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Quality of Tube Well and Open Well Water from Ausa Tahsil of Latur District

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Abstract: The study was carried out in Ausa tahsil of Latur district to estimate the quality of groundwater for agricultural purposes. Total 100 water sample was collected from tube well and open well in different location and analyzed for pH, EC, cations (Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}) and anions (CO_3^{2-}, HCO_3^{-} and Cl^{-}) to assess the irrigation water quality with sodium adsorption ration (SAR) and residual sodium carbonate (RSC). From the computation of SAR and RSC values, 100 percent groundwater samples were suitable. USSL diagrams show that the samples are safe for irrigation usage. Considering overall results, the concentration of EC, cations (Na^{+}, Ca^{2+} and Mg^{2+}) and anions (HCO_3^{-} and Cl^{-}) in tube well were higher as compare to open well water. Thus, can concludd that open well water is suitable for irrigation as compare to tube well water for irrigation.

Keywords: pH, Electrical conductivity, SAR, RSC and USSL diagram

In India, one-third of the land area is covered by dry and semi-arid climates and rainfall is seasonal and variable, supplemental irrigation is essential. Irrigation is used in areas where rainfall is insufficient to sustain agricultural development or when the rain does not fall when the plants need it most. Irrigation's purpose is to provide plants with water when needed in order to enhance yields. The magnitude of groundwater-related environmental issues varies by region, depending on geology, hydrologic climatic conditions and geochemical factors. In India, groundwater is the single largest and most productive source of irrigation water (Subramani et al 2005). Black soil was developed from weathered alluvium of Deccan basalt or basic parent material under arid and semi-arid condition. Major crop grown in this region are soybean, sugarcane, gram, sorghum, bajara, sunflower, pigeon pea and horticultural crops like pomegranate, mango and guava. For these crops farmers are applying regular and protective irrigation. The quality of a region's groundwater is largely determined by atmospheric precipitation, surface water, host rock, lithology and subsurface geochemical processes. Similarly, the composition of the water is primarily determined by mineral dissolution in the aquifers from which it flows. The form and amount of dissolved salts in irrigation water may have a significant impact on its consistency. Irrigation water contains salts in minimal but significant concentrations. They are formed by the dissolution or weathering of rocks and soil minerals such as lime, gypsum, and other slowly dissolved soil minerals. Water transports these salts to wherever they are required. The salts are applied with water during irrigation, they stay in the soil as the water evaporates or is consumed by the crop.

The chemical quality of groundwater can influence the chemical composition of the rocks and soil through which the water flows, depending on mineral dissolution, mineral solubility, ion exchange, oxidation, reduction as well as anthropogenic activities (population explosion, poor sanitary conditions, application of fertilizers and pesticides for higher crop yields without utmost care etc.). The quality of water for irrigation is determined by the concentrations of some elements that contribute to the specific conductance of groundwater. Particularly, higher concentration of sodium causes dispersion and swelling of soil which is inevitably unfavorable thereby leading to surface crusting. The pH of water is a measure of its acidity or alkalinity. The overall concentration of ionized components in natural water is generally determined by electrical conductivity. The ratio of sodium ions to calcium and magnesium ions can be used to predict the degree to which irrigation water tends to enter the cation exchange reaction in soil. This, ratio called the sodium adsorption ratio, is used to determine the sodium hazard for irrigation waters. Chloride is considered as the most prominent hazardous ion in irrigation water. Because chloride is not absorbed by colloids, it flows freely through the soil, is absorbed by the crop, passes into the transpiration stream and accumulates in the leaves. To determine the relative effect on water quality, the research utilizes multivariate statistical techniques such as correlation matrix. Therefore present investigation was carried out on assessment of ground water quality from Ausa, Latur district, Maharashtra state.

MATERIAL AND METHODS

Latur district is located between 18^0 05' to 18^0 75' North altitude and $76^0$25' to 77^0 25' East latitude. The geographical area of the district is 7166 sq. km with annual rainfall 787 mm. The elevation is 725 to 750 from sea level which comes under Central Marathwada Plateau Agro- climatic Zone and semi-arid region. In January 2021, five underground water samples (48 water samples from well and 52 water samples from tube well) were collected from each village. Both water samples were taken for further examination. By using standard procedure water samples were collected (Richards, 1954) for chemical analysis and completed using the appropriate standard methodologies for the analysis of groundwater. Electrical conductivity (EC) and pH were both measured using digital pH meter and EC meter. By using a flame photometer, sodium (Na+) and potassium (K+) were measured. Titrimetric analysis was used to determine the concentrations of calcium and magnesium. Titration with H_2SO_4 and standard solution were used to measure carbonate and bicarbonate concentrations, chloride were estimated by titration against $AgNO_3$. Sodium adsorption ration and residual sodium carbonate computed by following formula:

a) Sodium Adsorption Ration (SAR) {Richard 1954}:

$$SAR\ (meL^{-1}) = \frac{Na^{+}}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

b) Residual Sodium Carbonate (RSC){Eaton, 1950}:

$$RSC\ (meL^{-1}) = (CO_3^{-} + HCO_3^{-}) - (Ca^{2+} + Mg^{2+})$$

RESULTS AND DISCUSSION

pH: pH of irrigation water from Ausa tahsil in open well and tube well was 7.73 and 7.68 respectively. The highest pH value of open well was in Chulburga 8.57 followed by tube well water in Yerandi 8.45, while lower pH value of tube well was observed in Belkund 6.9 followed by open well water was in Haldurg 7.08 respectively. The data with respect to categorization of pH, out of 48 open well water samples, 11 samples found in neutral condition, 36 samples were alkaline and 1 sample was sodic. The 75 percent of open well water alkaline and 15 samples were neutral and 37 samples were alkaline. The 71.15 percent samples of tube well water were alkaline condition. pH of open well was high as compare to tube well water, most of the samples of open well and tube well were alkaline. The high pH value was due to atmospheric precipitation, soils, topography, subsurface geochemical processes and fluctuates due to the generation of hydrogen ions in various chemical reactions with the redox potential, temperature and pressure, the pH determines the chemicals dissolved and precipitated in the groundwater regime. The number of cations and anions in solution determines the number of redox potentials in groundwater (Bhat et al 2018). The sodium potential increases when the pH of the irrigation water rises over 8.2. The higher pH of groundwater might be attributed to high concentrations of sodium, calcium, magnesium, carbonate and bicarbonate, which produce hydroxyl ions. Subbarao et al (2012) recorded that pH value of open well from Varah river basin, Visakhapatnam ranged from 7.0 to 8.2 and might be due to carbon dioxide, carbonate and bicarbonate equilibrium were used to keep the pH in balance.

Electrical conductivity: EC value of open well and tube well varied from 0.27 to 1.17dSm^{-1} and 0.34 to 2.39 dSm^{-1} with an average 0.662 and 0.736 dSm^{-1} respectively. In the overall water samples, maximum EC of tube well was in Hasala followed by open well in Belkund while minimum EC was in tube well in Sarola (0.34 dSm^{-1}). On the basis of salinity classes indicated that out of 48 samples of open well water, 31 samples fall under class C_2, which were good in condition and 17 samples falls in C_3 class which was permissible limits. From 52 tube water samples, 31 samples fall under class C_2, 20 samples categorized under class C_3 and 1 sample in C_4 class under doubtful condition. The 64.58 and 59.62 percent samples of open well and tube well water were safe for irrigation but need moderate leaching. The 35.42 and 38.46 percent samples were cannot be used on soils with restricted drainage. One sample of tube well water falls within unsuitable under ordinary condition. Salinity of tube well water was high as compare to open well water this might be due to the leaching or dissolution of the aquifer material or mixing of saline sources at the sampling site and depends on temperature, precipitation, concentration of types of salts or ions present in groundwater. Salinity alters the accessibility of water to crops. EC of irrigation water affect the soil structure, permeability and aeration which indirectly impact on the plant growth (interfere with absorption of water and nutrient from soil) (Rajeswari et al 2019). Osmotic pressure of the soil water by plant roots results in a physiological drought condition. Sharma et al (2017) from Southwest Punjab observed that the high EC in water samples could be due to leaching or dissolution of the aquifers material or mixing of saline sources or combination of these activities.

Chlorine (Cl^-): The chloride concentration of open well and tube well was ranged from 1.7 to 8.4 and 1.5 to 12.7 meL^{-1} with an average value 3.44 and 3.64 respectively. In total water samples, the highest chlorine value of tube well in Nagarsoga followed by open well water in Nagarsoga while minimum chlorine value of open well in Borfal. Chloride is usually occurs as NaCl, $CaCl_2$, $MgCl_2$ and in broadly fluctuating concentration, in all natural water. Among the 48 samples of open well water12.5 percent were safe for all plants, 64.58 percent samples were sensitive condition and 22.92 percent were moderate tolerant. The 11.54 percent samples were safe for all plants, 67.31 percent samples were in sensitive condition, 19.23 percent were moderately tolerant to plants and 1.92 percent was not suitable for irrigation. The tube well water shows the higher concentration as compare to open well water, because chlorine in groundwater originate from various sources, including weathering, leaching of sedimentary rocks, soils and salt water intrusion. Chloride was widely distributed element in all type of rocks in one or the other form due to high affinity towards sodium. Therefore, its concentration was high in tube well water. Ramakrishnaiah et al (2009) studied water quality index of groundwater in Tumkur taluka, Karnataka and narrated that concentration of chloride was high in groundwater, temperature was high and precipitation was less and soil porosity and permeability also has a key role in building up the chlorides concentration. Subba Rao et al (2012) from Varah river basin, Visakhapatnam district revealed that chlorine content varied from 130 to 420mgL^{-1} where, chlorine anion is caused by the influence of poor sanitary condition irrigation return flows and chemical fertilizers.

Sodium adsorption ratio (SAR): The sodium concentration utilized for expressing interactions with the soil and recognizing the reduction in permeability were important aspects of water quality. Sodium adsorption ratio (SAR) of water is regarded a better measure of sodium (alkali) hazard in irrigation since it is directly connected to sodium adsorption by soil and was a valuable criteria for assessing the suitability of water for irrigation. The SAR values of open well and tube well water samples were ranged from 0.16 to 1.16 and 0.17 to 1.67 meL^{-1} with mean values was 0.493 and 0.643 meL^{-1} respectively. The maximum SAR value of tube well in Yerandi followed by open well water in Hasala while minimum value of tube well in Kalmata followed by open well water in Sarola village. As evident from the SAR values, the open well and tube water of the study area falls under the category low sodium hazard, which reveals that groundwater of the study area was free from any sodium hazard. The tube well shows the higher values as compare to open well water, due to concentration of cations present the deep water. All samples fall under, less than 10meL^{-1} category, so open well and tube well water was safe for irrigation. Jain et al (2012 reported that SAR ranged from 0.03 to 0.53 meL^{-1}in pre monsoons in bore well and ground water falls under the category of low sodium hazard, which reveals that ground water of the study area, is free from any sodium hazard. Ayisha et al (2016) assessed groundwater quality from open well from Malappuram district and recorded that SAR ranged from 0.11 to 1.36meL^{-1}where, all samples was suitable for irrigation purpose.

Residual sodium carbonate: The RSC values of open well and tube well water samples varied from -17.15 to -1.85 and -30.05 to -1.3 with mean value was -9.4 of both well respectively. The highest RSC value of open well in Wagholi followed by tube well water in Chulburga - while minimum was of open well in Belkund -followed by tube well water in Hasala village. In water having high concentration of bicarbonate there is a tendency for calcium and magnesium to precipitate as carbonate. The tube well water shows the higher RSC as compared to open well water. Negative value of RSC represents that magnesium and calcium precipitates of carbonates are excessively sufficient than sodium build up. All value of RSC in open well and tube well water was fall in less than 1.25meL^{-1} category, so all samples was suitable for irrigation purpose. Daxa et al (2017) collected twelve water samples from well in Ghogha taluka of Bhavnagar district, Gujarat and observed that RSC value ranged between -43.1 to 1.8 mg/L where, negative value of RSC represent that Mg^{2+} and Ca^{2+} precipitates of CO_3^{-} Kumar and Balamurugan (2018) observed that groundwater quality for irrigation purpose in Attur taluka, Salem, Tamilnadu and reported that RSC values ranged from -15.4 to 1.4 epm while, negative RSC indicate that Na^{+} buildup is unlikely since sufficient Ca^{2+} and Mg^{2+} are in excess and can be precipitated as CO_3^{2-} . Only one sample was marginal category due to occurrence of white patches of soil. Choudhary *et al.* (2020) in underground irrigation water of paddy and sugarcane growing area in Navsari district of Gujarat observed that RSC value of bore well water ranged from 0.05 to 2.23 meL^{-1} in pre monsoon, while for the post monsoon ranged between -0.10 to 2.23 meL^{-1} respectively. The higher mean value of RSC in pre monsoon might be due to dissolution salts present in the groundwater due to high rainfall during monsoon season in the study area.

Salinity and alkalinity hazard classes of irrigation water: The US Salinity Laboratory (USSL) has designed a graph to explain the combined effect of salinity and sodium hazards. The graph divides groundwater into C_1, C_2, C_3 and C_4 categories based on salinity hazard and S_1, S_2, S_3 and S_4 categories based on sodium hazard. The USSL classification was developed to investigate the suitability of groundwater for irrigation purposes. When classifying irrigation waters, it is expected that the water will be used under average conditions with respect to soil texture, infiltration rate and drainage, quantity of water used, climate and salt tolerant crop. The data classified as per village wise from Ausa tahsil based on salinity and alkalinity hazard indicated in Table 1 and narrated that the SAR and EC values of the water samples of water samples are plotted in the USSL diagram (Fig. 1 and 2). Village wise EC and SAR of open well water were ranged from 0.35 to 0.89 dSm^{-1} and 0.19 to 0.78 meL^{-1} respectively. The maximum salinity of open well in Wanwada and Belkund, alkalinity in Hasala village while minimum salinity and alkalinity were in Sarola village. Salinity and alkalinity hazard concentration of tube well water were ranged from 0.36 to 2.26 dSm^{-1} and 0.27 to 1.37 meL^{-1} respectively. The higher concentration of salinity and alkalinity observed in Hasala and Yerandi while lower concentration in Sarola and Belkund. From twenty villages, 85 percent of open well water were falls under C_2S_1 category (medium salinity with low sodium water), which are good quality water and 5 percent were categorized C_3S_1 class (high salinity with low sodium water) with medium to good quality of water and 55 percent villages tube well water were falls under class C_2S_1 (medium salinity with low sodium water), 40 percent villages categorized under class (high salinity with low sodium water) and only one village (Hasala) fall in C_4S_1 category (very high salinity with low sodium water) with

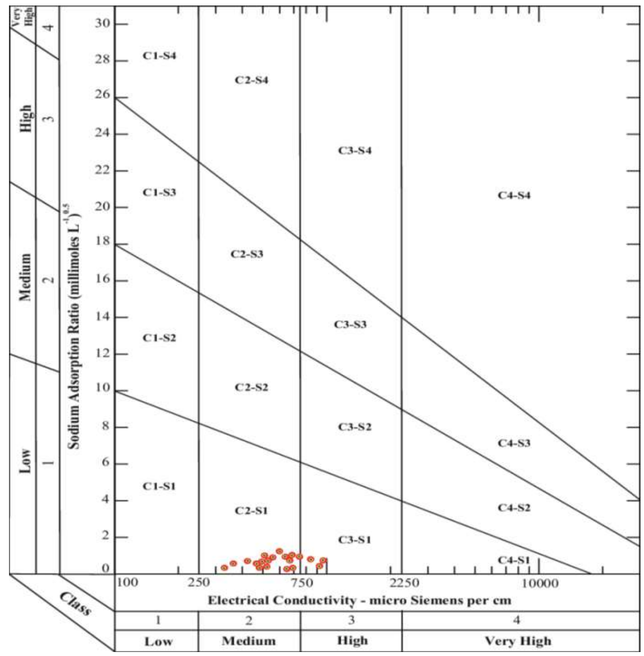

Fig. 1. USSL diagram for classification of open well irrigation water from Ausa tahsil

Table 1. Classification of water samples from Ausa tahsil based on salinity and alkalinity hazard

Village	Latitude	Longitude	Open well water samples			Tube well water samples		
			EC	SAR	Class	EC	SAR	Class
Gondri	18°24'35"	76°46'32"	0.66	0.43	C_2S_1	0.58	0.63	C_2S_1
Sarola	18°13'12"	76°35'12"	0.35	0.19	C_2S_1	0.36	0.81	C_2S_1
Yerandi	18°15'12"	76°36'42"	0.65	0.60	C_2S_1	0.87	1.37	C_3S_1
Yakatpur	18°14'32"	76°34'05"	0.67	0.58	C_2S_1	0.74	0.66	C_2S_1
Wagholi	18°11'13"	76°34'56"	0.46	0.55	C_2S_1	0.51	0.46	C_2S_1
Chulburga	18°10'78"	76°34'82"	0.66	0.61	C_2S_1	0.57	1.0	C_2S_1
Jawli	18°10'44"	76°41'06"	0.71	0.41	C_2S_1	0.62	0.48	C_2S_1
Lamjana	18°08'42"	76°42'22"	0.56	0.37	C_2S_1	0.66	0.45	C_2S_1
Chincholi	18°05'12"	76°32'12"	0.68	0.74	C_2S_1	0.83	0.58	C_3S_1
Talani	18°04'10"	76°51'52"	0.69	0.75	C_2S_1	0.80	0.46	C_3S_1
Wanwada	18°18'12"	76°46'12"	0.89	0.68	C_3S_1	0.82	0.67	C_3S_1
Malkondji	18°11'40"	76°42'03"	0.42	0.48	C_2S_1	0.47	0.46	C_2S_1
Belkund	18°15'24"	76°40'28"	0.89	0.33	C_3S_1	1.05	0.27	C_3S_1
Masurdi	18°17'04"	76°35"03	0.72	0.60	C_2S_1	0.67	0.80	C_2S_1
Borfal	18°19'03"	76°45'18"	0.56	0.44	C_2S_1	0.50	0.58	C_2S_1
Bhada	18°27'18"	76°37'08"	0.69	0.24	C_2S_1	0.81	0.52	C_3S_1
Kalmata	18°28'04"	76°38'50"	0.72	0.58	C_2S_1	0.69	0.6	C_2S_1
Haldurg	18°26'12"	76°43'06"	0.59	0.28	C_2S_1	0.91	0.7	C_3S_1
Nagarsoga	18°22'39"	76°39'17"	0.70	0.27	C_2S_1	0.95	0.45	C_3S_1
Hasala	18°19'56"	76°31'02"	0.82	0.78	C_3S_1	2.26	1.03	C_4S_1
Minimum			0.35	0.19		0.36	0.27	
Maximum			0.89	0.78		2.26	1.37	

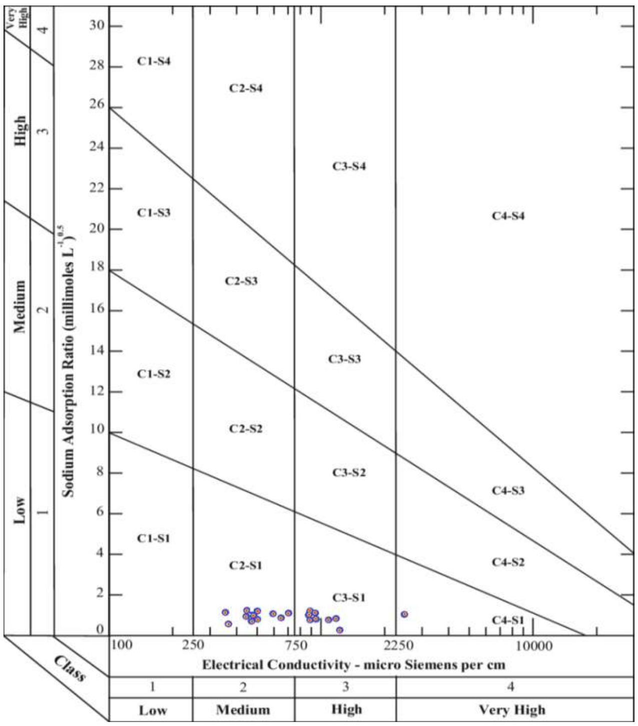

Fig. 2. USSL diagram for classification of tube well irrigation water from Ausa tahsil

medium to bad quality of water. Ahamed *et al.* (2013) studied comparative evaluation of suitability of groundwater use for irrigation in Karur district (T.N) and they reported that the SAR classification Based on USSL diagram, the water quality shows that the majority of the samples falls in the C_4-S_1 (very high salinity with low sodium), C_3-S_1 (high salinity with low sodium) categories, a single sample fall in the field of C_2-S_1 (medium salinity with low sodium), which can be used for irrigation on all types of soil without danger of exchangeable sodium. Adimalla et al (2018) evaluated groundwater suitability for domestic and agricultural utility in semi-arid region of Basara, Telangana and reported that 64.70 percent fall in category of C_2S_1, 12 percent samples fall in C_2S_2 class, 5.88 percent in C_3S_1 class and 5.88 percent into C_3S_2 category.

CONCLUSION

Most of water samples were alkaline condition. According to salinity classes 64.58 percent and 59.61 percent of open well and tube well water falls in C_2 class, while 35.2 percent and 38.46 percent of open well and tube well water categorized in C_3 class. In sodicity classes (SAR) all samples of open well and tube well water fall were suitable for irrigation purpose. Residual sodium carbonate was safe and suitable for irrigation. On the basis of salinity and alkalinity categorization, 85 percent of open well water samples were categorize under C_2S_2 class which was good quality and 5 percent in C_2S_3 class (medium to good quality of water). In tube well water, 55 percent fall under category C_2S_2 classes which are good quality of water, 40 percent in C_2S_3 category which are medium to good quality of water. The groundwater samples collected from Ausa tahsil was medium to good quality for irrigation. It can be concluded that open well water was suitable for irrigation as compared to tube well water.

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