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A CASE STUDY

An investigation of lentic water quality parameters and its suitability to irrigated agriculture

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ABSTRACT

The water bodies are facing a severe threat of pollution all over the world. To ensure fresh water availability from the local water sources has become a big challenge. The impact of point and non-point pollution sources on the quality of the receiving water and suitability of water for irrigation was evaluated based on sodium adsorption ratio and the US salinity diagrams of the lakes was investigated during pre-monsoon and post-monsoon seasons that is from Dec 2013 to May 2014 The condition of the lakes deteriorated sharply in the pre-monsoon due to low dilution of incoming pollutants during the low water flow lead to the increase the pollution of the lakes. In the vicinity of intensively cultivated areas, the high concentrations of electrical conductivity, nitrogen and phosphorus which were detected in the lakes during pre-monsoon may be partly attributed to the leaching of the applied fertilizers because of nitrogen mobilization and soil erosion.

KEY WORDS : Lakes, Water quality, Parameters, Sewage, Haveri

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INTRODUCTION

Haveri is situated in the center of Karnataka, it is the head quarter of Haveri District, which was declared as city municipal council on 05/12/2003. Haveri town has a population of over 15.99 lakhs as per 2011 census. The percentage decadal growth is 11.08 per cent and population density is 331/sq. km. Due to increase in the population city is experiencing rapid urbanization.

Akkamahadevi, Dundibasaweshwar, Mullankere, Neharuhalankere and Heggere lakes are few among the many lakes in Haveri (APHA, 1992). Most of the lakes mentioned are man–made and are directly used as a source of domestic supply and agricultural purpose and some of them are used as reservoirs to conserve rainwater but human activities are responsible for the degradation of the lake as lake water is used for bathing and washing clothes, during washing large amount of detergents directly goes into the lake which increases the phosphate content of the lake water and becomes unfit for potable use (Sharma *et al*., 2010; Tamot and Sharma, 2006; Dhote and Dixit, 2010). As there is no Sewage Treatment Plant (STP) in some areas so all the untreated wastes directly goes into the lake and changes the parameters of the lake, solid waste is also dumped close to the lakes, open defecation is also a common practice to the banks of the lake causing increase in Electrical conductivity, Total dissolved solids and chloride content (Jain *et al*., 2012 and Verma *et al.*, 2003). The main conclusion is that majority of lakes in Haveri are becoming detrimental to humans day-by-day, it is a major concern for the local administrative bodies to look after the solution of the problems related to the lake otherwise it will have serious threat for the future.

Nayak *et al.* (2003) conducted work on "Variation of water quality in Chilika Lake, Orissa". The water quality parameters were examined. The pH of water was alkaline throughout the lake and both pH and salinity varied widely. High pH with low salinity zones reflected disintegration of submerged weeds. Analysis supported the increase of pH, high photosynthetic activity, high nutrients as well as phosphate depletion due to phytoplankton utilization in the fresh water zone.

Prasad *et al.* (2009), evaluated the Tumkur amanikere lake for suitability of groundwater for irrigation was evaluated

based on sodium adsorption ratio, percent sodium, and the US salinity diagrams. It is observed from the US Salinity classification of water samples for irrigation purposes that, all the samples are fall in excellent class The suitability of water for irrigation is evaluated based on SAR, per cent Na and salinity hazards. Most of the samples in Tumkur Amanikere watershed fall in the suitable range for irrigation purposes either from SAR or per cent Na values.

Balachandra *et al.* (2010) evaluated the status of groundwater quality and its suitability to irrigated agriculture. For this study, 44 and 42 observation wells in 2005 and 44 and 39 observation wells in 2008 have been taken into consideration to study the variation in pre and post monsoon season. These observation wells are regularly maintained by public works department of Government of Tamil Nadu. Water quality data are utilized in the present study for the analysis of groundwater chemistry of years 2005 and 2008 for both pre-monsoon (July) and post-monsoon (December) seasons. Water quality data used in the analysis include Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH) and Sodium Adsorption Ratio (SAR).

EXPERIMENTAL PROCEDURE

In present study lakes are monitored by using conventional method (*i.e.* samples were collected manually) for pre-monsoon and post-monsoon (Dec., 2013 to May, 2014). After conducting reconnaissance survey, sampling spots were chosen in lakes. Grab water samples were collected twice in every month between 8:00 am to 10:00 am in polyethylene bottle and transported to laboratory for the examination of water using standard methods as prescribed in American Public health association (APHA), American Water Works Association (AWWA).

Graphical method was used for the hydrogeochemical and irrigation classifications of lake water samples US salinity laboratory diagram was selected for the classification. Hydrogeochemical ratios like Sodium Adsorption Ratio (SAR) was determined for the assessment of lake water quality in the study area.

EXPERIMENTAL FINDINGS AND ANALYSIS

The findings of the present study as well as relevant discussion have been presented under following heads:

General :

Lakes have been monitored for certain physico-chemical and biological parameters (*viz.*, pH, total alkalinity, total hardness, calcium hardness, magnesium hardness, electrical conductivity, total dissolved oxygen, biochemical oxygen demand, nitrate, chloride, sodium, potassium, total phosphorous).

It is evident that, pH is within the permissible limits of BIS and indicates all the lakes were alkaline during both pre and post-monsoon.

Conductivity and TDS of water increases with increase in temperature during pre-monsoon due to the presence of more dissolved ions. Higher values in Dundibasaweshwar and Mullankere lakes is probably due to direct discharge of untreated sewage into the lakes.

Total hardness and chlorides of all the lakes were within the desirable limits of BIS standards during the course of study. The higher values of chlorides and hardness during pre-monsoon season indicates the organic pollution due to disposal of sewage effluents, agricultural and road runoff, and very high concentration of chloride in Dundibasaweshwar and Mullankere Lakes is regarded as an indicator of eutrophication, The lower concentration of all lakes are observed during post-monsoon may be due to the higher dilution solubility properties because of precipitation.

The alkalinity of all lakes were within the desirable limits of BIS standards during the course of study and it is found to be higher during pre-monsoon season as compared to the post-monsoon season due to increase in ionic concentration and movements. High Alkalinity in Dundibasaweshwar, Mullankere and Neharuhalankere lake indicates pollution.

Sodium and Potassium in Akkamhadevi and Heggere lakes are within the prescribed standards of BIS throughout the study where Mullankere lake exceeds the standards throughout the study due to sewage discharge and leachate of nearby dump yard and Dundibasaweshwar and Neharuhalankere lakes are within prescribed standards in post-monsoon and exceeds the standards in pre-monsoon, the variation in the pre-monsoon and post-monsoon indicates that there are different sources of sodium and also water table fluctuations may give such kind of variations In general there increase in contamination by the increase in the sodium content. it is also important to note that larger quantities of fertilizers are used for agricultural purpose, which may enhance the potassium content.

Akkamahadevi, Dundibasaweshwar and Heggere lakes were having the D.O. greater than 4 mg/L during the course of study period except Mullankere lake and Neharuhalankere lakes. In Mullankere lake the DO value is lesser than 4mg/l during the course of study which indicates hypoxic conditions this is due to raw sewage inflow and stagnant conditions. In Neharuhalankere there is gradual increase in DO content from pre-monsoon to post-monsoon which indicates better algal photosynthetic activities and oxidative decomposition of dissolved organic matter. Photosynthesis by plants and algae adds oxygen to the water.

Nitrate levels within the BIS standards. It can be concluded that high nitrate concentration in water is probably due to intrusion of sewage or chemical fertilizer.

BOD of all lakes are greater than 30 mg/L during the course of study period except Neharuhalankere and Hegere lakes which have BOD less than 30mg/l during post-monsoon. The higher values of BOD are probably due to contamination by untreated sewage entry into lakes, The consequence of high BOD is low levels of dissolved oxygen in affected waterways resulting in aquatic organisms becoming stressed and in extreme cases, suffocating and dying, also the odour problem and aesthetically bad conditions make the lakes water unsuitable for bathing, washing clothes and other uses. All the lakes are having, total phosphorous levels which exceed the BIS standard. Hence it can be concluded that high phosphorous concentration in water is probably due to washing of large amount of clothes by dhobis, laundry workers. High phosphate content in the lake

Table 1 : Descriptive statistics of parameters (Pre-monsoon)

Parameters	Minimum	Maximum	Mean	Median	Standard Dev	C.V
Ph	7.775	8.105	7.904	7.88	0.124	0.016
EC	475	2420	1454.4	1697	776.06	0.534
TDS	281	1441	862.98	1003.9	463.37	0.537
TA	115	264	186.2	200	63.5	0.341
TH	205.07	384.22	289.90	286.80	65.77	0.227
Ca	61.19	86.95	72.50	70.655	10.018	0.138
Mg	12.5	40.04	26.08	26.44	9.90	0.38
Na	38.07	268.16	168.7	222.83	105.80	0.627
K	2.733	62.667	27.28	15.65	27.45	1
DO	3.26	7.26	5.455	5.55	1.43	0.262
Cl	77.80	278.09	193.76	204.47	85.63	0.44
BOD	20.35	91.66	46.07	31.665	30.133	0.654
Nitrate	5.59	22.98	12.274	11.28	7.03	0.573
TP	2.155	6.579	4.28	3.81	1.67	0.39

Table 2 : Descriptive statistics of parameters (Post-monsoon)

Parameters	Minimum	Maximum	Mean	Median	Standard Dev	C.V
Ph	8.028	8.475	8.301	2.311	0.18	0.022
EC	494	2668	1631.1	1851.5	918.96	0.563
TDS	290.53	1588.3	968.37	1100.4	548.17	0.566
TA	135.5	290.75	214.03	238.75	65.26	0.305
TH	213.91	404.29	297.9	279.35	73.34	0.246
Ca	63.055	87.3	72.838	9.88	72.2	0.136
Mg	13.50	44.65	27.79	23.72	11.89	0.426
Na	47.84	303.51	193.6	259.1	114.71	0.593
K	5.401	76.56	36.53	21.793	34.52	0.945
DO	1.323	6.255	4.076	4.566	1.905	0.467
Cl	90	284.87	202.13	215.69	86.23	0.427
BOD	22.95	105.55	51.211	35.57	33.513	0.654
Nitrate	8.264	26.517	14.858	13.11	7.36	0.496
TP	3.048	8.958	5.869	4.73	2.591	0.442

water indicates the prevailing hyper-eutrophic conditions.

Irrigational water quality classification :

Salinity laboratory classification :

The concentration and composition of dissolved constituents in the water determine its quality for irrigation use. Assessment of the suitability of water for irrigation purpose requires consideration of the total dissolved solids, relative proportion of sodium to calcium and magnesium, relative proportion of bicarbonate to calcium and magnesium. Suitability of water for irrigation is mainly dependent on the effect of total dissolved solids and sodium content which adversely affects the soil quality and plant growth. The sodium hazard is typically expressed as the Sodium Adsorption Ratio (SAR). The SAR quantifies the proportion of sodium to calcium and magnesium ions in a sample. There is a significant relationship between SAR values of irrigation water and the extent to which sodium is absorbed by the soil. When the SAR and specific conductance of water are known, the classification of the water for irrigation can be determined graphically by plotting these values on the US Salinity diagrams (USSL). The USSL diagram best explains the combined effect of sodium hazard and salinity hazard. Waters have been divided into C_1, C_2, C_3 and C_4 types on the basis of salinity hazard and S_1, S_2, S_3, S_4 types on the basis of sodium hazard. The significance and interpretations of quality ratings on the USSL diagram can be summarized as follows: [i] Low salinity water [C_1] can be used for irrigation with most crops on most soils. [ii] Medium salinity water [C_2] can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most instances without special practices of salinity control. [iii] High salinity water [C_3] cannot be used on soils with restricted drainage. Even with adequate drainage,

Table 3 : Distribution of lakes as per USSL classification during Pre-monsoon

Lakes	USSL types
Akkamahadevi Lake	C2-S1
Dundibasaweshwar Lake	C4-S2
Mullankere Lake	C3S2
Neharuhalankere Lake	C4-S2
Heggere Lake	C3-S1

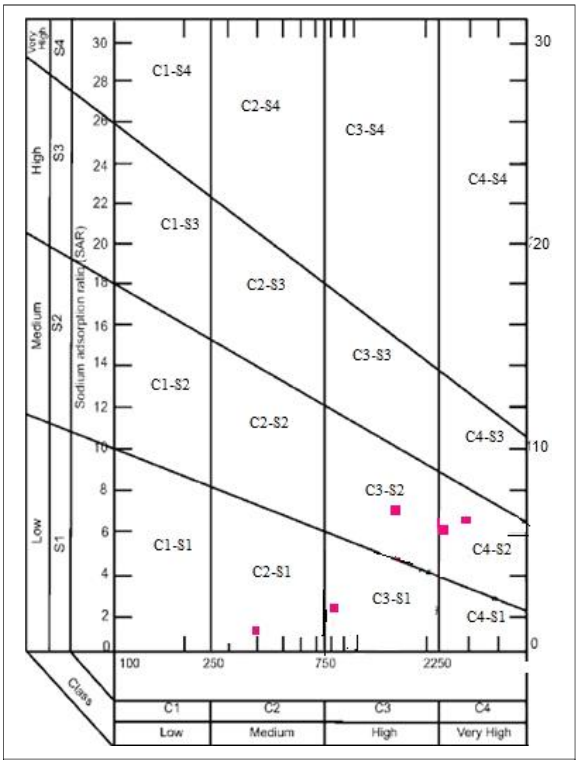

Fig. 1 : U.S.Salinity classification (Pre-monsoon)

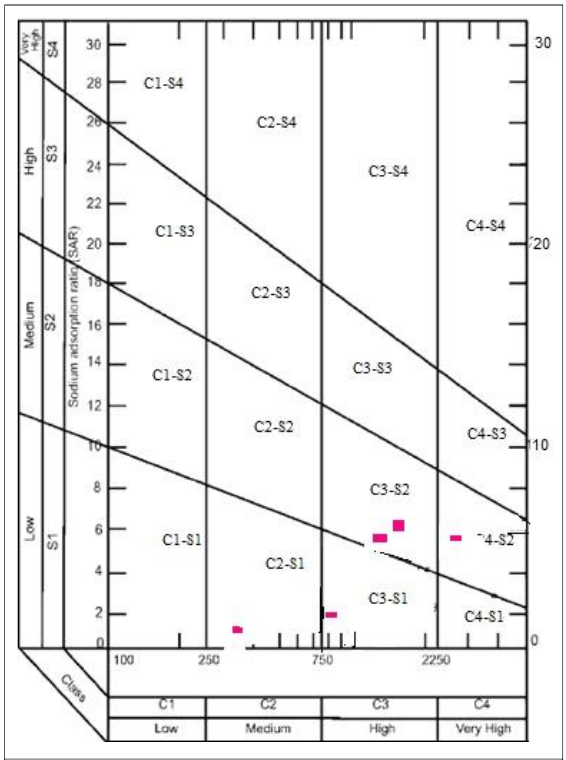

Fig. 2 : U.S.Salinity classification (Post-monsoon)

special management for salinity control may be required and plants with good salt tolerance should be selected. [iv] Very high salinity water [C_4] is not suitable for irrigation under ordinary conditions, but may be used occasionally, under very special circumstances. The soil must be permeable, drainage must be adequate, irrigation water must be in excess to provide considerable leaching and salt tolerant crops should be selected.

From the Fig. 1 and 2 it reveals that Akkamahadevi, Mullankere, Neharuhalankere and Heggere lakes fall under the field of C_2-S_1, C_4-S_2, C_3-S_2 and C_3-S_1, respectively throughout the study. Dundibasaweshwar lake Fall under C_4-S_2 in pre-monsoon and C_3-S_2 in post-monsoon, According to this the Akkamahadevi lake has Medium salinity water which can be used if a

Table 4 : Distribution of lakes as per USSL classification during post-monsoon

Lakes	USSL types
Akkamahadevi lake	C2-S1
Dundibasaweshwar lake	C4-S2
Mullankere lake	C3S2
Neharuhalankere lake	C3-S2
Heggere lake	C3-S1

Table 5 : Classification of Hydrochemical ratio

Sr. No.	Hydrochemical ratio	Range	Water classes
1.		< 10	Excellent
2.	SAR	10-18	Good
3.		18-26	Permissible
4.		>26	Unsuitable

Table 6 : Sodium adsorption ratio of lakes

Sr. No.	Lakes	Pre-monsoon	Post-monsoon
		SAR	SAR
1.	Akkamahadevi lake	1.16	1.43
2.	Dundibasaweshwar lake	5.51	6.19
3.	Mullankere lake	5.97	6.59
4.	Neharuhalankere lake	6.26	6.89
5.	Heggere lake	1.93	2.53

Table 7: Permissible values of various water quality parameters for drinking water

Sr. No.	Bureau of Indian Standards		
	Parameters	Desirable limits	Permisible limits
1.	pH	6.5	8.5
2.	EC (µS/cm)	2000(CPCB)	-
3.	TDS(mg/l)	500	2000
4.	TA(mg/l)	200	600
5.	TH (mg/l)	300	600
6.	Ca (mg/l)	75	200
7.	Mg (mg/l)	30	100
8.	Na (mg/l)	1	250
9.	K (mg/l)	1	250
10.	DO (mg/l)	4	-
11.	Cl (mg/l)	30	-
12.	BOD (mg/l)	250	1000
13.	Nitrate (mg/l)	45	100
14.	TP (mg/l)	5	-

moderate amount of leaching occurs, The salinity of Dundibasaweshwar lake water varies from high salinity to very high salinity category ,where the water cannot be used on soils with restricted drainage. Mullankere lake belongs to very high salinity where the water is not suitable for irrigation under ordinary conditions, but may be used occasionally, under very special circumstances. The soil must be permeable, drainage must be adequate, irrigation water must be in excess to provide considerable leaching and salt tolerant crops should be selected. Neharuhalankere and Heggere Lakes belongs to high salinity water, which cannot be used on soils with restricted and adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected.

Sodium Adsorption Ratio (SAR) :

The relative activity of sodium ion in the exchange reaction with soil is expressed in terms of a ratio known as Sodium Adsorption Ratio (SAR) which is defined as : SAR is calculated from the formula :

$$\mathbf{SAR} = \frac{\mathbf{Na}}{\sqrt{\frac{\mathbf{Ca} + \mathbf{Mg}}{\mathbf{2}}}}$$

where, all the concentrations are expressed in meq/l. It is an important parameter for determining the suitability of irrigation water because it is a measure of alkali/sodium hazard for crops. The SAR values in the study area range from 1.16 to 6.89 during the study period. All the values which are less than 10, indicates that the waters of the area belong to excellent category and are free from sodium hazards. The values between 10 and 18 indicate good quality, 18 to 26 indicate permissible quality and more than 26 indicates poor quality. According to this ratio, the samples fall under excellent to permissible quality for irrigation purpose. Similar findings were reported by Agarwal and Jegetia (1997); ANZECC (1992); Dashgupta (1980); Durvey *et al.* (1997) and Eaton (1950).

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