentration in July was $0.34mgl^{-1}$. The highest mean concentration of ammonia $0.78mgl^{-1}$ was obtained in month of August. Maximum concentration of ammonia was observed in September and it was $1.51mgl^{-1}$. In July, maximum recorded concentration was $1.11mgl^{-1}$. Concentration of ammonia in Dandugam Oya is given in table 4.31 and figure 4.31.

The maximum concentration of ammonia in Ja-Ela was $2.26mgl^{-1}$ in month of September. The highest mean ammonia concentration was recorded in the month of August. There was no significant variation of ammonia in each location during the above period. Table 4.32 and figure 4.32 indicate concentration of ammonia in Ja-Ela.

Chlorophyll -a

The mean value of chlorophyll -a concentration during the studied period is given table 4.33. Chlorophyll -a is essential to photosynthesis and is present in all plants. Several type of chlorophyll occurs in plants of which the most common variety is chlorophyll -a, which is considerable to be the main center of photosynthetic reactions. However, most of the chlorophyll content of water is present as chlorophyll -a, and an approximate estimation of chlorophyll content may be obtained from the absorbance at 665 nm.

The maximum concentration of chlorophyll -a in Negombo lagoon (Town canal opening) was $0.0023\mu gl^{-1}$ in the month of July. For month of August, maximum concentration of chlorophyll-a was $0.095\ \mu gl^{-1}$ .The turbidity and current velocity of water affect the density of phytoplankton diversity. Also, nutrient input into the water body is affected to the increase of biomass. Therefore, concentration of chlorophyll -a in entire lagoon was lower than Dandugam Oya and Ja-Ela. The lowest concentration was recorded in month of August ($0.000012\mu gl^{-1}$) in mouth of Dandugam Oya. Chlorophyll -a did not show any significant change.

The maximum concentration of chlorophyll 'a' was presented by D8 (effluent releasing point) during the month of July ($1.66\mu gl^{-1}$). It was due to effluent discharge to the point. The highest mean concentration of chlorophyll 'a' was recorded in D8 (Effluent releasing point) and it was 0.576μgl^{-1}. The lowest concentration of chlorophyll 'a' was recorded in month of September due to the heavy rain. Concentration of Chlorophyll in Dandugam Oya is shown in table 4.34.

When considering Ja-Ela, the concentration of chlorophyll 'a' was maximum in J4 (Nugape bridge) in the month of August (0.2665μgl^{-1}). In September, it was 0.1054μgl^{-1}. The lowest concentration was recorded in J1 (Ja-Ela, Dandugam Oya Junction) during the month of September (0.0038μgl^{-1}). It indicates the low nutrient content in the point indicating a lower pollution level. The highest mean concentration of chlorophyll was recorded in J4 (Nugape Bridge), it was 0.13μgl^{-1} during the studied period. Table 4.35 is shown concentration of chlorophyll-a in Ja-Ela.

Table 4. 1 Temperature in Negombo lagoon

SITE	NG1	NG2	NG3	NG4	NG5	NG6
JULY	28.5	28.3	28.5	30	29.1	29
AUG	27.9	27.8	27.5	28.5	28.8	27.7
MEAN	28.2	28.05	28	29.25	28.95	28.35
STDEV	123.390133	123.53155	123.390133	122.3295	122.96587	123.0366

Table 4.2 Temperature in Dandugam Oya

SITE	D1	D2	D3	D4	D5	D6	D7	D8	D9
JULY	30.4	30	30.4	27.9	26.4	29.9	29.3	29.9	29.9
AUG.	29	29.1	29.1	29	29.8	29.3	-	-	
SEP.	26.4	26.4	26.3	29.4	29.4	29.5		29.2	21
MEAN	28.6	28.5	28.6	28.76667	28.533333	29.56667	29.3	29.55	25.45
STDEV	1.657307053	1.52970585	1.710750323	0.6342099	1.51730756	0.2494438	0	0.35	4.45

Table 4.3 Temperature in Ja-Ela

JULY	30.6	30.5	30.7	30.6	30.1
AUG	28.9	29.2	29.3	29.1	28.8
SEP	26.4	26.5	26.4	26.3	29.4
MEAN	28.5	28.5	28.55	28.45	29.75
STDEV	2.96984848	2.8284271	3.04055916	3.040559	0.4949747

Table 4.4 Electrical conductivity in Negombo lagoon

SITE	NG1	NG2	NG3	NG4	NG5	NG6
JULY	40.8	18.2	38.6	22.3	9.52	24
AUG	40.4	15.48	39.6	7.37	9.93	3.14
MEAN	40.6	16.84	39.1	14.835	9.725	13.57
STDEV	0.28284271	1.9233304	0.70710678	10.5571	0.2899138	14.75025

Table 4.5 Electrical conductivity in Dandugam Oya

SITE	D1	D2	D3	D4	D5	D6	D7	D8	D9
JULY	3.37	2.4	1.6	1.508	1.546	1.402	1.603	1.546	1.919
AUG.	0.285	0.254	0.229	0.1579	0.1572	0.1438	-	-	-
SEP.	0.0752	0.0757	0.0718	0.0943	0.0928	0.0942	-	0.0756	0.0818
MEAN	1.2434	1.23785	0.8359	0.80115	0.8194	0.7481	1.603	0.8108	1.0004
STDEV	2.329775423	1.64352829	1.080600583	0.9996369	1.02756757	0.9247542	#DIV/0!	1.03973	1.299097

Table 4.6 Electrical conductivity in Ja-Ela

SITE	J1	J2	J3	J4	J5
JULY	3.84	2.23	1.721	0.766	0.1126
AUG	0.475	0.27	0.21	0.1355	0.931
MEAN	2.1575	1.25	0.9655	0.45075	0.5218
STDEV	2.37941432	1.3859293	1.06843835	0.445831	0.5786962

Table 4.7 Turbidity in Dandugam Oya

SITE	D1	D2	D3	D4	D5	D6	D7	D8	D9
JULY	-	-	-	-	-	-	-	-	-
AUG.	14.5	14.1	15.4	18.9	20.5	20	-	-	-
SEP.	13.6	13.4	14.1	12.3	12.5	14	-	15	15.2
MEAN	14.05	13.75	14.75	15.6	16.5	17	-		15.2
STDEV	0.636396103	0.49497475	0.919238816	4.6669048	5.65685425	4.2426407	#DIV/0!	#DIV/0!	#DIV/0!

Table 4.8 Turbidity in Ja-Ela

SITE	J1	J2	J3	J4	J5
JULY	-	-	-	-	-
AUG	11.9	13.1	14.7	14.7	23.4
SEP	-	-	-	-	-
MEAN	11.9	13.1	14.7	14.7	23.4
STDEV	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Table 4.9 Concentration of dissolved oxygen in Negombo lagoon

SITE	NG1	NG2	NG3	NG4	NG5	NG6
JULY	4.79	2.92	4.07	3.64	4.44	5.6
AUG	7.72	0.8	4.12	1.6	2.86	5.12
MEAN	6.255	1.86	4.095	2.62	3.65	5.36
STDEV	2.07182287	1.4990664	0.03535534	1.442498	1.1172287	0.339411

Table 4.10 Concentration of dissolved oxygen in Dandugam Oya

SITE	D1	D2	D3	D4	D5	D6	D7	D8	D9
JULY	2.95	3.02	1.79	3.2	2.48	2.21	2.04	2.65	3.08
AUG.	1.86	1.21	1.52	4.32	4.05	3.4			
SEP	2.92	2.13	3.04	1.98	1.85	1.93	-	1.91	1.92
MEAN	2.935	2.575	2.415	2.59	2.165	2.07	2.04	2.28	2.5
STDEV	0.0212132	0.629325	0.88388348	0.86267	0.4454773	0.19799	#DIV/0!	0.52326	0.82024

Table 4.11 Concentration of dissolved oxygen in Ja-Ela

SITE	J1	J2	J3	J4	J5
JULY	3.71	3.47	3.66	4.2	2.71
AUG	2.9	3.07	3.76	3.61	3.71
SEP	2.92	3.16	2.96	3.51	3.66
MEAN	3.315	3.315	3.31	3.855	3.185
STDEV	0.55861436	0.2192031	0.49497475	0.487904	0.6717514

Table 4.12 Salinity in Negombo lagoon

SITE	NG1	NG2	NG3	NG4	NG5	NG6
JULY	26.2	10.1	24.6	13.5	5.3	14.6
AUG	25.9	9	25.5	4.1	5.6	19.6
MEAN	26.05	9.55	25.05	8.8	5.45	17.1
STDEV	0.21213203	0.7778175	0.6363961	6.646804	0.212132	3.535534

Table 4.13 Salinity in Dandugam Oya

SITE	D1	D2	D3	D4	D5	D6	D7	D8	D9
JULY	1.7	1.02	0.8	0.8	0.8	0.7	0.8	0.8	1
AUG	0.1	0.1	0.1	0.1	0.1	0.1			
SEP	0	0	0	0	0	0	0	0	0
MEAN	0.85	0.51	0.4	0.4	0.4	0.35	0.4	0.4	0.5
STD	1.20208153	0.7212489	0.56568542	0.565685	0.5656854	0.494975	0.56569	0.56569	0.70711

Table 4.14 Salinity in Ja-Ela

SITE	J1	J2	J3	J4	J5
JULY	2	1	0.9	0.4	0.1
AUG	0.2	0.1	0.1	0.1	0
SEP	0	0	0	0	0
MEAN	1	0.5	0.45	0.2	0.05
STDEV	1.41421356	0.7071068	0.6363961	0.282843	0.0707107

Table 4.15 pH in Negombo lagoon

SITE	NG1	NG2	NG3	NG4	NG5	NG6
JULY	8.1	7.56	7.45	7.33	8.08	7.72
AUG	8.02	7.18	7.7	7.7	6.75	7.65
MEAN	8.06	7.37	7.575	7.515	7.415	7.685
STDEV	0.05656854	0.2687006	0.1767767	0.26163	0.940452	0.049497

Table 4.16 pH in Dandugam Oya

SITE	D1	D2	D3	D4	D5	D6	D7		
JULY	6.69	6.66	6.53	6.51	6.61	6.62	6.83	6.6	6.55
AUG	5.96	5.97	6.11	6.36	6.94	5.93			
SEP.	-	-	-	-	-	-	-	-	-
MEAN	6.325	6.315	6.32	6.435	6.775	6.275	6.83	6.6	6.55
STDEV	0.51618795	0.4879037	0.29698485	0.106066	0.2333452	0.487904	#DIV/0!	#DIV/0!	#DIV/0!

Table 4.17 pH in Ja-Ela

SITE	J1	J2	J3	J4	J5
JULY	6.78	6.78	6.72	6.9	6.46
AUG	6.06	6.6	6.04	6.06	5.99
MEAN	6.42	6.69	6.38	6.48	6.225
STDEV	0.50911688	0.1272792	0.48083261	0.59397	0.3323402

Table 4.18 Total dissolved solids in Negombo lagoon

SITE	NG1	NG2	NG3	NG4	NG5	NG6
JULY	0	9760	0	12600	5220	13500
AUG	0	8730	0	3960	5460	17700
MEAN	0	9245	0	8280	5340	15600
STDEV	0	728.31998	0	6109.403	169.70563	2969.848

Table 4.19 Total dissolved solids in Dandugam Oya

SITE	D1	D2	D3	D4	D5	D6	D7	D8	D9
JULY	1700	1210	778	734	754	679	779	754	942
AUG.	135	120	108	74	74	68			
SEP.	35	35	34	44	44	44		36	38
MEAN	867.5	622.5	406	389	399	361.5	779	395	490
STDEV	1177.33279	830.85047	526.087445	487.9037	502.04581	449.0128	#DIV/0!	507.703	639.225

Table 4. 20 Total dissolved solids in Ja-Ela

SITE	J1	J2	J3	J4	J5
JULY	1950	1000	841	365	53
AUG	226	128	99	75	43
SEP	40	33	32	29	25
MEAN	995	516.5	436.5	197	39
STDEV	1350.57395	683.77226	572.049386	237.5879	19.79899

Table 4.21 Concentration of nitrate in Negombo lagoon

SIT E	NG1	NG2	NG3	NG4	NG 5	NG 6
JULY	0.1336	0.1726	0.0266	0.1116	0.5173	0.1387
AUG	0.0195	0.0195	0.0177	0.0065	0.0082	0.0108
MEAN	0.07655	0.09605	0.02215	0.05905	0.26275	0.07475
STDEV	0.08068088	0.108258	0.00629325	0.074317	0.3599881	0.090439

Table 4.22 Concentration of nitrate in Dandugam Oya

SITE	D1	D2	D3	D4	D5	D6	D7	D8	D9
JULY	0.9699	1.1099	1.068	1.5641	1.577	1.4346	0.1338	0.2825	0.1052
AUG.	0.3128	1.088	0.0493	0.8875	1.0267	0.5253			
SEP.	0.0664	0.0865	0.083	0.0732	0.0543	0.0632		0.0673	0.0677
MEAN	0.4497	0.7614667	0.4494	0.8416	0.886	0.674367	0.1338	0.1749	0.08645
STDEV	0.63887098	0.7236531	0.69650018	1.054226	1.0767115	0.969726	#DIV/0!	0.15217	0.02652

Table 4.23 Concentration of nitrate in Ja-Ela

SITE	J1	J2	J3	J4	J5
JULY	0.083	0.0566	0.4862	0.0531	0.0468
AUG	0.0603	0.0065	0.0195	0.0002	0.0065
SEP	0.0635	0.1471	0.1608	0.1481	0.2034
MEAN	0.07325	0.10185	0.3235	0.1006	0.1251
STDEV	0.01378858	0.0639932	0.23009255	0.067175	0.1107329

Table 4.24 Concentration of total soluble phosphate in Negombo lagoon

SITE	NG1	NG2	NG3	NG4	NG5	NG6
JULY	0.016	0.1463	0.0134	0.0143	0.0099	0.0125
AUG	0.0195	0.0195	0.0177	0.0065	0.0082	0.0108
MEAN	0.01775	0.0829	0.01555	0.0104	0.00905	0.01165
STDEV	0.00175	0.0634	0.00215	0.0039	0.00085	0.00085

Table 4.25 Concentration of total soluble phosphate in Dandugam Oya

SITE	D1	D2	D3	D4	D5	D6	D7	D8	D9
JULY	0.0002	0.0091	0.016	0.0152	0.0125	0.0099	0.0838	0.9157	0.0108
AUG	0.0256	0.0256	0.0256	0.0256	0.0282	0.0169	-	-	-
SEP	0.0368	0.0308	0.0377	0.325	0.0343	0.0282		0.0299	0.0325
MEAN	0.02086667	0.0218333	0.02643333	0.121933	0.025	0.018333	0.0838	0.4728	0.02165
STDEV	0.02588011	0.0153442	0.01534422	0.219062	0.0154149	0.01294	#DIV/0!	0.626355	0.015344

Table 4.26 Concentration of total soluble phosphate in Ja-Ela

SITE	J1	J2	J3	J4	J5
JULY	0.0169	0.0099	0.0099	0.089	0.0195
AUG	0.0603	0.0065	0.0195	0.0002	0.0065
SEP	0.0334	0.0429	0.0421	0.036	0.0343
MEAN	0.02515	0.0264	0.026	0.0625	0.0269
STDEV	0.01166726	0.0233345	0.02276884	0.037477	0.0104652

Table 4.27 Concentration of nitrite in Negombo Lagoon

SITE	NG1	NG2	NG3	NG4	NG5	NG6
JULY	0.0002	0.0126	0.0126	0.0007	0.0109	0.0022
AUG	0.0252	0.0269	0.0269	0.0179	0.0177	0.0208
MEAN	0.0127	0.01975	0.01975	0.0093	0.0143	0.0115
STDEV	0.01767767	0.0101116	0.01011163	0.012162	0.0048083	0.013152

Table 4.28 Concentration of nitrite in Dandugam Oya

SITE	D1	D2	D3	D4	D5	D6	D7	D8	D9
JULY	0.01	0.0129	0.0243	0.0189	0.0189	0.0206		0.0299	
AUG	0.0272	0.032	0.0277	0.028	0.0289	0.0201			
SEP	0.0127	0.0129	0.0133	0.0088	0.0095	0.0107		0.01	0.0075
MEAN	0.01663333	0.0192667	0.02176667	0.018567	0.0191	0.017133	#DIV/0!	0.01995	0.0075
STDEV	0.00190919	0	0.00777817	0.007142	0.0066468	0.007	#DIV/0!	0.01407	#DIV/0!

Table 4.29 Concentration of nitrite in Ja-Ela

SITE	J1	J2	J3	J4	J5
JULY	0.0031	0.0031	0.0053	0.0037	0.0063
AUG	0.0187	0.0161	0.0255	0.0398	0.0167
SEP	0.0107	0.0088	0.0087	0.0131	0.0109
MEAN	0.0069	0.00595	0.007	0.0084	0.0086
STDEV	0.00537401	0.0040305	0.00240416	0.006647	0.0032527

Table 4.30 Concentration of ammonia in Negombo lagoon

SITE	NG1	NG2	NG3	NG4	NG5	NG6
JULY	0.1458	0.5942	0.0458	0.0891	0.0298	0.0569
AUG	0.0707	0.0502	0.0986	0.1093	0.1346	0.21
MEAN	0.10825	0.3222	0.0722	0.0992	0.0822	0.13345
STDEV	0.05310372	0.272	0.0264	0.0101	0.0524	0.07655

Table 4.31 Concentration of ammonia in Dandugam Oya

	D1	D2	D3	D4	D5	D6	D7	D8	D9
JULY	0.1621	0.1702	0.1774	0.2097	0.3655	0.6904	0.0938	1.1127	0.1552
AUG	0.1707	0.135	0.1908	0.2109	0.1689	0.1762			
SEP	0.9994	1.5058	0.1758	0.1835	0.2114	0.1973		0.1775	0.1771
MEAN	0.44406667	0.6036667	0.18133333	0.201367	0.2486	0.354633	0.0938	0.6451	0.16615
STDEV	0.59206051	0.9444118	0.00113137	0.018526	0.1089652	0.348674	#DIV/0!	0.66129	0.01549

Table 4.32 Concentration of ammonia in Ja-Ela

SITE	J1	J2	J3	J4	J5
JULY	0.108	0.0857	0.0694	0.1067	0.1406
AUG	0.3337	0.1409	0.205	0.2132	0.1035
SEP	0.229	0.1634	0.1458	0.1398	2.2568
MEAN	0.1685	0.12455	0.1076	0.12325	1.1987
STDEV	0.08555992	0.0549422	0.05402296	0.023405	1.4963794

Table 4.33 Concentration of chlorophyll-a in Negombo lagoon

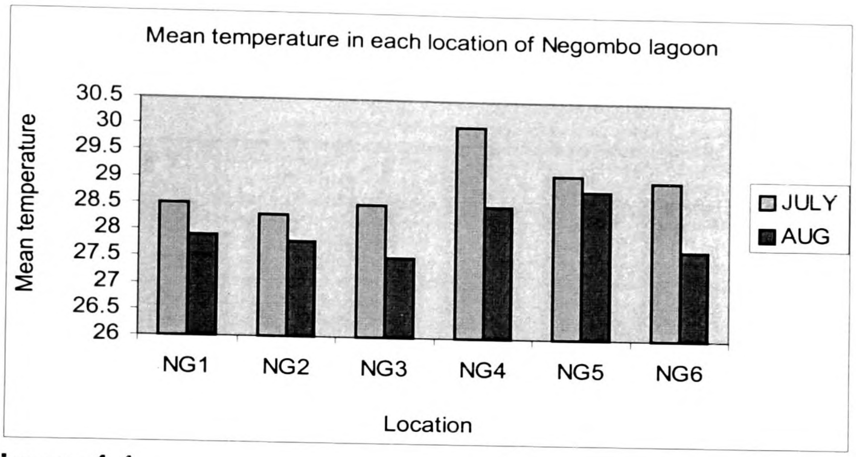
SITE	NG1	NG2	NG3	NG4	NG5	NG6
JULY	0.000449	0.002262	ND	ND	ND	ND
AUG	ND	0.013401	0.095851	0.01185	0.023703	0.035553
SEP						
MEAN	0.000449	0.0078315	0.095851	0.01185	0.023703	0.035553
STDEV	#DIV/0!	0.0078765	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Table 4.34 Concentration of chlorophyll-a in Dandugam Oya

SITE	D1	D2	D3	D4	D5	D6	D7	D8	D9
JULY	0	0.001188	0.001978	0.004365	0.005896	0.000736	0.05485	0.00323	0.00079
AUG	0.001543	0.0045863	0.121099	0.001545	0.003085	0	0	0	0
SEP	ND	ND	0	0.03462	0.046163	ND	0	ND	0.1154
MEAN	0	0.0028872	0.04102567	0.01351	0.0183813	0.000368	0.01828	0.00162	0.03873
STDEV	0	0.002403	0.06935259	0.018336	0.0241006	0.00052	0.03167	0.00228	0.0664

Table 4.35 Concentration of chlorophyll-a in Ja-Ela

SITE	J1	J2	J3	J4	J5
JULY	0.00079	0.000395	0.00054	-0.0034	-0.000155
AUG	0.014935	0.091717	0.013393	0.266435	0.037095
SEP	0.091545	ND	ND	ND	ND
MEAN	0.03575667	0.046056	0.0069665	0.131518	0.01847
STDEV	0.04882903	0.0645744	0.00908844	0.190802	0.0263397



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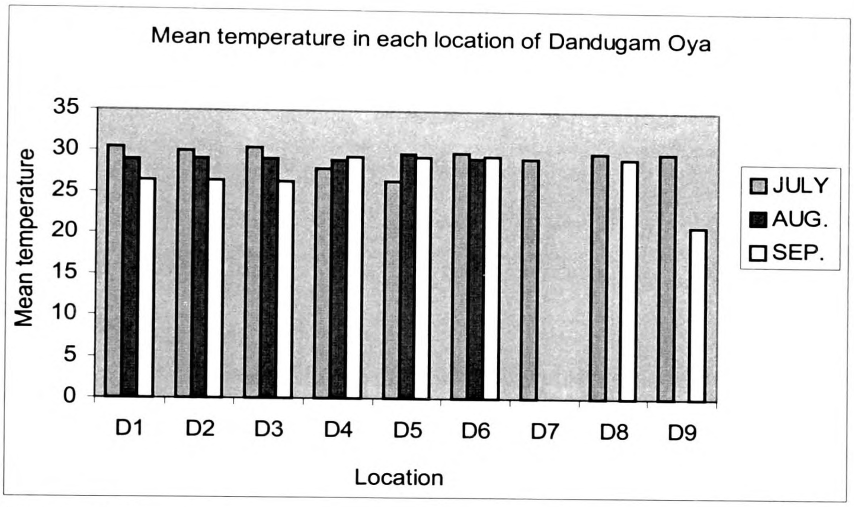

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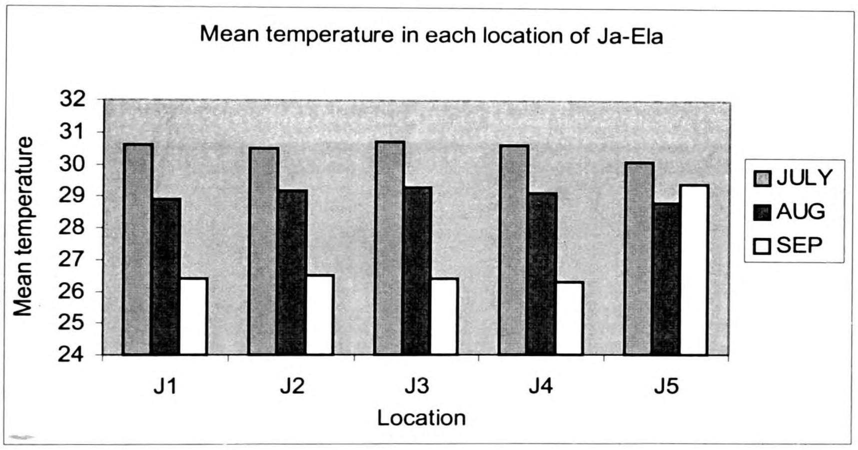

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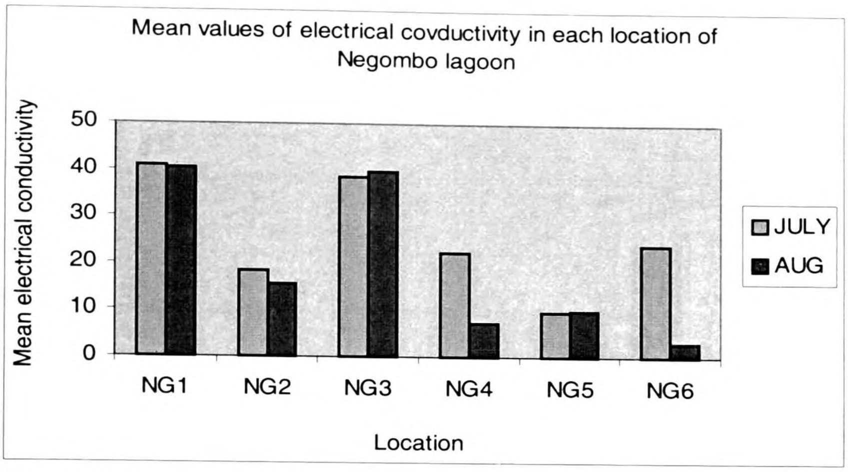

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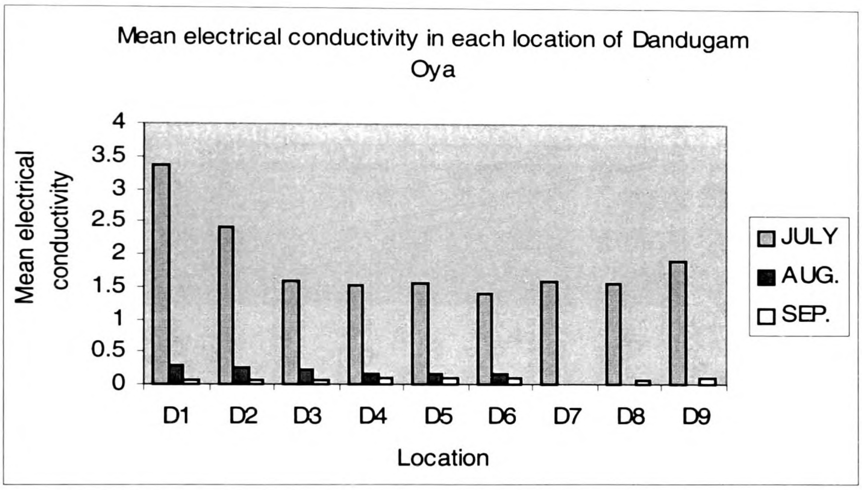

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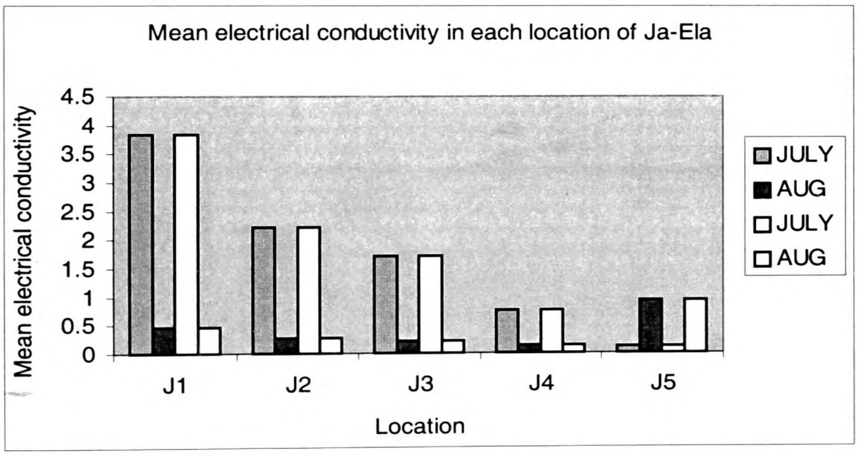

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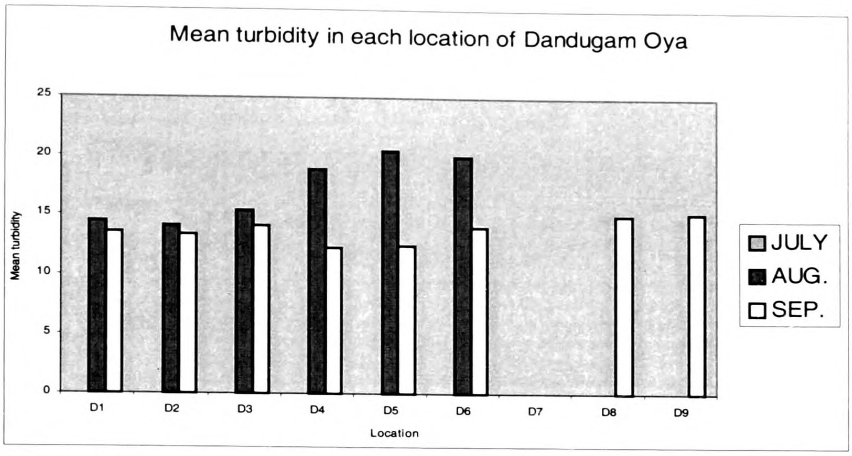

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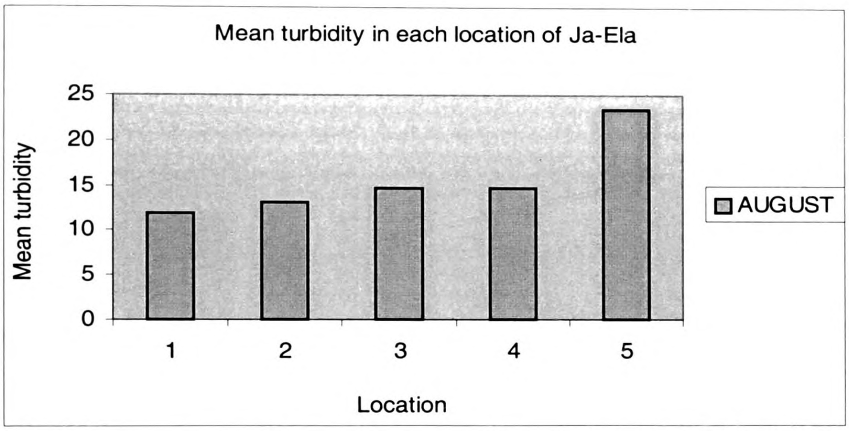

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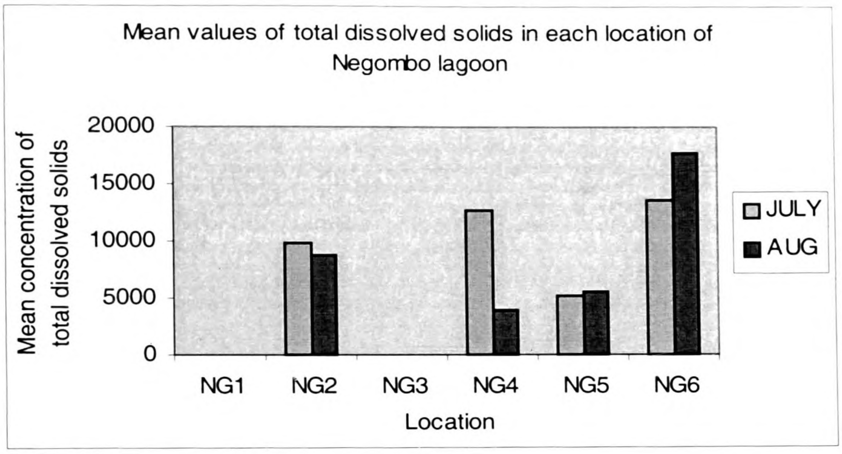

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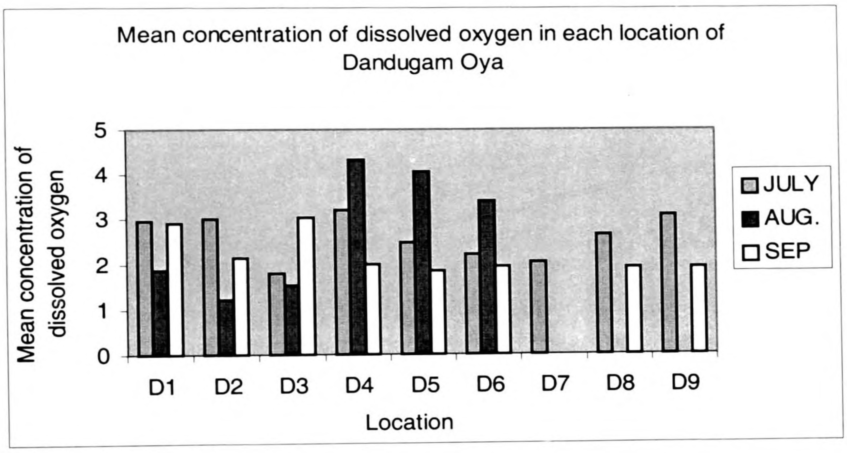

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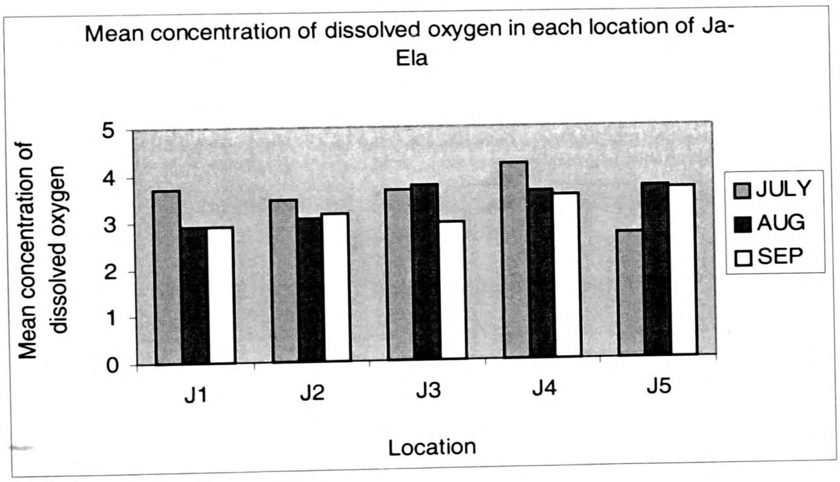

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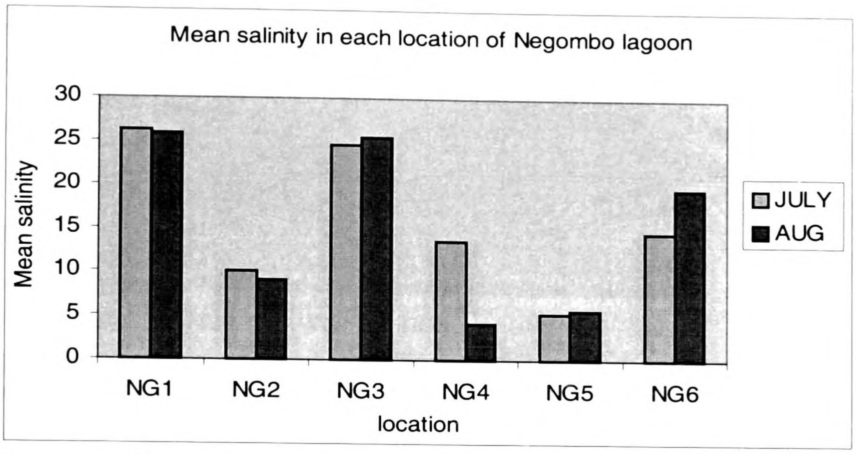

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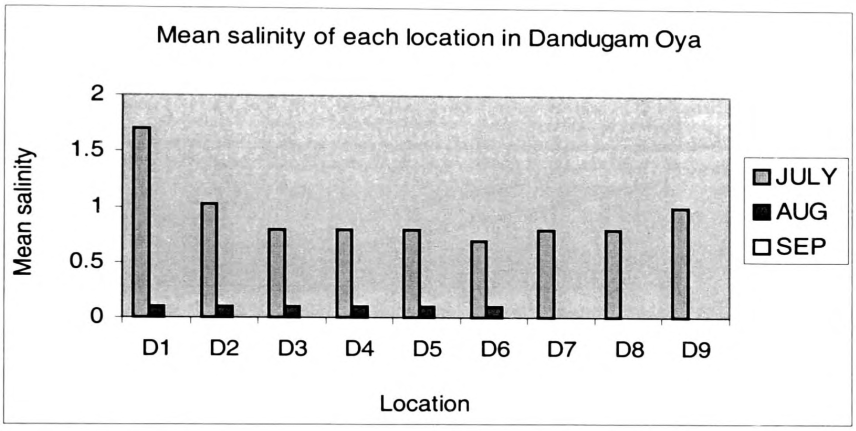

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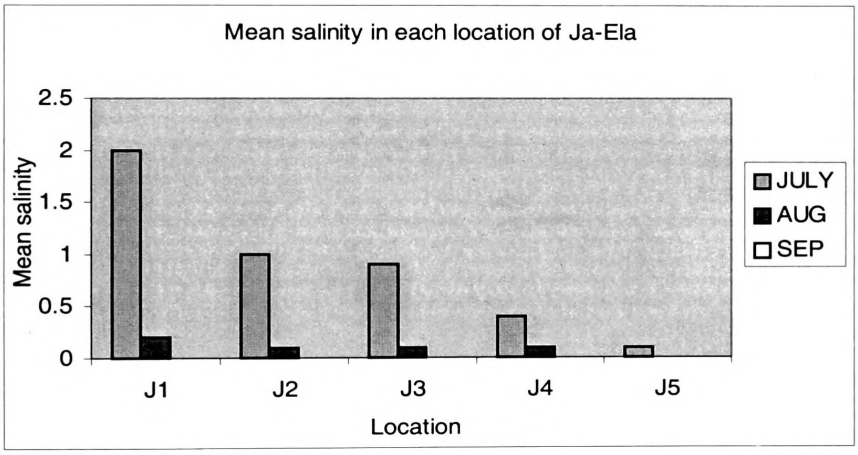

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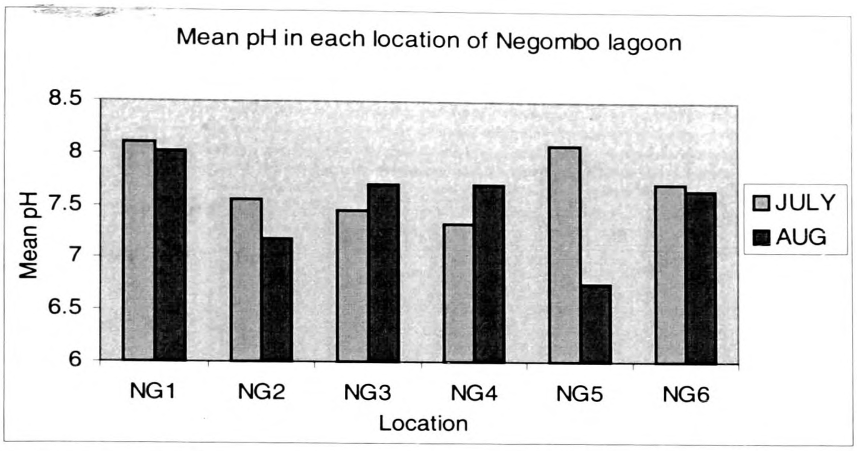

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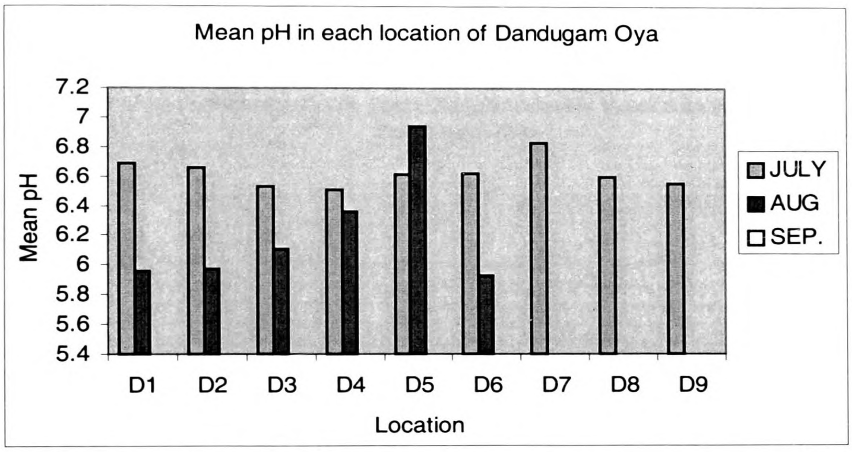

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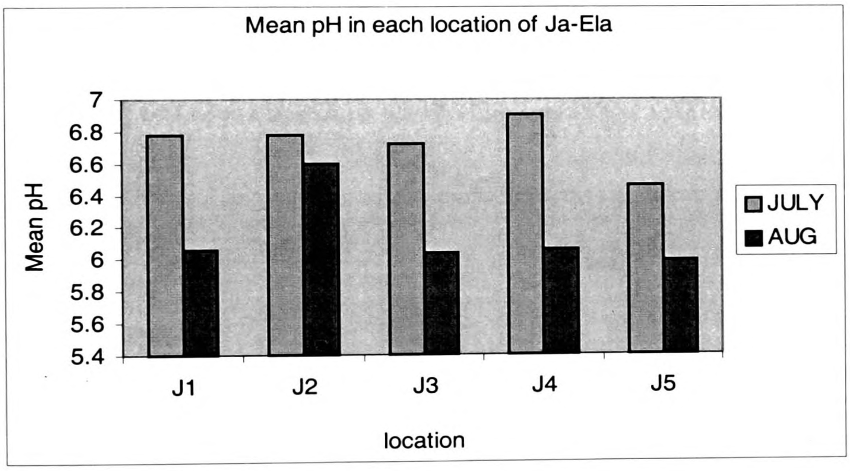

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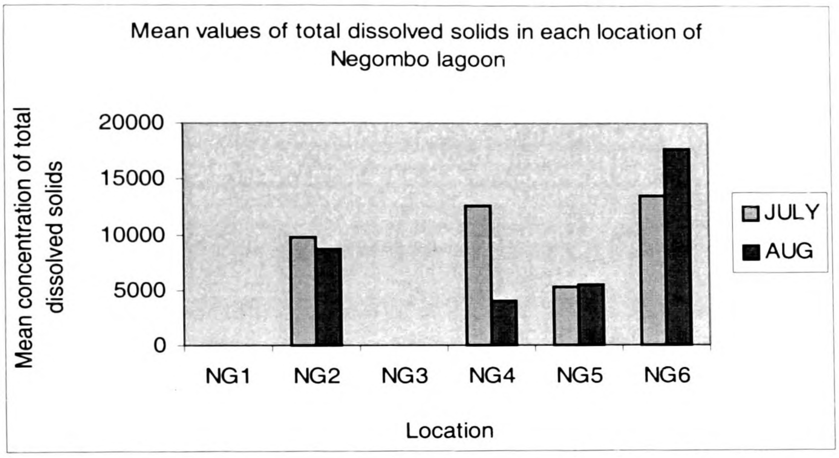

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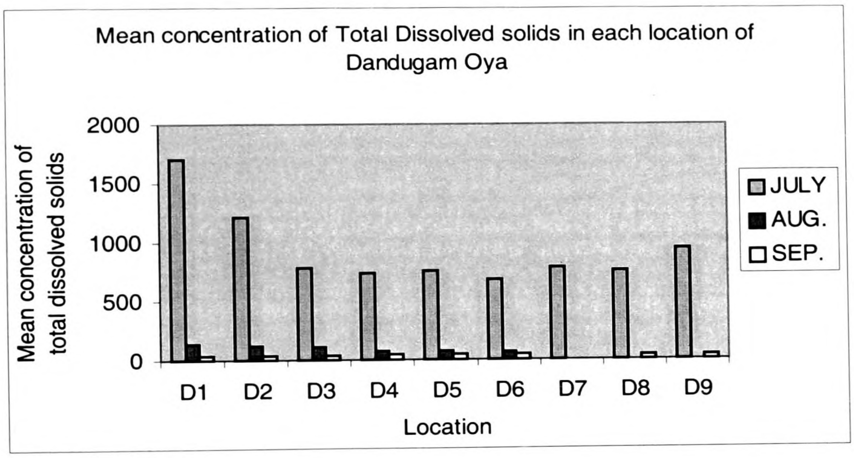

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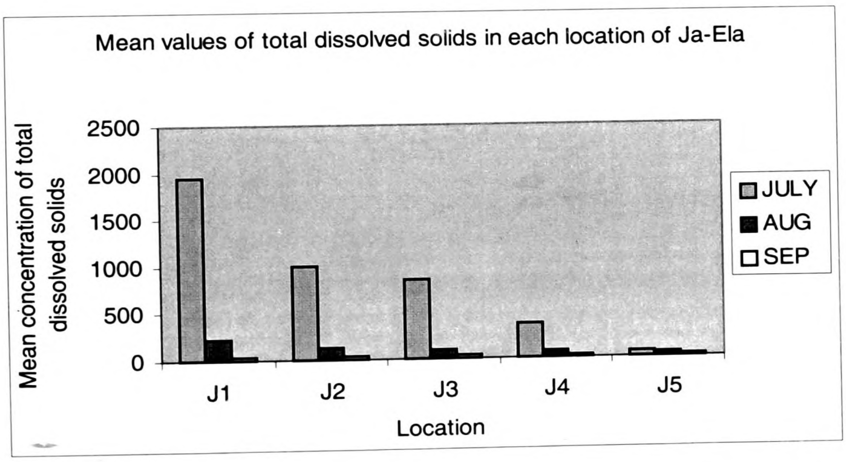

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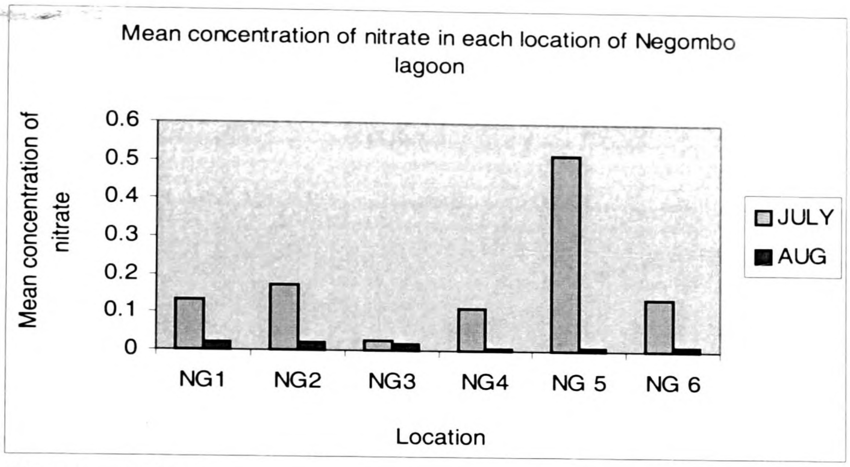

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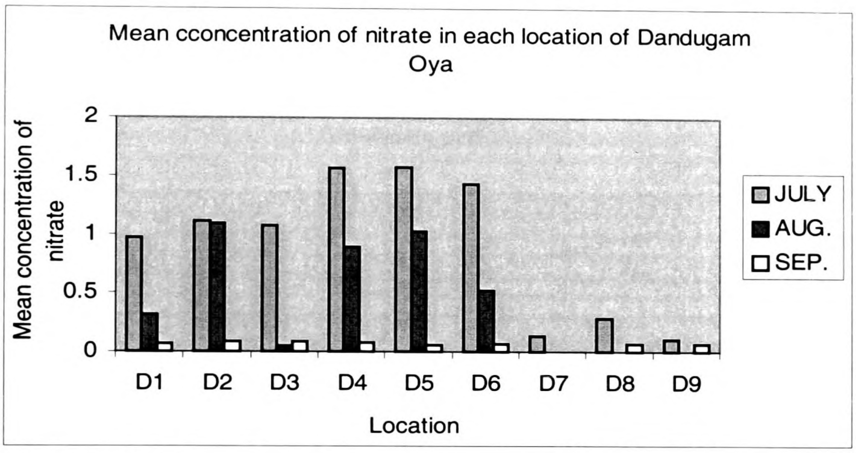

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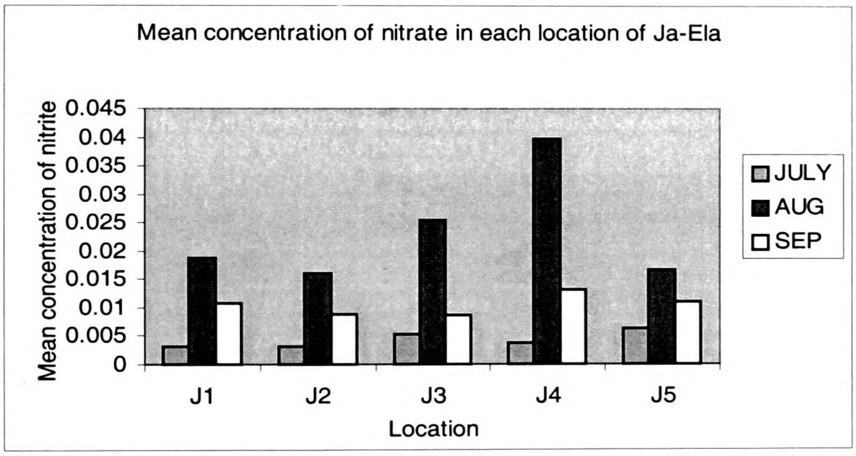

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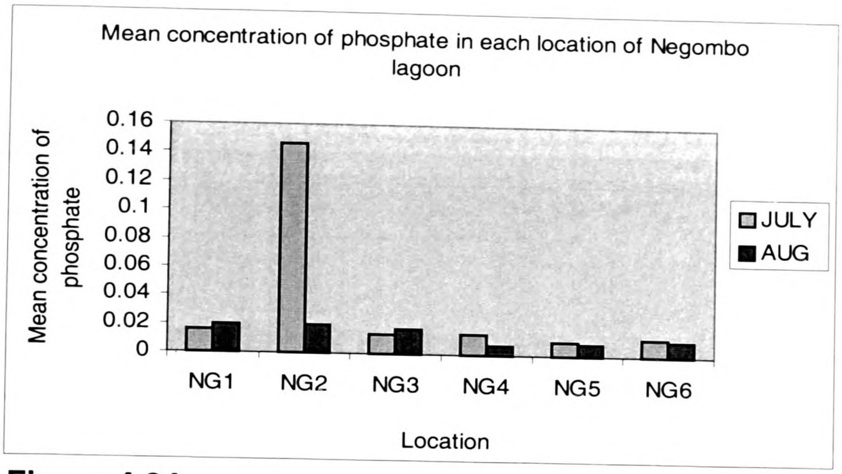

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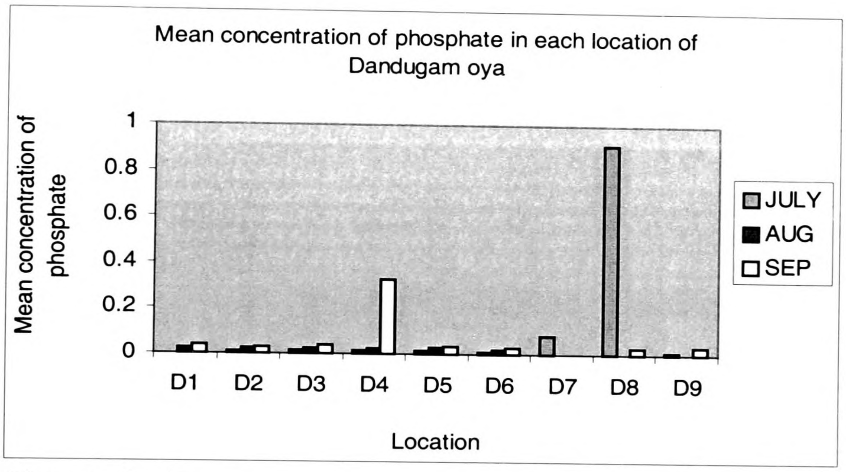

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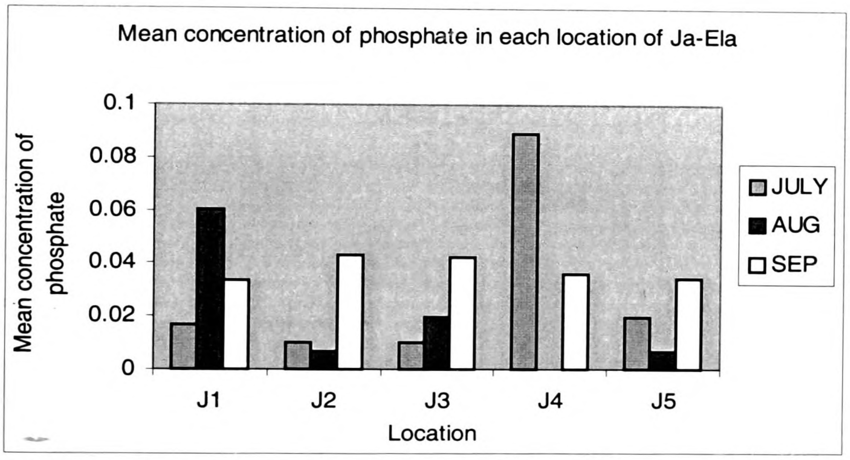

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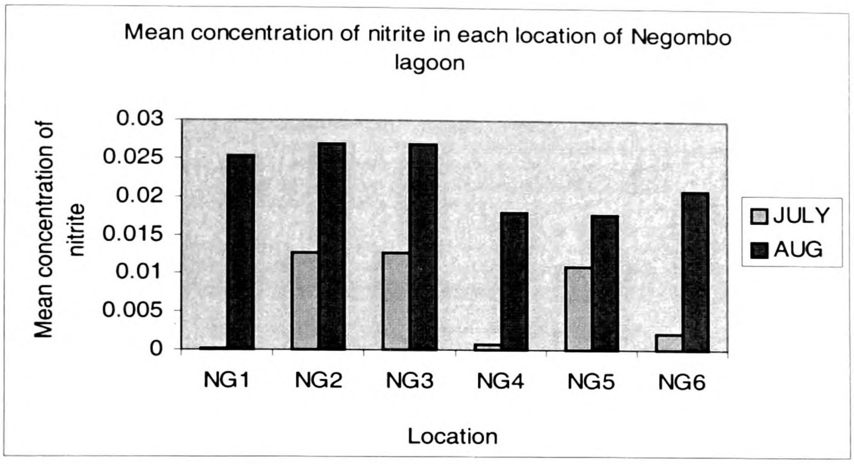

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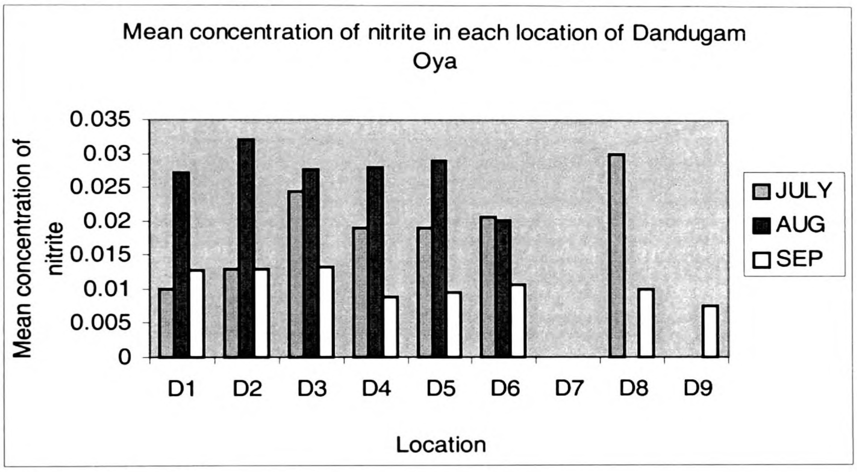

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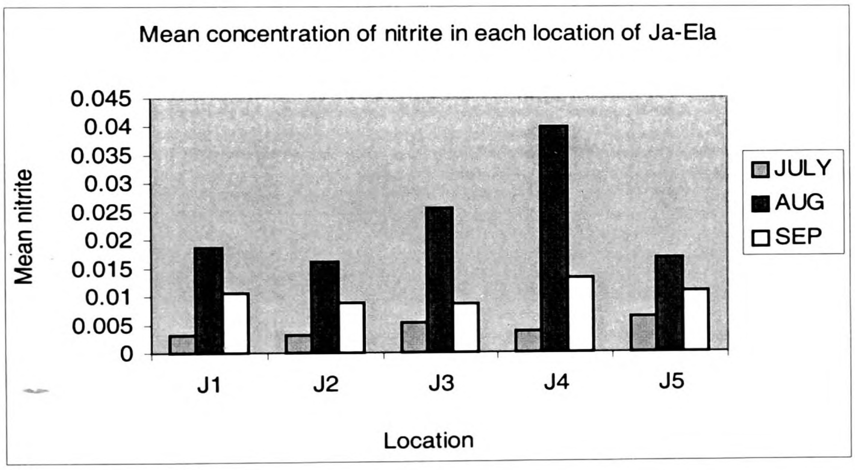

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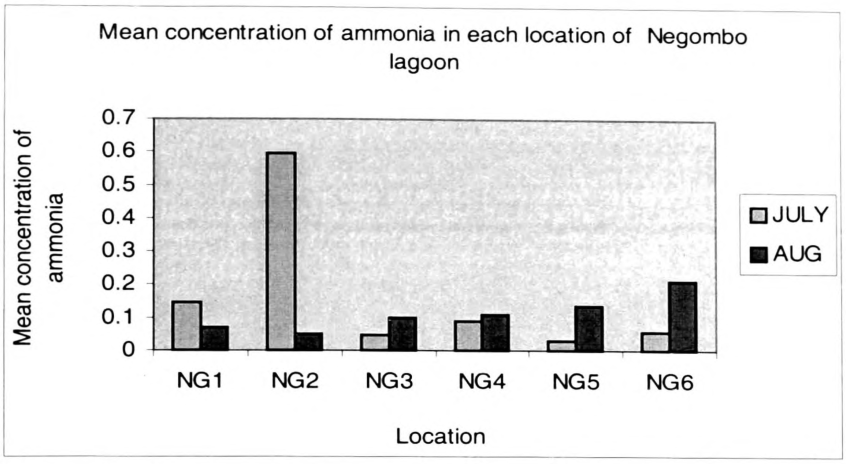

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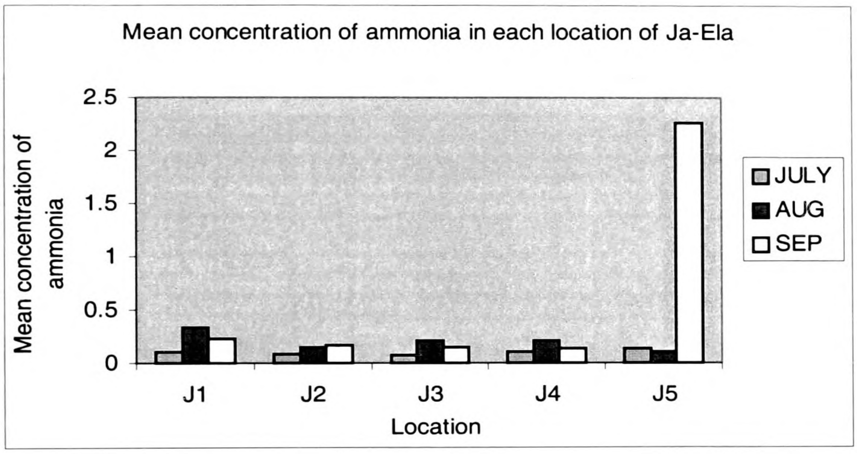

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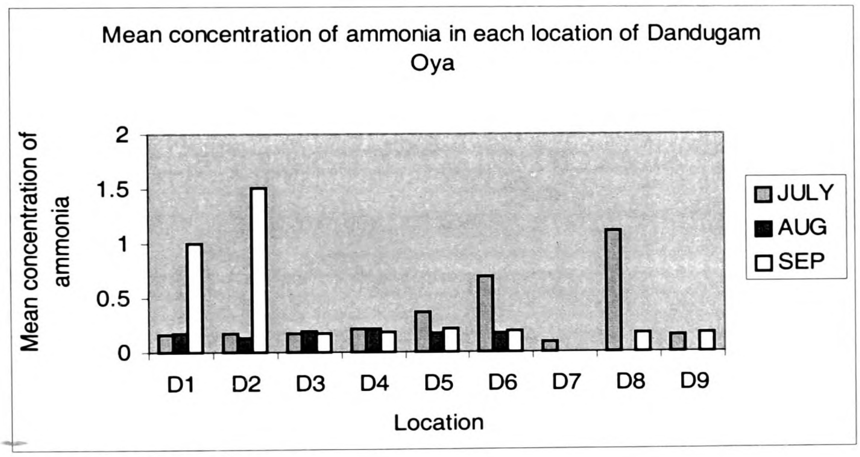

Figure 4.32

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

Negombo lagoon is one of the most important productive brackish water body in western province in Sri Lanka, and It is associated with mangrove ecosystem and sea grass beds. Negombo lagoon receives fresh water from Dandugam Oya and Ja-Ela.

Pollution problem in the Negombo lagoon has not yet reached like the magnitude like Lunawa lagoon. But at present, considerable pollution problems are recorded in the lagoon area. Waste water from two industrial zones (Katunayake and Ja-Ela) and agricultural runoff from the catchment can cause pollution problem in the lagoon. Relatively high pollution problems are found in the mouth area where the fish landing and urban activities concentrated.

The present study focuses on the profound changes in different physico-chemical parameters in the lagoon. The highest temperature and pH were recorded during the month of July. The acceptable pH range for the growth of marine organisms is 7.5 to 8.3, so it does not serious effect for culture practices in Negombo lagoon. Higher concentrations of nutrients were observed during the dry season. The highest chlorophyll 'a' was observed during the month of July.

There are heavy loads of wastes discharged from streams and canals to the lagoon. Due to the dumped of wastes directly in to the lagoon by rivers and streams causing damage to coastal marine ecosystem, and its' result affect on human health. Research on the effects of pollution other than from industrial sources is still scarce.

The treatment of industrial wastes and domestic wastes from rivers and streams need to be promoted throughout the country of the region. Also, monitoring programs need to develop for assessing sources, levels and effects of pollutants and programs need to implement on pollution abatement and control. Awareness programs need to be implement regarding pollution problems and mitigatory measures through people who live either side of the stream and rivers.

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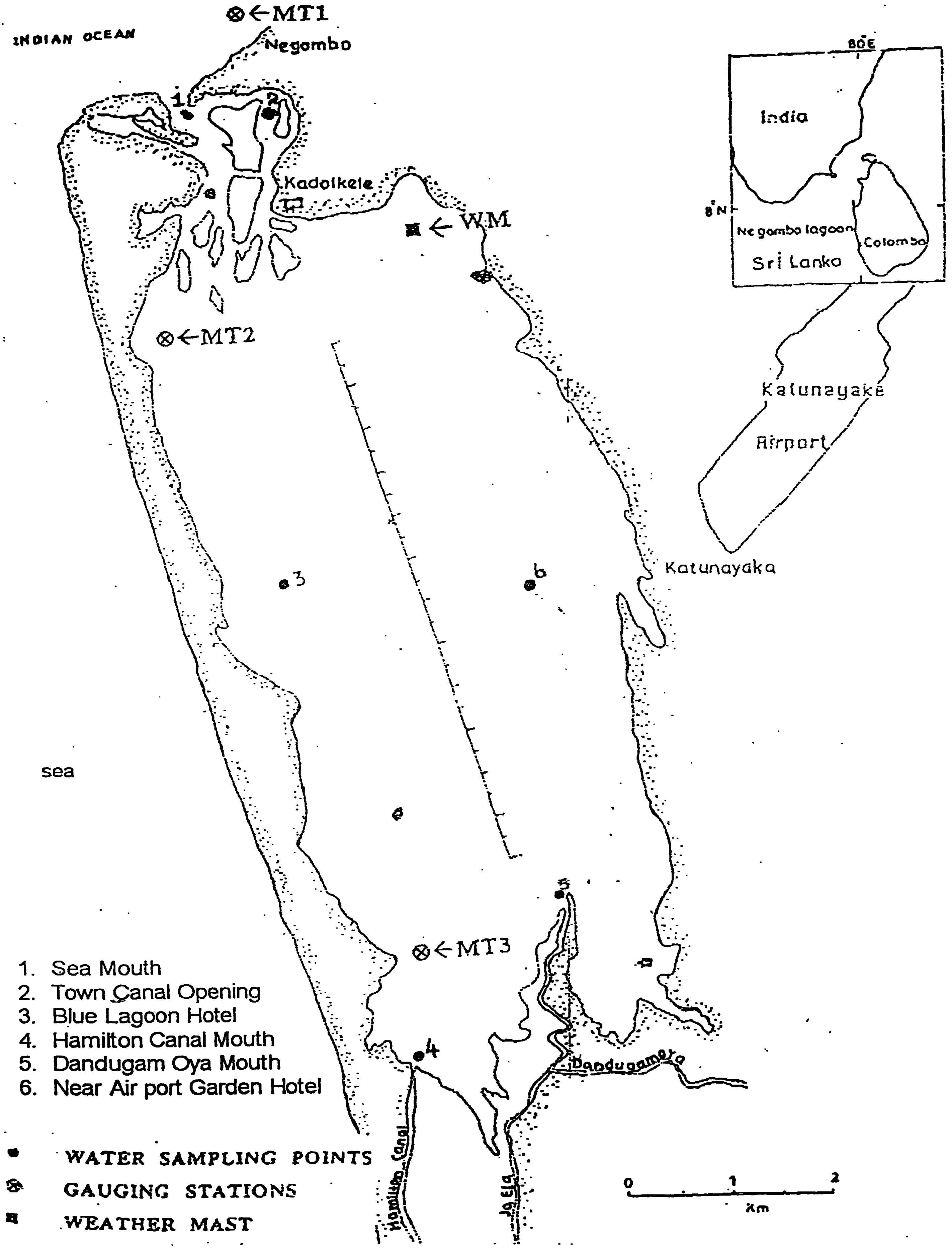
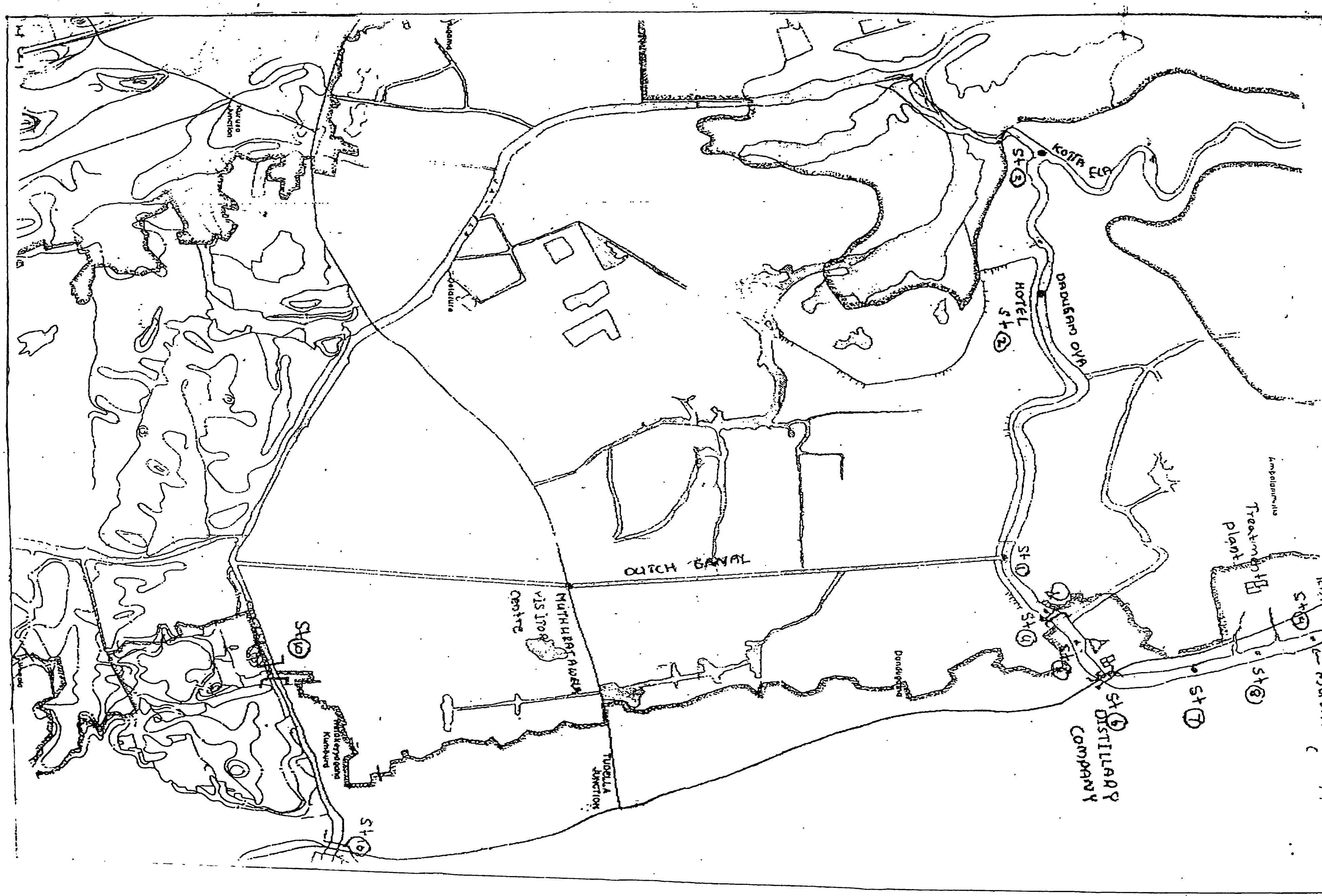
APPENDIX I MAP OF THE NEGOMBO LAGOON



APPENDIX II MAP OF THE DADUGAM OYA AND JA-ELA



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