RJC
http://www.rasayanjournal.com

RASĀYAN *J. Chem.*
Vol.3, No.4 (2010), 800-810
ISSN: 0974-1496
CODEN: RJCABP

STUDY AND INTERPRETATION OF PHYSICO-CHEMICAL CHARACTERISTIC OF LAKE WATER QUALITY IN NAGPUR CITY (INDIA)

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ABSTRACT

This paper is intended to be a study concerning lake water pollution in Nagpur city, Maharashtra (India). Regional and seasonal variation of some physico-chemical parameters such as nutrients salts, total nitrogen and total phosphorous, in addition, temperature, pH, conductivity, dissolved oxygen (D0), chemical oxygen demand(COD), biological oxygen demand (BOD) and suspended solid (SS) were determined for the estimation of pollution load during the period from January to December 2008. The sampling points were selected on the basis of their importance. A monitoring network was set at representative site in the whole studied area and water samples were taken on a regular basis for laboratory analysis. Important variations have occurred in the investigated area as a result of human activity and discharge of waste water. During present study, Ambazari, Gandhisagar and Futala Lake water showed significant pollution as compared to Gorewada Lake. This is attributable to pollution due to human activities such as immersion of idols of God and Goddess during festival season, surface runoff resulting from rainfall, washing activities and sewage (poor) around Lake. All the calculated water quality parameters in studied lakes showed fair water quality rating in autumn season which then change to medium in rainy season and higher during summer season. The situation is alarming and degradation is in continuous process, therefore immediate action is required for its better management.

Keywords: Lake; water quality; pollution; physico-chemical; surface water; management.

INTRODUCTION

Nagpur city is one of India's fastest growing cosmopolitan city. The city is spread in an area of about 220 Km^2. The road length of city under the Nagpur Municipal Corporation (NMC) is 1200 Km. Nagpur city is situated at an altitude of over 290 meters above sea level rising up to 350 meters towards NW, W and SW of the city [1]. In many areas of Nagpur city tap water supply is not available and people are dependent mainly on the ground water sources. In and around Nagpur city (M.S.), there are large numbers of water bodies. Nag River which is a tributary of Kanhan takes its origin from Ambazari and flows towards east through Nagpur city. The Nag river water is completely polluted on account of draining of sewage into river.[2] Lakes are significant resource base of Nagpur city. Some of these are used to supply water for drinking purpose like Gorewada lake and Wena tank. The water from Futala lake is used for irrigation and water from Ambazari lake is used for industrial purpose. The other water bodies in Nagpur city are, namely, Gandhisagar lake, Naik lake, Lendi lake, Sakkardara lake and Khadan lake. In Naik and Lendi lake, the ingress of sewage from nearby locality is rampant. Both of these lakes have been very much encroached by the weeds. This has been resulted into total degradation of Naik and Lendi lake. The major lakes in Nagpur city which once use to be eco-friendly and useful purposes, have lost their grandeur and have rather becomes a source of nuisance. Thus it is quite imperative to know the quality of status of these lakes water with a view to renovate them so that these serve for a useful purpose to the society. In recent years, there has been considerable research on nutrient dynamics, pollution control (and abatement)

of Lake water bodies. The value and importance of freshwater resources necessitates that they be well managed ecologically for meeting water quality standards.[3] Whether or not drinking water is safe for our health depends on which impurities are present and in what amounts.[4,5,6,7] Lakes play an important role in the, ecology and environmental aspects of the region. Climatic factors are modified by lakes by influencing relative humidity and vegetation of the region. It also acts as re-charger for aquifers. A complex web of fauna and flora is supported by the macroclimatic complex of the lake. These include aquatic well as terrestrial flora and fauna including birds. Many bird sanctuaries are basically supported by lakes and wet land ecosystems providing niche for food web of organism in the ecosystem.[8] All the lakes present in Nagpur city were used for supply of water for various purposes, but, now due to heavy pollutant level, these are no more suitable for human use. India is a country of festivals, therefore the use of flowers, fruits and leaves are unavoidable. During and after festivals like Ganesh chaturthi, Durga puja, Gouri, Mahalaxmi puja, Holi, Rang Panchami etc. the leaves, fruits, flower, ash and even idols of Gods and Goddess are immersed in the water bodies (**Lakes**). During year 2004, about 70 tones of biomass were collected by civic machinery. This material, if not removed, will result in depletion of oxygen due to bio-degradation of waste dumped resulting in anaerobic conditions. If the addition of bio-mass continues, the lake will be converted first into muddy ponds, then to marsh and finally to dry land[9] The present study was undertaken to study the water quality of these lakes and to check out strategy for their renovation either for drinking purpose or for irrigation, development of fisheries, industrial purpose and also to explore the possibility of recharge of these water bodies (lakes) to the ground water. In order to save these water bodies (Lakes), which would serve us as, reservoirs of fresh water, fishes and other products for hundreds of years, the studies on the level of their pollution have been undertaken throughout the year.

The objective of present study were

1. To determine physical, chemical and bacteriological profile of Lakes over an annual cycle, during a period from January to December 2008.
2. To have an overall picture of environmental impacts of pollutants also human action on Gandhisagar, Ambazari, Futala and Gorewada Lake.
3. To interpret the present water quality while submitting recommendation for future lake use and for protecting and improving water quality.

EXPERIMENTAL

Study area

The Gandhisagar, Ambazari, Futala and Gorewada Lakes are within Nagpur city India (Fig 1). The climate in the study area is continental, winter months are cold and rainy and summer is hot and dry.

Sampling and study sites

To characterized water quality throughout the main basin of Lake, four permanent stations for monthly sampling were established and marked within the inflow (S 1), out low (S2), mid-Lake region (S3) and corner (S4). The sampling points were selected on the basis of their importance.

During sampling program, information regarding lake status was collected. Polythene bottles of one liter capacity soared in acid and thoroughly rinsed with distilled water were used for the collection of water samples. The water samples were collected by using a clean stainless steel water sampler which was introduce into the Lake with the help of rope and water taken out. Prior to transferring the water samples the bottles were rinse thoroughly with the water to be sampled. A portion of the samples were immediately filtered through Whatman filter paper No.42 and acidified with 6N nitric acid (8ml/L).The second portion of the sample was utilized for physico-chemical analyses without adding any preservative.[10]

Analytical water quality procedures

Field and laboratory measurement of selected water quality were made during an annual cycle of one year for the session 2008. Temperature and dissolved oxygen were measured using (WTW, Welheim, Germany) field apparatus. Conductivity measurements were made using a Hanna portable conductivity meter. Laboratory samples were stored on ice at 4^0C until transport for analysis. Total nitrogen (TN),

total phosphorous (TP), suspended solid (SS), chemical oxygen demand (COD), biological oxygen demand (BOD) and pH values were determined using standard procedure in accordance with the standard methods[11] For microbiological determination a Sertorius semi – quantitative coliform bacteria system was used. These instruments were used in the limit of precise accuracy and chemicals used were of analytical grade.

RESULTS AND DISCUSSION

Seasonal variations were noted in physico-chemical properties of studied lake water. Different properties like pH, EC, BOD and COD showed maximum value during summer, while minimum values were recorded during autumn season. The observed trends could be attributed to the evaporation of water from studied lakes during summer and subsequent dilution due to precipitation and run – off from catchments area during rainy season.[12,13] Results of water quality parameter analyses of four selected stations from Gorewada Ambazari, Gandhisager and Futala Lake catchments area are depicted in Table 1-12 together with total pollution loads of point sources with their seasonal changes. Parameters are calculated individually as follows.

pH

Hydrogen ion concentration plays an important role in the biological processes of almost all aquatic organisms. Relatively lower pH values at site S1 and S4 may reflect the decreased productivity as a result of polluted water discharge into Futala Lake during winter and summer season. The data of present study reflects increase in pollution at Lake Futala. With some exception, the results of pH values revealed slight variations in its values. Higher pH values of studied lake water during summer could be ascribed to increased photo synthetic assimilation of dissolved inorganic carbon by planktons[14]. A similar effect could also be produced by water evaporation through the loss of half bound CO_2 and precipitation of mono-carbonate[15]. The alkaline pH and high alkalinity of Futala, Ambazari and Gandhisagar lake water might be due to the use of detergents by neighboring population for washing of cloths vehicles and utensils. The pH value in the present investigation showed slightly alkaline condition.

The regional and seasonal variation of pH values in Lakes Gandhisagar, Ambazari, Gorewada and Futala is given in Table 1-12. The pH values in Gorewada Lake water fluctuated from 7.4 to 7.8 in winter, 7.2 to 7.8 in rainy season whereas it varied from 7.9 to 8.3 in summer. For Futala Lake, pH values varied from 7.9 to 8.3 in winter season, 6.1 to 8.6 in rainy season and 6.1 to 9.3 in summer season.The pH values in Gandhisagar Lake water fluctuated from 7.8 to 8.2 in winter, 7.6 to 8.8 in rainy season whereas it varied from 8.3 to 9.1 in summer. For Ambazari Lake, pH values varied from 7.9 to 8.7 in winter season, 6.4 to 8.9 in rainy season and 6.0 to 6.3 in summer season.

Conductivity

It is an index to represent total concentration of soluble salts in water[16]. Electrical conductivity is an estimate of total dissolved salts in water[17] and water with EC values between 2.5 and 10.0mScm^{-1} is not recommended for human consumption and normally not suitable for irrigation[18] except for very salt tolerant crops with special management techniques. Gorewada, Gandhisager and Futala Lake showed higher values of conductivity during summer at studied sites. Measurements in both Lakes showed lower than 2000 μmhos/cm levels even in the highest measured sites of Futala Lake and may be suitable for use as irrigation water. Conductivity long been used as an important parameter in deciding whether water resources are suitable for irrigation water or not.Conductivity values showed seasonal variations. The values of conductivity in Gorewada Lake varied between 424 μmhos/cm to 680 μmhos/cm in winter season, 448 μmhos/cm to 940 μmhos/cm. in rainy season and 690 μmhos/cm to 1149 μmhos/cm during summer season. The values of conductivity in Futala Lake fluctuated between 534 μmhos/cm to 840 μmhos/cm in winter, 586 to 1110 μmhos/cm in rainy season whereas it varied from 784 μmhos/cm to 1264 μmhos/cm during summer. During summer, higher values of conductivity were observed at site S1 in Futala Lake whereas lower values were recorded at site S4 in Gorewada Lake during winter season. The values of conductivity in Gandhisagar Lake varied from 460 μmhos/cm to 695 μmhos/cm in winter

season, 980µmhos/cm to 1600 µmhos/cm in rainy season and 750 µmhos/cm to 1200 µmhos/cm during summer season. The values of conductivity in Ambazari Lake fluctuated between 550 µmhos/cm to 860 µmhos/cm in winter, 620 µmhos/cm to 1000 µmhos/cm in rainy season, whereas it varied from 880µmhos/cm to 1368 µmhos/cm during summer.

Dissolved Oxygen (DO)

The decomposition of organic matter might be an important factor in consumption of DO, as more vigorus deposition could be likely during warm weather, which also witnessed increased inflow of tourists in the region[19].The re-oxygenation of water during monsoon might be occurring due to circulation and mixing by inflow after monsoon rains[20] A good water quality should have solubility of oxygen 7.6 mgL^{-1} and 7.0 mgL^{-1} at 30^0C and 35^0C respectively[21]. The oxygen saturated water has pleasant taste. Gandhisagar, Ambazari, Futala and Gorewada Lake had lowest DO content; < 5 mgL^{-1} pollution is concentrated and magnified. Futala and Gorewada Lakes DO levels were consistently low. It must be concluded that Gandhisagar, Ambazari, Futala Lake is not suitable to support fish life in terms of DO levels. The lowest dissolved oxygen values were recorded in the central part of Gandhisagar, Ambazari, Futala and Gorewada Lake. In summer dissolved oxygen showed lower values than other season which may be due to several factors, the rise in temperature, increased biological activity, respiration of organisms and increased rate of decomposition of organic matter. The studied sites at Futala and Gorewada Lake shows low DO values in summer as expected from the converse relationship of water temperature versus DO content. In Gorewada Lake, dissolved oxygen (DO) fluctuated between 2.2 mgL^{-1} to 4.2 mgL^{-1} during winter season, 2.5 mgL^{-1} to 4.6 mgL^{-1} in rainy season and 2.2 mgL^{-1} to 4.3 mgL^{-1} in summer season. Dissolved oxygen in Futala Lake varied from 1.5 mgL^{-1} to 3.0 mgL^{-1} during winter season, 2.2 to 3.2 mgL^{-1} in rainy season whereas it varied from 1.5 to 3,0 mgL^{-1} in summer season. The solubility of atmospheric oxygen in fresh water ranges from 14.6 mgL^{-1} at 0^0C to about 7.0 mgL^{-1} at 35^0C under one atmospheric pressure. The maximum dissolved oxygen 4.6 mgL^{-1} was recorded at site S4 in Gorewada Lake and minimum 1.5 mgL^{-1} at S3 in Futala Lake. In Gandhisagar Lake, dissolved oxygen (DO) fluctuated between 2.0 mgL^{-1} to 3.1 mgL^{-1} during winter season, 2.2 mgL^{-1} to 3.5 mgL^{-1} in rainy season and 2.0 mgL^{-1} to 3.0 mgL^{-1} in summer season. Dissolved oxygen in Ambazari Lake varied from 1.2 mgL^{-1} to 2.2 mgL^{-1} during winter season, 2.5 to 3.2 mgL^{-1} in rainy season whereas it varied from 1.3 to 2.2 mgL^{-1} in summer season.

Total Nitrogen (TN)

The relatively high concentration of total nitrogen in Gandhisagar, Ambazari and Futala Lake may be due to the relatively lower content of dissolved oxygen that inhibits the rate of chemical oxidation of ammonia. It is seen that under anaerobic conditions, the decomposition of organic matter stepped at the ammonia stage. There was a noticeable variation of total nitrogen in Futala and Gorewada Lake; the lowest total nitrogen content was observed during winter seasons whereas higher values of nitrogen were recorded at various sites in rainy season at Futala and Gorewada Lake. This is probably due to the utilization of NH_4-N by phytoplankton. The total nitrogen content in Gandhisagar, Ambazari and Futala Lake revealed a higher value in rainy season than in the other season, probably due to the effect of huge amounts of drainage water discharged into Lake Futala, as well as decrease in the uptake by phytoplankton. Increase in organic matter decomposition processes is an important source of total nitrogen; on the other hand, lower values of total nitrogen in Lake Futala, Gandhisagar, Ambazari and Gorewada in winter are mostly due to its assimilation by phytoplankton and aquatic plants during spring blooms[22]. Nitrogen and phosphorous level indicates that Futala, Gandhisagar and Ambazari Lake is moderately productive. The present study indicates Futala Lake would be expected to support higher algal production with increased nutrient enrichment. Total nitrogen in present study found to vary from 0.12

mgL^{-1} to 0.34 mgL^{-1} in winter season, 0.09 mgL^{-1} to 0.41 mgL^{-1} in rainy season and 0.14 mgL^{-1} to 0.42 mgL^{-1} in summer season at Gorewada Lake. Highest values of total nitrogen was recorded as 0.42 mgL^{-1} in site S1 in summer and lowest 0.09 mgL^{-1} at site S3 during rainy season of Gorewada Lake. Total nitrogen concentration in Futala Lake was fluctuated between 0.28 mgL^{-1} to 1.79 mgL^{-1} in winter, 0.76 mgL^{-1} to 1.66 mgL^{-1} in rainy season whereas 0.22 mgL^{-1} to 1.78 mgL^{-1} in summer season. Futala Lake had highest load 1.79 mgL^{-1} at site S4 in winter season and lowest load 0.22 mgL^{-1} at site S3 in summer season.Total nitrogen in present study found to vary from 0.32 mgL^{-1} to 0.88 mgL^{-1} in winter season, 0.23 mgL^{-1} to 0.54 mgL^{-1} in rainy season and 0.18 mgL^{-1} to 0.45 mgL^{-1} in summer season at Gandhisagar Lake. Total nitrogen concentration in Ambazari Lake was fluctuated between 0.33 mgL^{-1} to 1.12 mgL^{-1} in winter, 0.88 mgL^{-1} to 1.68 mgL^{-1} in rainy season whereas 0.26 mgL^{-1} to 1.94 mgL^{-1} in summer season.

Total coliform

The purpose of the total coliform counts in water bodies was to estimate the number of coliforms in water samples as an index of magnitude of biological contamination. Total coliform counts in water bodies are an important parameter for checking possible sewage contamination. Measurements in Lake Futala during rainy season showed that total coliform counts increased considerably during summer months. During summer season, higher values of total colonies were observed at all sites in Gandhisagar, Ambazari and Futala Lake. The higher values in total coliform and counts most probably arise from untreated wastewater discharged into Futala Lake from time to time even though the facility does have a biological treatments plant. The presences of coliform organism are taken as an indication that pathogenic organism may also present and absence of coliform organism is taken as indication that water is free from diseases producing organism. From present study, it is revealed that in Gorewada Lake, total coliform counts were low in winter season and very high in summer and rainy season. The present study indicates that bacteriological pollution was highest in Futala Lake at site S1, S2 and S4 respectively in summer. Futala Lake was the highest with a load of 1242 total coliforms/100ml.Gorewada Lake was the second highest with 1210 coliforms/100ml at site S4 during summer season.

Biological Oxygen Demand (BOD)

BOD is a value of presence of organic materials in water which can support increasing of microbe organisms. Surface water (river, lake) containing BOD values 10 mgL^{-1} are consider to be moderately and more than 20 mgL^{-1} as to be highly polluted water[23]. The greater the decomposable matter present, greater the oxygen demands and greater the BOD values[24]. The regional distribution of BOD in Gorewada Lake varied between 8.0 mgL^{-1} to 18 mgL^{-1} in winter, 12 mgL^{-1} to 27 mgL^{-1} in rainy season and 12.0 mgL^{-1} to 34.0 mgL^{-1} in summer. The seasonal average concentration of BOD in Futala Lake fluctuate between 16.0 mgL^{-1} to 38 mgL^{-1} in winter, 16 mgL^{-1} to 54 mgL^{-1} in rainy season and 28.0 mgL^{-1} to 76 mgL^{-1} in summer. Seasonal variation show upward trend at all sites in Gorewada and Futala Lake. Futala Lake had highest load 76 mgL^{-1} at site 52 in summer. BOD variations depends on variable of dissolved oxygen and oxidizable organic matter. Lowest BOD content as 16 mgL^{-1} at site S3 was recorded during winter and rainy season. In Gorewada Lake, highest values were recorded at 34 mgL^{-1} at site S2 during summer whereas lowest content 8.0 mgL^{-1} at site S3 during winter season. The regional distribution of BOD in Gandhisagar Lake varied between 24 mgL^{-1} to 48 mgL^{-1} in winter, 24 mgL^{-1} to 40 mgL^{-1} in rainy season and 32.0 mgL^{-1} to 48.0 mgL^{-1} in summer. The seasonal average concentration of BOD in Ambazari lake fluctuate between 16.0 mgL^{-1} to 48 mgL^{-1} in winter, 14 mgL^{-1} to 45 mgL^{-1} in rainy season and 28 mgL^{-1} to 80 mgL^{-1} in summer.

Total Phosphorous (TP)

Phosphorous is an important element which controls the reproduction and growth of aquatic organisms. Many organisms utilize both organic and inorganic forms of phosphorus; however inorganic phosphorus seems to be more appreciated by plants than organic phosphorus. It is interesting to note that increasing values were noted in rainy and summer seasons. The higher concentration of reactive phosphate is mostly due to effect of sewage, domestic water enriched with phosphorus compounds. The present study indicates that incoming surface runoff, sewage (poor) and sediments, add adsorbed phosphorous to Gandhisagar, Ambazari and Futala Lake, some of which is available for algal growth. The Futala Lake would be expected to support higher algal production with increased nutrients enrichments. In contrast, the mentioned parameter reveals a significant decrease during the winter on the basis of increased uptake by phytoplankton in Futala and Gorewada Lake. The high total phosphorous levels in Futala Lake environs could possibly result from agricultural fertilizers, domestic waste water and surface runoff from botanical garden reaching Futala Lake by rain drainage. The second highest level found in Gandhisagar and Futala Lake could be due to closely located slum area housing wastewater and detergent discharge to Lake. Gorewada, Gandhisagar and Futala Lake show different loads depending on origin. The total loads by Lake generally are a function of discharge with few exceptions. Total phosphorous in Gorewada Lake has been found in between 0.08 mgL^{-1} to O.21 mgL^{-1} winter, 0.12 mgL^{-1} to 0.72 mgL^{-1} in rainy season and O.14 mgL^{-1} to 0.82 mgL^{-1} in summer. Total phosphorous in Gorewada Lake showed maximum concentration as 0.82 mgL^{-1} at S4 and minimum concentration as 0.08 mgL^{-1} at site S3 during summer and winter season respectively. The highest and lowest values such as 0.96 mgL^{-1} and 0.18 mgL^{-1}, were recorded at site S4 and site S3 in Futala Lake respectively. Total phosphorous in Gandhisager Lake has been found in between 0.09 mgL^{-1} to O.24 mgL^{-1} in winter, 0.12 mgL^{-1} to 0.66 mgL^{-1} in rainy season and O.26 mgL^{-1} to 0.62 mgL^{-1} in summer.

Suspended Solid (SS)

As can be seen in Table 1- 12, the maximum suspended solid (SS) pollution load observed at site S1 in Lake Futala and follows with a load which is less than the half of it, at site S2 S3 and site S4 of Lake Gorewada. The reason for such a high amount of suspended solid from Futala, Gandhisagar, Ambazari Lake would possibly organic from the erosion coming from immediate vicinity because areas near Futala, Gandhisagar and Ambazari Lake are barren, unforested land, therefore, the adverse effects of surface runoff, immersion of idols of God and Goddess during festival may cause increase in suspended solid levels. When seasonal variation is examined, suspended solid increases in rainy seasons because of increase in household waste water. Gorewada Lake has lowest SS load as in the case of other observed parameters since it is rehabilitated. Total suspended solid is comprised of organic and mineral particles that are transported in the water column. TSS is closely linked to land erosion and to erosion of Lake channels. Suspended solid values in Gorewada Lake varied from 22 mgL^{-1} to 51 mgL^{-1} in winter, 28 mgL^{-1} to 68 mgL^{-1} in rainy season and 48 mgL^{-1} to 110 mgL^{-1} in summer season. Suspended solid concentration was found to be highest as 110 mgL^{-1} and the lowest 22 mgL^{-1} at site S1 and site S3 respectively. Suspended solid concentration varied from 84 to 166 mgL^{-1} in winter, 72 to 2 1 0 mgL^{-1} in rainy season whereas 184 to 386 mgL^{-1} in summer season in Lake Futala. The highest value was recorded 386 mgL^{-1} at site S1 during summer season and lowest value 72 mgL^{-1} at site S3 in Futala Lake during rainy season. Suspended solid values in Gandhisager Lake varied from 90 mgL^{-1} to 210 mgL^{-1} in winter, 60 mgL^{-1} to 100 mgL^{-1} in rainy season and 154 mgL^{-1} to 200 mgL^{-1} in summer season. Suspended solid concentration was found to be highest as 110mgL^{-1} and the lowest 22 mgL^{-1} at site S1 and site S3 respectively. In Ambazari,Lake ,suspended solid concentration varied from 98 to 170 mgL^{-1} in winter, 70 to mgL^{-1} in rainy season whereas 244 to mgL^{-1} in summer season. The highest value was recorded mgL^{-1} at site S1 during summer season and lowest value mgL^{-1} at site S1 during rainy season in Ambazari and Gandhisagar Lake respectively.

Temperature

The various chemical and biological reactions in water depend to a great extent on temperature. The observed values of temperature indicate that the water quality would be certainly affected by this parameter. In the present study, it is found that, the minimum temperature of Gandhisagar, Ambazari, Futala and Gorewada Lake water were noted in winter and maximum during summer season which is due to greater solar radiation and higher atmospheric temperature due to high water level[25].

Chemical Oxygen Demand (COD)

The maximum permissible value of COD is 10 mgL^{-1} for drinking water.[26] Chemical oxygen demand of all the water samples collected from Gorewada and Futala Lake exceeds the limit. Chemical oxygen demand level in Gorewada Lake varied from 26 mgL^{-1} to 78 mgL^{-1}. COD values fluctuated between 26 mgL^{-1} to 39 mgL^{-1} in winter season, 38 mgL^{-1} to 64 mgL^{-1} during rainy season and 44 mgL^{-1} to 78 mgL^{-1} in summer in Gorewada Lake. Chemical oxygen demand in the present study, especially in Futala Lake varied from 52 mgL^{-1} to 114 mgL^{-1} in winter, 54 mgL^{-1} to 158 mgL^{-1} in rainy se ason and 75 mgL^{-1} to 216 mgL^{-1} in summer season. Chemical oxygen demand level in Gandhisagar Lake varied between 68 mgL^{-1} to 110 mgL^{-1}. COD values fluctuated between 60 mgL^{-1} to 90 mgL^{-1} in winter season, 88 mgL^{-1} to 168 mgL^{-1} ,during rainy season and mgL^{-1} to 120 mgL^{-1} in summer season. Chemical oxygen demand in the present study, especially in Ambazari Lake varied from 80 mgL^{-1} to 120 mgL^{-1} in winter, 34 mgL^{-1} to 130 mgL^{-1} in rainy season and 90 $mgL^{-1}$to 210 mgL^{-1} in summer season.In the present study, it is found that, all water samples collected from Futala, Gandhisagar, Ambazari and Gorewada Lake were beyond limit. These higher values indicated that Futala, Gandhisagar, Ambazari Lake were rich either with respect to some dissolved organic compounds or oxidisable inorganic substances. The highest COD is carried to Futala Lake; possible cause of this could be illegal discharge of slaughter house waste, dumping of garbage, (poor) sewage, and surface runoff to Futala Lake. Examination of seasonal changes in COD loads showed insignificant changes in Gorewada Lake. The studied sites in Futala, Gandhisagar, Ambazari Lake showed a general increase in COD in summer and rainy season. This is an indication of increased organic loads due to increased household wastewater and waste discharges.

CONCLUSION

Various physico-chemical parametes in studied lakes showed distinct, temporal and spatial variations throughout study period. Lake water quality parameters undergo seasonal changes and values are generally higher during summer season. The present study has shown that Futala, Ambazari, Gandhisager and Gorewada lakes are much more polluted in terms of various physico-chemical parameters such as BOD and nutrients. The BOD and COD pollution in studied lakes are higher throughout the year despite the dilution effect experienced in the rainy season. In the present study, it is found that water quality problems associated with Futala, Gandhisagar, Ambazari Lake includes severe dissolved oxygen depletion, poor water clarity and high level of algae growth, nuisance blue green algae blooms and dense beds of aquatic microphyte. Futala Lake have higher suspended solid as compared to Gorewada Lake. The physico-chemical parameter of Gorewada Lake is reasonable but in case of Futala Lake, quality of water is no longer good to support micro flora and fauna. Futala, Ambazari and Gandhisager Lake have declined in aesthetic quality at present situation following invasion of aquatic weeds such as hydrilia and water primrose. The discharges of sewage (poor), surface runoff resulting from rainfall, immersion of idols of God and Goddess during festival season and dumping of garbage, washing, recreational activities have contributed considerable pollution in Gandhisagar, Ambazari and Futala Lake, therefore, serious steps should be taken to remove this pollution There is therefore a need to properly manage wastes in the city and control as well as monitor human activities in order to ensure that such activities have minimal negative effects on lakes present within Nagpur city. Awareness, proper understanding, planning and management of environmental resources are essential to prevent environmental degradation of these surface water resources (lakes).

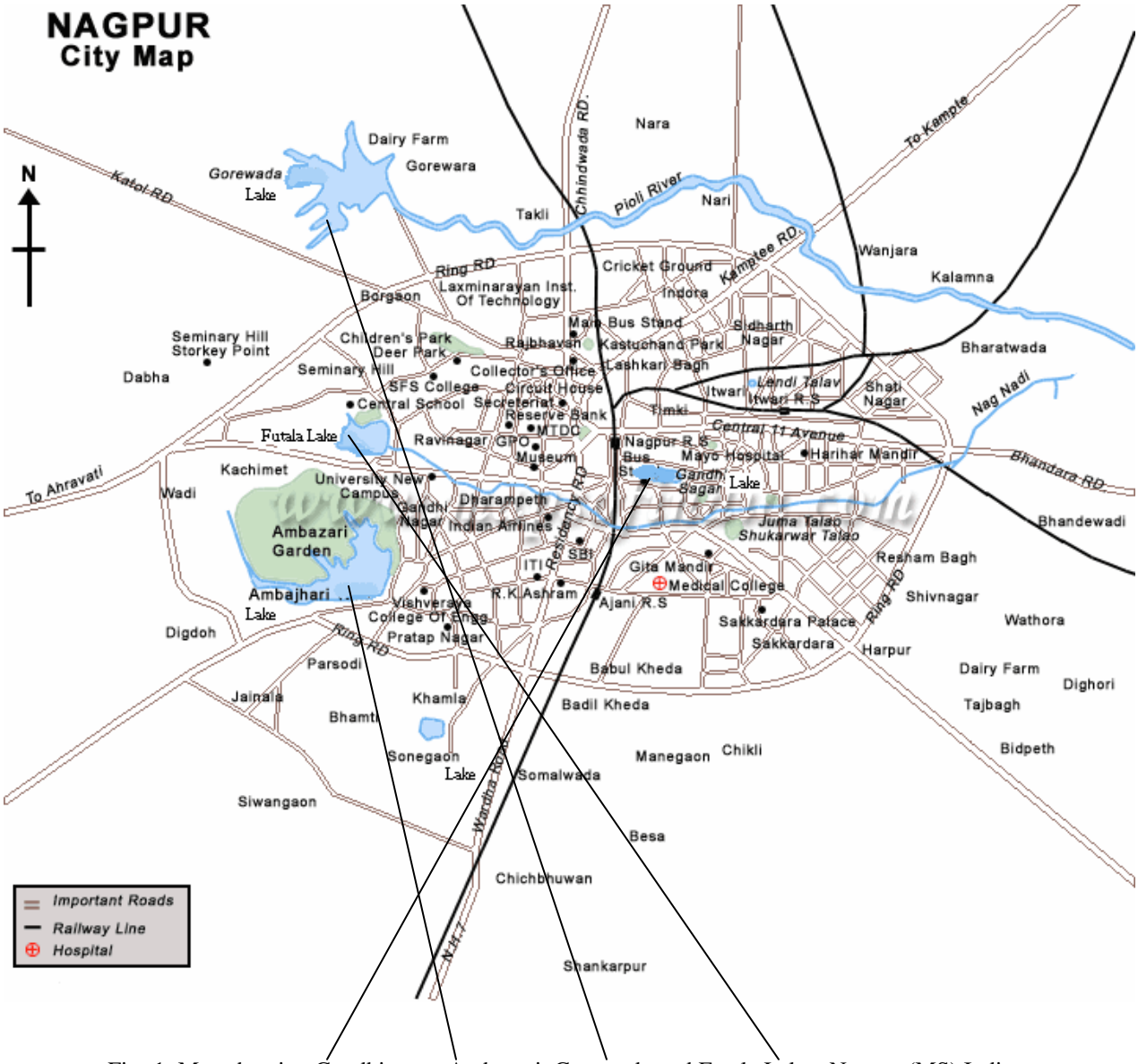

Fig.-1: Map showing Gandhisagar, Ambazari, Gorewada and Futala Lake , Nagpur (MS) India.

ACKNOWLEDGMENTS

The authors, hereby, acknowledge the kind and wholehearted support of the Director, Dr. S. B. Gholse (Professor), LIT, RTM Nagpur University, Nagpur.

Table-1: Water quality data collected and average pollution loads from four stations in the Gorewada Lake during winter season for the session 2008-2009

Reference Station/ 100ml	pH	Temp (^{0}C)	Conductivity (µmhos/cm)	DO (mg/L)	COD (mg/L)	BOD (mg/L)	Total P(mg/L)	SS (mg/L)	TN (mg/L)	Total Coliforms
S1	7.6	23.4	680	3.2	39	14	0.16	51	0.28	823
S2	7.4	22.2	560	2.2	32	10	0.12	38	0.22	428
S3	7.4	21.4	536	3.1	26	8	0.08	22	0.12	348
S4	7.8	20.2	424	4.2	34	18	0.21	32	0.34	960

Table-2: Water quality data collected and average pollution loads from four stations in the Gorewada Lake during rainy season for the session 2008-2009

Reference Station/ 100ml	pH	Temp (^{0}C)	Conductivity (µmhos/cm)	DO (mg/L)	COD (mg/L)	BOD (mg/L)	Total P(mg/L)	SS (mg/L)	TN (mg/L)	Total Coliforms
S1	7.8	30.2	940	4.1	46	20	0.21	68	0.32	848
S2	7.5	31.2	670	2.5	52	16	0.12	56	0.18	830
S3	7.2	29.4	580	3.2	38	12	0.14	34	0.09	390
S4	7.6	30.6	448	4.6	64	27	0.72	28	0.41	1180

Table-3: Water quality data collected and average pollution loads from four stations in the Gorewada Lake during summer season for the session 2008-2009

Reference Station/ 100ml	pH	Temp (^{0}C)	Conductivity (µmhos/cm)	DO (mg/L)	COD (mg/L)	BOD (mg/L)	Total P(mg/L)	SS (mg/L)	TN (mg/L)	Total Coliforms
S1	7.9	38.3	1130	4.3	68	27	0.23	110	0.42	926
S2	8.1	40.4	1149	2.2	70	34	0.14	90	0.27	1120
S3	8.3	39.9	690	3.0	44	12	0.26	82	0.14	464
S4	8.0	40.5	786	4.1	78	28	0.82	48	0.12	1210

Table-4: Water quality data collected and average pollution loads from four stations in the Futala Lake during winter season for the session 2008-2009

Reference Station/ 100ml	pH	Temp (^{0}C)	Conductivity (µmhos/cm)	DO (mg/L)	COD (mg/L)	BOD (mg/L)	Total P(mg/L)	SS (mg/L)	TN (mg/L)	Total Coliforms
S1	8.3	24.7	840	2.2	114	27	0.28	166	0.58	842
S2	8.0	23.2	670	2.0	64	20	0.21	120	0.39	436
S3	7.9	24.6	580	1.5	52	16	0.18	84	0.28	376
S4	8.1	22.4	534	3.0	90	38	0.76	92	1.79	1110

Table-5: Water quality data collected and average pollution loads from four stations in the Futala Lake during rainy season for the session 2008-2009

Reference Station/ 100ml	pH	Temp (^{0}C)	Conductivity (µmhos/cm)	DO (mg/L)	COD (mg/L)	BOD (mg/L)	Total P(mg/L)	SS (mg/L)	TN (mg/L)	Total Coliforms
S1	6.3	30.1	1110	3.0	158	54	0.38	190	1.66	916
S2	8.6	28.4	980	2.2	90	32	0.24	210	1.54	812
S3	8.2	29.1	720	3.2	54	16	0.22	72	1.32	432
S4	6.1	30.4	586	2.4	86	28	0.96	110	0.76	1192

Table-6: Water quality data collected and average pollution loads from four stations in the Futala Lake during summer season for the session 2008-2009

Reference Station/ 100ml	pH	Temp (^{0}C)	Conductivity (µmhos/cm)	DO (mg/L)	COD (mg/L)	BOD (mg/L)	Total P(mg/L)	SS (mg/L)	TN (mg/L)	Total Coliforms
S1	6.1	44.2	1264	2.2	172	64	0.35	386	0.74	1112
S2	6.5	42.8	1190	1.5	216	76	0.21	320	0.32	1136
S3	8.8	43.3	784	3.0	75	28	0.32	184	0.22	590
S4	9.3	45.2	838	2.0	96	30	0.96	235	1.78	1242

Table-7: Water quality data collected and average pollution loads from four stations in the Gandhisagar Lake during winter season for the session 2008-2009

Reference Station/ 100ml	pH	Temp (^{0}C)	Conductivity (µmhos/cm)	DO (mg/L)	COD (mg/L)	BOD (mg/L)	Total P(mg/L)	SS (mg/L)	TN (mg/L)	Total Coliforms
S1	7.8	25.8	695	3.0	68	44	0.24	90	0.42	800
S2	7.9	23.0	568	2.0	80	48	0.12	116	0.32	1000
S3	8.1	22.8	580	2.4	97	24	0.09	188	0.46	1012
S4	8.2	21.9	460	3.1	110	30	0.22	210	0.88	1140

Table-8: Water quality data collected and average pollution loads from four stations in the Gandhisagar Lake during rainy season for the session 2008-2009

Reference Station/ 100ml	pH	Temp (^{0}C)	Conductivity (µmhos/cm)	DO (mg/L)	COD (mg/L)	BOD (mg/L)	Total P(mg/L)	SS (mg/L)	TN (mg/L)	Total Coliforms
S1	7.6	30.2	1000	3.5	60	24	0.12	60	0.18	1000
S2	7.8	29.8	980	2.2	60	28	0.16	78	0.54	925
S3	8.8	28.5	1140	3.0	70	34	0.18	100	0.38	980
S4	8.0	29.4	1600	3.4	90	40	0.66	95	0.23	1060

Table-9: Water quality data collected and average pollution loads from four stations in the Gandhisagar Lake during summer season for the session 2008-2009

Reference Station/ 100ml	pH	Temp (^{0}C)	Conductivity (µmhos/cm)	DO (mg/L)	COD (mg/L)	BOD (mg/L)	Total P(mg/L)	SS (mg/L)	TN (mg/L)	Total Coliforms
S1	8.3	38.2	1145	3.0	88	38	0.38	148	0.45	1000
S2	8.4	39.1	1200	2.5	100	48	0.26	154	0.38	1160
S3	8.9	39.2	750	2.0	168	40	0.38	200	0.26	590
S4	9.1	40.0	895	2.4	94	32	0.62	168	0.18	1318

Table-10: Water quality data collected and average pollution loads from four stations in the Ambazari Lake during winter season for the session 2008-2009

Reference Station/ 100ml	pH	Temp (^{0}C)	Conductivity (µmhos/cm)	DO (mg/L)	COD (mg/L)	BOD (mg/L)	Total P(mg/L)	SS (mg/L)	TN (mg/L)	Total Coliforms
S1	8.7	25.3	860	2.1	120	30	0.21	170	0.22	9890
S2	8.2	24.2	690	1.9	80	25	0.31	140	0.45	500
S3	7.9	23.2	580	1.2	68	16	0.12	98	0.33	460
S4	8.3	23.0	550	2.2	110	48	0.84	120	1.12	1024

Table-11: Water quality data collected and average pollution loads from four stations in the Ambazari Lake during rainy season for the session 2008-2009

Reference Station/ 100ml	pH	Temp (^{0}C)	Conductivity (µmhos/cm)	DO (mg/L)	COD (mg/L)	BOD (mg/L)	Total P(mg/L)	SS (mg/L)	TN (mg/L)	Total Coliforms
S1	6.4	30.2	1000	3.2	130	45	0.33	200	1.68	1110
S2	8.9	28.5	784	2.5	82	36	0.22	210	1.28	990
S3	8.0	29.5	740	3.1	34	14	0.21	70	1.36	638
S4	6.4	30.5	620	2.8	80	24	0.82	100	0.88	1284

Table-12: Water quality data collected and average pollution loads from four stations in the Ambazari Lake during summer season for the session 2008-2009

Reference Station/ 100ml	pH	Temp (^{0}C)	Conductivity (µmhos/cm)	DO (mg/L)	COD (mg/L)	BOD (mg/L)	Total P(mg/L)	SS (mg/L)	TN (mg/L)	Total Coliforms
S1	6.0	44.2	1368	2.1	180	65	0,.36	420	0.88	1140
S2	6.3	44.8	1250	1.3	210	80	0.25	360	0.32	1184
S3	6.0	45.2	880	2.2	90	28	0.32	244	0.26	685
S4	6.0	45.2	900	1.6	112	38	0.98	310	1.94	1340

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[RJC-692/2010]