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Water Quality of Some Moderately Polluted Lakes in GHMC – India

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ABSTRACT: Telanga State, India during 2012-2013 to assess its quality for drinking, domestic and irrigation. Out of many lakes in GHMC, some lakes, Shameerpet Lake, Banjara Lake, Lungerhouse Lake, Rangadhamuni Lake, Durgam Lake, Hussainsagar Lake, Pragathi Nagar Lake, Lakshminarayana Lake, and Amber Lake or Ameersaheb Lake in the jurisdiction of Hyderabad Metropoliton Development Authority (HMDA), sequenced in increasing order of TDS averages ranging 398 – 874 mg/L indicate fresh water. The water quality of lake in respect of COD average, it ranges from 50 to 200 mg/L but wide deviations indicate organic loads and very low DO support the same. The lake water is not suitable for domestic purposes but suitability of simple treatment for recycling for the purpose of domestic and industrial usage. The lakes with isolated/protected catchments and rock base such as Shameerpet Lake, Lungerhouse Lake, Pragathi Nagar Lake, Lakshminarayana Lake and Amber Lake are suitable for drinking water storage also if needed by diverting inlet drains. Shameerpet Lake physicochemical hydrology is good for domestic and cattle feed if properly protected its catchment from sewage and industrial effluents and presently it is under stress. Banjara Lake is suitable recreation activities. Lungerhouse Lake is suitable for remediation to domestic/industrial water supply and storage as some of its inlet drains connected to Sewage Treatment Plant (STP). Rangadhamuni Lake is small water body with completely collapsed catchment. Durgam Lake is provided with STP for some of inlet drains. Hussainsagar Lake is heart shaped situated at the heart of the city and confluence point of many drains flowing from major ports of city. The outlet of these lakes joins to the River Musi.

KEYWORDS: Amber Lake, Banjara Lake, Durgam Lake, Hussainsagar Lake, Lakshminarayana Lake, Lungerhouse Lake, Pragathi Nagar Lake, Rangadhamuni Lake, Shameerpet Lake.

I. INTRODUCTION

Hyderabad Metropolitan Development Authority (HMDA) developed from the 400 years old Bhagyanagar city, geographically situated land locked arid zone and no perennial river but a seasonal River Musi flowing through it. For longer periods, it is the capital city of so many rulers and in long run expanded to the 8,005 sq km in Telangana State, India. To cater to the domestic and irrigation needs of people the local leaders/ rulers dug so many lakes and shallow dug wells distributing the entire area. By preserving the rain water in tanks leads increased harvesting fruits, attains a special stature to the city. Later increased population, city culture demands industrial growth spoils the catchment of all the Lakes in the city. It results in degradation of Lakes, their disappearance and few remained with most of their areas under encroachments. To study the quality of water of these lakes, an intensive study is started by the AP Pollution Control Board (APPCB) and the author took the key role from 1998 with the data base knowledge provided by the organization for record generation to a period of two years and later provided opportunity to monitor the area under the National Water Quality Monitoring Programme (NWMP) of Central Pollution Control Board (CPCB) projects, such as Global Environmental Monitoring System (GEMS) and Monitoring of Indian National Aquatic Resources (MINARS) [1]. The present research study is on physicochemical analysis of water of Shameerpet Lake, Banjara Lake, Lungerhouse Lake, Rangadhamuni Lake, Durgam Lake, Hussainsagar Lake, Pragathi Nagar Lake, Lakshminarayana Lake, and Amber Lake or Ameersaheb Lake.

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1.1. Water Quality Index (WQI) systems:

Initially, WQI was developed by Horton [2] (1965) in United States by selecting 10 most commonly used water quality variables like dissolved oxygen (DO), pH, coliforms, specific conductance (EC), alkalinity and chloride etc. However, a number of water quality indices viz. Weight Arithmetic Water Quality Index (WAWQI) [3], National Sanitation Foundation Water Quality Index (NSFWQI), Canadian Council of Ministers of the Environment Water Quality Index (CCMEWQI) [4], Oregon Water Quality Index (OWQI) [5] etc. have been formulated by several national and international organizations. Water Quality Rating as per different WQI methods are shown at Table 1.

WAWQI method [6] classified the water quality according to the degree of purity by using the most commonly measured water quality variables and the calculation of WQI was made by WQI = ∑Qi Wi / ∑Wi and the quality rating scale (Qi) for each parameter is calculated by Qi=100[(Vi-Vo)/(Si-Vo)]. Where, Vi is estimated value of ith parameter in the analyzed water, Vo is the ideal value of this parameter and equal to '0' except pH (=7.0) and DO (=14.6) and Si is recommended standard value of ith parameter. The unit weight (Wi) for each water quality parameter is calculated by using Wi=K/Si. The Proportionality constant K derived from K=1/∑(1/Si).

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OWQI is a single number expression introduced in 1970 by integrating measurements of eight water quality variables (temperature, dissolved oxygen, biochemical oxygen demand, pH, amminia+nitrate nitrogen, total phosphorus, total solids, and fecal coliform) [8]. OWQI is to improve understanding of water quality issues by integrating complex data and generating a score that describes water quality status and evaluates water quality trends. This process loss the important data but understanding is very important to water resource improvement efforts. OWQI cannot determine the quality of water for specific uses without considering all appropriate parameters data. The temperature sub index was specifically designed to be protective of cold water fisheries [9]. The original OWQI used a weighted arithmetic mean function.

NSFWQI [10] found the weighted geometric mean function to be more sensitive than the arithmetic function to changes in individual variables. For the idealized data sets, each sub indices value was varied from 100 (ideal) to 10 (worst case) while the other sub index values were set at a value of 100. In all trials, the un-weighted harmonic square mean formula [11] was most sensitive to change in single variables and has been suggested as an improvement over both methods with formula given by

$$WQI = \sqrt{\frac{n}{\sum_{i=1}^{n} \frac{1}{SI_i^2}}}$$

(Where WQI is Water Quality Index results, n is the number of sub indices, and SI_i is Subindex i). WQI methods of Rating are placed at Table 1.

TABLE 1: Water Quality Rating as per different WQI methods [12]

WQI	OWQI	NSFWQI	CCMEWQI	WAWQI		
Rating	Scores	Scores	Scores	Rating/usage	Score	Grading
Very poor	<60	0-25	0-44	Unsuitable for drinking	Above 100	E
Poor	60-79	26-50	45-59	Very poor	76-100	D
Fair	80-84	51-70	60-79	Poor	51-75	C
Good	85-89	71-90	80-94	Good	26-50	B
Excellent	90-100	91-100	95-100	Excellent	0-25	A

Conductivity and pH are considered as guiding factors because of their essentiality for arriving at the basic nature of water, to view and to track chemical analysis in the appropriate procedure. The low pH should be neutralized with standard base or vice versa and necessary correction should be carried out for the obtained TDS. On the same lines the conductivity is based on mobility of ionic species. Hence, the relation with TDS is variable based on the nature of ions present in the sample. In preparation of trends for each parameter, a standard limit or criterion is defined for

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possible safe utilization of water bodies by ISI (1986) for irrigation standards [13] of the monitored parameters are given in Table 2.

TABLE 2: Some of the drinking/irrigation/discharge water standards and WQI

Sl No.	Parameters	Limit as per BIS/ Guidelines for Quality of Irrigation Water IS 11624 (1986)		WAWQI [14]
1	(except pH, expressed as mg/L)	Acceptable	Permissible in the Absence of Alternate Source	Unit Weight (Wn)
2	pH	6.5 – 8.5	6.5 - 8.5	0.2190
3	TDS, mg/L	500	2000	0.0037
4	Calcium (as Ca), mg/L	75	200	0.025
5	Chloride (as Cl), mg/L	250	1000	0.0074
6	Magnesium (as Mg), mg/L	30	100	0.061
7	Sulphate (as SO4), mg/L	200	400	0.01236
8	Total Alkalinity (TA as CaCO3), mg/L	200	600	0.0155
9	Total Hardness (TH as CaCO3), mg/L	200	600	0.0062

Industrial effluents tolerance limits [15] notified by CPCB (IETL of CPCB) for some parameters are as follows. TSS for Inland and On-land surface waters are 100 and 200 mg/L (WQI-Wn: 0.0037). COD for Inland surface water is 250 mg/L. The CETP (JETL and PETL) is permitted to send treated effluents to Amberpet STP within the limits for TSS: 100, TDIS (Total Dissolved Inorganic Solids): 2100, COD: 500, Ammonical Nitrogen: 50 mg/L.

1.2. Irrigation hazardous water quality rating (Ir. HWQR) [16]

Carbonate and bicarbonate [17] concentrations in irrigation waters are important in residual sodium carbonate (RSC) [18] relation to Ca^{2+} and Mg^{2+}. There is a tendency for both calcium and magnesium to react with bicarbonate in the water or soil precipitating as either calcium carbonate or magnesium carbonate. Since magnesium carbonate is more soluble, there is lower tendency for it to precipitate. The precipitation of either calcium or magnesium from water as carbonate increases the relative proportion of sodium which directly raises the sodium hazard rating. RSC is a quick test to determine if irrigation water can reduce free calcium and magnesium in the soil. RSC is calculated by subtracting the water's calcium and magnesium from its carbonate and bicarbonate {RSC = (CO_3^{2-} meq/L + HCO_3^- meq/L) - (Ca^{2+} meq/L + Mg^{2+} meq/L)}. A negative value indicates little risk of sodium accumulation due to offsetting levels of calcium and magnesium. A positive value indicates the existence of RSC in water that the bicarbonate and carbonate content exceeds the calcium and magnesium content. The use of high RSC water binds free calcium and magnesium in the soil, thereby creating room for sodium to accumulate. This leads to excess soil salinity and decrease in permeability resulting unsuitability of soil for supporting plants.

In relation to hazardous effects of (1) Total Salt Concentration expressed as the EC in the scale of micro-mhos/cm, (2) SAR in the scale of Square root of millimole/litre, (3) RSC in the scale of milIiequivalent/litre, (4) Percent Sodium of the irrigation water are classified into four major groups. The Irrigation Equipment and Systems Sectional Committee, AFDC 58 had recommended Guidelines for Evaluation of Quality of Irrigation Water [19] through Bureau of Indian Standards (ISI, 1986). Table 3 is the Ir. HWQR based on EC, SAR, RSC and Percent Sodium Classifications in relation to hazardous effects as per IS 11624 - 1986. The standards are for each parameter by referring Std.1, Std.2 and Std.3 in incremental order of value in the concerned trend figures.

TABLE 3: Ir. HWQR based on Parameters in relation to hazardous effects

Ir. HWQR	Total Salt Concentration as EC	SAR	RSC	Percent Sodium (%Na)
	Range (micromhos/cm)	Range (millimole/litre)$^{1/2}$	Range (me/l)	Percent Sodium
Low	Below 1500	Below 10	Below 1.5	<20
Medium	1500-3000	10-18	1.5-3.0	20-40
High	3000-6000	18-26	3.0-6.0	40-60
Very high	Above 6000	Above 26	Above 6.0	60-80

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1.3. CPCB designated best uses [20] - Procedure for setting water quality goals

For setting water quality objectives of a water body, it is essential to identify the uses of water in that water body. In India, the Central Pollution Control Board (CPCB), an apex body in the field of water quality management, has developed a concept of "designated best use"and identified 5 classes (Table 4). According to which, out of several uses a particular water body is put to, the use which demands highest quality of water is called its "designated best use", accordingly it is designated.

TABLE 4: Use based classification of surface waters in India by the CPCB

Class of water	Designated-Best-Use	Criteria						
		pH	DO mg/L	BOD mg/L	Free NH3 as N mg/L	EC micro mhos/cm	SAR	Total Coliform MPN /100mL
A	Drinking Water Source without conventional treatment but after disinfection	6.5 – 8.5	$\geq$6	$\leq$2	-	-	-	$\leq$50
B	Outdoor bathing (Organised)	6.5 – 8.5	$\geq$5	$\leq$3	-	-	-	$\leq$500
C	Drinking water source after conventional treatment and Disinfection	6.0 – 9.0	$\geq$4	$\leq$3	-	-	-	$\leq$5000
D	Propagation of Wild life and Fisheries	6.5 – 8.5	$\geq$4	-	-	-	-	-
E	Irrigation, Industrial Cooling, Controlled Waste disposal	6.0 – 8.5	-	-	-	2250	26	-

II. RELATED WORK

The author presented a research paper on Saroornagar Lake, Miralam Tank, Hasmathpet Lake, Nallacheruvu, Safilguda Lake, Kapra Lake, Fox Sagar, Mallapur Tank, Pedda Cheruvu in Phirjadiguda, Noor Md. Kunta and Premajipet Tank on water quality, and it shows the alkaline character (pH: 6.4 to 7.6) with TDS varying fresh (878 to 950 mg/L) to brackish (1,056 to 3,984 mg/L) and moderate organic and inorganic pollution [21]. The RSC of these water bodies are negative indicate little risk of sodium accumulation due to offsetting levels of calcium and magnesium. These Lakes are having Low DO, High BOD and show either Class D or E under CPCB Criteria of Designated-Best-Use (Ref. Table 4).

The Shahpura lake inlet drains [22] showing high TDS (450 to 736 mg/L) and COD (20 to 130 mg/L) indicate deterioration due to some parts of Bhopal city sewage. Some of related works referred at appropriate places at following experimental results and discussions.

III. METHODOLOGY

Laboratory Practices: SOPs were prepared and upgraded from time to time based on the methods discussed with i) APHA (American Public Health Association), 16th (1985), 20th (1998) and 21st Edition (2005): titled "Standard Method for Examination of water and wastewater", ii) "Guide Manual: Water and Wastewater Analysis" published by the CPCB, New Delhi, iii) Indian Standard (IS) methods as mentioned against parameter. Procedures for checking correctness of the analysis are applied which include pH, EC, TDS and major anionic and cationic constituents that are indications of general water quality. In it, the acceptable range is Measured TDS / Calculated TDS $\leq$ 1.2, Anion and Cation Balance criteria for acceptance, Measured EC relation with ion sum and Calculated TDS to EC ratio are verified with the assurance of analysis data quality.

TDS by calculation = 0.6 (Alkalinity) $+Na^{+} +K^{+} +Ca^{2+} +Mg^{2+} +Cl^{-} +SO_4^{2-} +SiO_3^{2-} +NO_3^{-} +F^{-} +PO_4^{3-}$

Anion and Cation Balance: The anion and cation sums, when expressed as milliequivalents (meq.) per liter, must balance because all potable waters are electrically neutral. The typical criteria for acceptance ranges of Anion sum meq./L against percentage difference meq./L are 0 – 3.0, ± 0.2; 3.0 – 10.0, ± 2% and 10.0 – 800, ± 5% where as percentage difference defined as:

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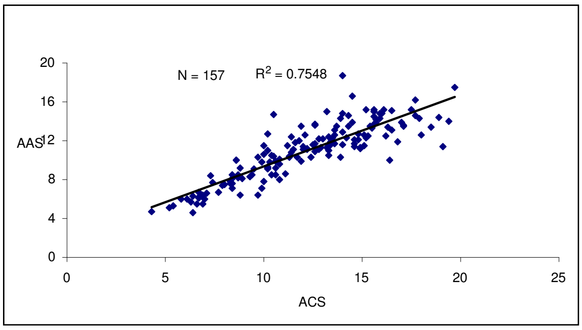
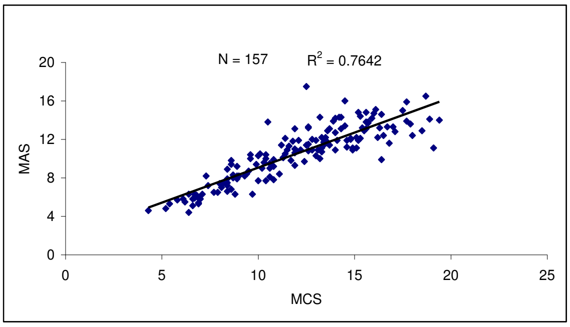
$$\%difference = 100 * \frac{(\sum cations - \sum anions)}{(\sum cations + \sum anions)}$$

Fig.1.1 is representing the procedures for checking correctness of the analysis at (a) is sum of all cations (ACS) verses sum of all anions (AAS), (b) is sum of major cations (MCS) verses sum of major anions (MAS) and (c) is TDS/calculated TDS with all ions (TDS/ACTDS) verses TDS/calculated TDS with major ions (TDS/MCTDS) of Lakes and the findings are as follows.

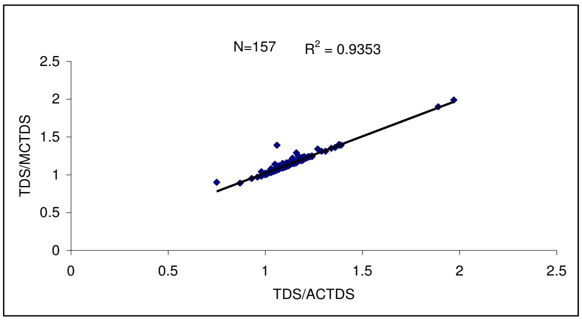
i. The deviations are in acceptable limits [23] showing 157 records in the period 2012 – 2013.
ii. The root mean square (R^2) value at (a) is 0.7548 and (b) is 0.7642 show the influence of other factors such as pH, TSS, organic constituents and COD.
iii. The (R^2) value at (c) is 0.9353 indicate the influence of ions such as Fluoride, Boron, Ammonium, Nitrate, Nitrite and Phosphate are meagre and non-significant.



(a)



(b)



(c)

Fig.1.1: Procedures for checking correctness of analysis (a) ACS verses AAS, (b) MCS verses MAS, (c) TDS/ACTDS verses TDS/MCTDS of Lakes.

IV. EXPERIMENTAL RESULTS AND DISCUSSION

The lake points sequenced on increasing order of average concentrations in TDS of lakes ranging 398 – 874 mg/L in the period 2012 – 2013, and listed as Shameerpet Lake (L08), Banjara Lake (L04), Lungerhouse Lake (L07), Rangadhamuni Lake (L03), Durgam Lake (L22), Hussainsagar Lake (L15), Pragathi Nagar Lake (L17), Lakshminarayana Lake (L16), and Amber Lake (Ameersaheb Lake) (L19). Table 5 show the longitude, latitude and altitude data of sampling points of these lakes. Some Lakes monitored in the period 1998 and 1999 also and total samplings are around 200.

TABLE 5: Lake sampling points with Latitude, longitude and altitude.

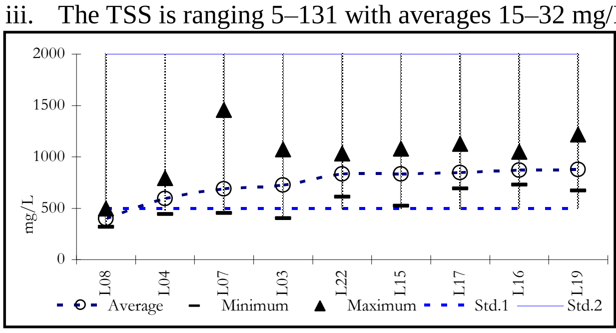
Code	Sampling point	Latitude N	Longitude E	Alt. m
L03	Rangadhamuni Lake	17°29’02”	78°23’59”	580.1
L04	Banjara Lake	17°24’41.1”	78°26’58.2”	535.5
L07	Lungerhouse Lake	17°22’46.4”	78°24’49.9”	550.1
L08	Shameerpet Lake	17°36’25.9”	78°34’6.8”	626.0
L15	Hussainsagar Lake	17°24’51.4”	78°28’6.4”	508.1
L16	Lakshminarayana Lake	17°25’11.7”	78°42’29.0”	455.5
L17	Pragathi Nagar Lake	17°30’33.5”	78°23’47.4”	568.2
L22	Durgam Lake	17°25’58.5”	78°23’20.6”	571.0
L19	Amber Lake	17°30’40”	78°23’49”	568.2

Fig.1.2 is the topographic view of these Lakes with code number marked in the GHMC on imposing latitude and longitude data via ViewNX 2 software provided with Nikon Camera.

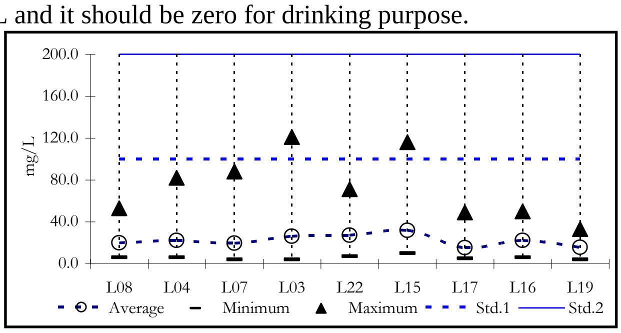
Fig.1.2: Topographic view of the Lakes.

Fig. 1.3 is minimum, average and maximum trends of lakes during 2012 – 2013 for the parameters (a) TDS (b) TSS in mg/L and observed

i. The TDS is ranging 317–1456 with averages 398–874 and acceptable limit is 500 mg/L [24].
ii. The lakes are arranged in increasing order of averages of TDS.
iii. The TSS is ranging 5–131 with averages 15–32 mg/L and it should be zero for drinking purpose.



(a)



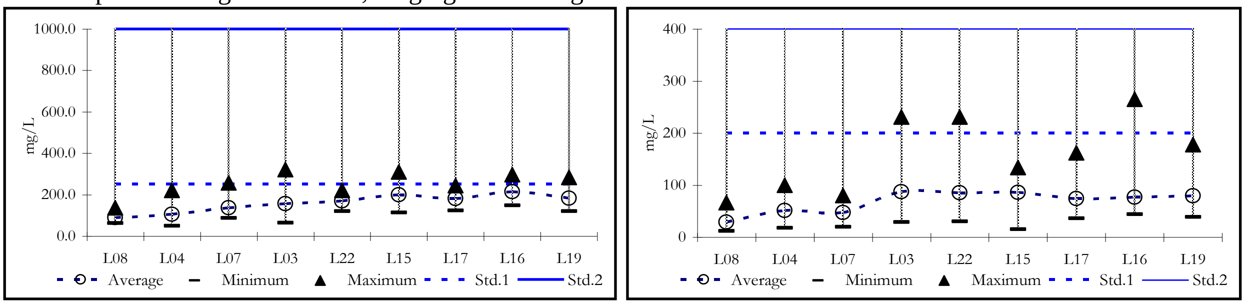
(b)

Fig.1.3: Minimum, average and maximum trends of Lakes during 2012 – 2013 of (a) TDS (b) TSS.

Fig.1.4 is minimum, average and maximum trends of Lakes during 2012–2013 (a) Chloride (b) Sulphate and observed

i. Chloride averages are 89–200, ranging 62–321 mg/L and acceptable limit is 250 mg/L as per IS 10500 (2012),

ii. Sulphate averages are 29-87, ranging 12–265 mg/L.

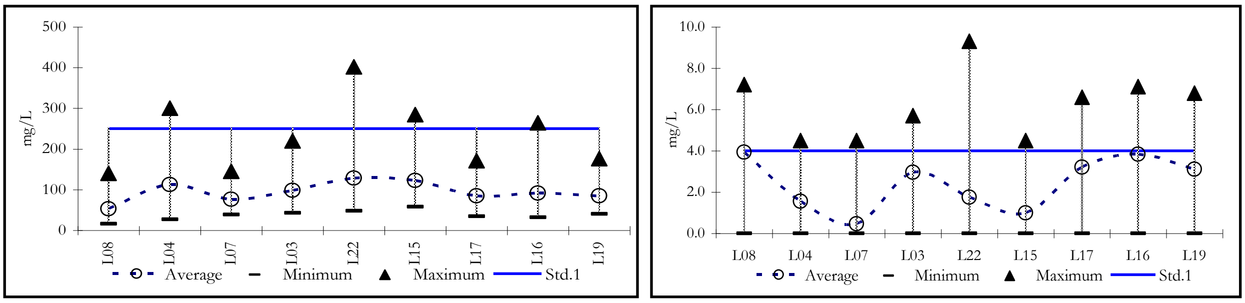


(a) (b)

Fig.1.4: Trends of Lakes during 2012 – 2013 (a) Chloride (b) Sulphate.

Fig.1.5 is minimum, average and maximum trends of Lakes during 2012 – 2013 (a) COD (b) DO and observed

i. Averages of CODs are 52–128, ranging 16-402 and Industrial Effluent Tolerance Limit of CPCB: 250 mg/L show accidences.
ii. DO values are varying widely from 0–8 mg/L indicating non suitability of fresh water fisheries and fall under Class E of use based classification of CPCB.

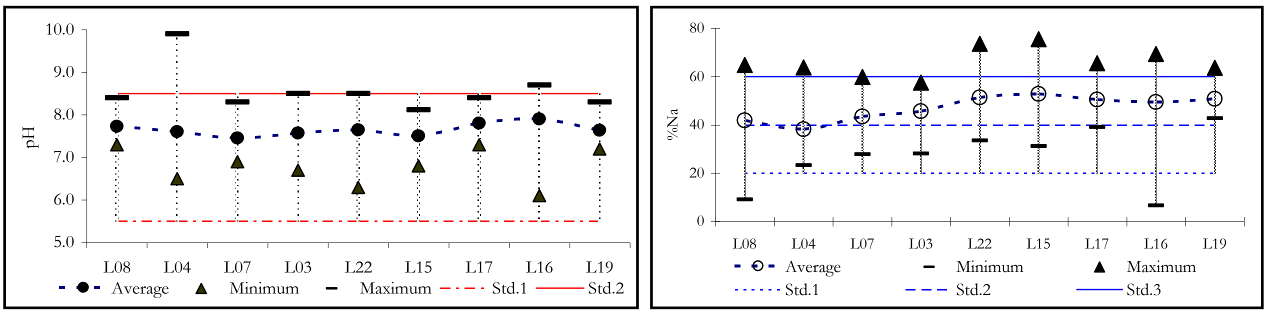


(a) (b)

Fig.1.5: Trends of Lakes during 2012 – 2013 (a) COD (b) DO.

Fig.1.6 is minimum, average and maximum trends of Lakes during 2012–2013 (a) pH (b) percent sodium and observed

i. Averages of pH are 7.5–7.9, ranging 6.1-9.9 and more deviations observed at L04 and accidences found against classification of designated best use by CPCB ranging 6.5-8.5pH.
ii. Averages of percent sodium are 38-53, ranging 7-75 varying widely and L08 and L16 showing fresh water catchment area.



(a) (b)

Fig.1.6: Trends of Lakes during 2012 – 2013 (a) pH (b) Percent sodium.

Fig.1.7 is minimum, average and maximum of SAR trends of Lakes during 2012 – 2013. Averages of SAR are 2.1-4, ranging 0.4-7.4 excellent for irrigation and well below the Low Hazard class on irrigation standards IS 11624 – 1986.

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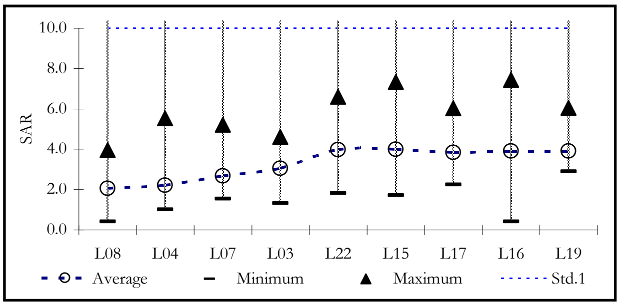

Fig.1.7: SAR Trends of Lakes during 2012 – 2013

1. Shameerpet Lake (L08)

It is adjacent to the Hyderabad-Kareemnagar state highway. Fig.1.8 is a photographic view of Shameerpet [25] Lake. A deer park [26] is developed adjacent to it. The NALSAR University of Law is established in the Shameerpet Lake upland. The catchment is under stress due to coming up establishments in recent years. This lake has good quality water among other Lakes.

Fig.1.8: A Photographic view of Shameerpet Lake.

TDS trends of Shameerpet Lake during 2012 – 2013 shown at Fig.1.9 and average of TDS is 398, ranging 317-494. Consider the period July – October to track the TDS, ranging 200-331 (1999), 347-427 (2012) and 366-500 (2013) show increase in TDS year after year.

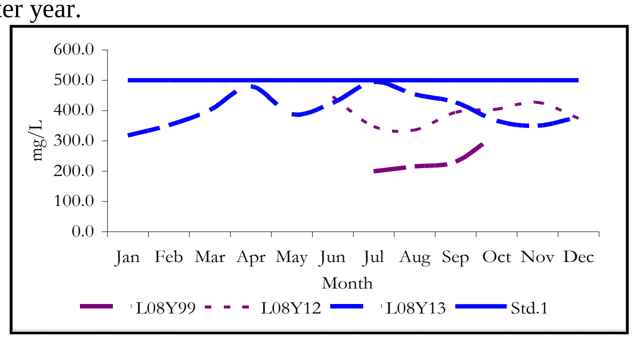

Fig.1.9: TDS trends of L08 during 1999 and 2012 – 2013.

Averages of TSS, COD, Chlorides and Sulphate at L08 are 20, 52, 89, 29, respectively, ranging 6-53, 16-140, 62-137 and 12-66. The pH average 7.7, ranging 7.3-8.4, respectively. The DO has reached zero in April 2013, June 2013,

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August 2012 and fluctuate 2.5-7.2 mg/L. The TDS values are not exceeding the standards because there is no such extent volume of pollution sources in the catchment area. TDS value in July 1999 was 200 mg/L and increased to more than 330 and reached 500 in July and August, 2013 with an average of 398 and show increased trend of pollution year after year from 1999 as at Fig.1.14. The percent Sodium fluctuate 30 to 60, and in June and August shows 65% indicating very high hazardous category with respect to Ir. HWQR. According to the same guidelines, the SAR value is excellent (< 4). Its suitability for domestic and cattle consumption is challenged due to remarkable fluctuations of parameters (TDS, COD, etc.) which represent dumping of industrial heavy pollutants, there by attracting attention for protection and treatment.

2. Banjara Lake (L04)

Fig.1.10 is a photographic view of the Banjara [27] Lake and also known as Hameed Khan Kunta. It is an 80-year old small water body located on the west of Banjara hills in Hyderabad. It is surrounded by apartment complexes on north. A commercial complex and Taj Banjara hotel on the south, and some slums and a graveyard are on the west of it.

1.10: A photographic view of Banjara Lake (L04)

The averages of TDS, DO, COD, Chloride and Sulphate of L04 are 591, 1.4, 112, 105 and 51, respectively, ranging 442-790, 0-4.5, 27-300, 49-220 and 18-100 mg/L. pH (9.9) in October 2012 and COD (300) in November 2012 exceeded the standards. The Percent Sodium values are medium and good where as SAR values represent low hazard class under Ir. HWQR.

4. Rangadhamuni Cheruvu (L03)

Rangadhamuni Cheruvu is situated adjacent to the 4th Phase of KPHB Colony and High Tech City. The averages of TDS, DO, COD, Chloride and Sulphate are 724, 3, 98, 157, 87, respectively, ranging 402-1070, 0-5.7, 43-220, 64-321 and 29-231 mg/L. TSS (116, 121) in June and July 2012, Chloride (321) in December 2012 and Sulphate (231) in December 2013 exceeded the standards. The Percent Sodium and SAR values are 46 and 3.1 represent medium and low hazard class as per Ir. HWQR. It is experiencing sewage and chemical Industrial effluents. High TDS with wide fluctuations and High COD are causing this water unfit for domestic purpose.

5. Durgam Cheruvu (L22)

Fig.1.11 gives a view of Durgam Cheruvu [28, 29, 30]. It is nearer to the High Tech City. Some of its inlet drains diverted through STP.

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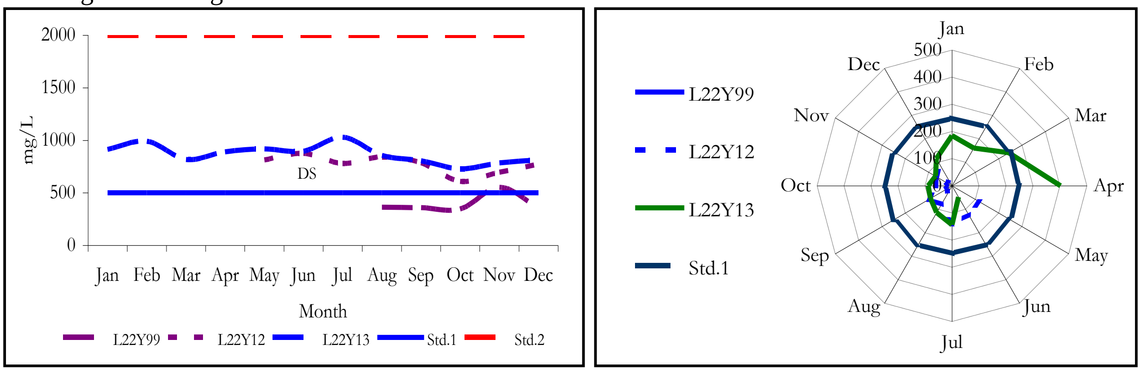
Fig.1.11: A photographic view of Durgam Cheruvu

Fig. 1.12 is showing Trends during 1998–1999 and 2012–2013 (a) TDS (b) COD and observations are

i. TDS ranging 264-553 in the year 1998 indicating <500, desirable limit of drinking water standards , and exceeded in 2012, 2013 ranging 610-896, 728-1038, respectively, though it is not suitable for drinking water purpose due to high COD in (b).
ii. COD in the years 1999, 2012 and 2013 ranging 18-32, 60-140 and 70-402, respectively, indicate receiving sewage from the grown habitation around it.



(a) (b)

Fig.1.12: Trends of L22 during 2012 – 2013 (a) TDS (b) COD

Average values of TDS, COD, Chlorides and Sulphate at Durgam Lake (L22) are 831, 128, 170, 85, respectively, ranging 610-1030, 18-402, 120-221 and 30-231 mg/L. Minimum-maximum and average values of pH are 6.3-8.5, 7.7. Average TSS is 27 mg/L. The DO has frequently reached zero and fluctuated to high values. COD and Sulphate higher deviations are attained in April 2013 and December 2013, respectively. Fig.1.8 shows the increased TDS trends indicating increase in pollution year after year. The Percent Sodium and SAR are 51 and 4, representing Medium and Excellent classes under Ir. HWQR. The wide deviations of parameters indicate the pollution of lake.

6. Lungerhouse Lake (L07)

Fig.1.13 is a photographic views of the Lungerhouse Lake [31] on adjacent to River Musi, its upstream side is Osmansagar then Golcoda fort and then canal reached to this lake.

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Fig.1.13: A view of the Lungerhouse Lake

Minimum-maximum and average values of TDS at Lungerhouse Lake (L07) are 450-1456 and 686, with 1456 mg/L on June 2013. Average TSS is 20 mg/L and DO reached zero frequently. Averages of COD, Chlorides and Sulphate are 77, 137, 47, respectively, ranging 39-145, 87-257 and 20-80 mg/L. The Percent Sodium and SAR (43 and 2.7) represent Medium and Excellent classes under Ir. HWQR. It is experiencing sewage and cottage electroplating industrial waste.

7. Lakshminarayana Lake (L16)

Fig.1.14 is photographic views of Lakshminarayana Lake and also called Edulabad Lake. It is after Pratapsingaram, its outlet joins to River Musi in Rangareddy District near to border of Nalgonda District.

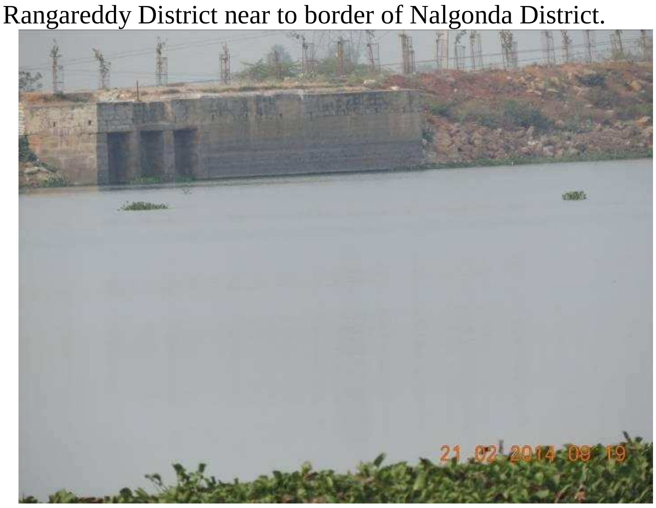

Fig.1.14: A view of Lakshminarayana Cheruvu (L16).

Average value of TDS at Lakshminarayana Lake (L16) is 867, ranging 726-1048 mg/L. The pH range is 6.1-8.7. Average TSS is 22 mg/L. The DO reached zero during April, June and October 2012, and it was around 4 mg/L in the year 2013. Range and average values of COD are 32-264, 92 mg/L, and the higher deviations attained in the June and October 2012. The average Chlorides and Sulphate concentrations are around 215$\pm$75 and 77 with range 44-265 mg/L, respectively. The Percent Sodium and SAR (49 and 2.7) represent Medium and Excellent classes under Ir. HWQR and the deviations indicate the pollution of lake.

8. Hussainsagar Lake (L15)

Hussainsagar Lake (Fig.1.15) [32, 33] is situated in the heart of the city by its topography and most of the drains in the city are joining it and in turn, the outlet drain is joined with River Musi. Major effluents from industrial areas and

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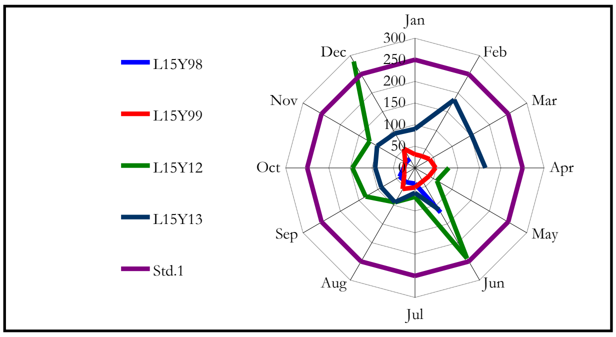
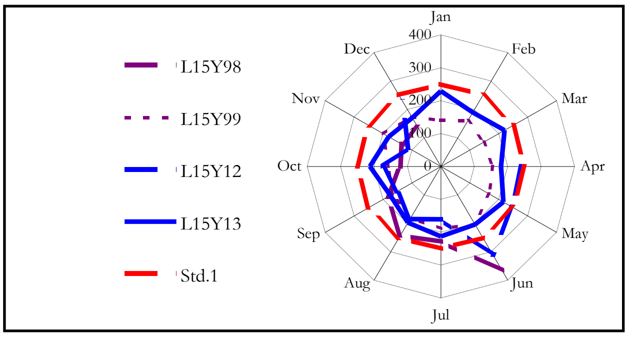
industries situated towards Bollaram, Jeedimetla, Patancheruvu and Kukatpalli are joining it through drains, in which major portion is diverted to River Musi through Amberpet STP. Some of the drains collecting sewage are diverted to Khairatabad STP for treatment and the STP outlet is used for charging the Lake.

Fig.1.15: Hussainsagar Lake photographic view.

Fig.1.16 shows Hussainsagar Lake (a) COD averages 122, ranging 58-284 and (b) Chloride averages 200, ranging 113-310 mg/L respectively. Chloride exceeded the standards in June 1998 and 2012. COD is lower than 56 in year 1998, increased to 112 in July 1999, 60-284 in 2012, 58-182 in 2013 and touches the industrial discharge standard limit in Jun and Dec 2012 indicating increased organic load in the Lake as shown at (b).





(a) (b)

Fig.1.16: L15 during 1998-1999, 2012 – 2013 of (a) COD (b) Chloride.

Averages of pH, TDS, TSS and Sulphate at Hussainsagar Lake are 7.5, 833, 32, 86, respectively, ranging 6.8-8.1, 251-1076, 10-116 and 15-134 mg/L. The DO is nearer zero. Minimum-maximum and average values of Percent Sodium and SAR are 31-76, 1.7-7.3 and 49, 4, respectively, representing Medium and Excellent classes under Ir. HWQR and wide variations (Figs.1.60 and 1.61) represent heavy population.

9. Pragathi Nagar Cheruvu (L17) and Amber Lake (L19)

Fig.1.17 is the photographic views of (a) Pragathi Nagar Lake (b) Amber Lake [34] separated both by a road and other side is covered with apartments.

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(a) (b)

Fig.1.17: photographic views (a) Pragathi Lake (b) Amber Lake.

Averages of TDS, TSS, COD, Chlorides and Sulphate at Pragathi Nagar Lake (L17) are 843, 15, 84, 181, 74, respectively, ranging 690-1126, 5-49, 34-171, 124-243 and 36-162. The pH average 7.8, ranging 7.3-8.4, respectively. Its average TSS is 15 mg/L. The DO has reached zero and fluctuate 1.6-6.7 mg/L. The Percent Sodium and SAR are around 50 and 3.8 represent Medium and Excellent classes under Ir. HWQR. The wide deviations of the values of parameters indicate the pollution of lake.
Averages of TDS, TSS, COD, Chlorides and Sulphate at Amber Lake (L19) are 874, 16, 85, 183, 80, respectively, ranging 671-1215, 4-33, 40-176, 121-283 and 39-178. The DO is reached zero and average 1. Average of pH is 7.6 fluctuate 1.6-6.7. The Percent Sodium and SAR are around 51 and 3.9 represent Medium and Excellent classes under Ir. HWQR. The wide deviations of the values of parameters indicate the pollution of lake.

V. CONCLUSION

The analysis data for the period 1998–1999 is a study for taking immediate control measures in implementation of controlling pollution. While the later period 2012–2013 covers many areas of the city, due to increased pollution and industrialization lead to gaining national importance and a vigil on water bodies against pollution due to increased public awareness. On observation of results for periods 1998–1999 and 2012–2013 for Lakes, the influence of insignificant ions' contribution is within the acceptable limits of data variations [35] and the impact is insignificant for heavy metals and other ions which are omitted for discussion. The percent sodium is valid parameter when the EC exceeds 1500 µmhos/cm.
The correlation analysis is not applicable because the deviations are of great value for characterizing each water body. Each monitoring had an objective to report the quality of water. Average TDS is ranging 400-874 mg/L, L08 indicating acceptable drinking water quality and other Lakes are permissible limit but other parameters such as total nitrogen, COD, Pharma intermediate residues, sewage sudden increase of pollutants rejects the usage even for domestic purpose.
Fig.1.18 is trends of Lakes during 2012-2013 (a) EC (b) RSC and observed

i. EC average ranging 584-1400 (µmhos/cm) with in Low hazard class (<1500).
ii. RSC of all the water bodies are negative indicates little risk of sodium accumulation due to offsetting levels of calcium and magnesium. There is no location having the hazardous toxicity [36] in respect of RSC toxicity [37] in interpreting irrigation water. These lakes indicate efficiency in reducing RSC toxicity to some extent.

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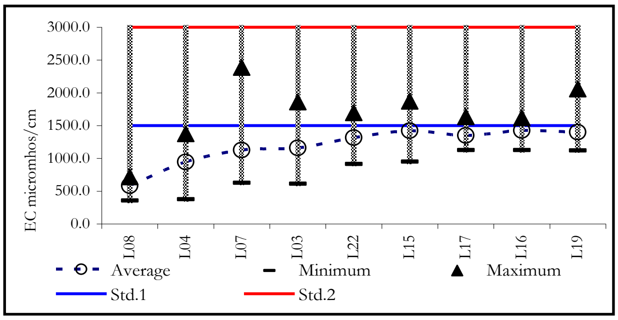

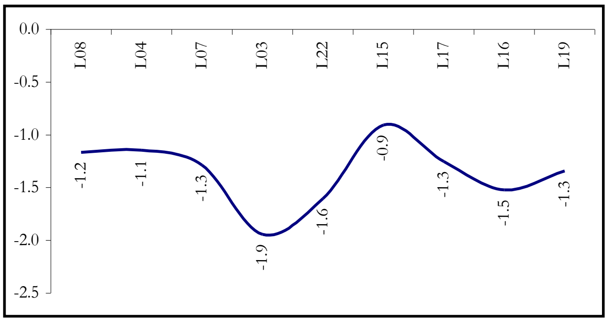

(a) (b)

Fig.1.18: Trends of Lakes during 2012–2013 (a) EC (b) RSC.

Most of the lake catchments are urbanized with human colonies and the sewage generated is joining the lake. The only alternative to charge the lakes is all inlet drains diverted through treatment facility. Hence, every lake inlet should be through STPs in addition to preliminary treatment of rain water for removal of silt, suspended solids, organic constituents and plastic waste. Lake Boundaries should be re-established to possible extent with clearing encroachments for retaining the capacity of lake and should be preserved for recreation / park for the public to feel the nature [38] and charging the ground water table with good quality water.

WAWQI (Tables 1-3), the BIS standards and CPCB designated best uses - procedure for setting water quality goals (Table 4) are causing confusing state. It seems the CPCB designated best uses - procedure for setting water quality goals missing major influencing parameters on each usage. Its modification to cover major influencing parameter would be more precise and appreciable to understand and decision making. It is suggested to include EC/TDS and SAR/RSC for all categories (A–E) in primary reporting.

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REFERENCES

[1] STATUS OF WATER QUALITY IN INDIA-2006, Monitoring of Indian National Aquatic Resources Series: MINARS /28 /2007-2008, CENTRAL POLLUTION CONTROL BOARD MINISTRY OF ENVIRONMENT & FORESTS Website: www.cpcb.nic.in e-mail: cpcb@nic.in.
[2] Horton, R.K., "An index number system for rating water quality", J. Water Pollu. Cont. Fed., 37(3). 300-305. 1965.
[3] Brown, R.M., McClelland, N.I., Deininger, R.A. and Tozer, R.G., "Water quality index-do we dare?", Water Sewage Works, 117(10). 339-343. 1970.
[4] CCME. 2001. Canadian water quality guidelines for the protection of aquatic life: Canadian Water Quality Index 1.0 Technical Report. In Canadian environmental quality guidelines. 1999. Winnipeg.
[5] Curtis G. Cude,Origon Water Quality Index: A tool for evaluating water quality management effectiveness, QEQ05-LAB-0036-TR, Journal of the American Water Resources Association, 37 (2001)
[6] Brown, R.M, McCleiland, N.J., Deiniger, R.A. and O'Connor, M.F.A. "Water quality index – crossing the physical barrier", (Jenkis, S.H. ed.) Proceedings in International Conference on water pollution Research Jerusalem 6. 787-797. 1972.
[7] Brown, R.M, McCleiland, N.J., Deiniger, R.A. and O'Connor, M.F.A. "Water quality index – crossing the physical barrier", (Jenkis, S.H. ed.) Proceedings in International Conference on water pollution Research Jerusalem 6. 787-797. 1972.
[8] Dunnette, D. A., 1979. A Geographically Variable Water Quality Index Used In Oregon. Journal of the Water Pollution Control Federation 51(1);53-61.
[9] Oregon DEQ, 1994a. Issue Paper; Temperature. Oregon Department of environmental Quality, Portland, Oregon.
[10] McClelland, N. I., 1974. Water Quality Index Application in the Kansas River Basin. U.S. Environmental Protection Agency Region 7, Kansas City, Missouri.
[11] Dojlido, J. R., J. Raniszewski, and J. Woyciechowska, 1994. Water Quality Index Applied to Rivers in the Vistula River Basin in Poland. Environmental Monitoring and Assessment 33:33-42.

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(An ISO 3297: 2007 Certified Organization)

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[12] Shweta Tyagi1, Bhavtosh Sharma2,*, Prashant Singh1, Rajendra Dobhal2,3, American Journal of Water Resources, 2013, Vol. 1, No. 3, 34-38 Available online at http://pubs.sciepub.com/ajwr/1/3/3 © Science and Education Publishing DOI:10.12691/ajwr-1-3-3. "Water Quality Assessment in Terms of Water Quality Index".
[13] IS 11624 (1986): Guidelines for the quality of irrigation water [FAD 17: Farm Irrigation and Drainage Systems], Chpt7is11624.1986.pdf.
[14] Ameetha Sinha1, Baidyanath Kumar2, Tanuja Singh3, Water quality assessment of two ponds of Samastipur District (India), Copyright by the authors - Licensee IPA- Under Creative Commons license 3.0, Research article ISSN 0976 – 4402, International Journal Of Environmental Sciences, 4 (2014).
[15] Pollution Control Law Series: PCLS/02/2010. Pollution Control Acts, Rules and Notifications issued there under. CPCB, GOI.
[16] IS 11624 (1986): Guidelines for the quality of irrigation water [FAD 17: Farm Irrigation and Drainage Systems]
[17] GUIDE TO INTERPRETING IRRIGATION WATER ANALYSIS. Spectrum Analytic, Inc. Soil Analysis 1087 Jamison Road 1-800-321-1562, Plant Analysis PO Box 639 (740) 335-1562, Fertilizer Analysis Washington C.H., Ohio 43160 Fax: (740) 335-1104, Manure Analysis. www.spectrumanalytic.com, http://www.spectrumanalytic.com/support/library/pdf/ guide_to_interpreting_irrigation_water_analysis.pdf
[18] INTERPRETING IRRIGATION WATER ANALYSIS II - PLANT NUTRITION AND WATER QUALITY Fact Sheet No. 701, Revised 1/2007, A & L Canada Laboratories, 2136 Jet stream Rd., London, ON N5V 3P5, 519-457-2575, www.alcanada.com
[19] C. K. Jain1, A. Bandyopadhyay1 and A. Bhadra2, Guidelines for evaluation of irrigation water quality, J. Indian Water Resour. Soc., 32 (2012). Assessment of Ground Water Quality for Irrigation Purpose, District Nainital, Uttarakhand, India http://www.iwrs.org.in/journal/july2012/2july.pdf.
[20] Guidelines for Water Quality Management, CENTRAL POLLUTION CONTROL BOARD, 'PARIVESH BHAWAN', EAST ARJUN NAGAR, DELHI. Website : http://www.cpcb.nic.in
[21] T.Vidya Sagar, "Water Quality of Some Polluted Lakes in GHMC Area, Hyderabad – India", International Journal of Scientific & Engineering Research, Vol. 6, No. 8, 1550-1557.
[22] TRIVEDI SONAL and H. C. KATARIA, Current World Environment Vol. 7(1), 139-144 (2012), Physico-Chemical Studies of Water Quality of Shahpura Lake, Bhopal (M.P) with Special Reference to Pollution Effects on Ground Water of its Fringe Areas.
[23] APHA (American Public Health Association), 16th (1985), 20th (1998) and 21st Edition (2005)
[24] IS 10500 (2012): Drinking water [FAD 25: Drinking Water].
[25] Ms. Sreoshi Singh, Scoping Study Report: Hyderabad, WATER SECURITY IN PERI-URBAN SOUTH ASIA, Adapting to Climate Change and Urbanization, http://saciwaters.org/periurban/Scoping_Study_Report_Hyderabad.pdf . www.saciwaters.org/periurban.
[26] http://aptdc.gov.in/special-tours/shameerpet_deerpark.html
[27] National River Conservation Plan, MOEF, GOI Official website, Banjara Lake. http://www.moef.nic.in/sites/default/files/nlcp/Lakes/Banjara%20Lake.pdf
[28] Editors: Frauke Quades and Podmini B Patell, Newsletter, Society to save rocks, 56 (2010), Qty. 1236, Rd. No. 60, Jubilee Hills, Hyderabad 500033. http://www.saverocks.org/newsletter/56_Save_Rocks_Newsletter.pdf.
[29] J. Deepa, M. Karuthapandi and Rehanuma Sultana, Zoological Survey of India, Freshwater Biology Regional Centre, Hyderabad - 500 048, ISSN 2277 – 758X, Deepa et al., IJALS, Volume (6) Issue (1) Feb - 2013. RESEARCH ARTICLE, Aquatic Coleoptera from Durgam Cheruvu, Hyderabad, Email: deepajzsi@gmail.com. http://www.unitedlifejournals.com/ms_files/ijals/MS05-IJALS-FEb-2013-_Aquatic_Coleoptera_from-Durgam.pdf.
[30] C. Ramachandraiah & Sheela Prasad, Working Paper No. 60 September 2004, Title: Impact of Urban Growth on Water Bodies - The Case of Hyderabad, by pub: Centre for Economic and Social Studies, Begumpet, Hyderabad-500016. http://www.soulhyd.org/articles/HydLakeHistory.pdf.pdf or www.cess.ac.in/cesshome/wp%5Cwp-60.pdf,
[31] HMDA notification of full tank level boundaries and buffer zones of lakes /water bodies in Hyderabad metropolitan region. http://www.hmda.gov.in/Tenders/BPP/VIII%20Phase%20Notification.pdf.
[32] SULEKH CHANDRA*, ARENDRA SINGH and PRAVEEN KUMAR TOMAR, Chem Sci Trans., 2012, 1(3), 508-515, Chemical Science Transactions, DOI:10.7598/cst2012.169, ISSN/E-ISSN: 2278-3458/2278-3318. Assessment of Water Quality Values in Porur Lake Chennai, Hussain Sagar Hyderabad and Vihar Lake Mumbai, India.. http://www.e-journals.in/PDF/V1N3/508-515.pdf.
[33] S.Umamaheswara Reddy, General Manager, Department of Construction Technology, Soma Enterprise Limited, Hyderabad and Dr.P.Venugopal Rao, Professor in Civil Engineering (Retired), Jawaharlal Nehru Technological Institute, Hyderabad. IJETAE, ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 3, Issue 3, March 2013, 'Analysis of Sediment and Pore Water samples of a Contaminated Lake - A Case Study of Hussain Sagar. http://www.ijetae.com/files/Volume3Issue3/IJETAE_0313_144.pdf.
[34] Delimitation of wards in Greater Hyderabad Municipal Corporation – Notification, File No.2109/Elec/TPS/HO/GHMC/2008 Date: 23-05-2009. http://ap.loksatta.org/documents/Wards.pdf.
[35] Book Title: Standard Methods for the examination of water and wastewater, Pub: Americal Public Health Association, 16th 1985, 20th 1998 and 21st 2005 Edn. Sec. 1030 E. Checking Correctness of Analysis.
[36] C. K. Jain, A. Bandyopadhyay and A. Bhadra. Journal of Indian Water Resources Society, Vol 32, (2012). Title: ASSESSMENT OF GROUND WATER QUALITY FOR IRRIGATION PURPOSE, DISTRICT NAINITAL, UTTARAKHAND, INDIA. Page 8 to 14.
[37] Fact Sheet No. 701, Revised 1/2007, A & L Canada Laboratories, 2136 Jetstream Rd., London, ON N5V 3P5, 519-457-2575, Title: INTERPRETING IRRIGATION WATER ANALYSIS II - PLANT NUTRITION AND WATER QUALITY www.alcanada.com Interpreting irrigation water analysisII.pdf, http://alcanada.com/index_htm_files/Interpreting% 20irrigation%20water%20analysisII.pdf
[38] Siddhartha Koduru and Swati Dutta, Creative Space (CS), Volume 1, Number 1, July 2013, pp. 19–37. Title: Urban Ecosystems: Preservation and Management of Urban Water Bodies, http://cs.chitkara.edu.in/pdf/02_CS_Sidhartha.pdf.

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