Int. J. Adv. Res. Sci. Technol. Volume 4, Issue 8, 2015, pp.490-494.

IJARST

International Journal of Advanced Research in Science and Technology

journal homepage: www.ijarst.com

ISSN 2319 – 1783 (Print)

ISSN 2320 – 1126 (Online)

Water Quality of Fox Sagar Lake, Hyderabad, Telangana State, India, Its Suitability for Irrigation Purpose.

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ARTICLEINFO

Article history:

Received	20 Nov. 2015
Accepted	17 Dec. 2015
Available online	24 Dec. 2015

Keywords:
Water Quality,
Lake waters,
Irrigation purpose,
Physico-Chemical parameters.

ABSTRACT

Water quality indices provide a simple and understandable tool for managers on the quality and possible uses for irrigation water, however an individual quality factor alone is not enough to evaluate the irrigation water quality because it could be restrictive and sometimes it could give an unfavorable qualification. The aim of this paper is to assess water quality and its suitability for irrigation purpose of Fox Sagar Lake, Hyderabad, Telangana State. As a part of this, fourteen samples were collected from the lake during monsoon season of 2014 and analyzed for various physico-chemical parameters like pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH), Carbonates (CO_3^{2-}), Bicarbonates (HCO_3^-), Total Alkalinity (TA), Chloride (Cl^-), Sodium (Na^+), Potassium (K^+), Calcium (Ca^{2+}) and Magnesium (Mg^{2+}) were analyzed. To assess the suitability of lake water for irrigation, various indices like Hydrogen Ion Activity (pH), Salinity Hazard, Sodium Adsorption Ratio (SAR), Soluble Sodium Percentage (SSP), Residual Sodium Carbonate (RSC), Scott quality factor (alkali-metric coefficient or K), Permeability Index (PI) and Kelly's Index (KI) were calculated and found that lake waters falls under good quality.

PAPER-QR CODE

IJARST
Volume-4, Issue-8

Citation: *Lingaswamy. et.al. Water Quality of Fox Sagar Lake, Hyderabad, Telangana State, India, Its Suitability for Irrigation Purpose, Int. J. Adv. Res. Sci. Technol. Volume 4, Issue 8, 2015, pp.490-494.*

Introduction:

Water resources are under enormous pressure due to increasing demands for more and better quality water; demands which are in turn conditioned by social, political and environmental factors (Fatima Moreno-Perez. M, Jose Roldan-Canas, 2013). Over the few decades, competition for economic development, associated with rapid growth in population and urbanization, has brought in significant changes in land use, resulting in more demand of water for agriculture, domestic and industrial activities (Vasanthavigar M. *et al*., 2012). Water pollution affects drinking water, rivers, lakes and oceans all over the world resulting in threat to human health, irrigation and natural environment. Changing of surface water body quality is influenced by long term of drought, decline in discharge, increase in salinity and waste disposal.

Evaluation of surface water is important to assess its suitability for irrigation. Consumption of surface water for irrigation purposes depend on type and quantity of dissolved salts (Ali Gholami and Nooshin Shahinzadeh, 2014). Irrigation water quality and quantity have direct and indirect impact on soil characteristics (physical, biological and chemical) especially in arid and semi-arid regions that unfortunately depend on irrigation (Rahimi H. *et al*., 2000). Therefore, the irrigation water quality should be considered as an important tool in the sustainable management of the soil resources and the agricultural production (Wilcox, 1955). Therefore, the control of quality of water is a necessity. Numerous water quality guidelines have been developed by many researchers for using water in irrigation under different condition (Kelly, 1940; F. M. Eaton, 1950; US Salinity

Laboratory, 1954; L.V Wilcox, 1955; R. S. Ayers and D. W. Westcot, 1985). In the present study the water quality and its suitability for irrigation of Fox Sagar Lake, Hyderabad has carried out with the objective to analyze parameters like Hydrogen ion activity (pH), Salinity Hazard (EC), Sodium Adsorption Ratio (SAR), Soluble Sodium Percentage (SSP), Residual Sodium Carbonate (RSC), Scott quality factor (K), Permeability Index (PI) and Kelly's Index (KI).

Materials and Methodology:

Location of the study area:

Fox Sagar Lake is the fifth largest lake in India spreading about 2 km^2. Situated (17°30'–17°20'N and 78°30'–78°20'E) 1 km west of Hyderabad-Nizamabad road at Jeedimetla near Kompally in Hyderabad. The local name of Fox Sagar Lake is Jeedimetla cheruvu or Kolla Cheruvu. Fox Sagar Lake, Hyderabad is characterized by semi arid conditions.

Methodology of Water Analysis:

Fourteen samples were collected during October 2014 from various locations of the lake. In situ measures such as pH, EC of the water samples were determined on the spot using pH meter and conductivity meter respectively and to analyze the water quality parameters the Standard Methods for Examination of Water and Wastewater (APHA, 1995) were used.

Results and Discussion:

The physico-chemical parameters of the lake water samples were analyzed and the results were tabulated (Table.1). Various irrigation water quality indices like Salinity hazard, Sodium Adsorption Ratio (SAR), Soluble Sodium Percentage (SSP), Residual Sodium Carbonate (RSC), Scott quality factor (K), Permeability Index (PI) and Kelly's Index (KI) were evaluated (Table.2&3). Graphical interpretation of results were plotted in USSL diagram (Figure.1)

Table: 1. Analytical data of Various Physico-Chemical parameters Fox Sagar

S. No	pH	EC	TDS	TH	CO_3^{2-}	HCO_3^-	TA	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-
1	7.5	1375	880	255	9	262	230	190	15	40	38	646
2	7.5	1424	911	260	12	275	245	199	15	40	39	628
3	7.7	1257	805	245	6	183	160	167	16	40	35	614
4	7.6	1047	670	265	9	244	215	110	15	40	40	589
5	7.9	1281	820	335	6	433	364	140	1	72	38	589
6	7.5	1369	876	395	0	622	510	129	7	104	33	469
7	7.5	1467	939	365	0	946	775	163	11	88	35	479
8	7.6	1411	903	260	9	354	305	196	15	46	35	639
9	8.2	1255	803	265	18	384	345	158	15	46	36	625
10	7.9	1224	783	255	9	378	325	156	14	48	33	632
11	7.8	1404	899	255	9	451	385	198	13	42	36	618
12	8.0	1312	839	250	12	464	400	179	13	36	39	607
13	7.9	1305	835	275	9	171	158	166	13	44	40	635
14	7.8	1252	801	250	6	433	365	164	15	48	32	632

(**Note:** pH in pH units, EC in µS/cm remaining all parameters given in mg/L)

Table: 2. Calculated data of Various Irrigation Water Quality Parameters of Fox Sagar

S. No	Salinity Hazard (EC in µS/cm)	SAR	SSP	RSC	K	PI	KI
1	1375	7.4	62.9	-0.5	119	77.38	1.62
2	1424	7.6	63.5	-0.3	121	77.84	1.66
3	1257	6.6	61	-1.7	127	74.03	1.48
4	1047	4.2	49.4	-1	138	67.32	0.9
5	1281	4.7	47.7	0.6	134	68.43	0.91
6	1369	4.0	42.3	2.3	166	65.11	0.71
7	1467	5.3	50.2	8.2	157	76.59	0.97
8	1411	7.5	63.1	0.9	120	79.56	1.64
9	1255	6.0	57.8	1.6	126	77.04	1.3
10	1224	6.1	58.3	1.4	125	77.98	1.33
11	1404	7.8	63.7	2.6	123	82.62	1.69
12	1312	7.0	61.9	3	127	82.42	1.56
13	1305	6.2	57.9	-2.4	123	69.29	1.31
14	1252	6.5	60	2.3	124	80.66	1.43

Table: 3. Irrigation water classes of Fox Sagar

Parameter Range	Water Class	% of Samples
Based on Electrical Conductivity (EC)		
<250	Excellent	Nil
250-750	Good	Nil
750-2250	Permissible	100
2250-5000	Doubtful	Nil
>5000	Unsuitable	Nil
Based on Total Dissolved Solids (TDS)		
<200	Excellent	Nil
200-500	Good	Nil
500-1500	Permissible	100
1500-3000	Unsuitable	Nil
Based on alkalinity hazard (SAR) after Richards (1954)		
<10	Excellent	100
10–18	Good	Nil
18–26	Doubtful	Nil
>26	Unsuitable	Nil
Based on Soluble Sodium Percent (after Wilcox 1955)		
<20	Excellent	Nil
20–40	Good	Nil
40–60	Permissible	50
60–80	Doubtful	50
>80	Unsafe	Nil
Based on Soluble Sodium Percent (SSP) (Eaton F.M. 1950)		
<60	Safe	50
>60	Unsafe	50
Based on Residual Sodium Carbonate (RSC) (after Richards 1954)		
<1.25	Suitable	50
1.25–2.50	Doubtful	29
>2.50	Unsuitable	21
Based on Permeability Index		
>75	Class I	64
25-75	Class II	36
<25	Class III	Nil
Based on Kelly's Index (KI)		
<1	Suitable	29
>1	Unsuitable	71

Hydrogen Ion Activity (pH):

pH is a measure of the intensity of acidity or alkalinity conditions of a solution (Ramesh K. and Bhuvana Jagadeeswari P, 2012). The normal pH range for irrigation water is from 6.5 to 8.4 pH units. In the study area pH varied from 7.5 to 8.2 pH units Table.1 which indicates that the water is slightly alkaline in nature.

Salinity Hazard:

Electrical conductivity (EC) indicates the total dissolved solids in water (Bhattacharya. T. *et al.*, 2012) and it is the most important parameter to determine salinity hazards and suitability of water for irrigation. In the study area EC varied from 1047 to 1467 µS/cm Table.1 falling under C3-High salinity water class Figure.1, while TDS values varied from 670 to 939 mg/L falling under permissible water class (Table.3). Water can be used for irrigation purposes with some management practices**.**

US Salinity Laboratory's Diagram:

The US Salinity Laboratory's diagram (Richards, 1954) is widely used for rating the irrigation waters, where SAR is plotted against EC. Lake water samples points as shown as a cluster samples fall in C3S1 zone Figure.1, indicating high salinity and low sodium water which can be used for irrigation in almost all types of soil with little danger of exchangeable sodium (Kumar M *et al*., 2007). This water can be suitable for plants having good salt tolerance but restricts its suitability for irrigation, especially in soils with restricted drainage (Karanth K.R., 1989).

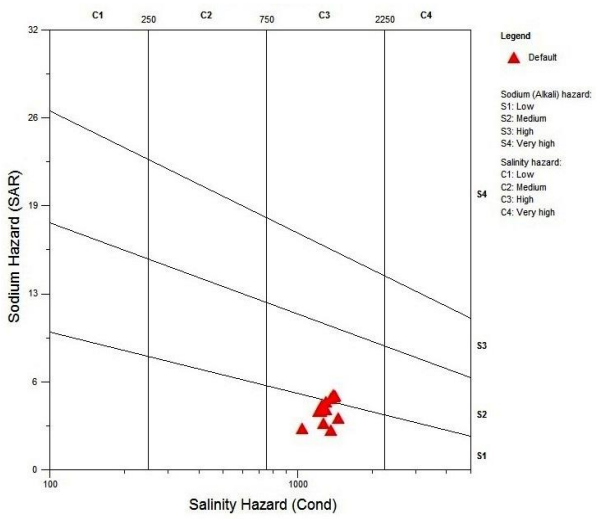

Fig. 1: Classification of Irrigation waters (after US Salinity Laboratory Staff 1954).

Sodium Adsorption Ratio (SAR):

The SAR measures sodicity in terms of the relative concentration of sodium to the sum of calcium and magnesium ions in water and used to assess the suitability of irrigation water. The degree to which irrigation water tends to enter into cation-exchange reactions in soil can be indicated by the sodium adsorption ratio. SAR calculated by using the formula;

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

Where, the concentrations are reported in meq/l.

All samples in the study area fall under excellent range (Table.3).

Soluble Sodium Percentage (SSP):

It is also used to evaluate sodium hazard. High SSP causes deflocculating, impairment of the tilth and permeability of soils (Karanth, 1987). Hence, air and water circulation is restricted during wet conditions and such soils are usually hard when dry (Collins and Jenkins 1996; Saleh *et al*., 1999). SSP was calculated as in reference by the following equation:

$$SSP=\frac{Na^{+}+K^{+}}{Ca^{2+}+Mg^{2+}+Na^{+}+K^{+}}X100$$

The Soluble sodium percentage (SSP) in the study area ranges between 42.3% and 63.7% (Table.2). According to Wilcox (1955) classification of irrigation water 50 percent of samples fall in permissible (40-60) and 50 percent of samples fall in doubtful (60-80) range (Table.3). According to Eaton F.M., (1950) classification of irrigation water 50 percent of samples fall in safe (<60) and 50 percent of samples fall in unsafe (>60) range (Table.3).

Residual Sodium Carbonate (RSC):

RSC is an important parameter to evaluate the suitability of irrigation water (Raju N.J. *et al*., 2009). The water with high RSC has high pH and land irrigated by such waters becomes infertile owing to deposition of sodium carbonate as known from the black color of the soil. RSC calculated using formula;

$$RSC=\left(HCO_3^{-}+CO_3^{2-}\right)-\left(Ca^{2+}+Mg^{2+}\right)$$

Where, the concentrations are reported in meq/l.

In the study area 50% of samples fall in suitable, 29% of samples fall in doubtful and 21% samples fall in unsuitable range (>2.5) (Table.3).

Scott Quality factor (Alkali metric Coefficient or K):

Scott quality factor (alkali-metric coefficient or K) classifies irrigation water according to the relation between sodium concentration and the chlorides concentrations. K is calculated by using formula;

$$K=\frac{6620}{Na^{+}+2.6(Cl^{-})}$$

If K>18, that water is good for irrigation (Canovas Cuenca, 1986). In the study area K value fall in the range of 119-166 (Table.2). So water is good for use in irrigation no need to take precautions.

Permeability Index (PI):

The effect on permeability has been evaluated by the term permeability index. Doneen (1964) classified irrigation waters based on the permeability index (PI). Soil permeability is affected by long term use of irrigation water with high salt content as influenced by Na^{+}, Ca^{2+}, Mg^{2+}, and HCO_3^{-} contents of the soil. High sodium in the irrigation water can cause severe soil permeability problem. Permeability is affected not only by high sodium but also by CO_3^{2-} and HCO_3^{-} content in water. A part of CO_3^{2-} and HCO_3^{-} is precipitated as $CaCO_3$ (or) $MgCO_3$ removing Ca^{2+} and Mg^{2+} from irrigation water and leads to increased proportion of solution. PI was calculated by using the formula;

$$\text{Permeability Index}=\frac{Na^{+}+\sqrt{HCO_3^{-}}}{Ca^{2+}+Mg^{2+}+Na^{+}}X100$$

Where, all the ions are expressed in meq/l.

Class-I and indicates that the excellent, class-II indicates good and class-III indicates unsuitable nature of water for irrigation. PI value ranges 65.11-82.62 meq/L (Table.2). 64% of the samples were falling class-I and 36% were falling class-II category (Table.3), indicating water is moderate to good for irrigation purposes (Arumugam and Elangovan, 2009).

Kelly's Index (KI):

Kelly's index is used for the classification of water for irrigation purposes. Sodium measured against calcium and magnesium is considered for calculate this parameter. A KI (>1) indicates an excess level of sodium in waters (Kelly, 1940). Therefore, waters with a KI (<1) is suitable for irrigation. KI is calculated by using the formula;

$$KI = \frac{Na^{+}}{Ca^{2+} + Mg^{2+}}$$

Where, all the ions are expressed in meq/l.

In the study area, 71% samples fall in the unsuitable limit for irrigation i.e., KI>1 (Table.3).

Conclusion:

Physico-Chemical analysis reveals that the lake waters are slightly alkaline in nature. Salinity hazard although 100% of samples fall in high salinity range (C3) can be used for irrigation purpose but with some management practices. US Salinity Laboratory's (USSL) diagram illustrate that all samples fall in the field of C3S1 (high salinity and low sodium) which can be used for irrigation in almost all types of soil with little danger of exchangeable sodium. SSP indicates 50% of samples fall in doubtful category this is due to high concentration of Na^{+} in Lake Water. RSC indicates suitable 50%, doubtful 29% and unsuitable 21% respectively. Scott quality factor (K) indicates all samples fall in suitable range for irrigation. PI indicates 64% fall in class-I (excellent) and 36% fall in class-II (good). According to Kelly's Index (KI) 71% of samples were unsuitable that indicates an excess level of sodium in waters. Overall analytical and calculated data reveals that maximum samples of Fox Sagar Lake were suitable for irrigation except for few samples. This indicates that the quality of Lake slowly deteriorating due to indiscriminate discharge of wastes. Lake waters can be utilized for irrigation with proper management and water treatment practices.

Acknowledgement:

I extend my special thanks to university grants commission (UGC) for providing financial assistance through Rajiv Gandhi national fellowship (RGNF) for doctoral research work. I also thankful to Dr. M. Ramana Kumar, Department of Applied Geochemistry, University College of Science, Osmania University for his enormous support in the laboratory during analysis.

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