Third International Research Symposium
Rajarata University of Sri Lanka

IRSyRUSl 2015

Study on the Relationship of Various Physico-Chemical Parameters of the Coastal Surface Water In Batticaloa Lagoon In Sri Lanka

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ABSTRACT

Natural water bodies are particularly vulnerable on its quality due to the natural and manmade activities. Nowadays, it is rare to have good quality water with the standard features and its availability also lack in Sri Lanka. Most of the anthropogenic activities in relation to the water resource management are unplanned and disorganized in Batticaloa, Sri Lanka. In addition, Batticaloa lagoon has been used as a yard for dumping municipal and domestic wastes and lead to rapid deterioration and degradation of water ecosystem and its biodiversity. With that aspect, a total of twenty five sampling points were randomly selected from the coastal surface water line of the Batticaloa Lagoon to collect the sample in monthly basis from the November 2013 to June 2014. And, 250 ml of sample was collected in a sterilized bottle in each visit towards the sampling points. Quality parameters such as pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS) and temperature were measured at the sampling site while Total Suspended Solids (TSS), Dissolve Oxygen (DO) and Biological Oxygen Demand (BOD) were analyzed in the laboratory of the department of Agricultural Engineering, Faculty of Agriculture, Eastern University, Sri Lanka. Finally, SPSS package was used as the analyzing tool to determine the relationships among various water quality parameters. Study showed that the temperature (31.77 °C), pH (7.94), EC (1115 µs/cm), TDS (557 mg/l), TS (579 mg/l), TSS (21.69 mg/l) and turbidity (9.35 NTU) were within the WHO standard level of surface water of river. However, phosphate (0.47mg/l), nitrate (1.56 mg/l), DO (5.89 mg/l) and BOD (5.91 ppm) were exceeded from the WHO standard value, at this study. Further, DO concentration of the lagoon water had a negative relationship ($P<0.01$) with BOD ($r=0.426$), turbidity ($r=0.525$) and TSS ($r=0.437$) where BOD showed negative significant relationship ($P<0.01$) with EC ($r=0.442$) and dissolved oxygen ($r=0.426$) and a strong positive relationship was ($P<0.01$) with TSS ($r=0.979$). Moreover, turbidity showed a strong significant positive correlation ($P<0.01$) with TSS ($r=0.941$) and BOD ($r=0.927$) and negative relationship was with P^H, TDS, TS and DO. In addition, TSS ($r=0.167$), BOD ($r=0.21$) and turbidity ($r=0.261$) showed negative relationship with temperature while others were in positive relationship ($P<0.01$) with temperature. And also, nitrate and phosphate level showed a positive significant relationship ($r=0.285$ at $P<0.01$ level) in-between them. In addition, BOD was observed with a negative significant relationship with DO ($r=0.426$) in Batticaloa Lagoon water.

Key words: *Bio Diversity, Pollution, Physico- Chemical Properties, Surface Water*

1. Introduction

Water is an elixir of life and an important component to human survival. Although, three-fourths of the earth is being surrounded by water, a little portion of water can be used for drinking purpose. Nowadays, the scarcity of available clean water is on the increase, as a result of various streams of untreated waste is constantly being discharged into water bodies. In addition, resulting pollution which affects the different range of uses of such water bodies as well as its physico-chemical properties, could range from activities in the oil and gas exploration (Ite *et al.,* 2013), runoffs from agricultural soils (Maghanga *et al.,* 2012) to disposal of sewage into natural waters (Longe *et al.,* 2010).

Further, aquatic ecosystems are particularly vulnerable to the environmental change and many are, at present, severely degraded (Williamson *et al.,* 2008). Hence the nature and health of any aquatic community are an expression of quality of the water. In recent years, increasing human population, demand for food, land conversion, and excess use of fertilizer have led to faster degradation of many freshwater resources (Mushini Venkata Subba *et al.*, 2012). The discharge of urban, industrial, and agricultural wastes has added the quantum of various harmful chemicals to the water body, considerably altering their inherent physico-chemical characteristics (Kim *et al.,* 2009) of lagoon water. The alteration in physico-chemical parameters lead to the eutrophication which has become a widely recognized problem of water quality deterioration (Jayakumar *et al.*, 2009). Among the many water quality indicators, the oxygen availability in a particular water system is an indicative of its general health, as high oxygen demand will ultimately lead to low amounts of dissolved oxygen available to sustain aquatic life (Adeogun *et al.,* 2011).

In Batticaloa District, rapid urbanization and industrialization have resulted in making this excellent water resource (Batticaloa Lagoon) unavailable or unsafe for usage (Wazniak *et al.*, 2007). Further, paddy cultivation around the lagoon increases the rate of deterioration of this precious water resource through uncontrolled entry of excess fertilizers and other agro-chemicals into the system. Disposal of raw sewage obviously affects aesthetic value of this lagoon. In recent years, there were many indicators of water quality deterioration of the lagoon such as blooms, explosive growth of water hyacinth, fish deaths and unidentified fish diseases. Even though, the scientific reasoning behind such incidences was not known. There is a growing consensus among lagoon user groups for the declining quality of water in Batticaloa lagoon. It is therefore vital to protect this lagoon from the deterioration through improved water management plans. Moreover, it is important to have basic information about the quality of water, with the concern of relationship of quality parameters among them. Moreover, a large number of factors and geological conditions influence among the different pairs of physico-chemical parameters of surface water directly and indirectly. Therefore, significant role of physical and chemical quality parameters need more attention on classifying and assessing water quality (Mohammad *et al.*, Heydari, 2013) in lagoon water.

For the effective maintenance of water quality through appropriate control measures, continuous monitoring of large number of quality parameters is essential. However, it is very difficult and laborious task for regular monitoring of all the parameters even if adequate manpower and laboratory facilities are available. Therefore, in recent years an alternative approach based on statistical correlation has been used to develop mathematical relationship for comparison of physico-chemical parameters (Mayur, 2007). Hence, this study was aimed to

provide sufficient information regarding the relationship (correlation) among physico-chemical properties of Batticaloa lagoon water.

1.1 Objectives of the study

1. To analyze the selected important physico-chemical parameters of coastal surface water of Batticaloa lagoon.
2. To study the relationship of physico-chemical parameters of surface water of Batticaloa lagoon.

2. Materials and method

Present study was conducted in Batticaloa District by selecting Batticaloa Lagoon as the study location during the period of January to June 2014. According to that, twenty five (25) sampling points were randomly selected at the coastal site of the lagoon. A volume of 250 ml water sample was collected in a well sterilized labeled bottle at the preferred depth of water column 0-25 cm from the surface of the water level. These samples were collected in an ice cooling box for the transportation, to prevent sampling loss or chemical absorption prior to laboratory analysis and then samples were stored at 4°C in refrigerator till analysis was completed. Samples for Biological Oxygen Demand (BOD) and Dissolved Oxygen (DO) were collected in dark color narrow-mouth bottles and kept at 20°C for 5 days in an incubator. The samples which were used to determine DO were fixed with Winkler's reagent at sampling points.

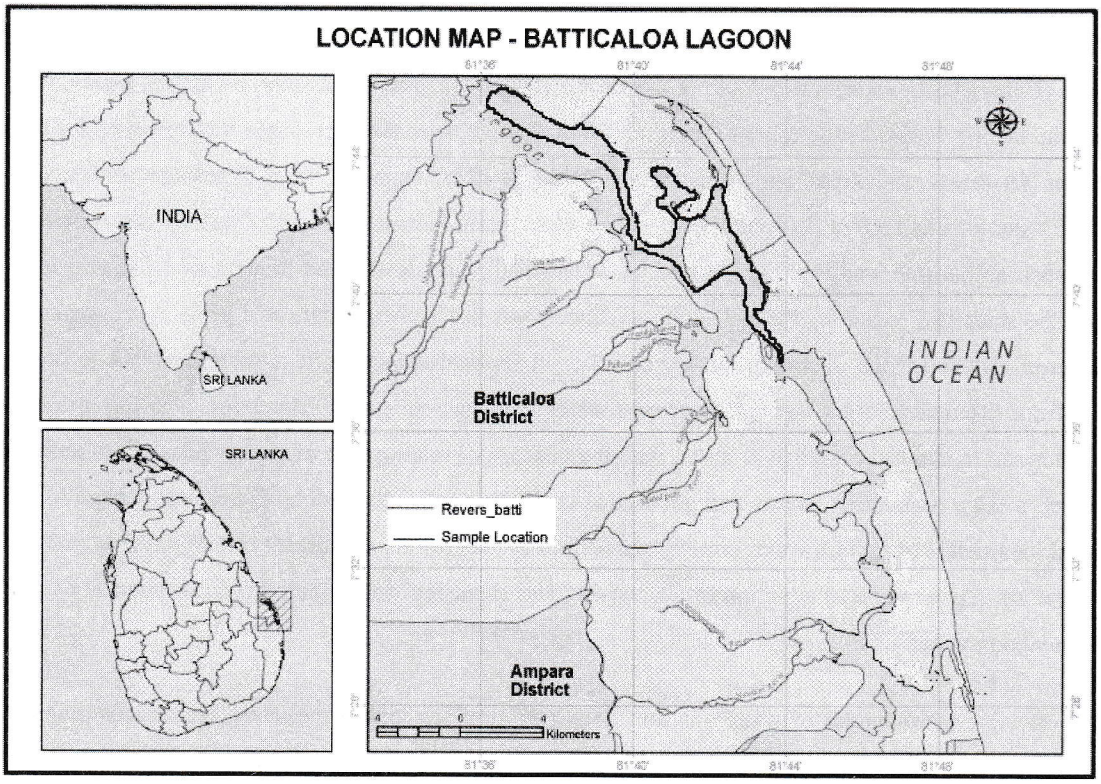

Figure 1: Location of the Batticaloa Lagoon (Batticaloa Map, 2013).

2.1 Analysis of water quality parameters

Temperature, pH, EC and TDS were measured immediately after sampling at the sampling site by using a portable thermometer, pH/EC/TDS Meter (Model HI 98130), respectively. And also, turbidity of water samples were measured by using turbidimeter (Model HACH 2100P). Total solids (TS) content was measured by evaporation method in which water sample was taken in a pre-weighed dish and dried in an oven at 105 °C until the weight of the dish become constant. TSS was measured by analyzing for total solids and subtracting total dissolved solids. Further, nitrate and Phosphate contents of lagoon water samples were determined using Spectrophotometer (HACH, 2010).

Dissolved oxygen of lagoon water samples was done immediately after returning to the laboratory using Winkler' method (APHA, 1995). Water samples were taken in 25 ml volume stoppered bottles and 0.1 ml of manganese (II) sulfate solution was added into each bottle and mixed carefully. Thereafter, 0.2 ml of alkaline potassium iodide was added and again mixed without letting in air until pinky-brown precipitate appeared. All these steps were done at sampling points. Thereafter, samples were transferred to laboratory. In the laboratory, a volume of 0.3 ml sulfuric acid was added in to each bottle and mixed. Then samples were allowed to stand for two minutes. For titration, 10 ml of sample was transferred into the conical flask and few drops of starch solution were added. These sub-samples were turned blue. Then sub-samples were titrated with Thiosulfate until it turns clear.

2.2 Data analysis

Recorded data was analyzed using MS Excel sheet and statistical Package for Social Science (SPSS, Version 22) was used to determine the relationship among various water quality parameters from the collected water sample of Batticaloa Lagoon.

3. Results and discussion

3.1 Sample analysis

The data was statistically analyzed by setting up and calculating a correlation matrix for the tested parameters using Statistical Package for Social Science (SPSS v.16). The analyzed data were illustrated graphically using Microsoft Excel software for easy interpretation of the results.

According to the Table 1, parameters such as Phosphate, Nitrate, DO and BOD were exceeded from its standard value and those were with the average mean value of 0.47 mg/l, 1.56 mg/l, 5.89 mg/l and 5.91 ppm, respectively. However, other water quality parameters were within the range of expected value, during the study period. The reasons for exceeding Nitrate and Phosphate content in Batticaloa Lagoon might be due to the excess use of fertilizers in the surrounded paddy cultivation which reached the lagoon during the rainy season along with the surface runoff. Further, that nutrient rich water enhanced the growth of aquatic plans and which ultimately lead to the reduction on BOD and DO in the lagoon water.

Table 1: The results of the analysis of sample of the coastal surface water of the lagoon

Parameters	Mean Value	WHO Standard	Significant level
Temperature (^{o}C)	31.77 ±0.19	28-32	0.077
pH	7.94±0.13	7.8-8.3	0.770
EC (µs/cm)	1115±52.21	50-1500	0.111
TDS (mg/l)	557±26.1	450-2000	0.111
TS (mg/l)	579±25.65	-	0.098
TSS (mg/l)	21.69±1.01	25	0.833
Phosphate (mg/l)	0.47±0.03	0.1/less	0.000*
Nitrate (mg/l)	1.56±0.14	1/less	0.000*
DO (mg/l)	5.89±0.12	4/more	0.539
BOD (ppm)	5.91±0.67	5/less	0.721
Turbidity (NTU)	9.35±0.33	20-150	0.969

*significant at 0.05 level.

3.2 Relationship of physico-chemical parameters of the coastal surface of lagoon water

Present study showed the relationship between and among the selected physico-chemical properties of surface water which was collected form, Batticaloa Lagoon (Table 2) during the period of January to June, 2014.

3.2.1 Influence of temperature on other physico-chemical parameters

According to the analyzed data, average mean temperature (31.77 °C) showed a positive significant relationship ($P<0.01$) with pH, electrical conductivity (EC), total dissolved solid (TDS), total solid (TS) and dissolved oxygen (DO) during the study period. These relationships were moderate in each conditions with r=0.288, r=0.33, r=0.333, r=0.293 and r=0.207, respectively. Further, this study period fell within the acceptable ambient temperature range of surface water of lagoon (Table 3.2). However, it was negative in its significant relationship ($P<0.01$) with total suspended solid (TSS), phosphate, nitrate, biological oxygen demand (BOD) and turbidity as r=0.167, r =0.089, r-0.019, r=0.210 and r=0.261, respectively. The temperature fluctuation is one of the factors in lagoon, which may influence in the changes of physico-chemical parameters and also influence in the distribution and abundance of flora and fauna (Soundarapandian *et al.*, 2009).

Table 2 : Inter-relationship among various physico-chemical parameters with correlation coefficient value (r value)

Parameters	Temperature	pH	EC	TDS	TS	TSS	Phosphate	Nitrate	DO	BOD	Turbidity
Temperature	1										
PH	0.288**	1									
EC	0.333**	0.767**	1								
TDS	0.333**	0.767**	1.000**	1							
TS	0.293**	0.721**	0.947**	0.947**	1						
TSS	-0.167*	-0.567**	-0.442**	-0.442**	-0.396**	1					
Phosphate	-0.089	-0.069	-0.044	0.044	0.031	-0.003	1				
Nitrate	-0.019	-0.061	0.016	0.016	0.029	-0.026	0.285**	1			
DO	0.207**	0.539**	0.634**	0.634**	0.620**	-0.437**	-0.003	0.018	1		
BOD	-0.210**	-0.570**	-0.442**	-0.442**	-0.394**	0.979**	-0.002	-0.028	-0.426**	1	.
Turbidity	-0.261**	-0.706**	-0.623**	-0.623**	-0.572**	0.941**	-0.008	-0.012	-0.525**	0.927**	1

3.2.2 *Relationship between pH and other physio- chemical parameters*

This study depicted that the average value of pH ranged within the standard level (Table 1) as 7.94 and which was recognized as alkalinity. The pH showed a positive significant relationship (P<0.01 level) with EC (r=0.767), TDS (r=0.767), TS (r=0.721) and DO (r=0.0.539) and significant negative relationship with TSS (r=0.567), nitrate (r=0.0.069), phosphate (r=0.061), BOD (r=0.570) and turbidity (r=0.706), as shown in Table 3.1. It might be due to the seasonal impacts and was evidenced with the study of Trivedi, et al., (2009) as turbidity to be on higher side in all seasons and pre-monsoon and monsoon seasons, respectively. In this analysis, relationship of pH on other parameters was strong and it was very low with nitrate and phosphate concentration in Batticaloa Lagoon. Seasonal fluctuation in pH values is attributed to factors like removal of CO2 by photosynthesis through bicarbonate degradation, dilution of seawater by freshwater influx, low primary productivity, reduction of salinity and temperature and decomposition of organic materials (Karuppasamy et al., 2000).

3.2.3 *Relationship of electrical conductivity with other quality parameters*

A very strong positive relationship (P<0.01) of EC was observed with TDS, TS and DO which were r=1.0, r=0.947 and r=0.634 and EC was the key contributor (100%) for the increase of TDS content in surface water of Batticaloa Lagoon. Further, around 90% contribution on TS and 40% on DO, were observed in this study. However, EC showed a negative relationship at P<0.01 level with TSS (r=0.442), phosphate (r=0.044), BOD (r=0.442) and turbidity (r=0.623) which was significantly moderate in lagoon water quality parameters. EC has strong significant negative correlation with TSS (r= -0.8865, t= 3.9316) supported by Narendra Singh Bhandari, (2007) and Mohammad Mehdi Heydari et al., (2013). In this circumstance, relationship with phosphate content was significantly lower (Table 3.1).

3.2.4 *Relationship between total dissolved solids and other parameters*

During the study period, TDS showed a strong positive significant relationship with TS (r=0.947) and DO (r=0.634). Contribution of TDS was much higher 89.67% on TS content as well relationship was moderate around 40% on DO content. Moderate negative correlation was observed with TSS (r=0.442), BOD (r=0.442) and turbidity (r=0.623) which was significant at P<0.01 level. Changes in pH could cause some of the solutes to precipitate or affect the solubility of the suspended matter.

3.2.5 *Relationship of total solids with other quality parameters*

Relationship between TS and DO was positive and significant at P<0.01 level and correlation was r=0.620 (R2=0.3844). It was observed as lower contribution in the positive increase of DO. Further, there was a negative significant relationship was observed with TSS (r=0.396), BOD (r=0.394) and turbidity (r=0.572). However, those relationships were moderate in its nature.

3.2.6 *Relationship between total suspended solid and other quality parameters*

Study showed that the relationship was positive and significant (P<0.01) with BOD and turbidity of the collected water samples (Table 1) where the influence on TSS on BOD and Turbidity was extremely higher. Contribution is as 99.84% and 88.55% with BOD and turbidity, respectively. A higher value of BOD indicates maximum consumption of oxygen and higher pollution load, which is supported with the decomposition of organic matter (Garg et al., 2006). And the relationship was negative and significant with DO where the r=0.437 at P<0.01 level in a moderate strength.

3.2.7 *Relationship of Nitrate and Phosphate content and other quality parameters*

There was a positive significant relationship occurred between nitrate and phosphate content during the study period where the relationship was r=0.285 and lower. Runoff from the nearby paddy fields might have attributed for the high concentration of nitrate and phosphate due to the agricultural runoff and its loadings to a water body. It was lack in observation and contribution on other physio- chemical parameters of surface water of Batticaloa lagoon during dry season.

3.2.8 Relationship of DO content and BOD level

It was obvious that the relationship between DO and BOD at P<0.01 level. There was a negative significant relationship felt during the study period which represented with r=0.426, as moderate issue. Measuring the Biochemical oxygen demand can be useful to determine the quantity of oxygen demanding waste in water. The availability of oxygen for living organisms decreases with increasing BOD in water (Odokuma et al., 1996).

3.2.9 Relationship of biological oxygen demand with water turbidity

The relationship was very strong between BOD and turbidity (Table 1). While turbidity level increases, the demand for oxygen also increases. Biological activities depend much on available organic matter present in water and it is the need for decomposition. It might be the reason for maximum need of oxygen for microbial activities in water surfaces. Here, the relationship was positively significant at P<0.01 level as r=0.927 (R2=0.859) in Batticaloa Lagoon water.

4. Conclusions

The results revealed that the temperature, EC, TDS, TS, TSS and turbidity of the surface water of the lagoon were within the standard level. However, pH, phosphate, nitrate, DO and BOD were exceeded its standard value and were under concern. Although, those parameters were beyond the limit, nitrate and phosphate were recognized as the issue in the Batticaloa lagoon. Relationship of parameters were significantly correlated at P<0.01 level. Study showed that the dissolved oxygen concentration of lagoon water had a negative relationship (P<0.01) with BOD, turbidity and TSS. Further, BOD showed negative relationship (P<0.01) with EC, and dissolved oxygen and positive relationship (P<0.01) with TSS.

Moreover, turbidity showed significantly a positive relationship (P<0.01) with TSS and BOD and negative relationship with others. And also, TSS (r=0.167), BOD (r=0.21) and turbidity (r=0.261) showed negative relationship with temperature while others were in positive relationship (P<0.01) with temperature. Nitrate and phosphate showed positive relationship (r=0.285 at P<0.01 level) between them. Further, BOD was observed with negative relationship on DO (r=0.426) level in Batticaloa lagoon. This study of relationship could be used in future to determine the changes of various physio-chemical parameters of lagoon, river, etc.

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