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Periodical Variations in the Irrigation Well Water Quality of Murud and Dapoli from Coastal Konkan of Maharashtra

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A B S T R A C T

Periodical variations in the irrigation well water quality studied for 25 wells from Dapoli and 25 wells from Murud of coastal Konkan (M.S.) in first week of December (2016), March (2017) and June (2017). All rabi and rabi hot weather crops are irrigated with the water from these wells during this period. Dapoli is at a higher altitude (800 ft) whereas Murud is at the sea level. These two locations are 7 km apart from each other. Then also there is difference in the quality of ground water from both locations. The properties *viz.* pH, EC, cations (Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}), anions (HCO_3^-, CO_3^{2-}, Cl^- and SO_4^{2-}), boron, sodium adsorption ratio (SAR) and residual sodium carbonate (RSC) were estimated and their respective water quality classes were decided. The result obtained from investigation revealed that the well water samples from Dapoli were within the safe limit throughout the irrigated cropping season. As far as salinity hazard, RSC class and chloride content are concerned most of the irrigation well water samples from Murud were under moderately safe limit from March. The relative cation contents in well water samples of Murud and Dapoli were $Na^{+} > Ca^{2+} > Mg^{2+} > K^{+}$ and $Ca^{2+} > Na^{+} > Mg^{2+} > K^{+}$, respectively. That of anion from Murud and Dapoli were $Cl^- > HCO_3^- > SO_4^{2-} > CO_3^{2-}$ and $HCO_3^- > Cl^- > SO_4^{2-} > CO_3^{2}$, respectively. There was no sodicity hazard in water samples Murud. The pH, EC, Cations, Anions, Boron, SAR and RSC values of irrigation water collected in the first week of June were higher as compared to those during first week of December and March might be due to evaporation and temperature was high during first week of June lead to decreased dilution of water.

Introduction

In India out of total cultivated area of 159.6 Million hectare, only an area of 64.7 Million hectare is under irrigation. Out of total irrigated area about 26, 19, 45, 3 and 7 per cent area is irrigated by canals, open wells, tube wells, tanks and other sources respectively (Anonymous, 2015). In Maharashtra irrigation by well is about 56 per cent and canal is about 23 per cent. Government of India encourages for use of ground water through well and bore well but approximately 32.84 per cent of total ground water used for irrigation in India is of poor quality (Patil *et al.,* 2014). Maharashtra state has a coastal belt 720 km in length, stretching through the

districts of Thane, Greater Bombay, Ratnagiri and Sindhudurg. The surface water resources of Konkan are finite and much of the irrigation needs are met by groundwater resources. Therefore groundwater has acquired a vital role in the development of Agriculture of Konkan region. Open wells and bore wells are the main sources of irrigation in Konkan.

The majority of ground waters are of poor quality due to excessive salt concentration, high sodium adsorption ratio (SAR) and residual sodium carbonate (RSC) values. Scarcity of good quality of waters forces farmers to use available saline and sodic water for irrigation (Girdhar, 1996). There is difference in the quality of ground water in the region of topographic elevation and at the sea level of coastal areas. Ground water quality of locations at the sea level is impeded by salinity. The periodic monitoring of ground water quality becomes a need to minimize the risk of soil health deterioration and its detrimental effects on crop production. This study undertook in that direction.

Materials and Methods

The study was confined to Dapoli and Murud village (Murud-Harnai) in Dapoli tehsil. These two locations of Konkan region comes under the agro-climatic zone, very high rainfall with lateritic soil zone. The geographical location of Dapoli is 17°45′32″N latitude 73°11′8″E longitude and that of Murud is 17°46′29.80″N latitude 73°7′5.34″E longitude. Dapoli is away from the sea as well as at a higher altitude (800 ft). Whereas Murud is near to Arabian Sea and at the sea level. These two locations are 7 km apart from each other.

For collecting irrigation well water samples, wells were selected in such that they cover the particular area of that village as per the GPS location. In all, 25 water samples were collected from different farms of College of Agriculture, Dapoli and 25 samples from Murud.

The representative water samples were collected from each well in first week of December, 2016 and first week of March, 2017 and subsequently in first week of June, 2017. By using standard procedure (Richards 1954) water samples were collected in clean plastic bottles of half litre capacity and tightly screwed and brought to the laboratory for further analysis. While collecting the water samples, the bottles rinsed thoroughly twice with the sample used. The water samples were analyzed immediately after collection from the wells.

Hydrogen ion concentration (pH) and electrical conductivity (EC) were measured, using pH and EC meters (Jackson, 1973). Calcium (Ca^{2+}) and Magnesium (Mg^{2+}) were determined by Versanate (EDTA) titration method described by Schwarzenbach *et al.,* (1946).

Sodium (Na^{+}) and potassium (K^{+}) were estimated Flame Photometerically as described by Jackson (1973). Carbonate (CO_3^{2-}) and bicarbonate (HCO_3^{2-}) were estimated by using dilute acid titration method given by Hesse (1971). Chlorides (Cl^{-}) were determined by titration of sample with silver nitrate according to Monr's titration method. Sulphates (SO_4^{2-}) were determined by Turbidimetric method. Boron was determined by using Azomethine-H method (John, 1975).

From these constituents sodium adsorption ratio (SAR) and residual sodium carbonate (RSC) were computed and their respective water quality classes were decided. All parameters, except the pH and EC are expressed in milliequivalent per litre (me L^{-1}). The EC is measured in ($\mu S\ cm^{-1}$) at 25^0C.

Results and Discussion

Water pH

The mean values of pH of well water samples from Dapoli were 6.2, 6.9 and 7.1 during the first week of December, March and June, respectively. While the corresponding values for the well water samples from Murud were 6.9, 7.2 and 7.7, respectively. Majority of water samples were slightly alkaline during first week of June in reaction.

Water salinity

The mean values of electrical conductivity of well water located at Dapoli were 10, 18 and 154 $\mu S\ cm^{-1}$, in the first week of December, March and June, respectively. The said values for the well water located at Murud were 60, 105 and 598 $\mu S\ cm^{-1}$, respectively.

At Dapoli, 100 per cent samples were safe (C_1 category) for irrigation throughout the sampling period. While at Murud all 100 per cent samples were safe (C_1 class) during first week of December and March but during June only 8 per cent water samples were safe (C_1 class) for irrigation. During first week of June well water from Murud, about 88 per cent wells can be used but required moderate leaching (C_2 class) whereas 4 per cent water

samples were fairly suitable (C_3 class) and cannot be used on soils with restricted drainage and sensitive crops like pulses.

Alkalinity *i. e.* Sodium hazard (SAR)

The average SAR values of well water samples from Dapoli were 0.84, 1.16 and 1.54 during the first week of December, March and June, respectively. Whereas the corresponding values for the well water samples from Murud were 3.73, 4.16 and 8.26, respectively. As far as the sodium hazard of water is concerned, the mean values sodium adsorption ratio (SAR) of the well water samples from both Murud and Dapoli were below 10 throughout the sampling period indicating the suitability of this water for irrigation.

Concentration of Sodium

Sodium is highly soluble chemical element, which is naturally found in ground water. The sodium concentration of Dapoli well water samples varied from 0.90 to 1.10, 2.00 to 1.40 and 2.60 to 2.80 me L^{-1} during the first week of December, March and June, respectively. The corresponding values for the well water samples from Murud ranged between 4.30 to 10.90, 5.50 to 14.60 and 12.40 to 22.90 me L^{-1}, respectively.

Concentration of Calcium

The calcium concentration in well water samples from Dapoli ranged between 1.32 to 2.77, 2.00 to 3.76 and 2.96 to 4.60 me L^{-1} during the first week of December, March and June, respectively. While calcium content in well water samples located at Murud was in the range of 2.06 to 6.02, 2.68 to 6.94 and4.24 to 8.12 me L^{-1}, respectively.

Concentration of Magnesium

Magnesium concentration in water samples from Dapoli varied from 0.83 to 1.19, 1.52 to 1.96 and 2.34 to 2.90 me L^{-1} during the first week of December, March and June, respectively. While that of Murud were 0.52 to 1.51, 1.67 to 2.79 and 2.10 to 3.23 me L^{-1}, respectively.

Residual Sodium Carbonate (RSC)

The RSC values of well water samples from Dapoli ranged between 0.01 to 0.47, 0.18 to 0.97 and 0.30 to 1.14 me L^{-1} during the first week of December, March and June, respectively. The pertinent values for the water of wells located at Murud were in the range of 0.02 to 0.53, 0.22 to 1.00 and 0.66 to 3.49 me L^{-1}, respectively.

Categorization of irrigation water based on RSC values showed that all the 25(100%) samples from Dapoli were suitable for irrigation throughout the sampling. All 25 (100%) samples from Murud were suitable for irrigation in the first week of December and March but during first week of June, out of 25 water samples from Murud 4 (16%) water samples were suitable for irrigation whereas 21 (84%) water samples were marginally suitable for irrigation.

Concentration of Carbonates

The study indicated the absence of carbonates in well water samples from Dapoli and Murud throughout the sampling.

Concentration of Bicarbonates

The bicarbonate concentration from well water samples of Dapoli varied from 2.20 to 4.00, 4.00 to 6.40 and 5.80 to 7.80 me L^{-1}, during the first week of December, March and June, respectively. The corresponding values for the well water samples from Murud ranged from 2.60 to 8.00, 4.60 to 10.40 and 7.00 to 14.00 me L^{-1}, respectively.

Specific ion concentration of boron, potassium, chloride and sulphate

Concentration of Boron

The boron concentration of well water samples from Dapoli ranged from 0.08 to 0.14, 0.12 to 0.21 and 0.13 to 0.23 ppm during the first week of December, March and June respectively. The said values in Table 4.15 for the well water samples from Murud were in the range of 0.10 to 0.19, 0.13 to 0.23 and 0.15 to 0.26 ppm, respectively. As far as boron toxicity is concerned, all the 50 (100%) samples collected from Murud and Dapoli were safe for irrigation purpose throughout the sampling months.

Concentration of Potassium

The concentration of potassium of well water located at Dapoli varied from0.20 to 5.00, 0.50 to 6.20 and 0.50 to

6.90 me L^{-1}, in the first week of December, March and June, respectively. The corresponding values for the well water samples located at Murud ranged between 0.40 to 1.10, 1.00 to 1.60 and1.70 to 2.30me L^{-1}, respectively.

Concentration of Chloride

The chloride concentration of well water samples located at Dapoli was in the range of 1.75 to 3.25, 2.25 to 4.25 and 5.50 to 6.50 me L^{-1} during the first week of December, March and June, respectively. Whereas the corresponding values of Chloride content for the well water samples from Murud ranged between 2.50 to 6.75, 9.25 to 11.00 and 9.00 to 18.00 me L^{-1}, respectively.

As far as specific concentration of chloride is concerned, during first week of December all 25 (100%) samples from Dapoli were suitable for irrigation. In March only 8 (32%) water samples from Dapoli were suitable for irrigation whereas remaining 17 (68%) samples were moderately suitable.

Hundred per cent water samples from Dapoli were moderately suitable for irrigation during the month of June. During first week of December 2 (8%) samples from Murud were suitable for irrigation whereas 23 (92%) were moderately suitable for irrigation.

About 10 (40%) and 15 (60%) samples from Murud in the month of March were moderately suitable and unsuitable for irrigation, respectively. Whereas during first week of June, 1 (40%) and 24(96%) samples were marginally suitable and unsuitable for irrigation, respectively.

Concentration of Sulphate

The data presented in for concentration of sulphate in well water samples from Dapoli ranged from 0.18 to 0.90, 0.48 to 0.99 and 0.70 to 1.25 me L^{-1} during the first week of December, March and June, respectively. While that of Murud was 0.24 to 0.77, 0.81 to 1.14 and 1.25 to 1.71me L^{-1}, respectively.

From the present study, it can be concluded that:

The water from all wells of Dapoli is suitable for irrigation throughout the irrigated cropping season. All the properties *viz.* pH, EC, cations (Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}), anions (HCO_3^{-}, CO_3^{2-}, Cl^{-} and SO_4^{2-}), boron, SAR and RSC of well water samples from Dapoli are within the safe limit during the irrigation period. During the first week of June, the average pH of well water samples from Murud was 7.7. The use of water from those wells needs caution.

During the first week of June, the well water samples from Murud showed medium salinity (C_2) category on the basis of salinity hazard. The water sample no. M_{15} belonged to C_3 (high salinity) class during the month of June. In this period continuous use of irrigation water needs caution. It may affect the growth of less tolerant vegetables taken in this area like brinjal, radish and sweet potato.

The SAR values for, all the samples from Murud and Dapoli were below 10 indicating all the samples were safe for irrigation throughout the sampling period. Such water can be used for irrigation with care.

Table.1 Variation in pH and electrical conductivity (µS cm^{-1}) of well water samples at various months from Dapoli and Murud

Location		pH			EC (µS cm^{-1})		
		Dec-16	Mar-17	Jun-17	Dec-16	Mar-17	Jun-17
Dapoli	Maximum	7.2	7.3	7.4	21	31	226
	Minimum	5.5	6.0	6.8	05	10	83
	Mean	6.2	6.9	7.1	10	18	154
Murud	Maximum	7.0	7.6	8.2	79	181	1450
	Minimum	6.1	6.5	7.3	11	34	165
	Mean	6.9	7.2	7.7	60	105	598

Table.2 Variation in Sodium Adsorption Ratio (SAR), Sodium, Calcium and magnesium concentration (me L^{-1}) of well water at various months from Dapoli

Location	SAR			Na^+ (me L^{-1})			Ca^{2+} (me L^{-1})			Mg^{2+} (me L^{-1})		
	Dec-16	Mar-17	Jun-17	Dec-16	Mar-17	Jun-17	Dec-16	Mar-17	Jun-17	Dec-16	Mar-17	Jun-17
Dapoli												
Maximum	1.02	2.45	1.72	1.10	2.00	2.80	2.77	3.76	4.60	1.19	1.96	2.90
Minimum	0.71	0.83	1.41	0.90	1.40	2.60	1.32	2.00	2.96	0.83	1.52	2.34
Mean	0.84	1.16	1.54	1.00	1.68	2.70	1.90	2.85	3.69	0.99	1.74	2.53
Murud												
Maximum	6.15	6.90	9.99	10.90	14.60	22.90	6.02	6.94	8.12	1.51	2.79	3.23
Minimum	2.58	2.82	6.96	4.30	5.50	12.40	2.06	2.68	4.24	0.52	1.67	2.10
Mean	3.73	4.16	8.26	6.60	8.74	18.55	4.97	6.06	7.21	1.25	2.53	2.85

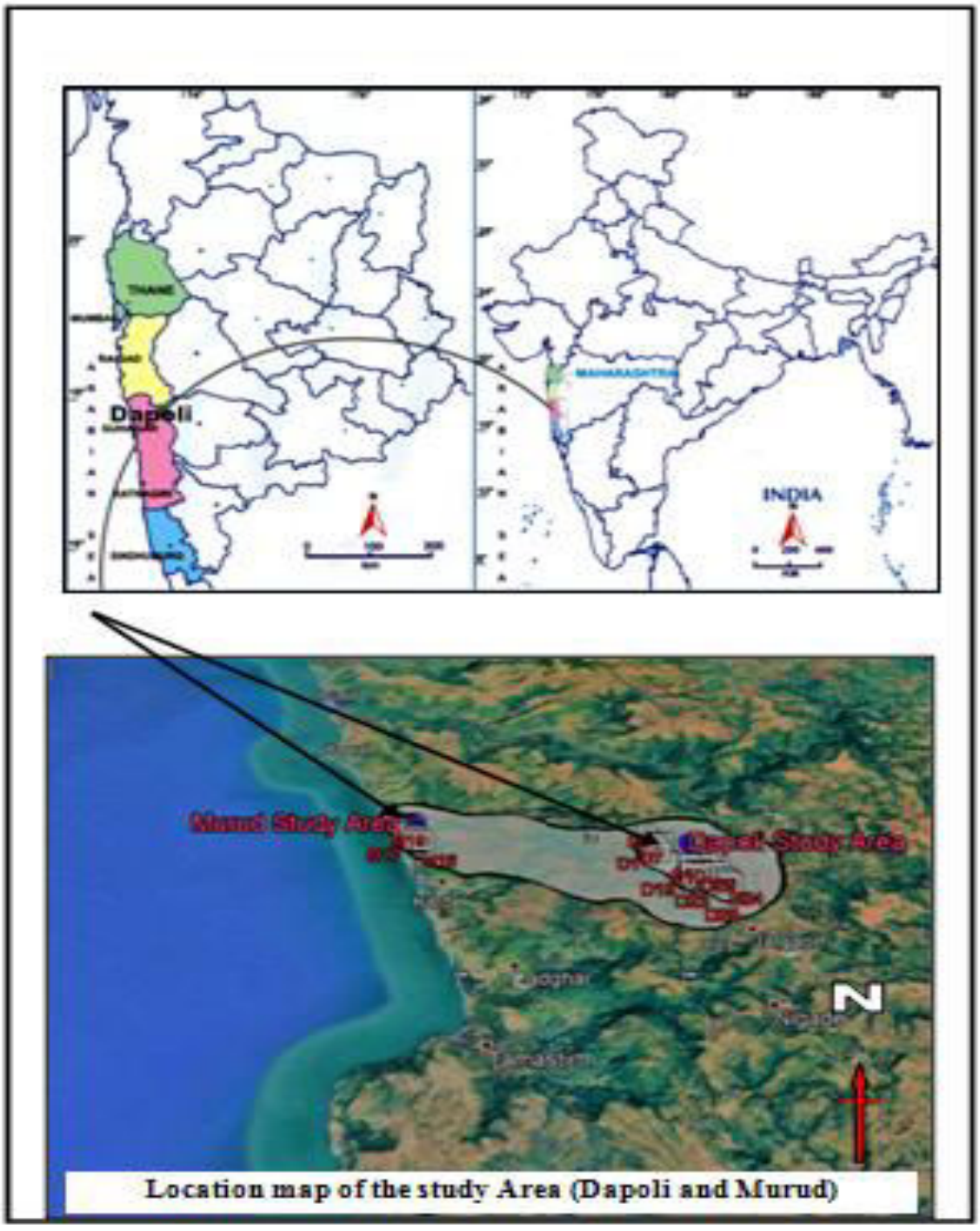
Table.3 Variation in Residual Sodium Carbonate (RSC) and Bicarbonate concentration (me L^{-1}) of irrigation well water at various months from Dapoli and Murud

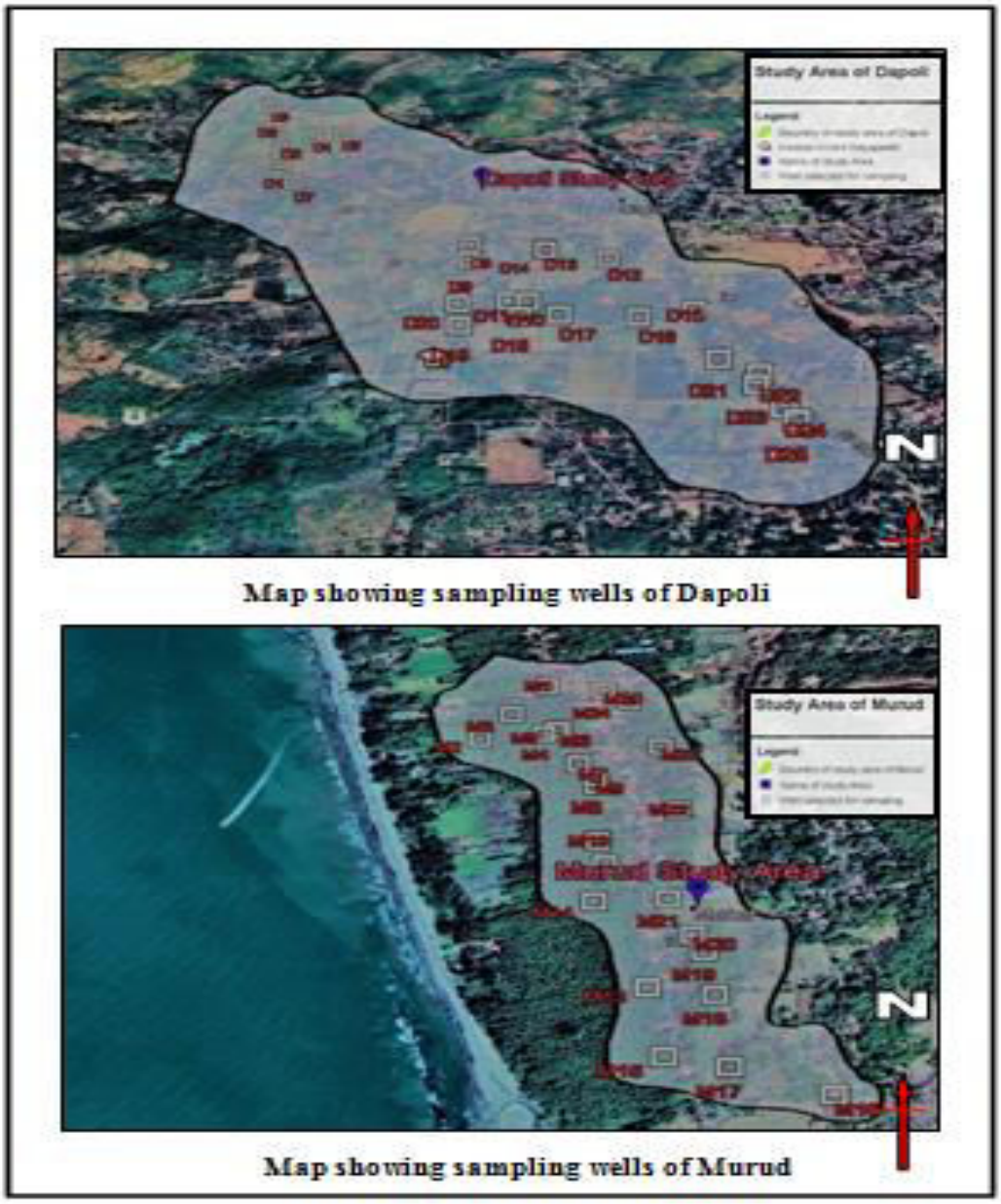
Location		RSC (me L^{-1})			HCO_3^- (me L^{-1})		
		Dec-16	Mar-17	Jun-17	Dec-16	Mar-17	Jun-17
Dapoli	Maximum	0.47	0.97	1.14	4.00	6.40	7.80
	Minimum	0.01	0.18	0.30	2.20	4.00	5.80
	Mean	0.21	0.40	0.58	3.10	4.99	6.80
Murud	Maximum	0.53	1.00	3.49	8.00	10.40	14.00
	Minimum	0.02	0.22	0.66	2.60	4.60	7.00
	Mean	0.29	0.50	1.89	6.51	9.09	11.95

Table.4 Variation in Potassium, Chloride and Sulphate concentration (me L^{-1}) of irrigation well water at various months from Dapoli and Murud

Location	K^+ (me L^{-1})			Cl^- (me L^{-1})			SO_4^{2-}(me L^{-1})			B (ppm)		
	Dec-16	Mar-17	Jun-17	Dec-16	Mar-17	Jun-17	Dec-16	Mar-17	Jun-17	Dec-16	Mar-17	Jun-17
Dapoli												
Maximum	5.00	6.20	6.90	3.25	4.25	6.50	0.90	0.99	1.25	0.14	0.21	0.23
Minimum	0.20	0.50	0.50	1.75	2.25	5.50	0.18	0.48	0.70	0.08	0.12	0.13
Mean	0.84	1.12	1.30	2.65	3.67	5.98	0.43	0.73	0.98	0.11	0.15	0.18
Murud												
Maximum	1.10	1.60	2.30	6.75	11.00	18.00	0.77	1.14	1.71	0.19	0.23	0.26
Minimum	0.40	1.00	1.70	2.50	9.25	9.00	0.24	0.81	1.25	0.10	0.13	0.15
Mean	0.96	1.37	2.07	5.86	10.07	14.17	0.65	1.01	1.51	0.14	0.17	0.20

Figure.1


THANE
Dapoli
INDIA
N
Location map of the study Area (Dapoli and Murud)



As far as specific toxicity of chloride is concerned, from Murud about 15 (60%) samples during first week of March and 24 (96%) samples during first week of June were unsuitable for irrigation. According to RSC values, about 84% samples during the first week of June were marginally suitable for irrigation.

Implications

However, the use of well water for irrigation needs caution about salinity hazard, RSC values, specific toxicity of chloride at Murud from the month of March. The tidal influence on well water quality evaluation is essential.

Author Contributions

M. C. Kasture: Investigation, formal analysis, writing—original draft. S. S. Prabhudesai: Validation, methodology, writing—reviewing. S. S. More:—Formal analysis, writing—review and editing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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