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RESEARCH ARTICLE

Temporal Variation in Water Quality Parameters of Bandematta Hosakere Lake – Peri Urban Area of Bengaluru, Karnataka, India.

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Abstract

Lakes have played an important role in the history of Bengaluru; these were the primary sources of drinking water and irrigation in the last two decades. Due to the boom in the IT and related sectors in the silicon valley of India, has created an acute stress on the natural resources and infrastructure of the city of Bangalore with exponential growth in population. Bandematta is located in southern part Bangalore metropolitan. An attempt has been made to ascertain the Temporal Variation of water quality parameters; present study was carried-out for one year for four seasons (January 2013 to December 2013) as prescribed by Indian Meteorological Department. Seasonally the water samples were collected to analyse different physical and chemical parameters by following the standard methods of APHA (2005). Temporal variations were recorded, analysed and compared with standards and the pollution status was investigated. High levels of EC, TDS, BOD, Nitrate-Nitrogen and Total Hardness was recorded at an average of 1387.50 µS/cm, 912.43 mg/L, 4.45 mg/L, 12.73 mg/L and 342.93 mg/L respectively. Sodium and potassium were also in excess concentrations and that reflects on the agriculture. The results revealed that there is heavy organic load in Bandematta Lake. High levels of variations in various physico – chemical parameters were recorded due to anthropogenic activity and discharge of wastewater. The Temporal Variation of water quality parameters recorded is alarming and if it is going to continues for the Bandematta Lake, it will be difficult to sustain.

INTRODUCTION

Freshwater is a finite resource, essential for agriculture, industry and even human existence. Freshwater habitats are divided into lentic systems, which are the still waters including ponds, lakes, Lakes have played an important role in the water. With the increase in urban areas, there is a pressure on basic infrastructure including access to water for both urban and peri urban locations. Due to a large influx of population mainly due to expansion of the Metropolitan city Bengaluru, the peri urban areas have been become majour importance for lakes to sustain the good condition. In turn, the aassessment of seasonal changes in surface water quality is also an important aspect for evaluating temporal variations in judgment of the impacts as pollution due to natural or anthropogenic inputs of point and non-point sources (Ouyang, 2006).

Further, the Seasonal patterns in the concentration of physicochemical variables occur, as land use, rainfall and farming activities change seasonally, and these concentrations should therefore be determined periodically.

An attempt has been made to ascertain the Temporal Variation of water quality parameters of Bandematta Lake, which is situated in peri urban area of Bengaluru. Prior to 1900's Bandematta Lake was called as 'Haddina Halla' meaning 'Vulture holes' since there were 3-4 huge deep wells.

People were used water from well for all purposes. In around 1940's, barriers were raised around the wells by local community to create a lake. In 1970's it was called as 'Bandematta Halla' as water used to flow towards the rock (Bande) and thus this lake came to be known as 'Bandematta' after the huge rocks. Also nallas was made upstream from Mallathalli. Then it became a huge lake (Kulkarni, 2012).

2. MATERIAL AND METHODS

Study area: Bandematta Hosakere is located at $12^0$55'28.27"N and $77^0$28'51.71"E in Southern part of Bangalore Peri Urban area with an area of 23.35 Hectare and is located in the Valgerahalli village of Kengeri Hobli.

Existing Status of the lake: Inlet is located at the northern and eastern side of the Lake. Sewage is entering mainly from the residential layouts. In the Northern and western side of the Lake there are agricultural land consisting of a variety of orchards such as *Mangifera indica, Cocos nucifera, Areca caticha, Phoenix sylvestris, Tectona grandis, Acacia nilotica*. A huge Bund is towards the south of the Lake. Settlements are towards the eastern side of the Lake and *Cyprus spp.*, and *Ipomoea carnea* were dominant in the study area. Diversity of aquatic vegetation is seen along the catchment area. During the study the lake was under rejuvenation process. The farmlands irrigation in the lake vicinities is in extinct condition.

Many Lakes exhibit the phenomenon of seasonal thermal stratification where in residence time of water that is the minimum time taken to reach equilibrium after a major change in input. Samples were collected 30 cm below the surface of the water (GEMS, 1992). All the samples were analysed for the following physicochemical parameters; pH, Temperature, Turbidity, Electrical Conductivity (EC), Total Dissolved Solid (TDS), Total Alkalinity (TA), Suspended solids, Chloride, Total Hardness (TH), Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Nitrate-nitrogen, Fluoride, Phosphate, Sodium and Potassium.

The study was carried out during the year 2013. The seasons and months were adopted as per Indian Meteorological Department, Bengaluru and were constituted as follows: Winter Season (January–February), Pre Monsoon Season (March–May), Southwest Monsoon Season (June –September) and Post Monsoon Season (October –December). The physico-chemical analysis of water samples are carried out following standard analytical procedures of APHA (American Public Health Association) 2005.

3. RESULTS AND DISCUSSION:

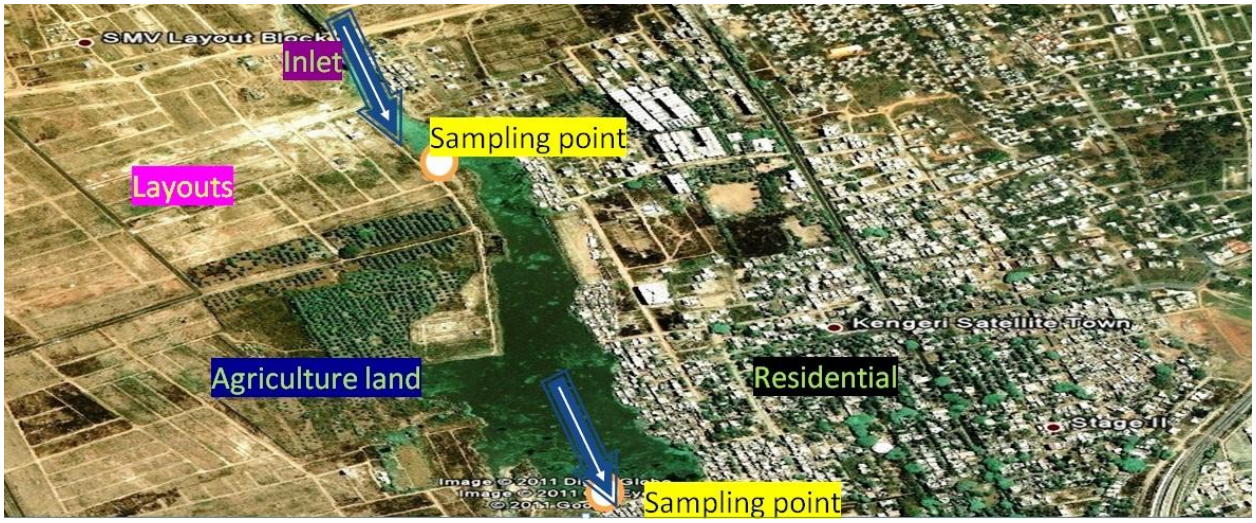

Figure 1: Google Earth view of Bandematta Hosakere Lake

Physico Chemical analysis of water provide a good indicator of the chemical quality of the aquatic system and water exhibits characteristics like dissolved salts, buffers, nutrients etc. The exact concentrations are dependent on local

conditions. Fluctuations of physico-chemical characteristics of Bandematta Hosakere is given in Table 1 and Figure 2-7, which explains the Temporal Variation of Water quality parameters.

Temperature: Temperature is a measure of how much heat is present in the water. Bandematta Lake water ranged from 25.60^{o}C to 29.10^{o}C. The highest temperature was noted during the Pre-monsoon (summer) and the lowest was recorded during South west monsoon. Generally water temperature was corresponding with air temperature indicating that the samples collected from shallow zone have direct relevance with air temperature as given by Welch (1952) as shallow water reacts quickly to changes in atmospheric temperature. Whereas according to Desai (1995), Water temperature may depend on the seasons, geographical location and sampling time.

pH: pH is a measure of the hydrogen ion activity in the water or, in general terms, the acidity of water. The pH value recorded ranged from 7.34 to 8.70. The highest value of pH was recorded during Pre-monsoon season and the lowest was recorded during winter season. The low value during monsoon may be due to dilution of rain water. A fall in pH value in monsoon season was also recorded by Shardendu and Ambasht (1988). pH values recorded maximum during the summer season. The study conducted by Jana (1973) was also exposed higher pH concentrations in Pre-monsoon (summer).

Total Alkalinity: Alkalinity is not a pollutant. It is a total measure of the substances in water that have "acid-neutralizing" ability. The value of alkalinity provides idea of natural salts present in the water (Gawas et al., 2006). The alkalinity recorded for different seasons in Bandematta lake water ranged from 162.6mg/L to 191.6mg/L. The high value of alkalinity was recorded during the pre-monsoon and the low value of alkalinity was recorded during South West Monsoon season. According to Solanki and Pandit (2006), the change in alkalinity depends on carbonates and bicarbonates and also depends upon CO_2 levels. The levels of alkalinity are at marginal to desirable limits.

Electrical Conductivity (EC): Conductivity measures the capacity of a substance or Solution to conduct electrical current. Electric conductivity recorded in Bandematta lake water ranged from 1316.40µS/cm to 1474.20µS/cm. The high value of conductivity was recorded during the summer season and low during monsoon season. According to Trivedy et al., (1989), the variation in the conductivity values seasonally is mostly due to increase in the concentration of salts, because of evaporation; the dilution resulted from precipitation brings down its values. Olsen (1950) classified the name for water bodies having conductivity values greater than 500µS/cm as eutrophic. According to this criteria, Bandematta Lake under the category of Eutrophic water body.

Turbidity: Turbidity is a measure of the ability of light to pass through water, that is, a measure of the water's murkiness. Suspension of particles in water interfering with the passage of light is called turbidity. Bandematta Lake ranged from 10.20NTU to 12.40NTU. The highest value was recorded during South west monsoon and low value was recorded during winter season. According to Saxena et al., (1966); Ansari and Prakash (2000) and Solanki (2001), the maximum values of turbidity in South west monsoon may be due to rainfall and surface runoff of water bringing a lot of sediment from the surrounding area.

Suspended Solids (SS): The Suspended solids are the product of algae, plants and animal decay, the decomposition process allows small organic particles to break away and enter the water column (Murphy, 2007), even chemical precipitates are considered a form of suspended solids and in times suspended solids can settle out into sediment at the bottom of a body of water over a period of time or seasons. In seasonal variation of Suspended solids, the maximum concentration of 68.74mg/L was recorded during the Post-monsoon (rainy) season and minimum concentration of 62.20mg/L was recorded during winter season. The source of suspendered solids are due to runoff flows, even in areas with storm drains, these drains usually lead directly to a local water source without filtration. In addition to being a warning sign for pollution, suspended solids can harbor pathogens such as bacteria and protozoa. These microorganisms attach to the suspended particles, aiding in their transportation and hiding them from disinfectants. Indirectly, the suspended solids affect other parameters such as temperature and dissolved oxygen. Because of the greater heat absorbency of the particulate matter, the surface water becomes warmer and this tends to stabilize the stratification (layering) (Volunteers protecting Kentucky Waterways, 2014).

Total Dissolved Solids (TDS): TDS is a measure of total inorganic substances dissolved in water and it is the general nature of water quality or salinity. In Bandematta Lake the concentration of total dissolved solid recorded

ranged from 610mg/L to 850mg/L. The high concentration of TDS was recorded during the winter season was as low concentration of TDS was recorded during monsoon season. The TDS concentration was found to be above the permissible limit may be due to the leaching of various pollutants into the ground water which can decrease the potability and may cause gastrointestinal irritation in human and may also have a laxative effect particularly upon transits. Similar results also reported by Saxena (1996).

Dissolved Oxygen (DO): The maximum value of dissolved oxygen was recorded during the Pre-monsoon (summer) and the minimum value were recorded during Southwest monsoon season. According to Singh et al., (1991), Low dissolves oxygen may due to low solubility of oxygen in water consequently affecting the BOD. Vijayan (1991) reported that the measurement of dissolved oxygen is a primary parameter in all pollution studies. The amount of dissolved oxygen is higher in those places where there is a good aquatic life. In Bandematta Lake the concentration of dissolved oxygen recorded ranged from 5.2mg/L to 5.9mg/L.

Biochemical Oxygen Demand (BOD): Refers to the amount of oxygen used by microorganism in the aerobic oxidation of organic matter. The BOD concentrations recorded in Bandematta lake water ranged between 4.1 mg/L to 5.1 mg/L. The maximum values were recorded during the Pre Monsoon (summer) season and minimum value was recorded during monsoon season. Sankar et al., (2002) suggested that high BOD may be due to the increase demand of oxygen to the degradation of the organic wastes dumped into the water. The results shows that the lake is high in BOD concentration as against the standards of <3mg/L.

Chemical Oxygen Demand (COD): Used as an organic pollution index including phytoplankton growth. The COD concentrations recorded in Bandematta lake water ranged between 28.9mg/L to 34.50mg/L. The maximum values were recorded during the Pre Monsoon (summer) season and minimum value was recorded during monsoon season. According to Environmental Quality Standards (EQS) for water pollutants (2014), COD of less than 1mg/l is assumed not to be caused by anthropogenic influence. Waters under this condition are suitable for conservation of the natural environment.

Total Hardness: Water hardness is usually due to the multivalent metal ions, which comes from minerals dissolved in the water. The concentration hardness in the water of Bandematta Lake ranged from 310.4 mg/L to 384.2 mg/L. The maximum value was recorded during the summer and minimum value was recorded during South West Manson season. Bandematta Lake has exceeded the desirable limit of 300mg/L. Udhaya kumar et al., (2006) also reported the excessive presence of calcium and magnesium in water makes the hardness.

Chlorides: The chloride concentration was used as an important parameter for the detection of contamination by sewage. The value of chloride recorded in Bandematta lake water ranged between 127.60mg/L and 212.40mg/L. The high concentration of chloride was recorded during the Pre Monsoon (summer) season and low value was recorded during South West Monsoon (Rainy) season. Many researchers like Laxminarayana (1965); Venkateswarlu (1969); Jana (1973); Verma et al., (1978) and Billore (1981) were also reported an increase in chloride concentration in lake water during summer season.

Fluorides: These are chemical compounds that occur naturally in both soil and water. The Temporal Variation of fluorides recorded at a maximum of 0.34mg/L during South West Monsoon (Rainy) season to a minimum of 0.54mg/L during Pre Monsoon (summer) season. The results recorded indifferent seasons were within standards.

Nitrate Nitrogen: The concentration of nitrate nitrogen recorded in Bandematta lake water ranged from 11.20mg/L to 14.92mg/L. The higher concentration of nitrate nitrogen was recorded during winter season and the low concentration was recorded during South West Monsoon (Rainy) season. Similar observations were made by Das (2003) and Sehgal (2003). According to Kumar and Ravindranath (1998), nitrate concentration of more than 5 mg/L in water usually indicates pollution made by human and animal wastes or fertilizer runoff. The lake has exceeded the limits of 10mg/L as per prescribed standards. During spring and summer, lakes are often supersaturated with oxygen due to the amount of aquatic plants. The excess oxygen remaining is released to the atmosphere and no longer available to decompose organic matter, these are the reasons for the depletion of oxygen in water. It can be a primary source of nutrients for plants and once taken-in nitrates (NO_3), it will be converted into nitrites (NO_2).
Studies by Alex et al., (1998) of USGS (United State Geological Survey) also revealed that, concentrations of nitrate in surface waters are highest during winter when storm runoff transports nitrogen from fields to streams. Lower

concentrations of nitrate in surface waters during the summer are caused by lower nitrate concentrations in ground water discharging to streams and uptake by plants.

Phosphates: Phosphates enter waterways from human and animal waste, phosphorus rich bedrock, laundry, cleaning, industrial effluents, and fertilizer runoff. Bandematta Lake ranged between 5.2 mg/L to 6.2 mg/L. The maximum concentration was recorded in Pre Monsoon (summer) and minimum concentration was recorded during South West Monsoon (Rainy) season. The results revealed that, the concentrations are above standards and shows the eutrophic status of lake. Hastler (1947) observed that, the constant addition of even low Levels of nitrogen and phosphorous in an aquatic environment could greatly stimulate algal growth. According to Patel and Ragothaman (2005), the decrease in Phosphate values in monsoon was due to absorption by planktons.

Sulphates: It can be naturally occurring or the result of municipal or industrial discharges. When naturally occurring, they are often the result of the decomposition of leaves that fall into a stream, of water passing through rock or soil containing gypsum and other common minerals, or of atmospheric deposition. The concentration of Sulphates recorded in Bandematta lake water ranged between 60.60mg/L to 73.60mg/L. The maximum concentration was recorded in Pre Monsoon (summer) and minimum concentration was recorded during South West Monsoon (Rainy) season. Point sources include sewage treatment plants and industrial discharges such as tanneries, pulp mills, and textile mills. Runoff from fertilized agricultural lands also contributes sulphates to water bodies (Volunteers protecting Kentucky Waterways, 2014).

Sodium: Evaporation of water is a significant factor in increasing the sodium level during summer season. Like sodium, potassium is also a naturally occurring element, but the concentrations in freshwater bodies remain quite lower than the sodium and calcium (Wetzel, 2000). Seasonal changes in Sodium concentration were ranged between 60.40mg/L to 106.20mg/L. The high concentration of sodium was recorded during the Pre Monsoon (summer) season and the lowest concentration was recorded during South West Monsoon (Rainy) season. According to Solanki (2001), the highest volume of sodium during summer is due to shrinkage of water volume. At present the concentrations of Sodium concentrations are within in the desirable limits but Sodium concentrations above 200 mg/L will make the water taste "salty". There are a number of anthropogenic sources of sodium that can contribute significant quantities of sodium to surface water, including road salt, water treatment chemicals, domestic water softeners, and sewage effluents. Water treatment chemicals such as sodium fluoride, sodium silico-fluoride, sodium hydroxide, sodium carbonate, sodium bicarbonate, sodium phosphate, sodium silicate, and sodium hypochlorite provide a relatively small contribution (WHO, 1979).

Potassium: It is an essential element in humans and is seldom. It occurs widely in the Environment, including all natural waters. Seasonal variation of Potassium concentrations was recorded as 7.2mg/L-11.9mg/L. Although concentrations of potassium normally found in drinking-water are generally low and do not pose health concerns.

Temporal Variation of water quality parameters in studied lakes showed individual, time-based and spatial variations. The water quality of Bandematta Hosakere Lake experiences the seasonal changes and the concentrations of water quality parameters are higher during Pre Monsoon (summer) season. The concentrations of BOD, Nitrate Nitrogen, Electric Conductivity, Total Dissolved Solids, Phosphates, Total Hardness and Turbidity highly varied during various seasons. The lake is highly polluted in spite of dilution.

Table 1: Temporal Variation in water Quality parameters of Bandematta Hosakere Lake

Parameter	Standards	Season	Mean	Standard

	ISI IS 2296-1982, IS 10500-2012, APHA-2005	Winter	Pre Monsoon (Summer)	South West Monsoon (Rainy)	Post Monsoon		Deviation
Temperature (^{O}C)	-	27.40	29.10	25.60	26.40	27.13	1.51
pH	6.5-8.5	7.40-7.60	8.54 - 8.70	7.62 -7.80	7.34 -7.60	7.88	0.56
Total alkalinity as $CaCO_3$ (mg/L)	200	177.60	191.60	162.60	170.60	175.60	12.30
Electrical Conductivity EC (µS/cm)	2250	1396.80	1474.20	1316.40	1362.60	1387.50	66.53
Turbidity (NTU)	10	10.20	11.60	12.40	11.90	11.53	0.94
Suspended Solids (mg/L)	100	62.20	63.40	68.74	61.50	63.96	3.28
Total Dissolved Solids (mg/L)	500	927.20	987.50	872.60	862.40	912.43	57.57
Dissolved Oxygen (mg/L)	>4	5.60	5.90	5.20	5.40	5.53	0.30
Biological Oxygen Demand (mg/L)	<3	4.40	5.10	4.10	4.20	4.45	0.45
Chemical Oxygen Demand (mg/L)	250	33.60	34.50	28.90	30.40	31.85	2.64
Total Hardness as $CaCO_3$ (mg/L)	300	342.60	384.20	310.40	334.50	342.93	30.73
Chlorides as Cl^- (mg/L)	600	162.40	212.40	127.60	146.40	162.20	36.36
Fluorides as F^- (mg/L)	1.5	0.48	0.54	0.34	0.42	0.45	0.09
Nitrate Nitrogen as NO_3 –N (mg/L)	10	14.92	13.14	11.20	11.64	12.73	1.68
Phosphates as PO_4^{3-} (mg/L)	5	5.70	6.20	5.20	5.30	5.60	0.45
Sulphates as SO_4^{2-}(mg/L)	400	68.20	73.60	60.60	62.40	66.20	5.90
Sodium as Na (mg/L)	200	90.00	106.20	61.40	74.50	83.03	19.37
Potassium as K (mg/L)	12	11.90	12.70	10.20	11.60	11.60	1.04

Note: pH has no unit

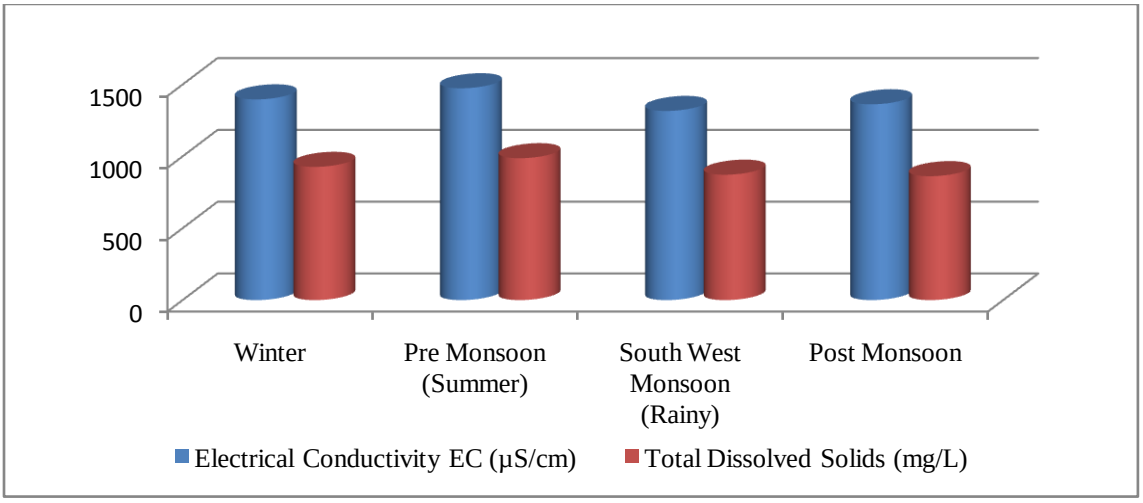

Figure 2: Temporal Variation of EC and TDS

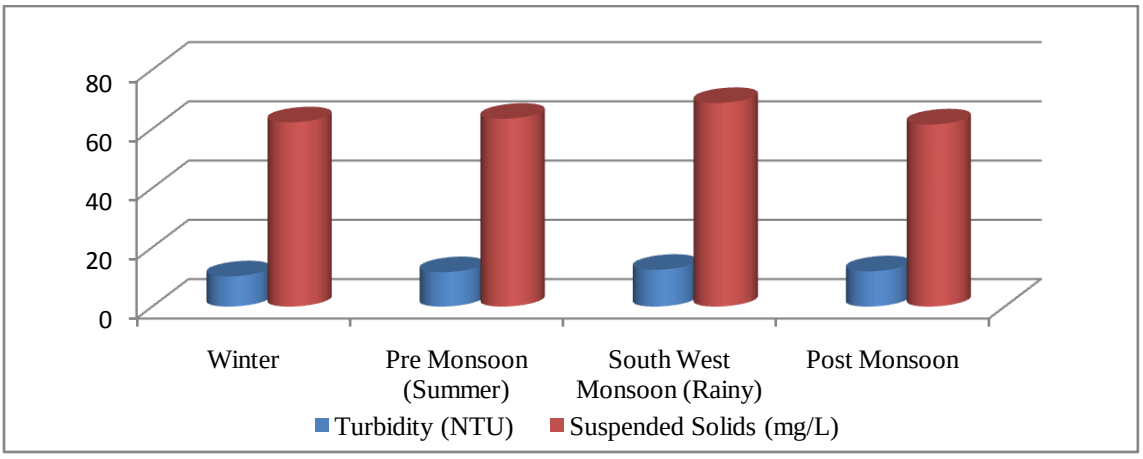

Figure 3: Temporal Variation of Turbidity and Suspended solids

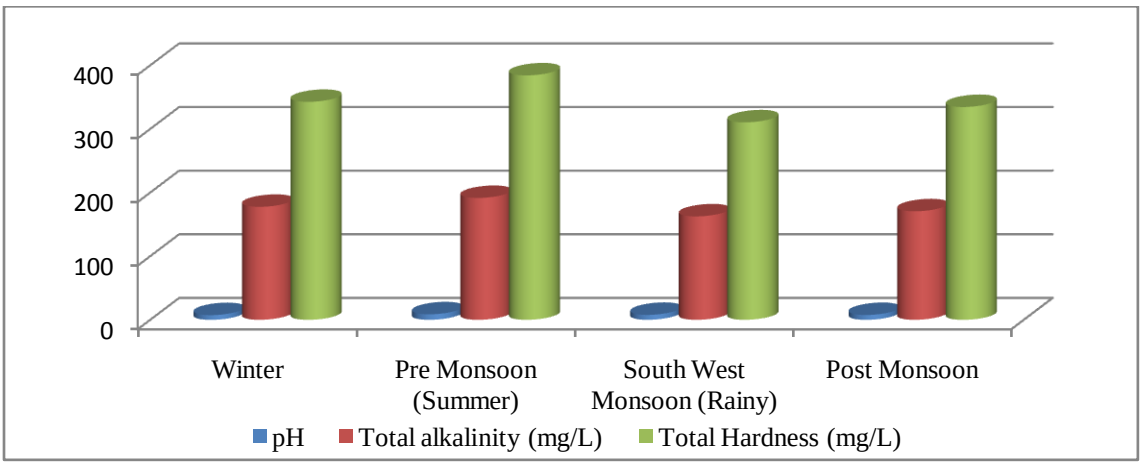

Figure 4: Temporal Variation of pH, Total Alkalinity and Total Hardness

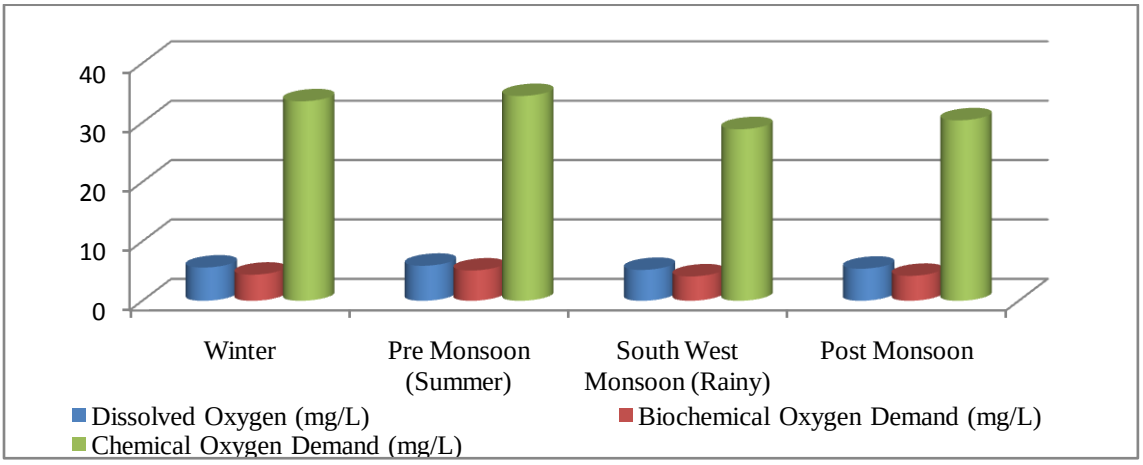

Figure 5: Temporal Variation of DO, BOD and COD

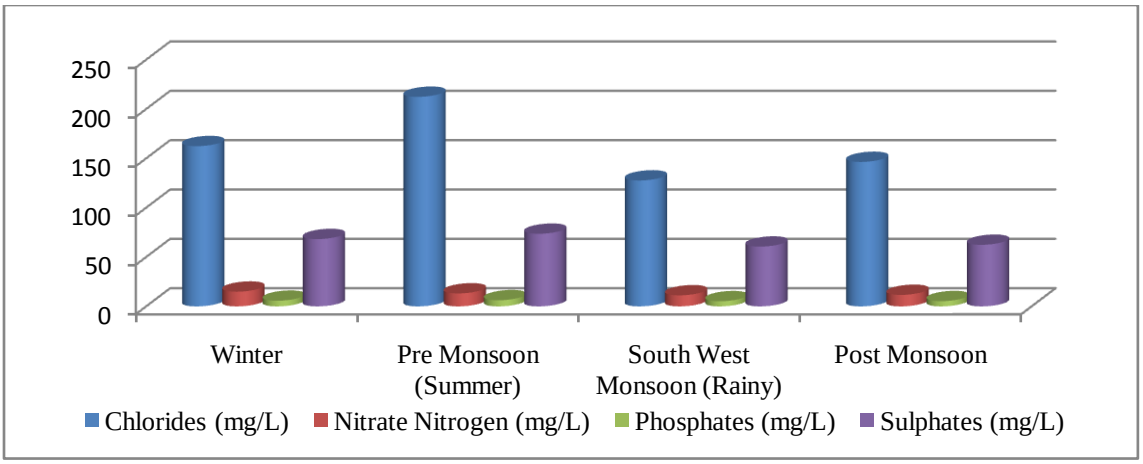

Figure 6: Temporal Variation of Chloride, Nitrate Nitrogen, Phosphate and Sulphates

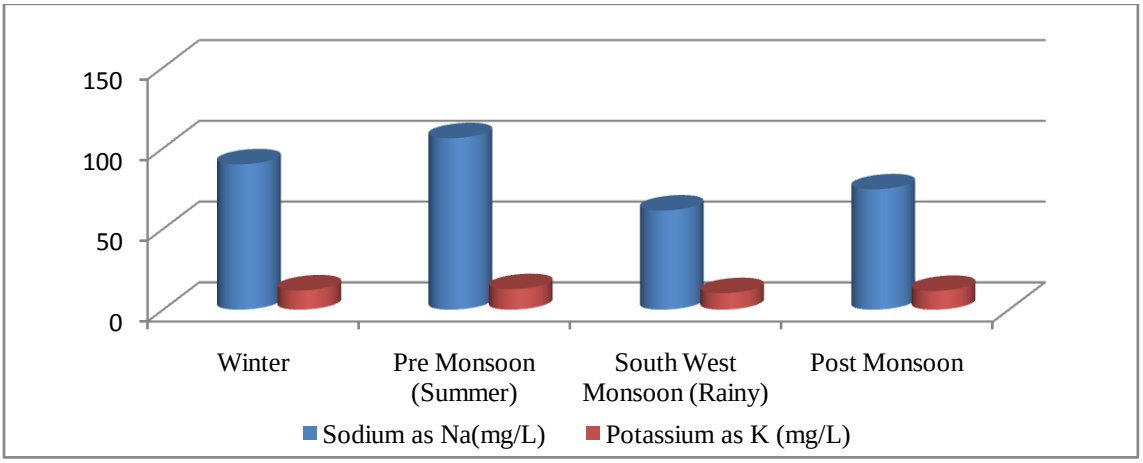

Figure 7: Temporal Variation of Sodium and Potassium

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