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ASSESSMENT OF GROUND WATER QUALITY IN SANGAMNER AREA FOR SUSTAINABLE AGRICULTURAL WATER USE PLANNING

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ABSTRACT

Analysis of groundwater samples of Sangamner area, Ahmednagar District, Maharashtra was carried out to evaluate the chemistry of ground water. The physico-chemical analysis of 53 open wells waters was carried out by standard methods. The result showed that higher values of chemical constituents of groundwater are found with those samples which are close to river channel and in the downstream part of Pravara river. Calcium and magnesium are dominant cations followed by sodium. Chloride is found to be predominant anion followed by bicarbonate, sulphate and nitrate. The chemical characteristics of ground water have been found to be dominated by Ca + Mg > Na + K-HCO_3 + CO_3 hydrochemical types followed by Na + K-HCO_3 + CO_3 and Na + K-SO_4 + Cl + NO_3 indicating dominance of cation and anion exchange. The Richard's classification as well as SAR, RSC, KR and Wilcox's classification showed the waters in the upper part of Pravara river are suitable for sustainable agricultural waters use planning while water from lower part needs treatment before use. Educating the farmers to adopt better farm practices have been suggested to reduce the problem of environmental degradation of ground water in the area.

Key words: Agro industries, Richard's classification, Piper's trilinear diagram, Sustainable agricultural water use planning.

INTRODUCTION

Agriculture is the base of Indian economy. The growing needs of food grains due to ever growing population are met with by the agriculture sector. As a result, this sector has undergone rapid changes from traditional methods to hightech agriculture. However, the environmental side effects of these technological efforts have started to manifest by way of

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degradation of soils as well as modifications in the ground water chemistry.

In Maharashtra, the co-operative sector has played a vital role in the agricultural development of the state. Due to this, the traditional concepts of practising agriculture have undergone radical changes. The co-operative sector has provided foundation for agricultural development through supplementary activities like dairy and poultry besides sugar as well as paper and pulp mill industries. In spite of these useful activities, today the need has arisen to review and recognise environmental problems associated with these agro industries. In many areas, over-use of irrigation water, monoculture type of cropping pattern and increased use of chemical fertilizers have led to problems of water and soil pollution. Incidences of degradation of groundwater quality have been reported by several workers[1-7]. There is however, very little data available on the effects of chemical weathering and human activities on the chemistry of groundwater of Sangamner area[8,9]. In view of this, an attempt has been made to assess the chemistry of ground waters of Sangamner area, Ahmednagar district of Maharashtra with regard to its suitability for irrigation and domestic purposes, which will be useful for sustainable groundwater resource use planning in the area.

The study area

The Sangamner area is located in the Ahmednagar District of Maharashtra. Sangamner is a Taluka headquarter, which is located at a distance of 150 km from Pune on Pune-Nashik National Hiwhway No. 50 (Fig. 1). The area is drained by the Pravara river, which is a tributory of Godavari. Pravara river originates in the mountainous region of Western Ghats and flows into low-lying fertile alluvial plain in the downstream part. Several dams and weirs have been constructed across Pravara river. Of these, Bhandardara dam is located in the source region and the Ozar dam is in the downstream direction of Sangamner town. These dams have been augmenting the irrigational water needs of the area. Over 90% of the study area is practising intensive agriculture. It should be noted that subsequent to the establishment of co-operative sugar-mill at Sangamner in 1967, the agriculture in the area has witnessed rapid changes in the cropping pattern. The industrial units developed in the area generate large volumes of waste water, which mixes with surface and groundwater resources; thereby contaminating them. At places, the lagoons used for storage of waste waters have caused degradation of soils as well as water due to infiltration of effluents. Thus, the groundwater resources are facing severe threat from both; irrigation practices as well as from agro-based industry.

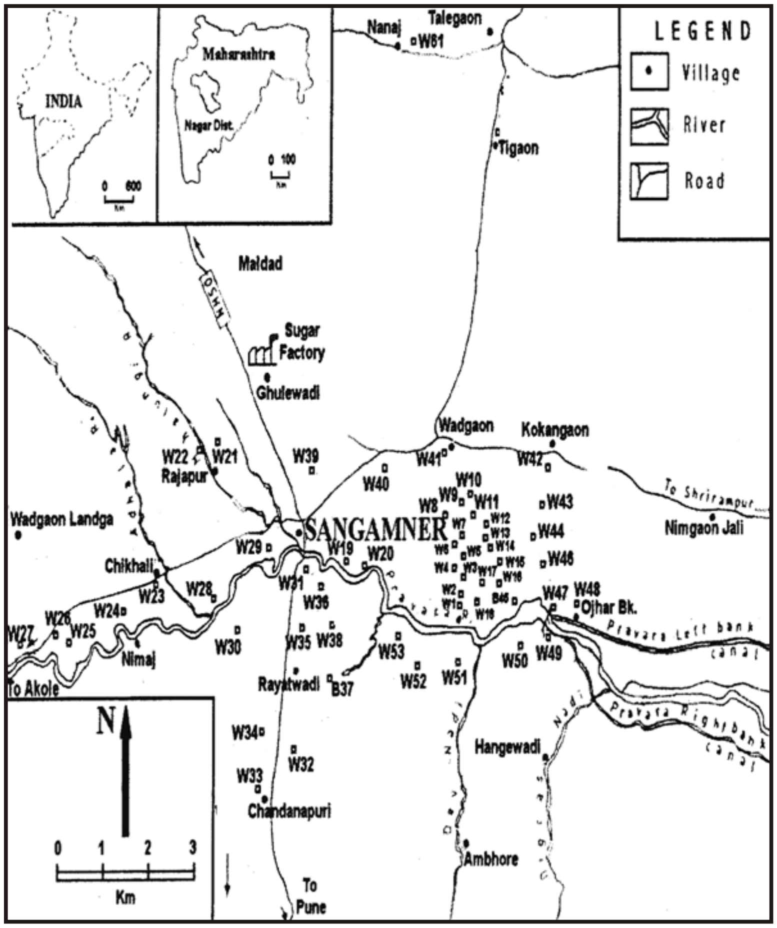

Fig. 1: Locations of ground water sampling stations in the study area

EXPERIMENTAL

Before collecting the water samples for analysis, a pilot survey of the area under study was made. During this survey, information regarding land use, types of crops, fertilizers used, the nature of fertilizers, the quantity of water used for irrigation and frequency of application of water was collected. Based on this information, a network of 53 sampling stations was established. Priority was given to those wells that are used for irrigation.

Water samples were collected in polythene bottles that were previously cleaned and washed with distilled water. The pH, electrical conductivity and temperature was measured in the field and then the samples were brought to the laboratory for analysis of sodium (Na^+), potassium (K^+), calcium (Ca^{2+}), total hardness as $CaCO_3$, chloride (Cl^-), sulphate (SO_4^{2-}), phosphate (PO_4^{3-}), nitrate (NO_3^-), silica (SiO_2) and boron (B). The methods used for the analyses were standardized as per procedures given by APHA, AWWA and WPCF[10].

The pH and EC were measured by portable pH and conductivity meters, respectively. Sodium and potassium were analyzed by Corning –400 make flame photometer. Sulphates, phosphates, nitrates and boron were detected by using Hitachi-2000 UV visible spectrophotometer. Total alkalinity as $CaCO_3$, total hardness as $CaCO_3$ and chlorides were analysed by titrimetric methods. The analytical accuracy was checked by using STIFF computer program for calculating the charge balance error (CBE). The CBE upto 10% was considered valid as some of the parameters were analysed by employing titrimetric methods. The analytical data obtained is presented in Table 1.

Table 1: Physico-chemical analysis of ground water from Sangamner area

S. No.	pH	EC	Na	K	Ca	Mg	Cl	HCO_3	SO_4	PO_4	NO_3	SiO_2	TH	B
W1	8.2	1660	300	5.1	92	306	825	582	340	1.66	ND	51.43	1490	3.94
W2	7.8	340	175	3.3	36	29.7	115	380	124	1.36	ND	33.46	130	10.4
W3	7.6	700	225	4.4	80	56	214	544	192	1.55	ND	41.10	430	22.9
W4	7.8	1700	440	4.8	80	289	850	692	360	1.51	3.23	53.92	1390	20.9
W5	7.7	2290	310	2.4	300	277	1224	390	375	1.46	3.70	50.0	1891	8.11
W6	7.6	1810	490	9.9	128	121	629	544	373	1.34	ND	52.74	817	6.97
W7	8.8	500	179	5.1	44	41	159	429	191	1.19	7.09	36.50	280	6.30
W8	7.8	710	200	3.2	36	85.2	227	429	233	1.35	4.84	46.29	440	5.44
W9	7.8	1730	292	3.2	292	144	992	304	362	1.87	ND	48.06	1324	8.72
W10	8.0	1060	385	4.2	40	56	310	447	357	1.22	ND	39.92	330	23.3
W11	7.9	810	385	1.8	56	40	240	560	290	1.16	ND	46.30	304	9.86
W12	7.4	2180	330	1.2	132	406	1204	604	238	1.48	ND	44.20	2001	12.8
W13	7.8	1600	310	3.4	128	199	577	700	371	1.29	12.91	48.85	1140	.359
W14	7.5	1290	200	3.4	144	250	495	722	353	1.48	4.77	39.05	1390	11.9
W15	8.1	1310	285	2.1	64	177	511	612	342	1.80	.430	44.02	888	12.3
W16	8.0	570	285	6.4	32	24	165	402	216	1.08	ND	35.22	178	12.2

Cont…

S. No.	pH	EC	Na	K	Ca	Mg	Cl	HCO_3	SO_4	PO_4	NO_3	SiO_2	TH	B
W17	7.7	1140	310	4.0	60	116	343	772	331	1.51	ND	39.36	627	0.67
W18	8.2	1210	320	13.6	88	102	386	698	352	1.49	ND	45.78	640	5.44
W19	7.4	1580	232	2.0	236	263	735	560	366	1.49	3.30	51.03	1672	0.25
W20	7.4	1280	232	3.0	160	211	541	740	354	1.28	ND	43.48	1268	14.6
W21	7.6	820	224	4.5	64	126	396	480	97.6	1.21	16.14	49.05	678	3.77
W22	7.3	1540	142	2.0	276	241	1023	300	254	1.50	12.84	37.85	1681	ND
W23	7.7	1320	148	2.0	480	102	679	560	217	1.15	1.62	45.82	1618	7.83
W24	7.6	1570	310	2.2	188	138	871	534	209	1.34	21.26	42.49	1037	ND
W25	7.6	1220	392	ND	84	143	653	476	168	1.51	5.90	44.66	798	6.76
W26	8.0	260	48	2.2	52	65	693	362	3.4	1.18	13.5	40.27	356	5.62
W27	7.8	240	80	2.60	44	40	49.5	390	2.4	1.19	3.02	36.80	274	11.6
W28	7.4	1010	350	ND	80	97	448	582	151	1.17	17.82	46.14	600	ND
W29	7.8	450	180	1.2	44	40	1584	446	41.4	1.98	ND	43.43	274	6.90
W30	7.4	598	132	2.0	116	124	485	486	81.4	2.00	3.02	21.44	800	6.05
W31	7.2	1110	89	4.2	276	176	768	274	94.3	2.01	19.7	40.10	1413	ND
W32	7.8	620	65	ND	96	121	310	296	49.3	2.01	82.4	43.90	737	6.45
W33	7.8	620	75	2.0	84	109	310.2	282	53.4	2.00	63.82	45.88	658	3.45
W34	7.4	900	90	2.3	120	155	570.9	300	53.8	2.00	39.07	46.16	937	ND
W35	7.2	850	168	2.0	204	143	488.4	340	84.0	1.99	54.14	46.20	1098	3.95
W36	7.4	860	92	1.4	136	165	481.8	360	132	2.00	5.47	38.68	1018	3.7
W37	7.3	1174	112	1.2	156	207	792	332	163	2.00	20.06	42.53	1241	5.3
W38	7.6	1080	105	2.4	180	240	742.5	308	202	2.00	21.96	33.37	1437	4.98
W39	7.7	530	142	0.9	48	78	214.5	506	13.4	1.98	28.62	40.24	440	6.47
W40	7.4	480	40	2.5	96	97	257.4	280	25.1	1.98	13.19	38.07	639	10.2
W41	7.4	500	60	0.8	110	97	257.4	324	57.4	2.00	13.68	42.63	674	4.62
W42	7.8	620	79	ND	104	130	349.8	328	49.5	1.99	39.63	34.68	794	4.59
W43	7.4	1550	125	6.6	252	397	891	390	316	1.99	54.63	41.43	1872	10.2

Cont…

S. No.	pH	EC	Na	K	Ca	Mg	Cl	HCO_3	SO_4	PO_4	NO_3	SiO_2	TH	B
W44	7.1	1310	80	2.5	300	215	852	278	241	2.0	24.55	42.59	1634	ND
W46	8.0	360	90	3.0	40	40	72.64	440	31.6	1.94	2.95	27.66	264	5.09
W47	7.7	380	54	2.7	56	70	95.7	342	58.6	1.97	10.39	38.13	428	37.0
W48	7.6	650	110	2.8	76	92	250	448	111	2.02	ND	32.56	568	5.05
W49	8.2	440	240	2.9	20	22	72.6	624	45.1	1.93	ND	35.95	140	8.01
W50	7.6	900	115	2.0	128	120	280	548	120	2.02	ND	28.38	813	2.24
W51	8.1	1340	120	4.4	60	134	381.6	682	3.5	1.97	ND	34.22	701	3.27
W52	7.8	440	148	4.3	72	78	110.2	402	280	2.01	0.15	40.79	500	7.76
W53	8.0	400	148	4.0	40	44	85.8	432	3.6	1.88	ND	26.19	281	8.36

RESULTS AND DISCUSSION

A glance at the analytical data on groundwater presented in Table 1 shows that there is considerable variation in the chemistry of ground water. These spatial variations has been described.

Variations in the major ion chemistry of ground water

The chemical analysis of ground water samples from Sangamner area included determinations of positively charged ions- Ca^{2+}, Mg^{2+}, Na^+ and K^+ and negatively charged ions HCO_3^-, Cl^- SO_4^{2-} and PO_4^{3-}. In addition to this, pH, EC, silica and boron have been considered.

Variations in the pH, EC, silica and boron.

The pH of the ground water from the study area varies from 7.1 to 8.8 indicating neutral to slightly alkaline nature of ground water. The lower values of pH have been obtained for sample No. W22, W31, W35, W37 and W44, which are away from valley floor and river bed areas. On the other hand, higher values of pH have been recorded for the wells (S. No. W1, W7, W15, W19 etc.), which are close to the river channel and also in the downstream parts of Pravara river.

Electrical conductivity (EC) of the ground water varies from 240 to 2290 μS/cm. It is known that EC represents the total dissolved solids content of the ground water. The majority of data from the study area suggests that the ground waters belong to low conductive (< 500 μS/cm) to medium conductive class II (1000-3000 μS/cm). The lower EC values have been obtained for the wells situated along the slopes of hills (S. No. W26 and W27) forming undulating topography leading to faster circulation of ground waters. In the downstream part of the Pravara basin, the values of the EC are higher (S. No. W4, W5, W6, W9, W12, W13 and W19). This is possibly the result of the poor drainage conditions that have reduced the flushing rate of salts from the basin.

The concentration of silica varies between 21.45 mg/L and 53.92 mg/L in the study area. Less variations in the silica values indicate that the lithological conditions in the area are fairly uniform and silicate weathering has contributed to release of silica in ground water.

Boron concentration varies from trace amounts to 23.31 mg/L in the study area. Although boron is an essential plant nutrient, it becomes toxic if present beyond tolerance level[11]. The boron is found to be higher in the downstream part of basin (S. No. W3, W4, W9, W12, W14, W15, W16 and W28) because of less leaching of the salts. Due to limited leaching of soils, boron has possibly not been removed in the same proportion as other salts.

Variations in the cationic constituents

Calcium and magnesium are the dominant cations in the ground water from the study area followed by sodium and potassium. On the average Ca^{2+} + Mg^{2+} in equivalent units accounts for 75% of the sum of cations. On the individual basis, the values of Ca^{2+} ranges from 20 mg/L to 480 mg/L. Similarly, the values of Mg^{2+} ranges between 22 mg/L and 445 mg/L. In general, the Mg^{2+} concentrations have been found to be higher in the wells, which are located in the downstream part (S. No. W1, W4, W5, W8, W9, W12, W14, W38, W43 and W44) than in the upstream part. The higher concentration of Mg^{2+} in ground water is due to the weathering of pyroxenes present in the basaltic rocks from the study area. The calcium concentration follow more or less similar trend, indicating plagioclase feldspar as a dominant source[12].

The concentration of Na^{+} varies from 40 to 490 mg/L and that of K^{+} from trace amounts to 13.8 mg/L. The values of both; Na^{+} and K^{+} increase in the downstream part of river (S. No. W1, W3, W4, W5, W6, W9, W10, W11 and W49). Sodium concentration in the ground water is the result of chemical weathering of plagioclase feldspar present in the basalt. Apart from the natural sources, human activities have significant influence on the concentration of sodium in the groundwater[12]. In the study area; however, the higher Na^{+} concentration is the combined effect of geological source as well as evaporative concentration in the downstream part where water-table is at shallow depth.

Variations in the anionic constituents

Amongest the four major anions (Cl^-, HCO_3^-, SO_4^{2-} and NO_3^-), the chloride is found to be the most predominant anion followed by bicarbonate, sulphate and nitrate. The concentration of bicarbonate ranges from 274 mg/L to 772 mg/L. The high bicarbonate concentration observed in the downstream part is possibly due to flat topography, providing sufficient length of time for the aquifer material to interact with the ground water[13]. Both silicate mineral weathering of basalt and dissolution of carbonate present in the alluvium seem to be the potential sources of bicarbonates in the water.

The chloride concentration in the ground water ranges from 49.5 mg/L to 1224 mg/L. The chloride concentrations are higher in the downstream part of the area possibly due to excessive use of fertilisers, poor drainage conditions and reuse of irrigation water (S. No. W1, W4, W5, W9, W11, W12, W22, W24, W43 and W44). There is no lithological source of chloride in the area. Hence, higher concentration of chloride indicate the input from fertilisers and recycling of water due to irrigation. In the area close to sugar-mill and other industries, contribution of chloride could be due to mixing of waste waters.

The sulphate concentration in the groundwater of the area varies from 2.4 to 366.1 mg/L. The higher concentrations of sulphate is observed in the downstream part, which could be due to excessive use of fertilisers or use of soil amendments (S. No. W1, W5, W6, W9, W13, W14, W19 and W20). The lower values of sulphate have been observed in the upstream part of the basin (S. No. W26 and W27) indicating negligible contribution from lithological sources.

Classification of ground water from Sangamner area

In order to classify the ground water from study area, the data were plotted on Piper's trilinear diagram. The plots of the chemical data on the Piper's trilinear diagram (Fig. 2) indicate that the ground water predominantly belongs to Ca + Mg > Na + K cations hydrochemical facies. Out of 53 samples, 31 (58%) samples belongs to Ca + Mg > Na + K and 22 samples (42%) belongs to Na + K > Ca + Mg cation hydrochemical facies. Similarly, 44 samples (83%) represent Cl + SO_4 > HCO_3 + CO_3 and 9 samples (17%) belong to HCO_3 + CO_3 > Cl + $S0_4$ anion hydrochemical species. Thus, the ground water from Sangamner area largely represents Ca + Mg-SO_4 + Cl type of water followed by Na + K-SO_4 + Cl type. This suggests that the ground water has chemically evolved from Ca + Mg-HCO_3 + CO_3 type to Ca + Mg-SO_4 + Cl and Na+K-SO_4 + Cl type. The rapid chemical evolution of ground water is attributable to the intensive irrigation practices in the study area. This is evident from the fact that most of the samples collected from the areas located close to the river channel or in the backwaters of Ozar dam have represented Na + K-SO_4 + Cl type of water. The areas away from the river bank largely belong to Ca + Mg-HCO_3 + CO_3 type of water indicating slow release of ions from geological sources.

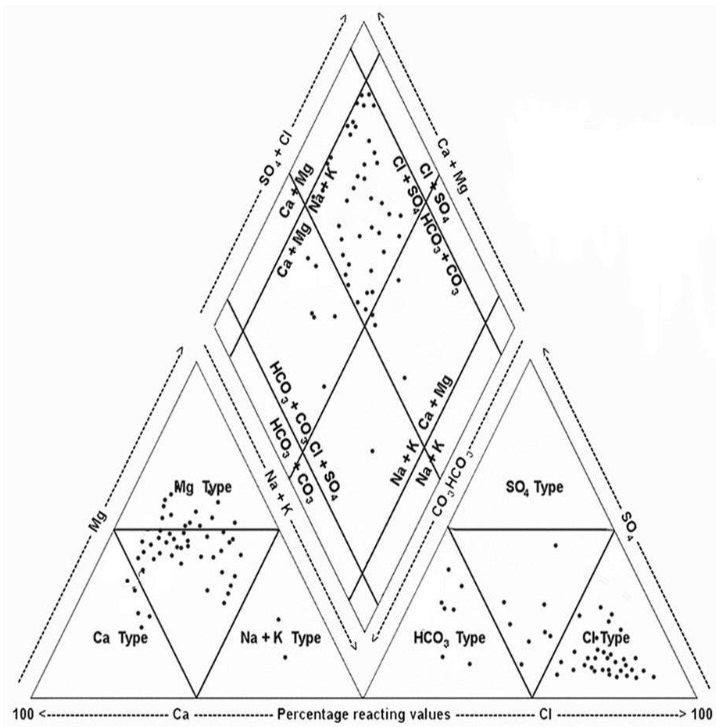

Fig. 2: Classification of ground water from Sangamner area

Ground water quality classification for sustainable agricultural water use planning

The quality of ground water for irrigation depends on the factors such as nature and composition of soil, depth of water table, topography, climate and type of crops etc.[13] In order to evaluate suitability of ground water from study area for sustainable water resource use planning in agriculture, the sodium absorption ratio (SAR), Kelly's ratio (KR), residual sodium carbonate (RSC), soluble sodium percentage (SSP) and Na% were calculated. The resulting data are given in Table 2.

It was observed from the table that the SAR values are less than 10 for nearly all the samples and they range from 0.69 to 9.6. This suggests that the largely ground water from the study area belongs to excellent to good class of water for irrigation purposes. The KR reflects alkali hazards of the water. It is observed that out of 53, 13 samples i.e. 25% (S. No.

W2, W3, W6, W7, W9, W10, W11, W16, W18, W25, W28, W29 and W49) show KR values above unity. These are mostly from the downstream part of the river. From the values, it is inferred that the continuous use of such waters for irrigation purpose may lead to alkali/sodium hazards to the soils.

Table 2: Ground water quality classification for agricultural planning in study area

S. No	SAR	KR	SSP	% Na	RSC
W1	3.38	0.4355	30.48	35.69	-20.22
W2	6.6	1.790	64.60	64.40	1.98
W3	4.72	1.138	53.23	53.51	0.32
W4	5.13	0.687	40.74	40.91	-16-49
W5	3.01	0.356	26.30	26.38	-31.40
W6	4.46	1.304	56.60	56.88	-7.40
W7	4.67	1.398	58.17	58.71	-0.36
W8	4.15	0.987	49.71	49.94	-0.05
W9	3.49	4.69	32.43	32.56	-21.23
W10	9.22	2.534	71.70	71.83	1.61
W11	9.06	2.754	73.36	73.42	3.16
W12	3.21	0.3590	26.42	26.46	-30.09
W13	4.2	0.606	37.21	37.36	-21.78
W14	2.34	0.3135	23.86	24.05	-15.92
W15	4.16	0.698	41.12	41.22	-7.37
W16	9.38	3.306	77.64	77.86	3.17
W17	5.39	1.0766	51.84	52.02	0.75
W18	5.5	1.0892	52.30	52.75	-1.35
W19	2.47	0.302	23.19	23.28	-24.23
W20	2.84	0.398	28.47	28.63	-13.20
W21	3.74	0.7188	41.82	42.09	-5.38
W22	1.15	0.1839	15.53	15.64	-28.67
W23	1.53	0.1991	16.60	16.61	-23.60

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S. No	SAR	KR	SSP	% Na	RSC
W24	4.19	0.6507	39.42	39.55	-11.98
W25	6.28	1.068	51.56	51.66	-8.15
W26	1.11	0.2939	22.71	23.13	-1.18
W27	2.10	0.6338	38.97	39.26	0.9
W28	6.22	1.272	55.99	55.99	-2.43
W29	4.73	1.426	58.78	58.87	1.83
W30	2.03	0.958	26.41	26.58	-8.02
W31	1.04	0.1369	12.16	12.46	-23.74
W32	1.04	0.1919	22.51	22.51	-9.89
W33	1.27	0.2477	19.85	20.08	-8.50
W34	1.28	0.209	17.29	17.16	-13.87
W35	1.05	0.333	24.99	25.13	-16.37
W36	1.29	1.1948	16.30	16.44	-14.63
W37	1.38	0.1962	16.40	16.48	-19.28
W38	1.21	0.1559	13.72	13.88	-23.67
W39	2.94	0.6975	41.20	41.7	-0.53
W40	0.69	0.1362	11.99	12.32	-8.18
W41	1.01	0.1937	16.23	16.33	-8.16
W42	1.22	0.2166	17.44	17.80	-10.05
W43	1.26	0.1202	10.73	11.03	-38.84
W44	0.86	0.1605	9.62	9.77	-28.1
W46	2.41	0.7012	42.56	43.05	1.62
W47	1.14	0.2690	21.55	21.98	-3.14
W48	2.01	0.4216	29.65	29.96	-4.02
W49	8.81	3.663	78.55	78.66	8.00
W50	1.75	0.3075	23.51	23.69	-7.28
W51	1.97	0.4335	27.14	27.59	-2.62
W52	2.88	0.643	39.14	39.55	-3.42
W53	2.41	0.7506	41.88	42.77	1.46

It is to be noted that if water contains carbonate and bicorbonate, in excess of calcium and magnesium, then it is likely to precipitate calcium displaced by exchange reaction. The result of this exchange reaction, there is increase in sodium hazard of water[14]. In the present study, 42 out of 53 samples i.e. 79% have RSC values less than 1.25 indicating that well waters are suitable for irrigation use. Out of the remaining, 8 samples i.e. 15% (S. No. W2, W3, W10, W18, W29, W46 and W53) are marginally suitable and 3 samples i.e. 6% (S. No. W11, W16 and W48) are unsuitable for irrigation use.

Further, 40 samples out of 53 i.e. 75% have SSP values less than 50 reflecting that the quality of water is good for agricultural planning. Out of the remaining, 13 samples (S. No. W2, W3, W6, W7, W10, W11, W16, W17, W18, W25, W28, W29 and W49) i.e. 25% have SSP higher than 50 showing unsafe character of water for irrigation use.

On the basis of sodium concentration, Wilcox[15] classified the water into 5 categories (Table 3).

Table 3: Classification of ground water based on sodium percentage in the study area

Na %	Class of water
< 20	Excellent
20 to 40	Good
40 to 60	Permissible
60 to 80	Doubtful
> 80	Unsuitable

In the study area, 12 (S. No. W22, W23, W31, W34, W36, W37, W38, W40, W41, W42, W43 and W44) out of 53 samples belong to excellent class of water and 21 samples i.e. 39% to good category. This indicates that the ground water is suitable for agricultural water resource use planning. The remaining 5 (S. No. W2, W10, W11, W16 and W49) belongs to doubtful category suggesting that they are marginally suitable for irrigation use planning.

In addition to the above by using EC and SAR values, Richard's classification (1954) criteria was adopted to classify the ground waters from study area for sustainable agricultural use planning. The data was plotted on USSL diagram and the classification of samples is given in Table 4.

Table 4: USSL classification of ground water from the study area

USSL classification	EC μS/cm	Class of water	Sample Nos.
C1-S1	100 to 250	Excellent	W27
C2-S1 C2-S2	250 to 750 250 to 750	Good	W2, W 3, W 7, W 8, W 16, W 26, W29, W32, W33, W39, W40, W41, W42, W46, W47, W48, W49, W52, W53
C3-S1 C3-S2	750 to 2250	Doubtful	W1, W4, W6, W10, W11, W12, W13, W14, W15, W17, W18, W19, W20, W21, W22, W23, W24, W25, W28, W30, W31, W34, W35,W36,W37,W38,W43,W44,W50,W51
C4-S1	> 2250	Unsuitable	W5

It is observed from the Table 4 that the samples belonging to C1-S1, C2-S1 and C2-S2 are suitable for agricultural planning in the area. The remaining samples belongs to C3-S1 and C3-S2 are of doubtful class for irrigation purpose. Those samples from C4-S1 category are totally unsuitable for irrigation under ordinary field conditions. It may however be noted that only under very special circumstances where the soil is permeable and the drainage is adequate, such waters can be used for agriculture.

CONCLUSION

The higher values of pH have been observed for the area close to river channel and in the downstream part of Pravara river. The EC of groundwater samples also show higher values in the downstream part of basin due to poor drainage conditions. The calcium and magnesium are the dominant cations followed by sodium. Amongst the four anions, the chloride is found to be most predominant anion followed by bicarboante, sulphate and nitrate.

On the basis of Piper's trilinear diagram, the ground water from the area can be predominantly classified as Ca + Mg > Na + K cation hydrochemical type. The area close to river channel or in the backwaters of Ozar dam have exhibited Na + K – SO_4 + Cl type of water. The areas away from river bank largely belong to Ca + Mg-HCO_3 + CO_3 type of water.

The Richard's classification criteria as well as SAR, RSC, KR and Wilcox's classification show the waters in the upper part of Pravara river are suitable for sustainable agricultural water use planning. On the other hand, ground water from the lower part needs treatment before use.

The study reveals that intensive irrigation has serious effect on the quality of water. The spatial variations in the ground water have been attributable to the effect of geology, land use and anthropogenic activities on water composition. The study suggest that excessive use of fertilizers and irrigation water in an area characterized by low flushing rates, presence of alluvium and flat topography have caused deterioration of ground water quality. Educating the farmers to adopt appropriate farm management practices based on judicious use of resources, controlled use of fertilizers and mixed culture of cropping pattern will help for sustainable agricultural water use planning.

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