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STUDY ON THE CHEMICAL AND BIOLOGICAL STATUS OF MALWATU OYA BASIN, ANURADHAPURA IN SRI LANKA.

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ABSTRACT: Water pollution is a serious problem to the entire world. It threatens the health and wellbeing of humans, plants, and animals. With the advancement of communications and trade due to industrialization, accidental and purposive waste dumping, and uncontrolled use of water sources have contributed to the problem of water pollution in both surface water and the ground water. This study was mainly concerned with the evaluation of water quality of Malwathu Oya and its four basin tanks in the dry zone of Sri Lanka namely Nuwara wewa, Tissa wewa, Nachchaduwa wewa and Mahakanadarawe wewa in the Anuradhapura district using some selected water quality parameters. Malwathu Oya has been using as a source of drinking water for Anuradhapura. Eutrophication through the process of nutrient enrichment of stagnant waters due to urbanization & chemical added agricultural practices has been considered as the significant cause for water pollution in these areas. They cause algal blooms and release of toxic substances from species like cyanobacteria. Low Secchi Depth value and high *chlorophyll a* concentration indicate eutrophic nature of the Nuwara wewa and Tissa wewa Lakes in dry periods. Malwathu oya too showed reasonably high Chlorophyll content during the same period. High nutrient loading was observed through the growth of phytoplankton species. *Cylindrospermopsis raciborskii* was the most dominant species recorded in the present study and *Microcystis aeruginosa*, *Microcystis incerta*, *Pediastrum duplex. Merismo pediatenuissima, Melosira granulate and Diatomaelongata* were also recorded from Nuwara wewa and Tissa wewa during the study period. With respect to physical and chemical parameters, very high turbidity, high nitrogen compounds (Ammoinia, Nitrate, Nitrite), high phosphate, total suspended solids, dissolved oxygen, chemical oxygen demand, biological oxygen demand were recorded in Nuwara wewa and Tissa wewa due to the influence of human activities such as recreational, dumping wastes and agricultural practices. However, data indicate that Nachchaduwa and Mahakandarawa lakes are well protected from above threats. At the same time Malwathu Oya stream also showed the same kind of pollution pattern causing more critical situations for water treatment and water quality aspects. Therefore, an effective Lake Management and Lake monitoring programmes with integrated catchment management have to be adopted and it is a prior necessity in planning of the management practices of the catchments to get first hand information through this kind of research on these lakes.

KEYWORDS: Malwathu Oya River Basin, Eutrophication, Urbanization, Phytoplankton, Coliforms, Water Quality

INTRODUCTION

Scarcity of unpolluted natural surface water resources, such as rivers and lakes has forced many parts of the dry zone in Sri Lanka to choose irrigation water tanks as the source for drinking water supply schemes. Malwathu Oya river forms the boundary between the sacred

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ancient city and the modern town of Anuradhapura. Malwathu Oya river basin consists of four irrigation tanks namely Nuwara wewa, Tissa wewa, Nachchaduwa wewa and Mahakanadarawe wewa . Both Nuwara wewa and Tissa wewa are already used as drinking water sources for public water supply. Nachchaduwa and Mahakanadarawe water supply projects are ongoing.

The major impacts on water resources as a result of agriculture, urbanization and industrialization are eutrophication and blooming in stagnant water bodies, nitrate pollution in ground water and spread of diseases due to organic pollutants (Silva, 1996). Due to surface run off through cultivated areas, the water becomes rich in nutrients causing rapid growth of algae. Algae are commonly occurring in any aquatic ecosystem. Thus, all sources of water will contain some algae but they tend to develop to larger populations particularly in stagnant and slow moving water bodies such as lakes, ponds, reservoirs and irrigation tanks. When the water bodies get polluted, its total algal population increases but diversity decreases and often blue-green algae become predominant (Piyasiri, 2000). Once a water body is eutrophicated, it will lose its primary functions and subsequently influence sustainable development of economy and society. Therefore, the solution for water eutrophication and recovery of the multiple functions of the water systems has become the key issues for environmental biologists.

Water eutrophication causes the degradation of healthy aquatic ecosystems. Therefore, the assessment methods and parameters should reflect the extent of aquatic ecosystem health. A set of ecological indicators including structural, functional and system-level aspects were proposed for lake ecosystem health assessment based on chemical stresses including acidification, eutrophication, and copper, oil and pesticide contamination(Gharib and Dorgham, 2006). The structural indicators include phytoplankton cell size and biomass, zooplankton body size and biomass, species diversity, macro- and micro-zooplankton biomass, the zooplankton/phytoplankton ratio, and the macro zooplankton/ micro zooplankton ratio.

Eutrophication, an excessive fertilization, which is manifested by excessive growth of planktonic(suspended) and attached algae, and aquatic macrophytes (water weeds) can have significant deleterious effects on the beneficial uses of lakes, impoundments, estuarine and marine waters(Piyasiri, 2000).

Chlorophyll is the green pigment in plants. This molecule is vital in the absorption of light for photosynthesis. Chlorophyll a is a specific form of chlorophyll used in oxygenic photosynthesis. It absorbs most energy from wavelengths of violet-blue and orange-red light. This photosynthetic pigment was essential for photosynthesis in eukaryotes, cyanobacteria and prochlorophytes. Used chlorophyll (algae biomass) can be taken as a measurement of the health of lakes and reservoirs. Chlorophyll is also an important link between the nutrient levels in water and the plant growth (Felip & Catalan, 1999).

In Anuradhapura area, most of the people use ground water from bore holes or dug wells. Total hardness, Fluoride and Alkalinity concentrations of surface water were very low compared to the ground water. However, surface water has higher colour and turbidity values than ground water. Average colour and turbidity levels were increased by 200 pt/Co units and 50 NTU respectively during the month of August. High algal population, high Biological Oxygen Demand(BOD), high Total Suspended Solid(TSS) and high Total Organic Carbon(TOC) values give trouble in treating surface water for consumption. In conventional

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treatment process, pre chlorination was proposed to remove algae in surface water but it was reported that disinfectant by-products will form in final purified water.

Presently, Malwathu Oya is an alternative source for the domestic water supply for Anuradhapura town. Nuwara wewa and Tissa wewa also used as a drinking water source for public in Anuradhapura and Sacred city areas. Mahakanadarawe and Nachchaduwa lakes are being studied through ongoing projects for the same purpose. This study was mainly aiming at comparing selected water quality parameters of surface water from Malwathu Oya and its four basin tanks to understand the suitability of lake water as potable water.

MATERIALS AND METHODS

In order to evaluate the extent of water quality used for drinking purposes in Malwathu Oya basin, sampling was done from the three stream sites which are used commonly by pilgrims and very close to the sewage lines passing through the urban areas of Anuradhapura and sacred city. Samples were collected from seven locations of Malwathu Oya river and its four tanks from December 2010 to August 2011 (nine months), once a month during the day time. Samples were analysed for Physical parameters (Colour, Turbidity, Temperature), Chemical parameters(pH, Alkalinity, NO_3^- and PO_4^{-3}content), Total Coliforms, Total algae population, Chlorophyll a Content, Biological Oxygen Demand(BOD) and Chemical Oxygen Demand(COD).

Table 01 - Sampling locations and measured parameters

Source	Location	Analysis				
		Chem	Bact	Algae	COD	BOD
Nachchaduwa	Near the Water Spill	√	√	√	√	√
Mahakanadarawa	Near the water spill	√	√	√	√	√
Nuwara wewa	Near the Water Board Intake Pump House	√	√	√	√	√
Tissa wewa	Near the Water Board Intake Pump House	√	√	√	√	√
Malwathu Oya	Near the Anicut (NWSDB Water Intake)	√	√	X	√	√
NWSDB Water Intake	Near the Gal palama	√	√	X	√	√
Kurunegala Road cross over the Malwathu oya	Near the German palama	√	√	X	√	√

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Sampling

For Chemical analysis, samples were collected in acid washed plastic bottles and transported to the laboratory in a cool box at 4^0C. These sample bottles were rinsed with water to be sampled before collection. Analysis was carried out after the immediate sampling. Also another set of sample was taken to plastic container and acidified with Conc. Nitric acid to have pH < 2.0. In- situ measurements was done for DO, Alkalinity, pH, Colour, Turbidity, Temperature and Conductivity. In the laboratory, measurements on Total Nitrate, Total Suspended Solids(TSS) and Total Phosphate were carried out. For Bacteriological analysis sample were collected in sterilized bottles and transported to the laboratory in a cool box at 4^0C using ice coolers.

1000 ml sample was collected using algae net. 1ml of Lugol's solution was added to the sample and analysis was carried out immediately after sampling. Samples were filtered using glass fiber filters for Chlorophyll a analysis. For BOD and COD, samples were collected in glass BOD bottles without allowing air bubbles to trap and transported to the laboratory in a cool box at 4^0C.

RESULTS AND DISCUSSION

Fig. 3.1 shows how Dissolved Oxygen (DO) varies over the months and clearly shows that all DO values are decreasing from December to June correlating very well with monsoon rains prevailing in May to June. Further, these values correlate well with high flow of pilgrims during the month of June indicating high addition of organic waste to the water. However, Tissa wewa recorded the highest DO drop from among all other tanks from March to June and this could be due to the use of Tissa wewa mainly for bathing by almost all the pilgrims. This DO results are very well endorsed by the BOD results observed for the same period(Fig 3.2). BOD values during the month of June were gradually increased with dry period(March to April) affecting the DO concentration of water.

According to the SLS 722 1985 (Tolerance limits for inland surface water used as raw water for water supply), BOD concentration must be below 5 mg/l and DO minimum limit is 4 mg/l. It is clear from the results of the present study that Mahakanadarawa and Nachchaduwa lakes confirm the SLS 722 ,1985 standards whereas Nuwara wewa, Tissa wewa and the Malwathu Oya have exceeded the standards of SLS 722 1985 indicating the not suitability of raw water for drinking purposes. This increased BOD could be due to organic contaminants from pilgrims especially during festive season in June and also due to dry weather conditions. Further, this could be due to surface run off through agricultural land as reported by Silva(2008).

Higher turbidity was detected in tanks as given in Figure 3.3. Turbidity is mainly due to higher concentrations of suspended matter such as clay, silt, organic, inorganic, plankton and other microscopic matter entering the tank from surface runoff, rainfall, bund erosion or bio perturbation (i.e. cattle incursions, fishing activities). In the present study, significantly high turbidity was recorded in 'Nuwara wewa' and 'Malwathu Oya' as 32 NTU and 28 NTU respectively in the month of June again correlating with high flow of pilgrims.

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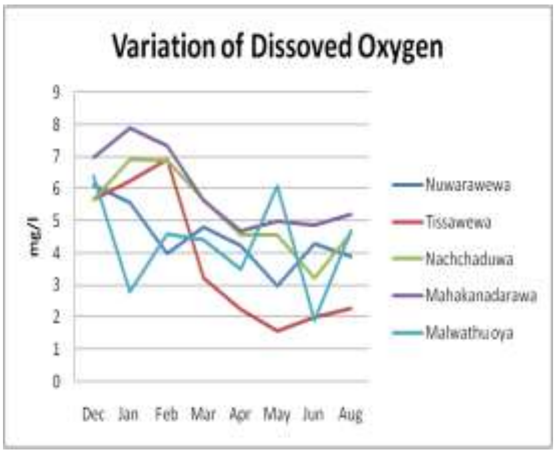

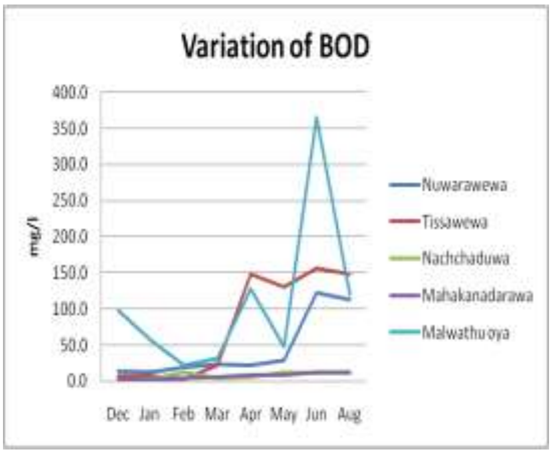

Fig 3.1 Variation of Dissolved Oxygen **Fig 3.2 Variation of Biological Oxygen Demand**

'Nachchaduwa' and 'Mahakanadarawa' lakes recorded their highest turbidity as 22 NTU and 17 NTU respectively. These lakes are located far away from the city and not affected with human disturbances. Even though,'Malwathu Oya' being a source for drinking water has failed to maintain the natural conditions compared to other lakes due to anthropogenic activities. It has become more polluted in June recording 28 NTU, due to extreme pilgrims' season in sacred town as reported by Silva, *et. al*. (2009) and Wijesinghe (2000).

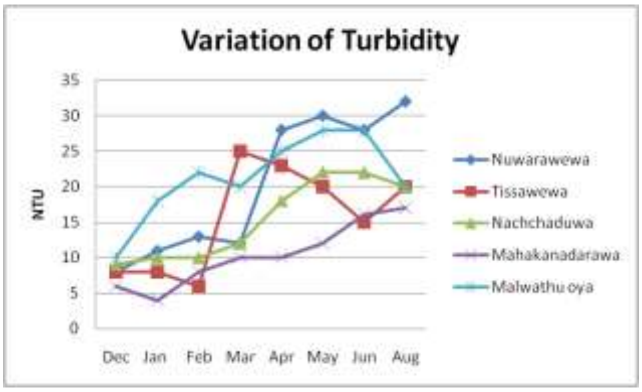

Figure 3.3 Variation of turbidity

The highest chlorophyll-a concentration was recorded for both Nuwara wewa and Tissa wewa again in the month of June. Further all the values were increasing from March to June except for Mahakandarawa wewa and Nachchaduwa wewa. Low Secchi Depth value («1 m) and highest Chlorophyll-a concentration indicated the highly eutrophic nature of 'Nuwara wewa' exceeding 100µg/l and 'Tissa wewa' nearly 90µg/l during the month of June. High nutrient loading was observed throughout the study period in Nuwara wewa, Tissa wewa & Malwathu Oya.

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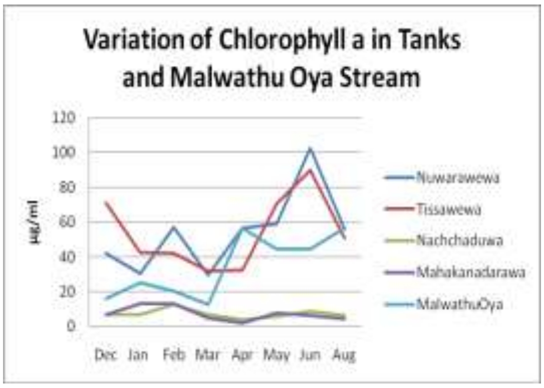

Figure 3.4 Variation of Chlorophyll-a

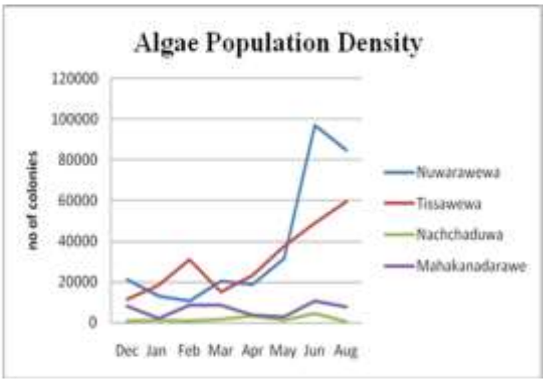

Figure 3.5 Variation of algae population density

Chlorophyll-a analysis is considered as a sensitive method of studying phytoplankton in aquatic environment (Welschmeyer, 1994). Chlorophyll-a fluctuated from time to time and that is due to chlorophyll fluorescence of plants vary depending on time course of photosynthesis (Strasser *et al.*, 1995) and algal levels are controlled by external inputs of plant nutrients (Jones *et al*., 1976). From the phytoplankton species recorded in 'Nuwara wewa' and 'Tissa wewa' tanks during the study period, *Cylindrospermopsis raciborskii* was the most dominant species in Nuwara Wewa and Tissa Wewa while *Microcystis aeruginosa. Microcystis incerta, Pediastrum duplex, Merismopedia tenuissima, Melosira granulate and Diatomaelongata* were other recorded species. Presence of phytoplankton is varied by phosphorous loading and lake depth (Jones *et al*., 1976) and that might be the reason of their fluctuations over the months. Phosphorus is the element of controlling algal biomass (Jones *et al*., 1976). According to physiochemical and biological observations of the present study, 'Malwathu Oya' stream has also reached eutrophic level. The least Chlorophyll-a concentration was recorded less than 10µg/l in Nachchaduwa and Mahakanadarawa tanks concluding that those were not polluted by plant nutrients compared to other tanks. 'Nuwara wewa' and 'Tissa wewa' also showed eutrophic conditions and its bottom sediment may contain high nutrient concentrations adsorbed. Therefore, even if further nutrient inputs are controlled, the blooming could occur due to accumulated nutrient loads in the bottom sediments. However, remedial efforts should be followed to protect the tanks from further pollution.

The monitoring of phytoplankton is of great importance because monitoring of pollution based solely on physicochemical analysis is sometimes insufficient. The phytoplankton composition not only reflects the real condition of the waters but also the previous conditions of that water.

Phytoplankton reflects water quality through changes in its community structure, patterns of distribution and the proportion of sensitive species. Throughout the study, the phytoplanktons in the waters off the Matrouh beaches were dominated by diatoms. Similar findings were reported from most Egyptian coastal waters by Shams El-Din & Dorgham (2007) in Abu-Qir bay and Gharib & Dorgham (2006) in the Western Harbour.

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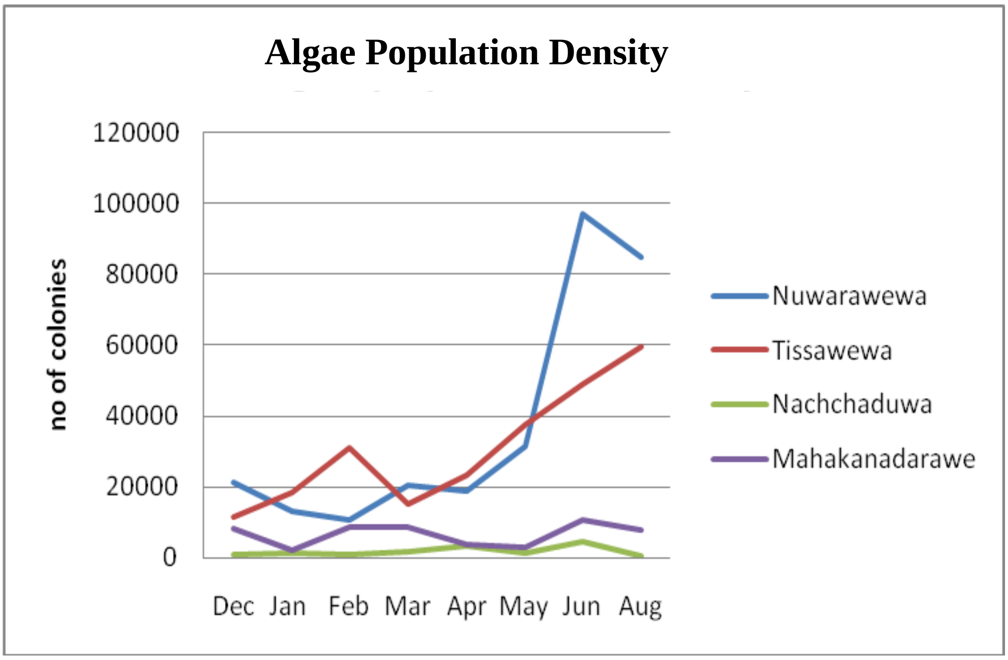

Figure 3.5 Variation of algae population density

As shown in Fig. 3.5, algae population was incredibly greater in 'Nuwara wewa' and 'Tissa wewa' than two other lakes. Algae population has increased in tanks relative to the nutrient levels. Phytoplankton population was gradually increased in 'Malwathu Oya' basin during dry conditions. 'Mahakanadarawe' and 'Nachchaduwa' tanks showed less densities of phytoplankton than 'Malwathu Oya' tank due to less pollution. Temperature of North Central Province is usually very high in the day time due to the presence of photosynthetic microbes in water. Direct sunlight helps to growth of photosynthetic algae. When the total algal population is increased including cyanobacteria, the bio diversity was decreased in water bodies. Cyanobacteria population was increased along with pollution of water bodies. Piyasiri (2000) and Silva (2008) recorded that *Cylindrospermopsiss raciborskii*, *Microcystis* sp., *Peridinium* sp. and dinoflagellates were predominant in the dry zone reservoirs. The toxin producing *Cylindrospermopsis raciborskii* was the most dominant species of the irrigation lakes in Sri Lanka. Padmasiri (2004) reported that cyanobacteria count was exceeded the permissible limits recommended by WHO guidelines. Different species of cyanobacteria have observed in Anuradhapura district with a wide diversity and altogether a total of 123 plankton genera were recorded by Piyasiri (1995). With reference to the distribution of cyanobacteria species, highest diversity has observed in the Anuradhapura district. When considering the present study, it is clear that total algal population has increased and the diversity has decreased. Blue green algae population has become the predominant species. Algae population was very much less in 'Nachchaduwa' and 'Mahakanadarawe' lakes even in most dry conditions. Nutrient levels in those two lakes were much less and less human interference might be the cause for it. Phytoplankton assembly of the tank water is more than 20,000 colonies / ml in the 'Nuwara wewa' and 'Tissa wewa'. Both these lakes have exceeded the alarm level given by WHO guidelines. In the present study, it was recorded that the most dominant species was *Cylindrospermopsis raciborskii* while *Microcystis aeruginosa*, *Pediastrum simplex*, *Chroococcus sp*, *Synedra* sp, *Oscillatoria sp*, *Closterium sp.*, *Spirogyra sp.* and *Melosira granulate* were the other common species. These

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cyanobacteria species produce hepatotoxic and neurotoxic cyanotoxins which are harmful to humans. Liyanage and Magana Arachchi (2012) documented that *Cylindrospermopsis raciborskii* was the most dominant species in the tanks of North Central Province as similar to the present study.

Some areas along 'Malwathu Oya' are dominated by higher plants like '*Kankung*', '*Diyasiyabala*', '*Diyahabarala*', '*Thamburu*', '*Salvienia*' and '*Japan Jabara*'. In the dry season also, whole surface of the 'Malwathu Oya' is covered by higher plants. Slow water moving condition may facilitate the growth of both macro and micro plants. However, heavy rain falls flushed all the plants coverage and naturally cleans 'Malwathu Oya'. Findings of the present study were similar compared to the studies of Piyasiri *et al*. (2000) and Silva *et al*. (2005). They have recorded that higher plants could be easily grown on the river banks due to high nutrient content and static low water level.

Nitrate is one of the chief sources for a new primary production of a water body (Eppley *et al*., 1979). As given in Figure 3.6. 'Malwathu Oya' recorded a remarkable fluctuation of nitrate concentration in April, June and August compared to other tanks. It has reached maximum concentration greater than 15mg/l in August. This high value could be due to the unauthorized dumping of both organic and inorganic waste over the years. However, when compared to phytoplankton data, it is clear that nitrate concentration had no much effect on the growth of the phytoplankton/chlorophyll a. This observation further confirms that highly eutrophic lakes even do not show any correlation with nitrate levels as reported by Eppley *et al*., (1979). He has further recorded that nitrogen source could be predominantly utilized from ammonia than nitrates. Therefore, higher ammonia concentration might affect the chlorophyll-a concentration than nitrates.

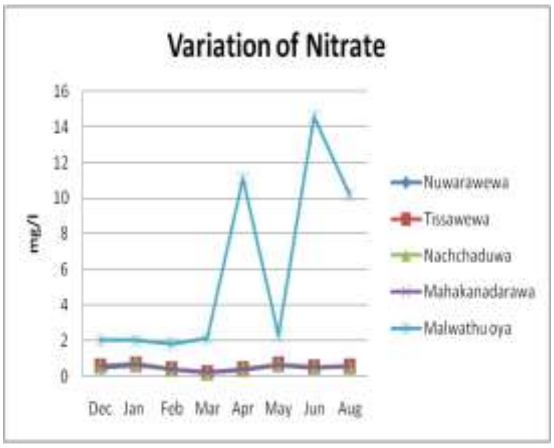

Figure 3.6 Variation of Nitrate

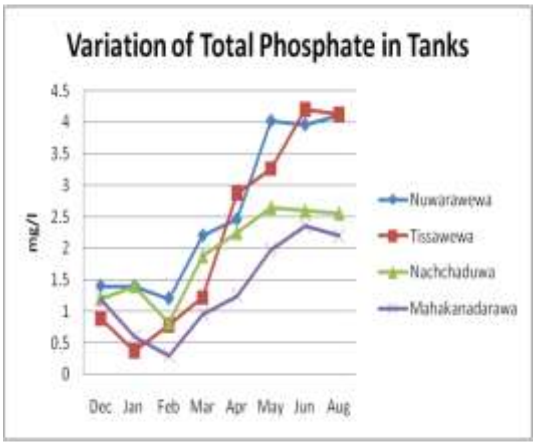

Figure 3.7 Variation of Total Phosphate

As per SLS722:1985(Tolerance limits for inland surface water used as raw water for water supply), Concentration of Nitrate (as N) must be below 10 mg/l. However, Malwathu Oya raw water has exceeded the standards of SLS 722 1985 and is not suitable to use as a raw water source for water supply for public.

Phosphate concentration has gradually increased over the months in every tank and the concentrations were recorded in 'Nuwara wewa' and 'Tissa wewa' in August exhibiting 4.11

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mg/l and 4.12 mg/l respectively (Fig 3.9). It is obvious from the results of present study that phosphate concentration has directly affected on the phytoplankton and algae growth of water bodies.

Water bodies are contaminated by coliform bacteria from waste water effluent discharges and non point sources (Mancini, 1978). According to the WHO drinking water guidelines, total coliform in drinking water should be zero mg/l. Presence of coliforms are considered as an indicator of sanitary quality of water bodies (WHO, 2001).

'Malwathu Oya' stream detected significantly high concentrations of total coliforms fluctuating over the time period (Fig. 3.10). Maximum concentration was recorded as 6000 colonies/100ml in June. SLS 722:1985 mentioned tolerance limits of the coliform bacteria should be not more than 5000 colonies/100 ml. The season of pilgrims and tourists might have caused for this extremely high pollution of tanks by coliforms. 'Tissa wewa', 'Nuwara wewa' and 'Nachchaduwa' tank recorded relatively low, but higher concentrations of coliforms. These water bodies should be properly treated before consumption and household usages.

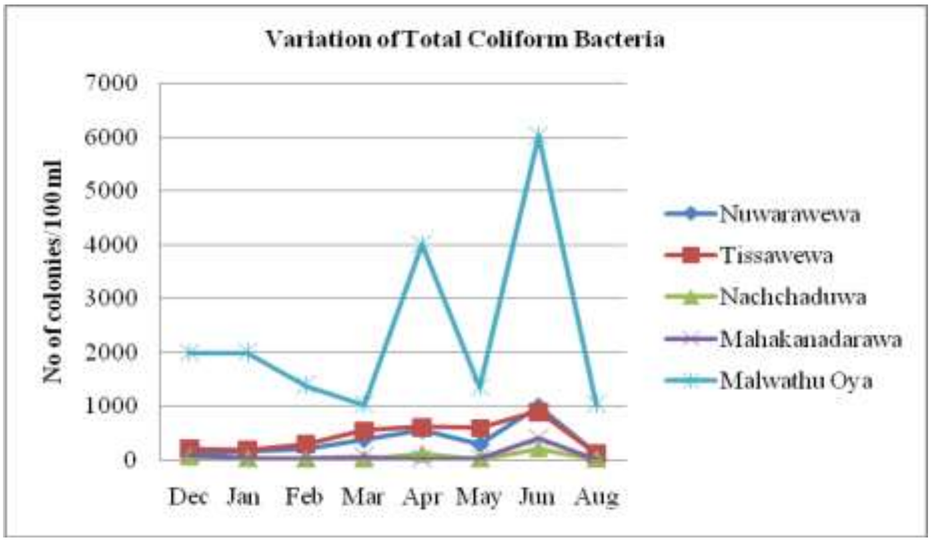

Figure 3.8 Variation of total coliform bacteria

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