Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

ISSN: 0972-6268	Vol. 11	No. 2	pp. 283-287	2012

Original Research Paper

Water Quality Assessment of Certain Selected Tank Waters of Tiptur Taluk, Karnataka, For Irrigation Purpose

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Nat. Env. & Poll. Tech.
Website: www.neptjournal.com
Received: 22/11/2011
Accepted: 24/12/2011

Key Words:
Water quality
Irrigation water
Sodium hazard
Salinity problem

ABSTRACT

Physico-chemical properties of six selected tank waters of Tiptur taluk were examined for the suitability of water for irrigation purpose through pH, EC, CO_3^{-2}, HCO_3^{-}, Cl^{-}, SO_4^{-2}, PO_4^{-3}, Na^{+}, K^{+}, Ca^{+2}, Mg^{+2} and boron. The assessment of the samples was made in terms of salinity problem, sodium hazard, permeability (infiltration) problem and toxicity problem through the parameters EC, SAR, RSC, RSBC, % Na, chloride and boron content of water. These values were compared with the guidelines set by Ayers and Westcot, Eaton and Wilcox. Results of analysis showed that water of Vaddaramallenahalli tank has EC<0.2dSm^{-1}and SAR 0-3meq/L and was not ideal for irrigation. Waters of the remaining five tanks, i.e., Eachanoor tank, Karadi tank, Halkurke tank, Honnavalli tank and Albur tank were falling into moderate class. No sample in the study area was ideal for irrigation.

INTRODUTION

Irrigation is very important for meeting the food and clothing needs of the world's population. The largest use of freshwater in the world is in agriculture with more than 70% being used for irrigation. About 240 million hectares, 17% of the world's crop land, are irrigated producing more than one third of the world's food supply (Shanan 1998).

To meet the growing demands for irrigation, the government and the farmers are focusing on supply side rather than improving the efficiency of the existing irrigation systems and reducing the pollution level of irrigation. In agriculture, water quality is related to its effect on soil and crops. Hence, some management practices are necessary to compensate the problems linked to water quality. All problems of soil degradation like salinity, permeability and toxicity can be related to irrigation water quality (Kirda 1997). In evaluating water quality for irrigation, emphasis is placed on the chemical and physical characteristics of the water and rarely any other factor considered important (Sarkar & Hassan 2006). When good quality water supplies were plentiful and readily available, there was no concern for water quality. But the situation is changing now in many areas (Ayers & Westcot 1989). The increasing industrialization, urbanization and developmental activities to cope up with the population explosion have brought an inevitable water crisis (Rao et al. 1998) in terms of quantity and quality.

In agriculture, it is quite common to concentrate more on quantity than quality of water. Use of poor quality water leads to low crop yield. For example, the average yield of wheat decreased by 24% over normal yield when poor quality water was used (Datta & Dayal 2000). Hence, it is necessary to check the quality of water for its suitability before it is put to agricultural use.

MATERIALS AND METHODS

The study was conducted in Tiptur taluk of Tumkur district, Karnataka (Fig. 1) from December 2010 to May 2011. The six tanks selected for the study were: Eachanoor tank (Sample-S_1), Vaddaramallenahalli tank (Sample-S_2), Karadi tank (Sample-S_3), Halkurketank (Sampl-S_4), Honnavalli tank (Sample-S_5) and Albur tank (Sample-S_6).

Water samples from each of the tanks were collected in pretreated and dried polythene containers of two-litre capacity at an interval of 30 days. In order to assess their suitability for irrigation, parameters like temperature, pH, electrical conductivity, carbonate, bicarbonate, total alkalinity, chloride, sulphate, phosphate, boron, sodium, potassium, calcium and magnesium were determined as per the procedures mentioned in APHA (1995), Trivedy & Goel (1986) and Manivasakam (1984). The values of SAR, % sodium, RSC and RSBC were calculated using the standard formulae as suggested by Richard (1954), Manivasakam (1984), Eaton (1950) and Gupta & Gupta (1987) respectively.

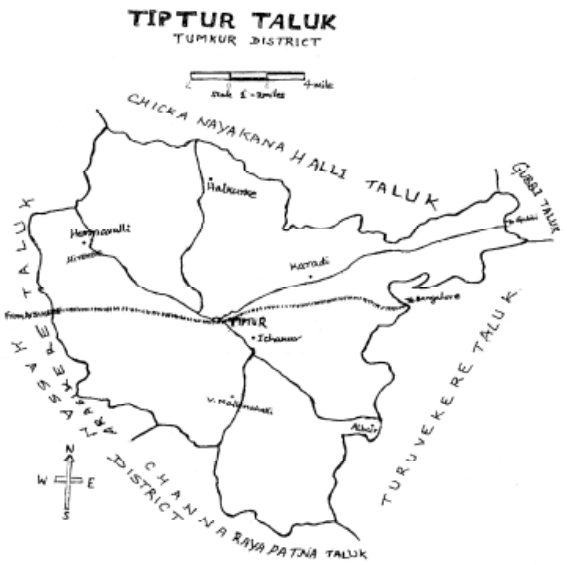

Fig. 1: Map of the study area.

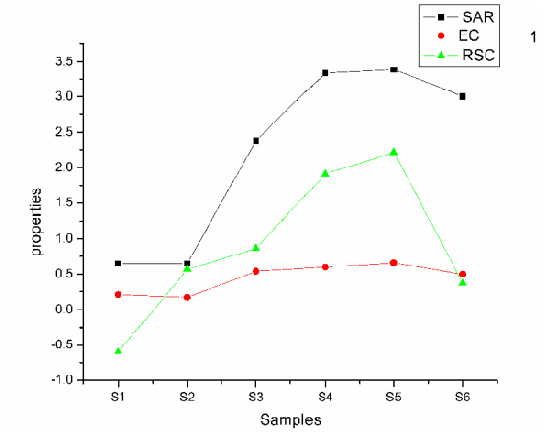

Fig. 2: Variation of SAR, EC and RSC values at different sites of the study area.

Irrigation water quality criteria: According to Michael (1978) and Raghunath (1987), irrigation water is judged by the four most important criteria as given below.

I. Salinity hazard: It is the most influential water quality guideline on crop productivity and is measured by electrical conductivity (EC). It quantifies the amount of dissolved salts in a sample.

II. Sodium hazard: It is expressed as the Sodium Adsorption Ratio (SAR). It quantifies the relative proportion of sodium to calcium and magnesium ions.

III. Toxicity: Concentration of certain specific elements like sodium, boron and chloride will cause toxicity problems to different crops.

IV. Residual Sodium Carbonate (RSC): It gives the value of carbonate ion concentration in excess of calcium and magnesium ions present in water sample.

Other factors, soil $CaCO_3$, nitrate, potassium and phosphates also influence indirectly irrigation water quality (Michael 1978). Furthermore, Ayers & Westcot (1989) explained that the use of poor quality water for irrigation creates four types of problems as: salinity, permeability (water infiltration rate), toxicity and miscellaneous. The parameters SAR, SSP (% of sodium), RSC and total hardness are also considered in addition to pH, EC, TDS, ferrous and arsenic, for judging the quality of irrigation water (Sarkar & Hassan 2006).

Salinity hazard: The salts present in water, besides directly affecting the growth of plants, will also affect the soil structure, permeability and aeration which will indirectly affect the plant growth (Jain et al. 2001). The problem is referred to as the salts that contribute to salinity of soil are water soluble and transported readily by water. Electrical conductivity (EC) is a useful parameter of water quality for indicating salinity hazard. The salinity problem exists if salt accumulates in the root zone to such an extent that the crop is no longer be able to extract sufficient water from the salty soil and the plant wilts. In such a stage, plant osmotic pressure increases and plants wilt permanently (Raghunath 1987). TDS is a direct measurement of dissolved salts and EC is an indirect measurement of ions by an electrode.

Sodium hazard: High concentration of salts in water will lead to the formation of saline soil and high sodium leads to development of an alkali soil. The sodium hazard in the water for irrigation is expressed in terms of sodium adsorption ratio (SAR) **(**Guy Fipps 1914 **)**. There is a significant relationship between SAR values of irrigation water and the extent to which sodium is adsorbed by the soil. Calcium will flocculate while sodium disperses soil particles. The dispersed soil will have water infiltration and permeability problems.

SAR is calculated using the formula,

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

Concentration of all the ions is taken in meq/L. Richard (1954).

Sodium percentage is calculated using the following formula (Manivasakam 1984-85).

$Na\% = Na^{+} \times 100/(Ca^{2+}+Mg^{2+}+Na^{+}+K^{+})$, where concentrations of all ions are in meq/L.

Prolonged irrigation with saline water causes secondary problems such as excessive weeds, nutritional disorders and

drowning of the crop, poor crop stands in low lying wet spots. One of the serious side-effects of an infiltration problem is the potential to develop disease and vector (mosquito) problems (Ayers & Westcot 1989).

Toxicity problems (**Concentration of some specific elements):** The usual toxic elements in irrigation water are sodium, chloride and boron. Toxicity problems occur within the plant itself and are not caused by water shortage and are different from salinity problems. Toxicity results when these ions are taken up by plants and accumulate in the leaves during water transpiration to an extent to damage the plant, whose degree depends on concentration, crop sensitivity, time and crop water use (Sarkar & Hassan 2006). The permanent, perennial type crops (tree crops) are the more sensitive ones.

Residual sodium carbonate (RSC): Water with high concentration of bicarbonate will tend to precipitate calcium carbonate and magnesium as their carbonates. Now the soil solution becomes concentrated increasing SAR value causing more sodium hazard (Michael 1978).

Eaton (1950) suggested the following formula to obtain RSC:

$RSC = (CO_3^{2-}+HCO_3^-)-(Ca^{2+}+Mg^{2+})$, where concentration of all the ions is in meq/L.

It was reported that although ordinarily bicarbonate is not thought to be a toxic ion, but it is reported to cause zinc deficiency in rice and is severe when it exceeds 2 meq/L in water used for flooding and growing paddy rice (Ayers & Westcot 1989).

RESULTS AND DISCUSSION

According to Ayers & Westcot (1989), Eaton (1950) and Wilcox (1955) the rating of water for its suitability for irrigation is given in Table 1. The analysis of tank waters and the derived irrigation parameters are provided in Tables 2 and 3 and Fig. 2.

Sodium hazard: If the proportion of sodium is high, sodium hazard is also high, and conversely, if calcium and magnesium predominates the hazard is less (Jain et al. 2001). There is a significant relationship between SAR values of irrigation water and the extent to which sodium is adsorbed by the soil. SAR value of < 3meq/L indicates little danger from sodium. SAR values of Halkurke tank (S_4), Honnavalli tank (S_5) and Albur tank (S6) were 3.34, 3.39 and 3.0 meq/L respectively. As per the standard values of Ayers and Westcot (Table 1) these samples are of medium quality for irrigation. The higher values of SAR may be attributed to runoff from the catchment area of the tanks or due to discharge of domestic waste into the tank particularly in case of Halkurke tank (S_4). It may also due to high HCO_3^- concentration (204.8 and 250.8 mg/L respectively), which may precipitate calcium and magnesium as their carbonates, increasing SAR value. Other tank waters have SAR values < 3 meq/L and fall into 'no restriction to use' range.

Table 1: Limits of some important parameter indices for rating water quality and its suitability in irrigation.

Category	EC (dSm^{-1})	RSC (meq/L)	SAR	Restriction on use
I	<0.7	<1.25	<3.0	None
II	0.7-3.0	1.25-2.5	3.0-9.0	Medium
III	>3.0	>2.5	>9.0	Severe

Infiltration problems: At the same SAR, water with low EC has greater potential harm than water with high EC. Sodium in irrigation water can also cause toxicity problems for some crops, especially when sprinkler is applied (John Alexander & Mahalingam 2011).

At the same level SAR of 0-3.0 meq/L, water is ideal for irrigation if EC of that water is < 0.7dSm^{-1}, of medium quality if EC is in the range of 0.7-0.2 $dSm^{-1}$and not suitable when EC is < 0.2 dSm^{-1}. As per this classification of Ayers and Westcot (Table 1), water of V. Mallenahalli tank (S_2) is not suitable for irrigation as its EC value is 0.17 dSm^{-1} and SAR is 0.65 meq/L, as it decreases infiltration rate. Hence, the degree of restriction on use is 'severe'. All other samples were found to be of medium quality as their SAR values are between 3 and 6 meq/L and EC values in the range of 0.50 to 0.66 dSm^{-1} imposing 'moderate' restriction on use.

As per the Indian standards (BIS 1991), a maximum limit of 60% sodium is recommended for irrigation water. In the study area, water samples have % sodium in the range of 20.6 % to 54.56%, which is less than the desired limit and they are suitable for irrigation purpose.

RSC factor: If the RSC exceeds 2.5meq/L, it is generally not suitable for irrigation. If the value is in the range of 1.25-2.5, the water is of medium quality, while the value of <1.25 indicates that the water is safe. In the study area, RSC value of Halkurke tank (S_4) was 1.91, and Honnavalli tank (S_5) 2.21. They are of medium quality for irrigation. Other water samples have RSC value of <1.25 and are of safe quality. Negative RSC value (-0.60 meq/L) in Eachanoor tank (S_1) indicates that dissolved calcium and magnesium ions are more than that of carbonate and bicarbonate contents. RSBC values of the samples varied from 0.10 meq/L to 2.63 meq/L, which are satisfactory (<5meq/L) according to the criteria set by Gupta & Gupta (1987).

Boron: Boron is an essential nutrient for plant growth. But it becomes toxic beyond 2mg/L in irrigation water for most

Table 2: Average values of different characteristics of the water samples studied.

Samples	Parameters								
	pH	EC (dsm^{-1})	CO_3^{2-} (mg/L)	HCO_3^- (mg/L)	Cl^- (meq/L)	Na^+ (mg/L)	K^+ (mg/L)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)
S_1	6.65	0.21	-	63.33	0.72	13.94	0.11	18.8	8.38
S_2	6.86	0.17	-	67.5	0.35	11.20	5.34	13.76	4.39
S_3	7.39	0.54	16.6	183.3	1.07	63.63	6.92	36.00	9.96
S_4	7.82	0.60	8.33	204.8	1.49	71.9	6.02	16.45	10.87
S_5	7.61	0.66	27.66	250.8	0.81	91.6	4.93	29.60	16.0
S_6	7.32	0.50	10.83	135.66	1.34	69.7	6.45	21.4	13.8

S_1 = Eachanoor tank; S_2 = Vaddaramallenahalli tank; S_3 = Karadi tank; S_4 = Halkurke tank; S_5 = Honnavalli tank; S_6 = Albur tank

Table 3: Values of some important parameters used as indices to assess water quality for irrigation.

Samples	SAR (meq/L)	EC(dsm^{-1})	% of Na	RSC (meq/L)	RSBC (meq/L)	B (mg/L)
S_1	0.65	0.21	20.6	-0.60	0.10	0.14
S_2	0.65	017	24.8	0.57	0.46	0.12
S_3	2.30	0.54	44.8	0.86	1.21	0.39
S_4	3.34	0.60	54.6	1.91	2.53	0.22
S_5	3.39	0.66	52.3	2.21	2.63	0.09
S_6	3.00	0.50	50.2	0.37	1.57	0.49.

of the field crops. It does not affect the physical and chemical properties of soils. However, at higher concentration it affects the metabolic activities of the plant (Jain et al. 2001). In the study area, water samples of all the tanks have boron in the range of 0.09 mg/L to 0.49mg/L and are safe for all the crops.

Chloride concentration: High concentration of chloride in irrigation water causes leaf burn and defoliation (Pule-Meulenberg & Emongor 2005). If chloride ion concentration is < 2 meq/L, it is generally safe for all plants. In the study area chloride ion concentration of all the selected tanks was in the range of 0.35-1.49 meq/L. Hence, all the water samples are safe for all the crops.

pH: pH of water samples varied from 6.65 to 7.82. Hence, water samples of all the tanks are well within the desired limit of 6.0 to 8.5 (Ayers & Westcot 1989).

CONCLUSION

The water quality investigation results for pH, EC, SAR, RSC, RSBC, Na%, chloride and boron revealed that Vaddaramallenahalli tank (S_2) water is not suitable for irrigation. Halkurke (S_4) and Honnavalli (S_5) tank waters are of medium quality as their SAR, EC and RSC values revealed that these waters may cause little sodium hazard due to higher SAR (>3) and low EC (0.7-0.2 dSm^{-1}). Eachanoor (S_1), Karadi (S_3) and Albur tank (S_6) waters are of medium quality as their SAR <3 and EC <0.7 dSm^{-1}. This classification is as per the guidelines set by Ayers and Westcot, Eaton and Wilcox for crop production. Low EC and high SAR values cause permeability problems due to decreased infiltration. Some management practices may help to get the required yield of crops.

ACKNOWLEDGEMENT

The first author is grateful to Kalpataru Vidya Samsthe, Tiptur, and the Principal, Kalpataru First Grade Science College, Tiptur for their continuous support to carry out this work and also thank the University of Mysore for permission to do this research.

REFERENCES

APHA 1995. Standard Methods for Examination of Water and Waste water, 19th edition. American Public Health Association, American Water Works Association and Water Environment Federation Washington, DC.

Ayers, R.S. and Westcot, D.W. 1989. Water Quality for Agriculture. FAO Irrigation and Drainage Paper No. 29: 1-109.

BIS 1991. Specifications for Drinking Water, IS:10500; 1991. Bureau of Indian Standards, New Delhi.

Datta, K.K. and Dayal, B. 2000. Irrigation with poor quality water: An empirical study of input use, economic loss and coping strategies. Indian Journal of Agricultural Economics, 55(1): 26-37.

Eaton, F.M. 1950. Significance of carbonate on irrigation waters. Soil Sci., 67: 112-133.

Gupta, S.K. and Gupta, I.C. 1987. Management of Saline Soils and Water. Oxford and IBH Publ. Co., New Delhi, pp. 399.

Guy Fipps 1914. Irrigation water quality standards and salinity management strategies. Texas Co-op. Extension - The Texas A&M university.

Jain, C.K., Bhatia, K.K.S., Kumar, C.P. and Purandara, B.K. 2001. Irriga-

tion water quality in Malaprabha sub-basin, Karnataka. IJEP, 21(4): 348-354.

John Alexander, J. and Mahalingam, B. 2011. Sustainable tank irrigation: An irrigation water quality perspective. Indian Journal of Science and Technology, 4: 22-26.

Kirda, C. 1997. Assessment of irrigation water quality. CIHEAM-Options Mediterraneennes.

Manivasakam, N. 1984-85. Physico-chemical Examination of Water, Sewage and Industrial Effluents. Pragati Prakashan, Meerut.

Michael, A.M. 1978. Irrigation Theory and Practice. Vikas Publishing House Pvt. Ltd, New Delhi, pp. 713.

Pule, F., Meulenberg and Emongor, V.E. 2005. Suitability of underground water for irrigated agriculture in some parts of Botswana. Journal of Applied Sciences, 5(8): 1420-1423.

Raghunath, H.M. 1987. Ground Water, 2nd edition. Wiley Eastern Limited, New Delhi, India, pp. 344-369.

Rao, L.M., Vani, S. and Rameshwari 1998. Incidence of heavy metal pollution in Mahadrigedda stream of Vishakapatnam. Poll Res., 17(2): 153-155.

Richards, L.A. 1954. Diagnosis and Improvement of Saline and Alkali Soils. Agricultural Handbook 60, USDA and IBH Publishing Co. Ltd, New Delhi, India, pp. 98-99.

Sarkar, A.A. and Hassan, A.A. 2006. Water quality assessment of groundwater basin in Bangladesh for irrigation use. Pakistan Journal of Biological Sciences, 9(9): 1677-1684.

Shanan, L. 1998. Irrigation development: Proactive planning and interactive management. In: The Arid Frontier (H. Bruins and Harvey, eds.) Kluwer Academic Press, London.

Trivedy, R.K.and Goel, P.K. 1986. Chemical and Biological Methods for Water Pollution Studies. Environmental Publications, Karad.

Wilcox, L.V. 1955. Classification and Use of Irrigation Water. U.S. Deptt. of Agriculture, Circular 969.