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Correlation studies of groundwater quality of Manjra river basin from Latur district

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Abstract
The present investigation was conducted to evaluate the ground water quality of Manjra River basin from Latur district. Total 100 water samples were collected and analyzed for pH, EC TDS, TH, cations (Na+, K+, Ca+2 and Mg+2), anions (SO4-2, Cl-, HCO3- and CO3- 2), SAR, RSC and RSBC. The pH and electrical conductivity of ground water samples were 7.01 to 8.35 and 0.35 to 1.8 dSm-1, respectively. Total dissolved solids and total hardness of water were ranged from 224 to 1152 mg L-1 and 145 to 450 mg L-1, respectively. The relative abundance of major ions for most of the water samples were Na+ > Mg+2 > Ca+2 > K+ for cations and SO4-2 > Cl- > HCO3- > CO3-2 for anions. Sodium adsorption ratio (SAR), residual sodium carbonate (RSC) and residual sodium bicarbonate (RSBC) varied from 2.6 to 6.36 (mmole/l1/2), nil to 3.5 me L-1 and 1.5 to 6.4 me L-1, respectively. According to AICRP classification, it was found that 93% water samples were good quality and 7% were marginal alkali in nature. On the basis of correlation studies it can be concluded that pH, EC, TDS, TH, Na+, K+, Ca+2, Mg+2, SO4-2, Cl-, HCO3-, CO3-2, SAR, RSC and RSBC showed good positive correlation with each other.

Keywords: ground water quality, pH, EC, cation, anion, correlation, SAR, and RSC

Introduction
In recent times, there has been a tremendous increase in demand for freshwater and water shortage in arid and semiarid regions due to population increase, urbanization, industrialization, and intense agricultural activities in many parts of world. Due to inadequate supply of surface waters, most of the people in India are depending mainly on groundwater resources. According to studies by (Shiklomanov, 1997) [29], groundwater demand for irrigation is about 67% of the global water withdrawal and 87% of the consumptive water uses. The quality of groundwater is as important as its quantity because it is the major factor in determining its suitability for drinking, domestic, irrigation and industrial purposes. The salt content and their composition in underground water depend upon the location and geo climatic factors. The growing ground water usage and pollution generation has got over the threshold limits in various parts, owing to fast shifting land use pattern (Singh *et al*., 2015) [32].
Agricultural anthropogenic activities have resulted in deterioration of water quality rendering serious threats to human beings. Natural water is never pure water but it is complex mixture of dissolved suspended particles, inorganic and organic substances or molecules. Quality of water is affecting human and soil health. In India out of the total irrigation potential, 54 % of irrigation is done by well. In Maharashtra 63 % irrigation by well, 29 % by canal and 8 % others. The irrigated agriculture is dependent on the availability of adequate water. Irrigation water quality is important consideration in an irrigated area (Ghodke *et al*., 2016) [11]. Application of saline irrigation water or upward movement of soluble salts from the saline water table causes accumulation of salts in root zone of crops. As the amount of soluble salts increase in the root zone, due to osmotic effects decrease in the water potential. In India, the exploitable water resource is not sufficient to irrigate the cultivatable area. For this reason, efforts are required to increase the chances of water for irrigation in agriculture (Sharma, 2005; Ahmad *et al*. 2013) [28, 2].
Latur is one of the drought district of Marathwada regions of Maharashtra State. The district forms a part of Godavari basin. Manjra River, a tributary of Godavari River flowing south-easterly is the major river in the district. Total catchment area of Manjra River is 30,844 Sq. kms (Kotwad and More, 2017) [15].

Materials and Methods

Location of Latur district is 17°52' North to 18°50' North and 76°18' East to 79°12' East in the Deccan plateau. The entire district is on the Balaghat plateau. Average elevation of 631 M above mean sea level. The geographical area of Latur district is 7157 sq. kms. Latur district is divided into 10 Taluka and 5 Sub Divisions. Manjra River originates from the Balaghat range of hills at an altitude of 823 meters Patoda tahsil of Beed district and empties in Godavari River (Krishnaji, 2014) [16].

Twenty villages (Table 1) were selected for collection of water samples. Total 100 water samples were collected from Manjra river basin of Latur district and analyzed for calcium, sodium, potassium, magnesium, carbonate, bicarbonate, chloride, sulphate, pH, electrical conductivity, sodium absorption ratio, residual sodium carbonate, residual sodium bicarbonate total hardness and total dissolved solids.

Table 1: Name villages and geographical location of the study area.

Sr. No.	Village Name	Latitude & Longitude
1	Bhatkheda	18^0 25' 48.56" N, 76^0 40' 10.44" E
2	Bhatangli	18^0 25' 42.75" N, 76^0 40' 24.12" E
3	Chikalthana	18^0 27' 46.24" N, 76^0 39' 44.08" E
4	Kasarkheda	18^0 27' 4.50" N, 76^0 38' 29.53" E
5	Shelu Bk	18^0 22' 13.83" N, 76^0 39' 56.05" E
6	Sai	18^0 28' 17.81" N, 76^0 32' 57.15" E
7	Mahapur	18^0 28' 29.43" N, 76^0 34' 21.48" E
8	Borwati	18^0 27' 28.70" N, 76^0 34' 26.45" E
9	Kasargaon	18^0 26' 17.74" N, 76^0 35' 2.29" E
10	Khulgapur	18^0 76' 23.22" N, 76^0 36' 34.88" E
11	Sonwati	18^0 23' 49.45" N, 76^0 39' 4.69" E
12	Bhadgaon	18^0 24' 29.20" N, 76^0 40' 34.28" E
13	Sarsa	18^0 33' 12.36" N, 76^0 20' 14.13" E
14	Bodkha	18^0 31' 58.75" N, 76^0 22' 59.09" E
15	Jawala Bk	18^0 31' 21.30" N, 76^0 23' 6.89" E
16	Tandulwadi	18^0 28' 25.41" N, 76^0 26' 56.76" E
17	Karsa	18^0 30' 33.06" N, 76^0 27' 0.93" E
18	Tadki	18^0 32' 76.25" N, 76^0 25' 43.21" E
19	Jewali	18^0 27' 16.80" N, 76^0 30' 15.91" E
20	Harangul Kh	18^0 25' 56.55" N, 76^0 29' 13.77 E

pH: The pH of water samples were determined by using glass electrode pH meter (Jackson, 1973) [12].

Electrical conductivity (EC): Electrical conductivity of water samples were determined by using EC meter (Jackson, 1973) [12].

Soluble Cations

Calcium and Magnesium (Ca2+ and Mg2+): Versenate (EDTA) titration method was used for determination of Calcium and Magnesium (Richards, 1954) [27].

Sodium and Potassium (Na+ and K+): These were determined by using flame photometer (Jackson, 1973) [12].

Soluble Anion

Carbonates and bicarbonates (CO32- and HCO3-): The carbonates and bicarbonates were determined by titrimetric method (Richards, 1954) [27].

Chloride and sulphate (CO32- and HCO3−): The chloride and sulphate were determined by Mohr's titration method and Turbidity method, respectively (Richards, 1954) [27].

Sodium Adsorption Ratio (SAR): SAR was determined by the formula (Richards, 1954) [27] as given below.

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

Where, all cations are expressed in me L-1

Residual Sodium Carbonate (RSC): RSC was determined by following formula given by Eaton (1950) [9].

RSC (me L-1) = (CO32- + HCO3−) – (Ca2+ + Mg2+)

Where, all cations and anions are expressed in me L-1

Total dissolved solids (TDS): TDS was determined by following formula given by Rhoades (1996) [26].

TDS (mg L-1) = EC × 640

Where, EC is electrical conductivity

Total Hardness (TH) = Total hardness was determined by following formula given by Raghunath (1987) [24].

TH (mg L-1) = (Ca2+ + Mg2+) × 50

Statistical analysis

The correlation among the water quality parameters were carried out as per the standard method given by Panse and Sukhatme (1976) [23].

Results And Discussion

pH: Data regarding pH of ground water samples are presented in Table 2. The pH of water samples collected from Manjra River basin of Latur Tehsil were ranged from 7.01 to 8.35 with an average value of 7.67. These are in conformity with the results of Borawake *et al.* (2015) [5] and Thakur *et al.* (2015) [33].

Electrical Conductivity (EC): Salinity hazard is measured by electrical conductivity. Data presented in Table 2 showed that electrical conductivity of water samples were varied from 0.35 to 1.8 dSm-1 with mean value of 0.71 dSm-1. Similar result was also reported by Nandimandalam *et al.* (2011) [20].

Total Dissolved Solids (TDS): Data regarding total dissolved solid of water samples are presented in Table 2. Data revealed that TDS of water samples were ranged from 224 to 1152 mg L-1 with an average value of 453.76 mg L-1. Similar results were also observed by Mishra *et al.* (2011) [18].

Total Hardness (TH): A perusal of data presented in Table 2 indicated that total hardness of ground water was varied from 145 to 450 mg L-1 with mean value of 261.65 mg L-1.

Cations

Calcium: Data regarding concentration of calcium ion in ground water samples of Manjra River basin from Latur Tehsil are presented in Table 2 indicated that, values of calcium ion were ranged from 1 to 4.1 me L-1 with an average value of 2.06 me L-1. Similar results also revealed by Kaur and Singh (2011) [13] and Gangaraju *et al.* (2015) [10]

Magnesium: A perusal of data presented in Table 2 indicated that concentration of magnesium ion in ground water samples were varied from 1.72 to 5.1 me L-1 with mean value of 3.18 me L-1. Dhembare (2012) [8] and Das *et al.* (2015) [6] also

reported the similar results.

Sodium: Data presented in Table 2 concluded that, concentration of sodium ion were ranged from 3.72 to 13.5 me L-1 with an average value of 6.81 me L-1. Similar results were also observed by Rathi *et al.* (2018) [25] and Kaur and Singh (2011) [13]

Potassium: Concentration of potassium ion in water samples are presented in Table 2. The Data revealed that values of potassium ion were varied from 0.2 to 1.5 me L-1 with mean value of 0.68 me L-1. Similar results also reported by Mudgal *et al.* (2009) [19] and Bhardwaj *et al.* (2010) [3].

Data presented in Table 2 revealed that among the cations in ground water samples, sodium was most dominant cation followed by magnesium, calcium and potassium. These results are in concurrence with the findings of Kumar *et al.* (2015) [17], Pal *et al.* (2018) [21] and Rathi *et al.* (2018) [25].

Table 2: Range and mean value of ground water quality parameters of the study area

Sr. No.	Parameters	Range	Average
1	pH	7.01 to 8.35	7.67
2	Electrical Conductivity (dSm-1)	0.35 to 1.8	0.71
3	Total Dissolved Solids (mg L-1)	224 to 1152	453.76
4	Total Hardness (mg L-1)	145 to 450	261.65
5	Sodium (me L-1)	3.72 to 13.5	6.81
6	Potassium (me L-1)	0.2 to 1.5	0.68
7	Calcium (me L-1)	1 to 4.1	2.06
8	Magnesium (me L-1)	1.72 to 5.1	3.18
9	Carbonate (me L-1)	nil to 1.8	0.77
10	Bicarbonate (me L-1)	2.7 to 10.02	5.63
11	Chloride (me L-1)	3.1 to 8.3	6.01
12	Sulphate (me L-1)	4.9 to 11.2	6.98
13	Sodium Adsorption Ratio (mmole/l1/2)	2.6 to 6.36	4.20
14	Residual Sodium Carbonate (me L-1)	nil to 3.5	1.61
15	Residual Sodium Bicarbonate (me L-1)	1.5 to 6.4	3.57

Anions

Carbonate: Concentration of carbonate ion in ground water samples (Table 2) were ranged from nil to 1.8 me L-1 with an average value of 0.77 me L-1. These results are strongly supported by the findings of Pandian *et al.* (2016) [22].

Bicarbonate: Data regarding bicarbonate concentration in water samples (Table 2) varied from 2.7 to 10.02 me L-1 with mean value of 5.63 me L-1. Similar results about bicarbonate also reported by Das *et al.* (2015) [6] and Siddha and Sahu (2020) [30].

Chloride: The perusal of data presented in Table 2 concluded that concentration of chloride ion in water samples were ranged from 3.1 to 8.3 me L-1 with an average value of 6.01 me L-1. These results are in agreement with the findings of Mudgal *et al.* (2009) [19].

Sulphate: Data presented in Table 2 indicated that sulphate content in water samples were varied from 4.9 to 11.2 me L-1 with mean value of 6.98 me L-1. These results are in accordance with the results reported by Bhat *et al.* (2018) [4, 21] and Pal *et al.* (2018) [21]

Data conclude that among the anions sulphate was most dominant and present in higher concentration as compare to other anions. Concentration of anions in ground water samples were SO4-2 > Cl- > HCO3- > CO3-2. These results are in concurrence with the findings of Ahmad and Khan (2013) [2].

Water Quality Parameters

Sodium Adsorption Ratio (SAR): The perusal of data presented in Table 2 indicated that sodium adsorption ratio of ground water samples were collected from Manjra River basin of Latur Tehsil were ranged from 2.6 to 6.36 with an average value of 4.20 (all cations concentration expressed in me L-1). Similar results were also concluded by Deshpande and Aher (2012) [7].

Residual Sodium Carbonate (RSC): Data regarding residual sodium bicarbonate of water samples are presented in Table 2 revealed that RSC values were varied from nil to 3.5 me L-1 with mean value of 1.61 me L-1. These results are in accordance with the results concluded by Bhat *et al.* (2018) [4, 21].

Residual Sodium Bicarbonate (RSBC): Data presented in Table 2 concluded that residual sodium bicarbonate content in ground water samples were ranged from 1.5 to 6.4 me L-1 with an average value of 3.57 me L-1.

According to AICRP (Gupta *et al*. 1994) [34] ground water classified for irrigation into seven different classes based on EC, SAR and RSC values which are presented in Table 3. Among the 100 samples, 93% water samples were categorized under good quality of water while only 7% water samples were categorized under marginal alkali which indicate that maximum water samples are suitable for irrigation.

Table 3: Classification of water according to AICRP. (Gupta *et al*., 1994) [34].

Sr. No.	Water Quality	Parameters			% of samples
		EC (dSm-1)	SAR (mmole/l1/2)	RSC (me L-1)	
1	Good	< 2	< 10	< 2.5	93
2	Marginal saline	2 – 4	< 10	< 2.5	Nil
3	Saline	> 4	< 10	< 2.5	Nil
4	High SAR saline	> 4	> 10	< 2.5	Nil
5	Marginal alkali	< 4	< 10	2.5 – 4.0	7
6	Alkali	< 4	< 10	> 4.0	Nil
7	Highly alkali	Variable	> 10	> 4.0	Nil

Correlation Matrix

Pearson correlation analysis was performed to check relationship between key variables of ground water. Inter-element correlation was performed among the 15 different variables of ground water like pH, EC, TDS, TH, Na+, K+, Ca+2, Mg+2, CO3-2, HCO3-, Cl- SO4-2, SAR, RSC and RSBC.

The perusal of data regarding correlation among the water quality parameters are presented in Table 4. The data present in Table 4 revealed that pH of water samples showed positive and significant correlation with EC (0.884**), TDS (0.884**), TH (0.786**), Na+ (0.915**), K+ (0.871**), Ca+2 (0.754**), Mg+2 (0.755**), HCO3- (0.806**), Cl- (0.824**), SO4-2 (0.829**), SAR (0.750**), RSC (0.622**) and RSBC (0.756**). Electrical conductivity and total dissolved solids of irrigation water showed perfect positive and significant correlation (1.000**) with each other. EC of irrigation water exist positive and significant correlation with pH (0.884**), TH (0.764**), Na+ (0.863**), K+ (0.818**), Ca+2 (0.719**), Mg+2 (0.746**), HCO3- (0.820**), Cl- (0.707**), SO4-2 (0.756**), SAR (0.678**), RSC (0.679**) and RSBC (0.796**).

Correlation matrices also shows significant positive correlations between TH-RSBC (0.810**), TH-TDS (0.764**), TDS- SAR (0.678**) and TDS-RSC (0.679**). Statistical studies concluded that major ions like Na+, K+, Ca+2, Mg+2, HCO3-, Cl- and SO4-2 exhibit good positive correlation with pH, EC, TDS, TH, SAR, RSC and RSBC. Sodium adsorption ratio showed positive correlation with pH (0.750**), EC (0.678**), Na+ (0.870**), K+ (0.654**), Cl- (0.739**) and SO4-2 (0.708**). Residual sodium carbonate showed positive correlation pH (0.622**), EC (0.679**), K+ (0.638**), HCO3- (0.761**) and RSBC (0.853**). Residual sodium bicarbonate exhibit good positive correlation with TDS (0.796**) and other water quality parameters. These results are in concurrence with the findings of Sidhu *et al.* (2010) [31] and Kaur *et al.* (2016) [14].

Conclusion

The pH of ground water was neutral to slightly alkaline in nature while electrical conductivity show medium to high salinity. Total dissolved solids and total hardness not affect ground water quality for irrigation. Among the cations and anions most dominant ions were sodium and sulphate, respectively. According to SAR, RSC and RSBC maximum water samples were good quality. Statistical studies concluded that all the water quality parameters showed good and positive correlation with each other. In general, the analysis of various parameters indicated that quality of groundwater is suitable for irrigation purpose.

Table 4: Correlation matrix of ground water parameters from study area

Parameters	pH	EC	TDS	TH	Na+	K+	Ca+2	Mg+2	CO3-2	HCO3-	Cl-	SO4-2	SAR	RSC	RSBC
pH	1	0.884**	0.884**	0.786**	0.915**	0.871**	0.754**	0.755**	0.578**	0.806**	0.824**	0.829**	0.750**	0.622**	0.756**
EC		1	1.000**	0.764**	0.863**	0.818**	0.719**	0.746**	0.543**	0.820**	0.707**	0.756**	0.678**	0.679**	0.796**
TDS			1	0.764**	0.863**	0.818**	0.719**	0.746**	0.543**	0.820**	0.707**	0.756**	0.678**	0.679**	0.796**
TH				1	0.779**	0.773**	0.954**	0.965**	0.532**	0.920**	0.671**	0.750**	0.378**	0.477**	0.810**
Na+					1	0.842**	0.739**	0.754**	0.521**	0.793**	0.835**	0.874**	0.870**	0.584**	0.745**
K+						1	0.758**	0.727**	0.548**	0.808**	0.720**	0.790**	0.654**	0.638**	0.756**
Ca+2							1	0.841**	0.474**	0.888**	0.673**	0.725**	0.360**	0.466**	0.737**
Mg+2								1	0.543**	0.879**	0.619**	0.715**	0.364**	0.450**	0.813**
CO3-2									1	0.425**	0.524**	0.628**	0.376**	0.378**	0.355**
HCO3-										1	0.668**	0.727**	0.462**	0.761**	0.965**
Cl-											1	0.819**	0.739**	0.498**	0.600**
SO4-2												1	0.708**	0.527**	0.656**
SAR													1	0.506**	0.475**
RSC														1	0.853**
RSBC															1

* Correlation is significant at 5% level (2-tailed)

**Correlation is significant at 1% level (2-tailed)

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