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ON WATER QUALITY ASPECTS OF MANCHANABELE RESERVOIR CATCHMENT AND COMMAND AREA (KARNATAKA)

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ABSTRACT
Reservoirs and lakes occupy a prominent place in the history of irrigation in South India. Tanks are considered to be useful life saving mechanism in the water scarcity areas which are categorized as Arid and Semi-arid zones. The lakes and reservoirs, all over the country without exception, are in varying degrees of environmental degradation. The degradation is due to encroachments, eutrophication (due to the inflow of domestic and industrial effluents) and siltation. There has been a quantum jump in population during the last century without corresponding expansion of civic facilities resulting in deterioration of lakes and reservoirs, especially in urban and semi urban areas becoming sinks for the contaminants. The degradation of reservoir and lake catchments due to deforestation, stone quarrying, sand mining, extensive agricultural use, consequent erosion and increased silt flows have vitiated the quality of water stored in reservoirs and lakes. Infrastructure development, housing projects, and inflow of untreated wastewater into the water bodies have resulted in deterioration of urban and rural lakes and reservoirs. The paper discusses the physico-chemical and bacteriological studies carried out on surface and ground water in the reservoir catchment and the command areas .The results of analyses of water samples reveal that water is polluted at certain locations. The presence of total –Coliform and Faecal-Coliform in ground water and reservoir and lake water at certain locations indicates that water is polluted with waste water. The nitrate level varies between 0.6ppm to 135.8ppm, and exceeds the drinking water standards at 10 locations in the catchment and command area. The suitability of water for irrigation is evaluated based on SAR, %Na, RSC and Salinity hazards. Most of the samples fall in the suitable range for irrigation purpose. The inflow of urban runoff into the surface water bodies has resulted in pollution of reservoir and ground water at certain locations. The paper also discusses the measures proposed to reduce pollution levels in the reservoir, its catchment and command areas

KEY WORDS: Catchment, Irrigation, Urbanization, chemical classification, SAR, USSL diagram

INTRODUCTION
Water has become an increasingly important ingredient in the development of all countries. It is a key resource in agricultural production and is also required for domestic, industrial, navigation and other purposes. The importance of irrigation water lies not only in its own productivity but also in its ability to increase the productivity of other crops production inputs such as fertilizer. Thus there is an imperative need for the efficient use of this scare resource to increase agricultural production to meet the demand for food for the growing population. In general, irrigated agriculture plays a major role in regional economics. The awareness that water is no longer a free and plentiful natural resource but is a precious economic commodity and imperiled social asset is yet to sink in. Experts and agencies both inside the country and outside have many times drawn attention to the depletion of water (particularly with Ground water), shrinking of water bodies, deterioration of surface and ground water quality and prospects of water in the coming years. The alarm sounded by the World bank over the sinking ground water table in India is not new. Therefore over-exploitation, misuse and lack of conservation and augmentation efforts are normal in the country. The scenario is bleak across the world, provoking comments that countries may in future resort to war over water. But the situation is especially critical in India (particularly in Karnataka) with an increasing population exerting greater pressure on the resources for agricultural, drinking water and industrial purposes. The over use of water could lead to reduction of agricultural output by as much as 25 percent and lead to serious drinking water shortages. Industry will also be badly affected by the shortage.

Ecological and socio-economic impacts of small reservoirs are not yet well understood. In many semi-arid areas in developing countries, small reservoirs are an integral part of improved rural water management strategies. Although, in general, reservoirs are managed at village level and, as such, are less prone to conflicts of interest than large scale irrigation schemes. A large expansion of the number of small reservoirs will have to be accompanied by crop diversification. Percolation from reservoirs, which may be perceived as losses, should be considered a benefit to the larger groundwater system, because percolation feeds aquifers and thereby wells. The Ministry of Water Resources (GoI) suggests that the climate change is likely to affect the hydrological cycle which will result in, more rainfall in lesser time, decrease in number of rainy day, over all increase in precipitation, increase in runoff but less groundwater recharge etc.

Reservoirs and lakes occupy a prominent place in the history of irrigation in South India. Tanks were considered to be a useful life saving mechanism in the perennial water scare areas which are categorized as Arid and Semi-Arid Tropics. The Lakes and Reservoirs, all over the country without exception, are in varying degrees of environmental degradation. The degradation is due to encroachments, eutrophication (due to the inflow of domestic and industrial effluents) and siltation. There has been a quantum jump in population during the last century without corresponding expansion of civic facilities resulting in deterioration of lakes and reservoirs, especially in urban and semi-urban areas becoming sinks for the contaminants. The degradation of reservoir and lake catchment areas due to deforestation, stone quarrying, sand mining, extensive agricultural use, consequent erosion and increased silt flows have vitiated the quality of water stored in reservoirs and lakes. Infrastructure development, housing projects, and inflow of untreated wastewater into the water bodies have resulted in deterioration of urban lakes and rural lakes and reservoirs. The paper discusses the physico-chemical and bacteriological studies carried out on surface and ground water and physical and chemical characterization of soil in the catchment, and command areas following accepted practices. Soil samples were analyzed for available macro and micro nutrients. The results of analyses of water samples reveal that water is contaminated at certain locations. The paper also discusses the measures proposed to reduce pollution levels in the reservoir, its catchment and command areas.

STUDYAREA:

Manchanabele reservoir is located near Manchanabele village latitude N 12º52'30" and longitude E 70º20'15" Magadi taluk, Ramanagaram district. Manchanabele dam is constructed across the River Arkavathy a tributary to the River Cauvery. The catchment area at the Manchanabele dam site is 1590km^2. Out of which 1438 km^2 is intercepted by the Chamarajasagar Reservoir at Thippagondanahalli and a balance of 152km^2 is an independent catchment area. The storage capacity of the reservoir is 34.61 M.Cum. The length of the left bank canal is 36km and the length of right bank canal is 35 km. The cultivable command area of the left bank canal and right bank canal is 1767ha and 2078ha respectively. The discharge capacity of left bank canal and right bank canal is 1.44 cumecs and 1.67 cumecs respectively. The rainfall over the catchment varies from 76.00 to 91.00cm. The rainfall occurs during the months of June to September, the south west monsoon during September being predominant. The main crop in the area is Mulberry and is essential for silk industry which employees thousands of people of Ramanagaram and Kanakapura taluks. The crops as recommended are ragi, groundnut, mulberry, sugarcane, paddy and coconut. The natural vegetation of the area consists of small shrubs and trees. The common trees observed are coconut, banyan, mangoes, jack fruit, basari, neem, tamarind, etc. and shrubs consisting of lantana and yekka. Geologically the Ramanagaram area is composed of older peninsular gneisses and is intruded by closepet granite, batholiths which stretch from Ramanagara to Bellary in North of Karnataka which spreads to a length of about 500km having a width of about 5-50km. The area is also intruded by basic dolerite rocks intruded in the form of dykes. These three litho units are used as building stones, decorative stone, road metal etc. The soil in the catchment and command area comprises of deep red gravelly soil and deep red clayey soil.

Fig 1.Catchment area of ManchanabeleReservoir

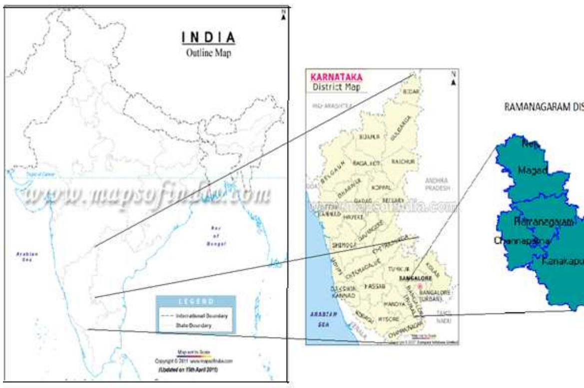

Fig 2. Location of the Study area.

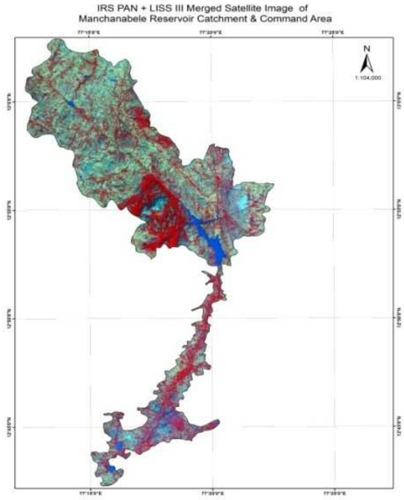

Fig 3.Sattelite Image of the Study area.

METHODOLOGY:

Ground water samples were collected from catchment and command areas of the reservoir and surface water were collected from lakes and the reservoir durning mosoon(septemder2011), post-monsoon(december2011) and pre-monsoon (march2012). Physico-chemical and biological analyses were carried out for the watersamples collected from various locations using standard procedures recommended by APHA-1994. The location of various sampling points is as shown in Fig 3. The results were used for classifying water for irrigation requirements and drinking water standards.

RESULTS AND DISCUSSION :

The seasonal variation of the Physico-chemical and bacteriological analyses of water samples for and premonsoon, monsoon,and postmonsoon is presented in the Table 1. The water is classified based on hardness by Sawer and McCarthy and the classification is presented in Table 4. The suitability of ground water for irrigation purposes depends upon its mineral constituents. The general criteria for judging the quality are (i)total salt concentration as measured by electrical conductivity (ii)relative proportion of sodium to other principal cations as expressed by SAR,(iii) soluble sodium percentage.(iv)residual sodium carbonate (v) residual sodium bi carbonate. The above values for premonsoon, monsoon and post monsoon are presented in the Tables 2,3&4. The classification of water based on hardness is shown in Table 5

Table-1 Seasonal variation of water quality parametres in the Manchanabele Catchment and Command areas. (Min - Max values)

Sampling Points	(S.A.R)	(S.S.P)	Magnesium Hazard	Chloride	(R.S.B.C)	Permeability Index (P.I)	Kelley's Ratio
MB-W1	1.064	23.619	0.229	1.157	1.77	56.094	0.309
MB-W2	2.962	49.395	0.479	4.251	2.199	72.967	0.976
MB-W3	2.691	42.930	0.406	1.834	4.447	68.537	0.752
MB-W4	2.908	51.724	0.261	0.666	4.146	86.080	1.071
MB-W5	2.861	44.833	0.226	1.128	4.787	72.392	0.813
MB-W6	2.545	33.729	0.236	5.06	2.959	52.475	0.509
MB-W7	2.688	36.661	0.326	4.612	3.768	56.167	0.579
MB-W8	1.297	24.549	0.249	2.514	1.978	51.329	0.325
MB-W9	2.131	38.502	0.410	3.955	2.382	64.059	0.626
MB-W10	2.718	55.335	0.434	1.577	2.027	89.496	1.239
MB-W11	1.471	20.034	0.440	3.641	7.576	39.282	0.251
MB-W12	2.606	53.141	0.424	1.461	2.223	87.477	1.134
MB-W13	3.162	50.919	0.358	2.79	3.444	77.709	1.037
MB-W14	1.637	27.271	0.270	2.325	2.578	50.839	0.375
MB-W15	1.676	31.936	0.407	2.718	2.598	58.879	0.469

Table 2 . Quality of water for irrigation requirements (pre monsoon season)

I	PARAMETERS	Ground water			Surface water (Reservoir and Stream)		
	Season	**Pre-monsoon**	**Monsoon**	**Post monsoon**	**Pre-monsoon**	**Monsoon**	**Post monsoon**
1	pH	7.01-7.59	6.66-7.49	7.08- 7.81	7.1-7.59	7.21-7.61	7.11- 8.5
2	Temperatureº(C)	27	26	27	27	26	27
3	DO(mg/lt)	2.7-6.9	5.9-6.8	2.4- 7.1	2.0-6.4	5.5-6.5	5.2-7.1
4	BOD(mg/lt)for 5 days	<1.0 – 5.6	<1.0-5.4	1.2-7.7	1.0- 5.9	1.0-2.1	1.2-4.2
5	COD,mg/lt	1.6- 7.1	<1.0- 14.2	2.7- 6.7	5.6 – 23.3	6.6-17.0	6.7-14.1
6	TSS,mg/lt	<1.0-8.0	<1.0-4.0	<1.0 – 6.9	4.0 -19.8	2.0-8.4	1.0-6.0
7	Turbidity,NTU	0-7.0	0-6.9	0- 7.0	5.4 – 8.0	1.0-4.1	3.8-5.3
8	TDS,mg/lt	484- 2158	570.0-1956	496- 2147	328 – 765.3	256.4-556.0	396-745.3
9	Conductivity, micromhos/cm @25 C	760-2614.9	800.4-2430.4	778 – 2488.3	511-1191.6	395.6-873.0	619 - 1391.6
10	Sodium as Na ,mg/lt	42.7- 146. 3	47.9-147..3	41.86-151.3	59.84- 103.3	47.9-86.44	57.94- 91.53
11	Potassium as K,mg/lt	0.54 – 7.49	1..58-17.0	0.43-27.0	1.84 – 29.36	0.67-11.82	0.69 – 25.36
12	Calcium as Ca,mg/lt	59.79 – 193.4	18.3-197..6	61.79 - 204.6	27.3 – 63.5	18.30-62.40	31.2 – 64.6
13	Magnesium as Mg,mg/lt	16.5 – 92.2	13.2-68.3	23.43 - 88.2	11.7 – 29.8	9.9-31.5	9.5- 34.98
14	Total Hardness as $CaCO_3$,mg/lt	230 – 861.52	198.7-724.5	250.5 – 835.12	120.0 – 290.06	99.87-284.6	120.9- 410.4
15	Total Alkanility,as $CaCO_3$,mg/lt	178.4 – 645.2	234.0-612.3	264.0 – 612.3	169.5 – 343.4	170.4-346.3	154-330.0
16	Chlorides as mg/lt	40 – 179.4	68.5-183.4	42.0 – 212.4	23.6 – 150.7	68.4-211.3	19.9-201.5
17	HCo_3 asmg/l	386.3- 1051.0	285.4-747.1	305.6- 747.03	222.8 – 353.87	121.8-208.1	168.6- 322.1
18	Fluorides asF,mg/lt	0.58 – 3.8	0.28-0.38	0.44 – 3.5	0.3- 2.0	0.05-0.83	0.5--1.8
19	Nitrates as NO_3,mg/lt	3.0- 58.4	0.97-88.5	3.1- 66.8	2.9 – 9.8	0.73-5.60	1.2-8.60
20	Phosphorous as PO_4,mg/lt	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
21	Sulphates as SO_4,mg/lt	10.4 – 48.5	9.5-68.4	11.5 -72.4	8.3 – 42.5	7.0-45.2	9.22-49.5
22	Hexa valent–Chromiun as Cr6+,mg/lt	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
23	Iron, as Fe ,mg/lt	0.06 – 0.70	0.04-0.1	0.05 – 0.16	0.03 – 0.47	0.05-0.38	0.09-0.34
24	Copper,as Cu,mg/lt	< 0.02	0.02-0.04	< 0.02	<0.02	<0.02	<0.02
25	Lead,as Pb,mg/lt	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
26	Nickel as Ni,mg/lt	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
27	Zinc,as Zn mg/lt	0.02 – 0.09	0.02-0.09	0.02 – 0.08	0.05 – 0.49	0.02-0.21	0.03-0.07
28	Total -Coliform/100ml	NIL	NIL	NIL	48 - 1910	52-101X102	50 – 98X102
29	Faecal-Coliform/100ml	NIL	NIL	NIL	27 - 454	31-42X102	29X102

Table3. Quality of water for irrigation requirements (monsoon season)

Sampling Points	(S.A.R)	(S.S.P)	Magnesium Hazard	Chloride	(R.S.B.C)	Permeability Index (P.I)	Kelley's Ratio
MB-W1	1.022	22.473	0.305	1.184	1.221	51.811	0.289
MB-W2	2.526	44.500	0.347	4.524	-0.158	64.115	0.801
MB-W3	2.667	42.961	0.414	2.547	3.586	67.463	0.753
MB-W4	2.565	50.348	0.298	0.561	3.033	86.002	1.014
MB-W5	2.915	43.565	0.303	1.323	4.267	67.609	0.771
MB-W6	2.470	31.684	0.280	5.991	0.587	47.503	0.463
MB-W7	2.529	34.895	0.316	5.255	2.351	53.354	0.536
MB-W8	1.243	23.489	0.210	2.631	0.116	47.429	0.307
MB-W9	2.061	36.933	0.464	5.684	0.357	56.449	0.585
MB-W10	2.484	51.371	0.437	2.510	1.206	80.596	1.056
MB-W11	1.088	15.843	0.434	4.409	2.793	33.471	0.188
MB-W12	2.421	52.382	0.322	1.410	1.877	89.256	1.100
MB-W13	2.711	46.139	0.384	3.876	1.925	70.196	0.856
MB-W14	1.295	23.138	0.233	2.296	0.385	45.840	0.301
MB-W15	1.796	34.058	0.392	2.777	1.606	59.102	0.516

Table 4. Quality of water for irrigation requirements (post monsoon season)

Sampling Points	(S.A.R)	(S.S.P)	Magnesium Hazard	Chloride	(R.S.B.C)	Permeability Index (P.I)	Kelley's Ratio
MB-W1	1.281	26.583	0.241	1.184	-0.072	51.935	0.362
MB-W2	2.244	40.110	0.461	4.524	0.486	60.094	0.669
MB-W3	2.745	45.004	0.232	2.547	1.313	68.197	0.818
MB-W4	2.223	49.856	0.361	0.561	0.908	81.580	0.994
MB-W5	2.726	43.102	0.299	1.323	1.942	65.461	0.757
MB-W6	2.548	33.478	0.246	5.991	2.396	51.498	0.503
MB-W7	2.759	37.290	0.247	5.255	1.862	55.674	0.594
MB-W8	2.084	51.038	0.543	2.631	1.083	85.645	1.042
MB-W9	2.021	37.454	0.453	5.684	0.255	57.613	0.598
MB-W10	2.840	52.240	0.461	2.510	1.552	78.244	1.093
MB-W11	1.104	17.014	0.386	4.409	3.341	37.023	0.205
MB-W12	2.563	57.259	0.269	1.410	0.822	91.556	1.339
MB-W13	2.789	49.726	0.370	3.876	1.468	74.921	0.989
MB-W14	2.618	58.420	0.771	2.296	7.088	123.911	1.405
MB-W15	2.352	44.165	0.284	2.777	1.26	70.726	0.790

Table 5: **Classification of water based on hardness by(Sawyer and McCarthy 1967)**

Hardness as CaCo3in mg/l	Water class	Water samples PreMonsoon season	Water samples Monsoon season	Water samples Post Monsoon season
0-75	Soft	NIL	NIL	NIL
75-150	Moderately Hard	MB-W10 ,MB-W12	MB-W4,MB-W8, MB-W12	MB-W10 ,MB-W12
151-300	Hard	MB-W1, MB-W2, MB-W4 MB-W9, MB-W13	MB-W2,MB-W3, MB-W9,MB-W10, MB-W13,MB-W15	MB-W2, MB-W4 MB-W13 ,MB W-8
>300	Very Hard	MB-W3, MB-W5 MB-W6, MB-W7, MB-W8, MB-W11, MB-W14, MB-W15	MB-W1,MB-W5, MB-W6 MB-W7, MB-W11, MB-W14	MB-W1, MB-W3, MB-W5 MB-W6, MB-W7, MB-W9, MB-W11, MB-W14, MB-W15

Wilcox (1948) classified groundwater for irrigation purposes based on percent sodium and electrical conductivity.Eaton recommended the concentration of residual sodium carbonate to determine the suitability of water for irrigation purposes.The US Salinity Laboratory, Department of agriculture adopted certain techniqes based on which the suitability of water for agriculture is explained.Classification of irrigation water based on sodium water content is shown in Fig4

$$\%Na^{+} = (Na^{+}) \text{ X } 100/ (Ca^{2+} + Mg^{2+} + Na^{+} + K^{+})$$

Where Ca, Mg, Na and K are expressed in milliequivalents per litre(epm).

The classification of watersamples with respect to soluble sodium percent is shown in Table-9. In water having high concentrations of bicarbonate,there is a tendency for calcium and magnesium to precipitate as water in the soil becomes more concentrated. As a result, the relative proportion of sodium in the water is increased in the form of sodium carbonate RSC is calculated using the following equation.

$$RSC= (HCO_3^{-} + CO_3) – (Ca^{2+} + Mg^{2+})$$

Where all the ions are expressed in epm
According to the US Department of Agriculture, water having more than 2.5epm of RSC is not suitable for irrigation purpose. RSC classification of water samples of the study area is presented in the Table-10. A better measure of the sodium hazard for irrigation water is Sodium adsorption ratio(SAR) .which is used to express reactions with the soil. SAR is computed as

$$\mathbf{SAR= Na^{+}/[\ (Ca^{2+}+Mg^{2+})/2]½.}$$

(All ionic concentrations are expressed in epm).
The graphical presentation of results of SAR and Specific conductance for all the water samples as per USSL diagram is as made in the Fig 4 .The classification of water samples from the study area with respect to SAR is represented in Table8. The total concentration of soluble salts (salinity hazard) in irrigation water can be expressed in terms of specific conductance. Classification of water based on salinity hazard is presented in Table7. The Piper trilinear diagram is used to infer hydro-geochemical facies. These trilinear diagrams are useful in bringing out chemical relationships among water samples in more definite terms rather than with other possible plotting methods. Chemical data of represented samples from the study area presented by plotting them on Piper-tri linear diagram for pre monsoon, monsoon and post monsoon seasons. Water samples of premonsoon season are represented in Piper trilinear diagram as Fig 5. The results of analyses reveal that 90% of water samples were Ca-Mg and 95% of samples were of bi-carbonate type.

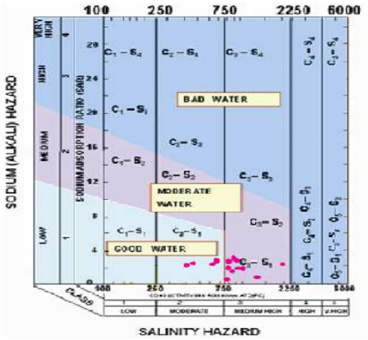

Fig 4 USSL Diagram for pre monsoon (April 2012)

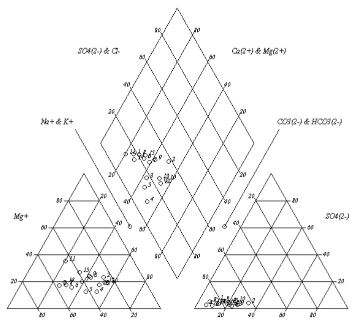

Fig 5 Premonsoon samples plotted on piper-Trilinear diagram (April 2012)

Table 6.Classification of water quality based on Piper Trilinear plot.

Subdivision of the diamond	Characteristics of corresponding subdivision of diamond – shaped fields	Percentage of samples in this category		
		Pre monsoon	Monsoon	Post monsoon
1	Alkaline earth (Ca + Mg) Exceed alkalies (Na + K)	90	90	90
2	.Alkalies exceeds alkaline earths	10	10	10
3	Weak acids (CO3 + HCO3) exceed Strong acids (SO4 + Cl)	10	10	10
4	Strong acids exceeds weak acids	90	90	90
5	Magnesium bicarbonate type	66.66	53.33	50
6	Calcium-Chloride type	0	0	0
7	Sodium-Chloride type	0	0	6.67
8	Sodium-Bicarbonate type	0	0	0
9	Mixed type (No cation-anion exceed 50%)	33.34	46.66	43.33

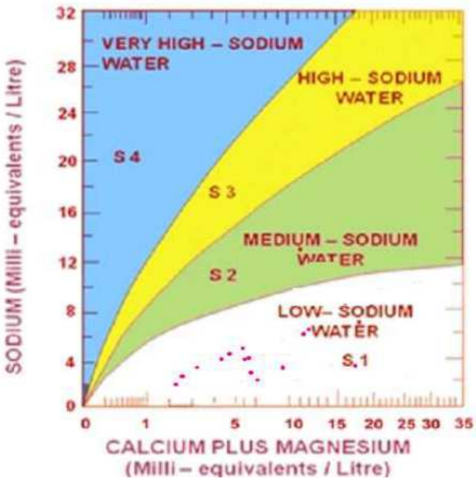

Fig 6 Classification of irrigation water based on Sodium water content premonsoon (April 2012)

Table -7 Classification of water for salinity hazard

Sodium Hazard class	SAR	Remarks on water quality	Water samples of pre monsoon	Water samples of monsoon	Water samples of post monsoon
S1	10	Excellent	Range 1.06 to 3.16 All water samples belongs to this category	Range 1.0 to 2.78. All water samples belongs to this category	Range 1.10 to 2.91 All water samples belongs to this category
S2	10-18	Good	NIL	NIL	NIL
S3	18-26	Moderate	NIL	NIL	NIL
S4	>26	Unsuitable	NIL	NIL	NIL

Table –8 Classification of water for sodium hazard based on USSL classification.

Salinity hazard class	EC (micro-mohs/cm)	Remark on water quality	Water samples of pre monsoon	Water samples of monsoon	Water samples of post monsoon
C1	100- 250	Excellent	NIL	NIL	NIL
C2	250-750	Good	516-725.2 4samples	395.6-625 ,4 samples	511-710,4samples
C3	750- 2250	Moderately good	778-1863 11 samples	763-1756, 11 samples	766-1463.4,11 samples
C4	2250-6000	Unsuitable	NIL	NIL	NIL
C5	>6000	Highly Unsuitable	NIL	NIL	NIL

Table. 9 Classification of water based on soluble sodium percentage

Sodium%	Water class	Pre monsoon	Monsoon	Post monsoon
< 20	Excellent	NIL	MB-W11,	NIL
20-40	Good	MB-W1,MB-W6,MB-W7, MB-W8,MB-W9, MB-W11, MB-W14 ,MB-W15,	MB-W1, MB-W6, MB-W7, MB-W9,	MB-W1,MB-W6,MB-W7, MB-W8,MB-W9, MB-W11, MB-W14, MB-W15,
40-60	Permissible	MB-W2, MB-W3, MB-W4, MB-W5 , MB-W10, MB-W12, MB-W13,	MB-W2, MB-W3, MB-W4, MB-W5 ,MB-W8, MB-W10, MB-W12, MB-W13, MB-W14,MB-W15,	MB-W2, MB-W3, MB-W4, MB-W5 , MB-W10, MB-W12, MB-W13,
>60	Not suitable	NIL	NIL	NIL

Table – 10 Classification of water based on RSC (Residual sodium carbonate)

RSC(epm)	Remarks on water quality	Pre Monsoon	Monsoon	Post monsoon
<1.25	Good	All the samples belongs to this category	All the samples belongs to this category	All the samples belongs to this category
1.25-2.5	Moderate	Nil	Nil	Nil
>2.5	Unsuitable	Nil	Nil	Nil

CONCLUSIONS

From the above results and discussions following conclusions can be drawn.

1. The results of the analysis of water samples at various locations of catchment area, reservoir and command area reveal that water is polluted at certain locations and exceeds permissible limits of drinking standards.
2. The presence of Total –Coli form and Faecal-Coliform in ground water and reservoir and lake water at certain locations indicates that water is polluted with waste water.
3. The value of TDS varies between min of 481ppm.to a max of 2158ppm.The presence of higher TDS at various locations indicates that water in unfit for drinking.
4. The inflow of urban runoff into the surface water bodies has resulted in pollution of reservoir and ground water at certain locations.
5. The hardness of water is high at 6 locations and unfit for drinking purpose.
6. The nitrates level varies between 0.97ppm to 88.5ppm, and exceeds the drinking water standards at 6 locations in the catchment and command area.
7. The result of the analysis reveals that the 90% of water samples were Ca-Mg and 95% of samples were bi-carbonate type.
8. The suitability of water for irrigation is evaluated based on SAR, %Na, RSC and Salinity hazards. Most of the samples fall in the suitable range for irrigation purpose either from SAR, %Na or RSC.

9. The salinity levels as per USSL classification reveal that 4samples are grouped within C2S1 and 11 samples are grouped within C3S2.
10. 10. The waste water (Domestic and Industrial) entering in to the water bodies should be prevented to mitigate further deterioration of water quality in the study area.
11. Intensive application of chemical fertilizers and pesticides should be controlled in the reservoir catchment and command areas.
12. Industrial waste water and domestic waste water should be treated before disposal into the water bodies.

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