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Water Quality Assessment: A case study on suitability of water for Irrigation purpose of Kota Mandal, Nellore district, Andhra Pradesh, India

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ABSTRACT: *Irrigation with poor quality waters may bring undesirable elements to the soil in excessive quantities affecting its fertility. In the present study water samples were collected from canal, bore wells, open wells and rivers in Kota mandal and analyzed for pH, EC, TDS, chloride, total alkalinity, sulphate, nitrate, phosphate, sodium, magnesium, calcium and potassium. To evaluate the suitability of water for irrigation purposes, Sodium Adsorption Ratio (SAR), Soluble Sodium Percentage (SSP) and Magnesium Adsorption Ratio (MAR) were calculated using the standard equations and found experimentally as (2.66 – 28.94), (62.34 – 100), (16.92 – 89.47) respectively. Through proper management the water sources can be effectively used for irrigation purpose*

Keywords: *Irrigation, sodium adsorption ratio, sulphate, magnesium adsorption ratio.*

I. Introduction

Irrigation means drawing the water for agriculture from the canal, tank, well etc. for the purpose of growing crops. Almost 80 per cent of the water in the world is taken up for irrigation. In India, the irrigation sector uses approximately 85 percent of its available water resources. Irrigated agriculture is independent on adequate water supply of usable quality. Water quality concerns have often been neglected because good quality water supplies have been plentiful and readily available [1, 2]. Irrigation water quality is related to its effects on soils, crops and its management. High quality crops can be produced only by using high quality irrigation water keeping other inputs optimal.

Presently, 85 % of the water requirement for domestic in rural areas, 55 % for irrigation and over 50 % for industrial and urban uses is met from ground water [3]. Many areas in the country are facing a serious problem of not only scarcity of water, but also of its poor quality. Water used for irrigation can also vary greatly in quality depending upon the type and quantity of dissolved salts.

Adamu, 2013 [4] carried out the work in Watari river irrigation project, located on the slopes of Watari river valley in Bagwai local government of Kano state with the aim of assessing soil properties and quality of irrigation water. Irrigation water quality was determined based on salinity hazard, sodium hazard and bicarbonate hazard. Out of tested wells, 20.6 % of the wells have good quality irrigation water, 44.1 % of the wells have permissible to doubtful irrigation water quality, 35. 3 % of the wells have unsuitable irrigation water quality and based on SAR, almost all the wells have good quality irrigation water respectively [5].Verma, et al. (2012) [6] conducted by monitoring four canal water i.e Ariyl canal, Ghoorpur canal, Sharda canal and agricultural canal of Allahabad region for irrigation water suitability.

II. Materials and Methods

2.1. Study area

Kota Mandal in S.P.S.R Nellore District, Andhra Pradesh. Kota town is located in the 14°27’ 13” N Latitude 79°59’12”E Longitude. The study area is habituated with around 2,12,640 population of the Kota Mandal living in the 12,166 residents that is spread across total 69 Villages.

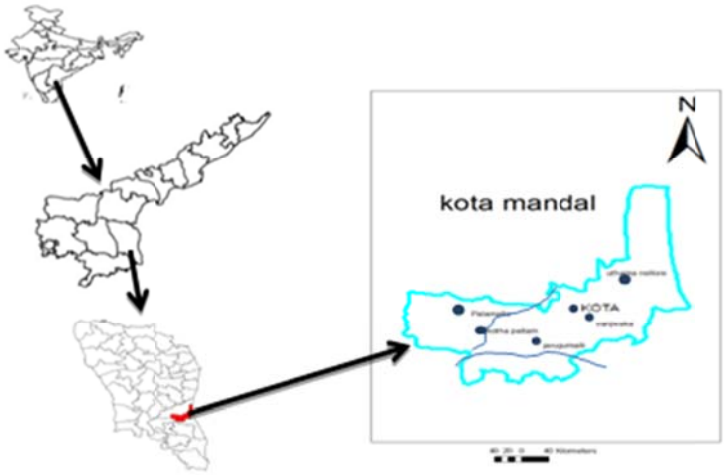

Fig. 1. Location Map of the Study area.

2.2. Selection of parameters

The samples were analyzed for various water quality parameters such as pH, Electrical conductivity (EC), Total Dissolved Solids (TDS), Total Alkalinity, Chloride, Phosphate, Sulphate, Nitrate, Sodium, Calcium, Magnesium and Potassium using standard procedures [7]. The methods used for estimation of various physical - chemical parameters are tabulated in Table 1.

Table 1: Methods used for estimation of Physical - Chemical Parameters

S. No	Parameters	Methods
1	pH	pH meter (Hanna)
2	Electrical Conductivity (µS/cm)	Conductivity meter (Hanna)
3	Total Dissolved Solids (mg/L)	TDS Meter (Hanna)
4	Total Alkalinity (mg/L)	Indicator method
5	Chloride (mg/L)	Silver nitrate method
6	Sulphate (mg/L)	Colorimetric method
7	Phosphate (mg/L)	Stannous chloride method
8	Nitrate (mg/L)	Phenol Disulphonic acid method
9	Calcium and Magnesium (mg/L)	EDTA complexometric method
10	Sodium and Potassium (mg/L)	Flame photometer

Use of poor water quality can create four types of problems namely toxicity, water infiltration, salinity and miscellaneous [8].For current irrigation water quality assessment, the following parameters were considered. According to Richards (1954) [9], sodium adsorption ratio (SAR) is expressed as:

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

Todd (1980) [10] defined soluble sodium percentage (SSP) as:

$$SSP = \frac{Na^{+} + K^{+}}{Ca^{2+} + Mg^{2+} + Na^{2+} + K^{+}} \quad X\ 100$$

Magnesium adsorption ratio (MAR) [11] was calculated as:

$$MAR = \frac{Mg^{2+}}{Ca^{2+} + Mg^{2+}} \quad X\ 100$$

Kelley's ratio (KR) [12] described as:

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

III. Results and Discussion

Generally pH values for normal irrigation should be between 6 to 7, while values above 7 are considered hazards [13,14].The recommended pH values specified by BIS for irrigation purpose are between 6.8 to 8.5. The values of pH in the study area are within desirable limits (Table 2).The concentration of total salt content in irrigation waters is estimated in terms of EC and it may be the most important parameter for assessing the suitability of irrigation water [15, 16]. The EC value for irrigation water specified by the BIS limits is 3000

µmho/cm (1998). In the current study the EC value ranged between 501 to 5560 µs/cm (Fig. 2). Water with a high salinity is toxic to most plants and poses a salinity hazard.

The TDS ranged between 315 to 2840 mg/L (Table 2). The TDS limits for irrigation water specified by the BIS is 600 mg/L (1998). The observation shows that the TDS is not within the permissible range as prescribed by BIS (1998) [17]. Certain study area showed higher TDS value due to pollution of canal water. TDS is an important water quality parameter which determines the plant growth, crop yield and quality of the product.

Total alkalinity was found to be in the range of 102.0 to 510.6 mg/L. High alkalinity indicates that the water will tend to increase the pH of the soil or growing media, possibly to a point that is detrimental to plant growth. The total alkalinity limit for irrigation water specified by BIS is 140 mg/L. Excess of chloride ions in irrigation water lead to phytotoxicity. The normal and safe limit for chloride ions in irrigation water specified by BIS is 500 mg/L, If the chloride contamination in the leaves exceeds the tolerance limits (0.3 to 1.0 percent) of the crop, symptoms like leaf burn occur. The value of the chloride in the study area ranged between67.35 to 825.98 mg/L.

Phosphate concentration was found within the permissible limit (2 mg/L, FAO) of irrigation standard in all sampling sites. It is one of the most important nutrient and a limiting factor in the maintenance of reservoir fertility. Sulphate concentration varied between 6 to 50mg/L and was found within the prescribed limit (<400 mg/L) as per BIS.

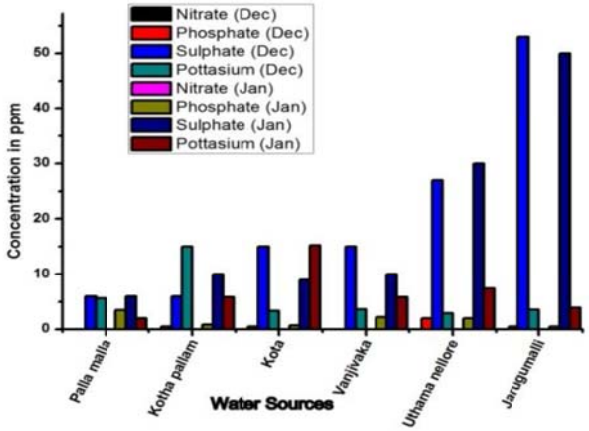

Fig. 2.

Sodium adsorption ratio (SAR) is an indication of the probable pressure on the soil properties caused by sodium. SAR states the concentration of sodium in water relative to calcium and magnesium. When the amount of sodium in the irrigation water exceeds than allowable limit, it disperses the soil resulting in low penetration rate of air and water into the soil. Thus it is difficult to harvest on the dispersed soil. Soils can have excess sodium because of the waste water irrigation that is why it is important to measure SAR [18]. The amount of sodium ions in the water predicts the sodicity danger [13].

Low SAR values have been found in the month of December whereas high and very high SAR values have been found in the month of January in the study area. The data showed clearly that increasing salinity levels in the irrigation water had led to an increase in the SAR values on all locations under study. Similar results were obtained by Ahmed Ibrahim Mohamed, 2013 [19]; El Kholy, 2004 [20]; El Kholy and Kandil, 2004 [21].

The soluble sodium percentage (SSP) values were found to vary from 62.34 to 100 % depending upon locations in different months (Table 3). However, in terms of MAR, irrigation water of all samples is not acceptable. MAR causes a harmful effect when exceed a value of 50 [22]. In the study area, MAR ranged from 86.36 to 55.55 in the month of December and 89.47 to 16.92 in the month of January.

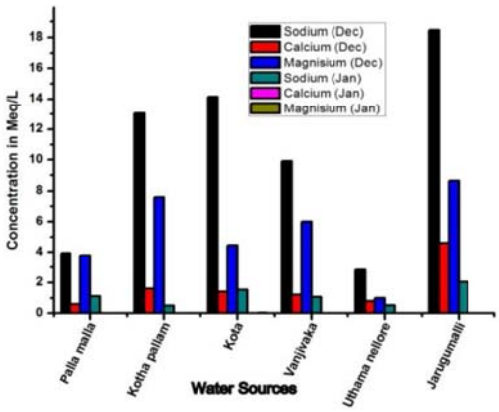

Fig. 3

Kelly (1963) [12] suggested that KR for irrigation water should not exceed 1.0. KI (Kelley's index) or Kelley's ratio of more than one indicates an excess level of sodium in waters. Therefore, waters with a KI less than one are suitable for irrigation, while those with a ratio more than one are unsuitable. The KI in the present study varied from 0.89 to 2.47 in the month of December and 80.52 to 366.6 in the month of January. Similar study was reported in the water quality of Mayur river [23].

Wilcox (1955) [24] suggested a graphical method for knowing the suitability of water for irrigation purposes. The proposed method is widely used and is based on percent sodium and electrical conductivity plot. The diagram consists of five distinct areas i.e., excellent to good, good to permissible, permissible to doubtful, doubtful to unsuitable and unsuitable. The data was calculated and subsequently plotted on the Wilcox diagram (Fig. 4).In this diagram, EC in µs/cm is taken as salinity hazard and SAR in meq/L as alkalinity hazard [25].Percentage of sodium values of water samples indicate that some of the water samples showed good to permissible category for irrigation use, except two samples which are under unsuitable category

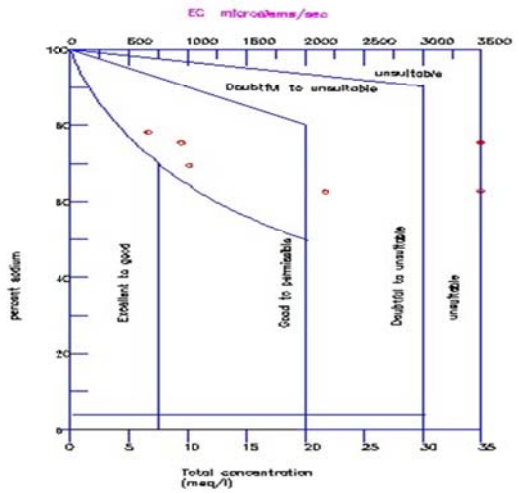

Fig. 4. Wilcox diagram for classification of water quality in the study area.

Table 2: Physical – Chemical characteristics of Irrigation water in the study area.

Parameters	December 2014						January 2015					
	1	2	3	4	5	6	1	2	3	4	5	6
pH	6.78	6.74	7.08	6.79	6.21	7.07	7.05	6.95	7.60	7.30	7.56	7.74
EC (µs)	1077	945	4590	2244	726	5560	890	501	5150	1079	693	2140
TDS (Mg/L)	621	483	2300	1093	374	2840	590	368	2570	956	315	1054
Chloride (Mg/L)	120.53	443.12	684.18	251.69	67.35	825.98	127.8	312.4	568	99.4	56.8	340.8
Total Alkalinity (Mg/L)	205.5	455.6	510.6	102.0	135.0	295.5	202	501	525.4	160.5	160.0	377.1
Nitrate (Mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phosphate (Mg/L)	ND	0.5	0.5	ND	2.0	0.5	3.5	0.8	0.7	2.2	2	0.5
Sulphate (Mg/L)	6	6	15	15	27	53	6	10	9	10	30	50
Sodium (Meq/L)	3.94	13.06	14.13	9.91	2.82	18.45	1.1	0.49	1.53	1.06	0.53	2.05
Calcium (Meq/L)	0.6	1.6	1.4	1.2	0.8	4.6	0.0014	0.0006	0.0024	0.0008	0.0006	7.41
Magnesium (Meq/L)	3.8	7.6	4.44	6.0	1.0	8.64	0.0016	0.002	0.017	0.0022	0.0014	0.0092
Potassium (Mg/L)	5.6	15	3.35	3.6	2.9	3.55	1.95	5.85	15.21	5.85	7.41	3.9

*ND = Not Detected

Table 3: Calculated parameters to evaluate water quality for irrigation use.

Location	December 2014				January 2015			
	SAR	SSP	MAR	KR	SAR	SSP	MAR	KR
1	2.66	68.43	86.36	0.89	28.94	99.90	53.33	366.6
2	6.10	70.30	82.60	1.41	13.61	100	16.92	188.46
3	8.31	74.95	76.02	2.47	15.61	99.93	89.47	80.52
4	5.24	65.23	83.33	1.37	27.89	100	73.33	353.3
5	3.0	76.06	55.55	1.56	18.70	99.97	70	290
6	7.17	62.34	65.25	1.39	27.70	99.82	82.14	183.0

IV. Conclusion

Based on the results of this study, it has been concluded that the current usage of irrigation waters is comparably safe and acceptable. Since the concentration of sodium is quite alarming there is every possibility of the soil to become sodic after prolonged usage in near future. Apart from this, it has been observed that, the way and manner in which the water is put into use might likely impose some toxic substances into the water which might get deposited into the soils and enter into the food chain leading to deleterious effects. Therefore it is recommended that the prevailing unaesthetic conditions of water pertaining to various human activities and effluent discharge from industries have to be curtailed in order to prevent the soil from deterioration.

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