Journal of Applied Geochemistry
Vol.12 No.2 (2010) pp 261-271

WATER QUALITY STUDIES OF HOSKEREHALLI LAKE OF BANGALORE, KARNATAKA

N. Latha and M. Ramachandra Mohan
Lake Management and Water Quality Research Unit
Department of Zoology, Bangalore University, Bangalore-560 056

Abstract

The aim of the current study was to evaluate the status of the Hoskerehalli lake water with respect to different physicochemical parameters [pH, temperature, total dissolved solids (TDS), turbidity, electrical conductivity (EC), total hardness (TH), alkalinity, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), phosphate, sulphate, nitrate and potassium] during the year 2005. These parameters were compared with water quality standards to indicate probable pollution. However, the overall water quality of the lake remained within the safe limits throughout the study period. Correlation coefficient matrix between each parameter were estimated to throw light on relationship between different physicochemical parameters under investigation, few parameters like pH – temperature ($r = 0.712$), TDS – turbidity ($r = 0.800$), TDS – conductivity ($r = 0.988$), turbidity – conductivity ($r = 0.781$), temperature – alkalinity ($r = 0.822$), sulphate – potassium ($r = 0.724$) showed good positive correlation. The lake water quality is good and fit for irrigation and fish culture purpose.

Keywords : Limnology, Hoskerehalli lake, Physicochemical Parameters, Water quality.

1. Introduction

Water is an essential component for survival of life on Earth, which contains minerals, important for human beings as well as plant and aquatic life (Versari et al., 2002). Lakes and surface water reservoirs are the planet's most important freshwater resources which provide innumerable benefits. They are used for domestic and irrigation purposes and provide ecosystem for aquatic life especially fish, thereby functioning as a source of essential protein and significant elements for the world's biological diversity. They are source of important social and economic benefits as a result of tourism, recreation and are culturally, aestically important for people throughout the world. These surface water bodies also play an equally important role in flood control (An et al., 2002). However, the remarkable increase in population resulted in a considerable consumption of the water reserves worldwide (Ho et al., 2003). The quality of surface water is largely affected by natural processes (weathering and soil erosion) as well as anthropogenic inputs (municipal and industrial waste water discharge). The anthropogenic discharges represent a constant polluting source, whereas surface runoff is a seasonal phenomenon largely affected by climate (Singh et al., 2004 and Vega et al., 1996).

The quality of water is now the concern of experts in all countries of the world. The decision of WHO 29th Session (May 1976) emphasis that water delivered to the consumer should meet the high requirement of modern hygiene and should at least be free from pathogenic organisms and toxic substance. Also, the quality of water depends on the location of the source and the state of environmental protection in a given area. Therefore, the quality and the nature of water are determined by physical and chemical analysis (Voznoya, 1983).

Aquatic ecosystems are much too complex and integrated to be simply regulated by a single nutrient. Metabolism, growth, productivity and behavior are certainly regulated by many organic compounds in addition to traditional macrofactor controls, example: major nutrients (Wetzel, 2000).

The continuing increase in global population is increasing the demand on freshwater supply. One important factor affecting freshwater availability is associated with socioeconomic development and another factor is the general lack of sanitation and waste treatment facilities in high population areas of developing countries. A principle cause of water scarcity is water quality degradation, which can critically reduce the amount of freshwater available for potable, agriculture and industrial use. Thus, the quantity of available freshwater is closely linked to the quality of the water, which may limit its use.

Land alteration and associated changes in vegetation have not only changed the water balance, but typically have altered processes that control water quality as number of factors influence water chemistry. Gibbs (1970) proposed that rock weathering, atmospheric precipitation, evaporation and crystallization control the chemistry of surface water. The influence of geology on chemical water quality is widely recognized (Lester and Birkett, 1999). The influence of soils on water quality is very complex and can be ascribed to the processes controlling the exchange of ions between the soils and water (Hesterberg, 1998). Apart from natural factors influencing water quality, human activities such as domestic and agricultural practices impact negatively on water quality. It is therefore important to carry out water quality assessment for sustainable management of water bodies.

The quality of water is described by its physical, chemical and microbial characteristic. But, if some correlations are possible among these parameters, then the more significant ones would be useful to indicate fairly the quality of water (Dhembare and Pondhe, 1997). A systematic study of correlation and regression coefficients of the quality parameter not only helps to assess the overall water quality but also to quantify relative concentration of various pollutants in water and provide necessary clue for implementation of rapid water quality management programmes (Dash et al., 2006). The correlation provides an excellent tool for the prediction of parametric values within a reasonable degree of accuracy (Gajendran and Thamarai, 2008). This study serves to determine the water quality of Hoskerehalli lake. It provides the physicochemical characteristics of water and finally contribute towards the limnological knowledge of the lake.

2. Study Site

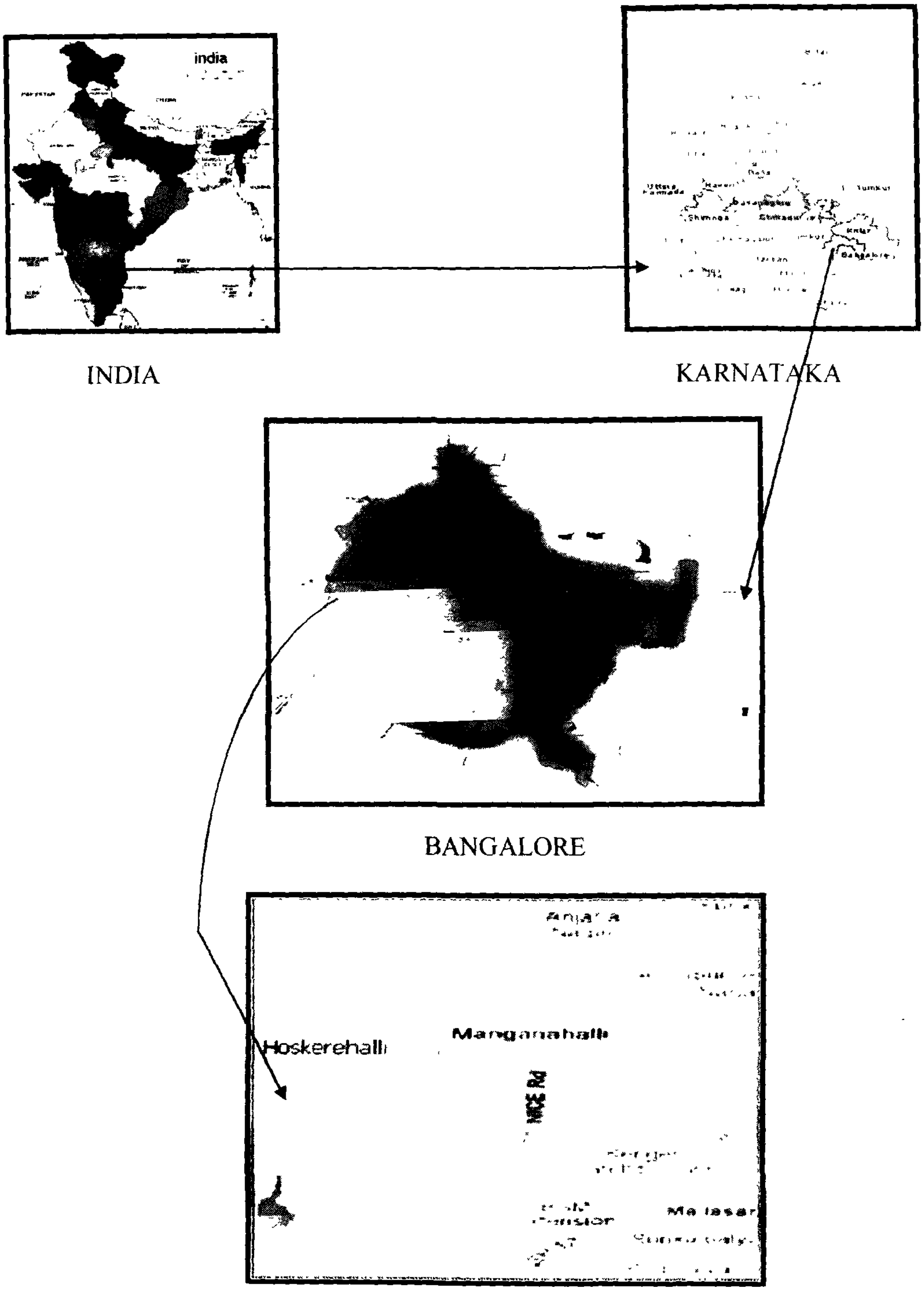
Hoskerehalli is a shallow natural water lake of Hoskerehalli village situated at a distance of about 4Km from the Kengeri Satellite town, Bangalore (12^0 56$^\backslash$ 109$^{\backslash\backslash}$ N latitude 077^0 26$^\backslash$ 196$^{\backslash\backslash}$E longitude) (Fig. 1). The mean depth of the lake is approximately 2.5-3.5m and covers an area of 17 hectares. It is a huge natural depression flanked by the forest range in the north and lake bund at the south. Agricultural land surrounds the east and west side. Flood barrier has been constructed on the sides of lake. The human activities have been significantly changing the original regime of the lake over the last 50 years.

3. Materials and Methods

Water samples from Hoskerehalli lake were collected from January 2005 to December 2005. All the sample collections and observations were made between 08.00A.M. to 12.00Noon. throughout the study period twice every month. The water samples collected from the lake in bottles were brought to the laboratory and the parameters studied comprised TDS, turbidity, electrical conductivity, total hardness, total alkalinity, dissolved oxygen, biological oxygen demand, chemical oxygen demand, phosphates, sulphates, nitrates and potassium as per the standard methods described by APHA (1985), Trivedy and Goel (1986), Mathur (1999). While pH and temperature were noted on spot at the time of sampling

3.1 Laboratory Studies

pH values were obtained using pH scan, W.P. 1.2 (Eutech instruments, Singapore) and pH metre (Elico, Modle, Lil 20). Temperatures were recorded in field by OAKTON Thermometer (made in China) and values were expressed in 0^0C. TDS of



12^0 56 109' N latitude, 077^0 26' 196' E longitude

Fig. 1. Showing the Location of Hoskerehalli Lake.

water samples measured by drying temperature at $103^0 - 105^0C$ temperature and values were expressed in mg/l. Turbidity of water is estimated by Spectrophotometer (P.C. Spectra) and values were expressed in FAU units (Formazin Attenuation units). Electrical conductivity (EC) of water is measured using (Elico-P.E. 132) and values were expressed in µmhos/cm. Total hardness of water is estimated by titrating the water samples with standard EDTA (O.OIN) using buffer solution and Erichrome black-T indicator and the values were presented in mg/l. Dissolved oxygen (DO) content of water was estimated by modified Winkler's method, the results were expressed in mg/l. Biological oxygen demand (BOD) was estimated by incubating the water samples at 20^0C for five days in the dark under aerobic conditions and the values were expressed in mg/l. Total alkalinity was determined by titrometric method using hydrochloric acid and thus carbonate and bicarbonate alkalinity was calculated, the values were presented in mg/l. Chemical oxygen demand (COD) estimated by dichromate oxidation method and the results were expressed in mg/l. Phosphates of water samples were estimated by spectrophotometric method at 470nm and values were expressed in mg/l. Sulphates of water samples were measured by spectrophotometric method at 420nm and values were expressed in mg/l. Nitrate of water is estimated by titrating the water samples with Phenol-disulphonic acid using Beer's law and the values were presented in mg/l. Potassium of water samples was measured by Flame photometer method at 769nm and values were expressed in mg/l.

4. Statistical Analysis

Pearson's rank correlation was used to establish relations between parameters; all tests were two-tailed. The analyses were executed by SPSS (version 12 for windows-2003).

5. Results and Discussion

The results of the physico-chemical analysis of water samples from Hoskerehalli lake are given in Table 1. Pearson's correlation matrix of the physico-chemical of water samples from Hoskerehalli lake are given in Table 2. The parameters showing a good positive correlation are represented in the graph which is presented as Fig. 2.

pH is an important factor in measuring water quality since every aspect of water like acid and base neutralization, water softening, precipitation, coagulation, acid disinfection is pH dependent. High pH value of 8.4 was recorded in March and lower as 7.8 in December. Aquatic organisms are affected by pH because of their metabolic activities that are pH dependent (Wang et al., 2002). Optimal pH range for sustainable aquatic life is PH 6.5-8.2 (Murdock et al., 2001). The pH recorded was within this optimal level. However, if urbanization continues, in and around the waterbody, the increase or decrease in pH levels will have damaging effects on the lake aqua life. Monitoring and reducing human actions will help keep lake at an optimum pH level. The pH of water varies with the geological nature of the source and the presence of dissolved solids. Increase in environmental temperature increases water solubility of atmospheric carbondioxide and the rate of degradation of organic matter leading to further build up of organic matter leading to increase of carbondioxide in water (Sukand and Patil, 2004). The carbondioxide level influences pH of water. pH is positively correlated with alkalinity (0.652).

The temperature is of utmost important for its effect on controlling the metabolism, species composition and reproduction of aquatic organisms. According to FWPCA (1967), temperature, a catalyst, a depressant, an activator, a stimulant, a controller, a killer is one of the most important and influential water quality characteristic to life in water. Temperature plays an important role in the physical and chemical characteristics of the lake environment; it seems to have pronounced effect on the rate of carbon dioxide fixation by phytoplankton (Primary productivity). In addition, temperature affects the bacterial activity which is

Table 1. Monthly variation of Physicochemical parameter of Hoskerehalli lake 2005.

Parameters	Units	JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
pH	-	8.00	8.10	8.40	8.10	8.20	8.10	8.10	8.20	8.00	8.10	7.90	7.80
Water Temp	°C	23.50	24.00	29.00	27.00	28.00	24.00	26.00	27.00	26.00	24.00	25.50	23.50
TDS	mg/l	320.00	300.00	298.00	310.00	315.00	395.00	385.00	380.00	378.00	365.00	344.00	330.00
Turbidity	FAU	13.00	12.00	11.50	13.00	12.00	15.00	18.00	19.00	15.00	13.00	14.00	12.50
Conductivity	µmhos/cm	465.00	450.00	428.00	458.00	462.00	562.00	548.00	530.00	528.00	515.00	498.00	485.00
Total Hardness	mg/l	236.00	234.00	240.00	248.00	258.00	216.00	220.00	204.00	208.00	225.00	230.00	240.00
Alkalinity	mg/l	343.00	342.00	378.00	382.00	370.00	356.00	360.00	352.00	348.00	342.00	348.00	340.00
DO	mg/l	8.00	6.20	5.90	7.90	7.40	9.30	7.20	6.80	6.60	6.80	7.20	8.20
BOD	mg/l	26.50	25.30	24.40	26.60	25.20	22.40	23.50	23.30	25.40	24.62	25.50	25.40
COD	mg/l	33.50	35.20	32.60	36.40	38.20	30.20	35.50	35.80	35.80	36.50	34.40	36.20
Phosphates	mg/l	3.35	3.39	3.40	3.43	3.58	3.35	3.34	3.32	3.42	3.39	3.48	3.50
Sulphates	mg/l	17.10	17.50	16.20	15.80	15.30	16.80	17.20	17.80	18.10	18.00	18.20	17.50
Nitrates	mg/l	2.20	1.85	1.32	1.66	2.00	2.20	1.85	1.62	1.75	2.30	1.80	1.66
Potassium	mg/l	10.40	10.54	10.30	10.28	10.40	10.60	10.80	10.74	10.80	10.70	11.10	11.20

Table 2. Showing correlation matrix of some Physico-chemical parameter of Hoskerehalli lake during 2005.

	pH	Temp	TDS	Turbidity	Conductivity	TH	Alkalinity	DO	BOD	COD	PO_4	SO_4	NO_3	K
pH	1.000	.712**	-.167	.000	-.251	-.066	.652*	-.448	-.363	-.135	-.239	-.518	-.261	-.736**
Temp		1.000	-.217	.056	-.297	.206	.822**	-.449	-.071	.203	.220	-.539	-.633*	-.424
TDS			1.000	.800**	.988**	-.834**	-.299	.285	-.681*	-.193	-.447	.494	.326	.450
Turbidity				1.000	.781**	-.781**	-.110	.071	-.588*	-.038	-.568	.385	-.027	.322
Conductivity					1.000	-.786**	-.326	.373	-.667*	-.191	-.410	.478	.375	.487
Total Hardness						1.000	.426	.073	.586*	.304	.698*	-.716**	-.065	-.389
Alkalinity							1.000	-.046	-.008	.009	.169	-.0816**	-.444	-.636*
DO								1.000	-.110	-.315	.041	-.205	.467	.114
BOD									1.000	.424	.452	-.117	-.066	-.144
COD										1.000	.515	-.066	-.075	.122
Phosphates											1.000	-.356	-.105	.148
Sulphates												1.000	.123	.724**
Nitrates													1.000	-.029
Potassium														1.000

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

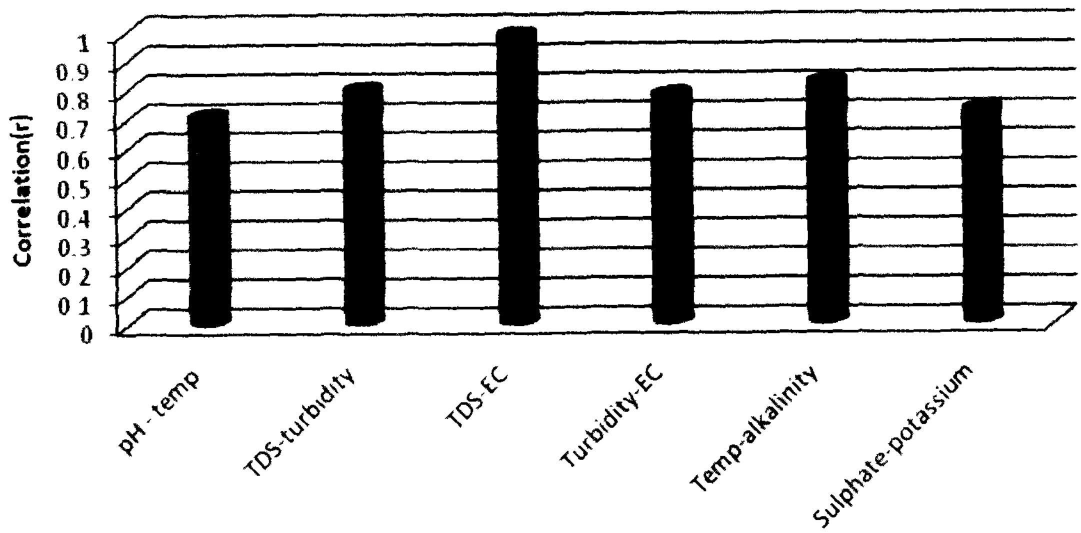


Fig. 2. Indicates the positive correlation coefficient (r>0.5) of the physicochemical parameter.

responsible in the decomposition of organic matter for nutrient recycling, as well as solubility and liberation of dissolved gases like oxygen, carbon dioxide, ammonia and hydrogensulphide. Also, it may affect the best fishing and thus total fish catch (Entz, 1974). High temperature value was recorded as 29.0°C in March and lower as 23.5°C in January. Temperature positively correlated with pH value (0.712). During summer due to the high water temperature in the surface layer, the bicarbonate and carbonate are hydrolysed and appearance of hydroxyl ions lead to accompanying increase in pH. Increased temperature not only reduces oxygen availability, but also increases oxygen demand, a situation that would add to physiological stress of organisms (Giller and Matmiqvist, 1998). Temperature showed negative correlation with dissolved oxygen (r = -0.449).

TDS indicate the total amount of inorganic chemicals in solution. The portion of dissolved solids include carbonate, bicarbonate, sulphate, chloride, sodium, calcium apart from other elements. High TDS value was recorded as 395mg/l in June and lower as 298mg/l in March. High TDS concentration produces laxative effect and can give an unpleasant mineral taste to water. A maximum value of 400mg/l of TDS is permissible for diverse fish population (Chhatwal, 1998) TDS showed positive correlation with turbidity as observed by other authors Salam and Rizvi (1999).

Turbidity is suspension of particles such as clay, silt and organic matter in water that interfere with the passage of light. The high turbidity value was recorded as 19.0 FAU in August and lower as 11.5 FAU in March. Turbidity has been considered as limiting factor for biological productivity in freshwater (Kaushik and Saxena, 1999). The observed high value of turbidity suggests the presence of greater amounts of soluble organic matter such as Humic and fulvic acids.

Electrical conductivity (EC) is a numerical expression of the ability of an aqueous solution to carry electric current. High conductivity value recorded was 562µmhos/cm in June and lower as 428 µmhos/cm in March. EC can be related to the adsorption of dissolved salts on the surface of suspended particles while coming with flood water and discharged to bottom sediments. EC is positively correlated with TDS (r = 0.988) and turbidity (r = 0.800).

Total hardness (TH) is an important parameter in decreasing the toxic effects of poisonous element (Charu Parashar et al., 2006). Cations of calcium, magnesium, iron and manganese contribute to the hardness of water (Shrivastava and Patil, 2002). High TH value was recorded as 258 mg/l in May and lower as 204 mg/l in August. Barret (1953) has reported that the hard water is more productive than the soft water from fisheries point of view. High values of hardness are probably due to the regular addition of quantities of sewage, detergents and large scale human use. TH is positively correlated with phosphate (0.689).

Alkalinity of water is its acid neutralizing capacity and in surface water it is primarily a function of its carbonate and hydroxide content. High alkalinity value was recorded as 360 mg/l in July and lower as 340 mg/l in December. High alkalinity can be due to biological activity in water and low alkalinity may be due to the effect of rainfall in decreasing it as suggested by Mookherjee and Bhattachary (1949). According to Moyle (1946), water bodies having total alkalinity above 50mg/l can be considered productive.

Importance of dissolved oxygen (DO) in an aquatic ecosystem brining out various biochemical changes and many ecologists discussed its effect on the metabolic activities of the organisms (Mishra and Yadav ,1978). High DO value was recorded as 9.3 mg/l in June and lower as 5.9 mg/l in March. The low oxygen level was recorded during March mainly due to the removal of free oxygen through respiration by bacteria and other animals (Korium and Toufeek, 2008) as well as the oxygen demand for decomposition of organic matter. Free oxygen (DO) is the single most important gas for most aquatic organism. When the aquatic organisms exposure to less than 2.0mg/l free oxygen for few days, may kill most of the biota in the aquatic system (Goel et al., 1980). While values of 5.0 to 6.0mg/l are usually for most of the fish population (Singh et al., 2008). The low DO value may adversely affect the survival of the most of the biological community and self purification process. DO showed inverse relationship with water temperature (r = -0.449). Organic matter present in water utilizes the DO of water for its decomposition, which depletes the oxygen and makes it difficult for biota to live in heavily loaded waterbodies. BOD is the amount of oxygen required for the biochemical degradation of organic material and the oxygen used to oxidize the organic material such as sulfates and ferrous ions (Kiran and Ramachandra, 1999).

High BOD value was recorded as 26.6 mg/l in April and lower as 23.3 mg/l in August. High BOD could be attributed to the photosynthetic activity and abundance of phytoplankton during hot period (Abdo, 2004). It is the indicator of water pollution.

COD measures the oxygen equivalent of the organic and inorganic matter in water sample that is susceptible to oxidation. High COD value was recorded as 38.2 mg/l in May and lower as 30.2 mg/l in June. High COD is mainly attributed to the increase in the air and water temperature, facilitating the decomposition and oxidation of organic matter (Abdo, 2002). COD is the amount of oxygen required by the organic substance in the water to oxidize them by strong chemical oxidant that is largely determined by the various organic and inorganic materials (Jhingran, 1982).

The cycling of phosphorous within lakes is dynamic and complex, involving adsorption and precipitation reaction, interchange with sediments and uptake by aquatic biota (Broberg and Persson, 1988). Phosphate is a nutrient required by all organisms for the basic process of life. High phosphate value was recorded as 3.58 mg/l in May and lower as 3.32 mg/l in August. Weathering of phosphorous bearing rocks, cattle dung and night soils are the main sources of phosphorous to natural water. The high value of phosphate value was probably, due to increase in the evaporation rate under rises of the air-water temperature leading to the facilitating of phosphorous release from the decay organisms (Abdo, 2002). The lower values of phosphates may be due to the sedimentation and renewal rates of water (Marsden, 1989).

Sulphate ions usually occur in natural waters. It contributes to the total solid content in a reduced and anaerobic condition. High sulphate value was recorded as 18.2 mg/l in November and lower as 15.3 mg/l in May. The high sulphate content is probably due to the decay of phytoplankton and aquatic macrophytes or due to the oxidation of sulphide or sulphite to suplhate, in the presence of photosynthesis sulphur bacteria oxidizes sulphur and sulphite to sulphate (Dunette et al., 1985 and Fayed, 1980). The high concentration of sulphates could be attributed due to runoff from the agriculture land during monsoon period which enter into the lake waterbody from catchment area through surface runoff and domestic waste water. Sulphate when added to water, tend to accumulate to progressively increasing concentration (WRC, 2003). This could account for the high level of sulphate recorded in November.

Nitrate, the major form of nitrogen in oxidizing water is the product of aerobic decomposition of organic nitrogenous matter, however main source of elevated nitrate concentration may be inorganic fertilizers used indiscriminately in and around the lake. Direct relation exists between the degree of pollution and concentration of nitrate. High nitrate value was recorded as 2.3 mg/l in October and lower as 1.32 mg/l in March. High value of nitrate could be attributed to oxidation of ammonia by nitrifying bacteria and biological nitrification (Seike et al., 1990) and also large amount of drainage water reaching the lake. The lower values recorded may be related to the denitrification of nitrate into nitrite and ammonia by denitrifying bacteria (Merck, 1980). Nitrates were statistically insignificant at 5% level.

Potassium is the main cation in natural fresh water. It is an important macro-nutrient and plays a vital a role in metabolism of fish. High potassium value was recorded as 11.2 mg/l in December and lower as 10.28 mg/l in April. Higher values were observed in monsoon months. A significant correlation between apparent unrelated species include those between potassium and sulphate ($r = 0.724$).

6. Conclusions

On the basis of physicochemical characteristics and statistical analysis of lake, it can be concluded that the water quality of Hoskerehalli lake is not polluted and remained safe throughout twelve months of study period. The lake water quality is good for irrigation and fish culture purpose also supports biodiversity.

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Received on 15-03-10; Revised Ms accepted on 04-05-10