Original Article

Deciphering groundwater quality for domestic and agricultural purposes in PTW-1 Watershed, Buldhana District, Vidharbha region, India

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Abstract

Abstract: The present hydro-geochemical study of groundwater samples from the in PTW-1 Watershed, Buldhana District, Vidharbha region, India was carried out to assess their suitability for agricultural, domestic and drinking purposes. For this study, samples were collected from 25 locations during the post-monsoon sessions. Groundwater samples were analyzed for their physical and chemical properties using standard laboratory methods. Physical and chemical parameters of groundwater such as pH, electrical conductivity, and total dissolved solids, Na+, K+, Ca2+, Mg2+, Cl-, CO3−, H CO3−, SO42−, NO−3 and F− were determined. Various water quality indices like SAR, SSP, PI, RSC, MAR, CR and KR have been calculated for each water sample to identify the agricultural suitability standard. According to these parameters, the groundwater has been found suitable for agricultural use. For determination of the drinking suitability standard of groundwater, three parameters have been considered is total hardness (TH), nitrate and fluoride. Groundwater of the present study area has been found to be good for domestic use except few locations where quality of groundwater get deteriorated.

Keywords Groundwater quality; agricultural and domestic suitability; PTW-1 watershed

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INTRODUCTION

Groundwater is the purest form of water sourced from natural resources and meets the overall demand of rural and semi-urban people. But the development of human societies and industry result in bioenvironmental problems; pollution puts the water, air and soil resources at risk (Milovanovic, 2007). Assessment of the hydro chemical characteristics of water and aquifer hydraulic properties is important for groundwater planning and management in the study area. It is not only the basic need for human existence but also a vital input for all development activities (Das and Nag, 2015). Intensive agricultural activities have increased the demand for groundwater in India. Water quality is influenced by natural and anthropogenic effects including local climate, geology and irrigation practices. Once undesirable constituents enter the ground, it is difficult to control their dissolution. The chemical characteristics of groundwater play an important role in classifying and assessing water quality. Geochemical studies of groundwater provide a better understanding of possible changes in quality. Many naturally occurring major, minor and trace elements in drinking water can have a significant effect on human health either through deficiency or excessive intake (Frengstad, *et al*, 2001). Hence, the understanding of the processes that control the water quality is needed before one can speak or act intelligently towards the aim of water-quality control and improvement (Hem, 1991; SubbaRao, *et al*, 2006.). Adverse quality conditions increase the investment in irrigation and health, as well as decrease agricultural production (Aher and Deshpande, 2015). This in turn, reduces agrarian economy and retard improvement in the living conditions of rural people (Deshpande and Aher, 2011). Since groundwater is the

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primary source of water for domestic, agricultural and industrial uses in many countries and its contamination has been recognized as one of the most serious problems in India. Due to rapid growth of population, urbanization, industrialization and agriculture activities, ground water quality is depleted; it is also influenced by a contribution from the atmosphere and surface water bodies (Singh, *et al*, 2015). The objective of this study is to deciphering groundwater quality for domestic and agricultural purposes of in PTW-1 Watershed

Study area

The present study has been carried out in watershed PTW-1 included in part of the taluka Motala and Malkapur district Buldhana, Vidharba region, Maharashtra, India. Watershed area is lies in between 20^{0}43' and 21^{0}59'N Latitudes and 75^{0}56' and 76^{0}15'E Longitudes (Fig.1.) The climate of the area is characterized by a hot summer and general dryness throughout the year except during the south-west monsoon season, i.e., June to September. Summer temperatures soar to a maximum of 42.3°C whereas in winter, temperatures dip to around 13°C. The rainy season starts in June and lasts till the September. The area receives rainfall from southwest monsoon. The area falls in assured rain fall zone. This area receives an average annual rainfall of 675 mm. The annual rainfall is distributed in 40 rainy days during June to October. While since last 2 years deficit rainfall has occurred and the deficiency is from 0% to 35% to average annual rain fall. The area is containing hard rock terrain towards the southwest part while alluvium thickness is increasing towards the north. The area is divided into three structural cum physical units i.e. run off Zone (a), Recharge zone (b) and Storage zone(c). These zones indicate the area of recharge i.e. ground water potential. Total area of this watershed is 16293 hectare. Topographically southeast part is situated on high elevation i.e. 360m from mean sea level at village Sonbardi in taluka Motala while low elevation i.e. 260m is encountered at village Nimbhari of taluka – Malkapur nearer to Jalgaon district of Khandesh area (Kathane *et al*, 2015).

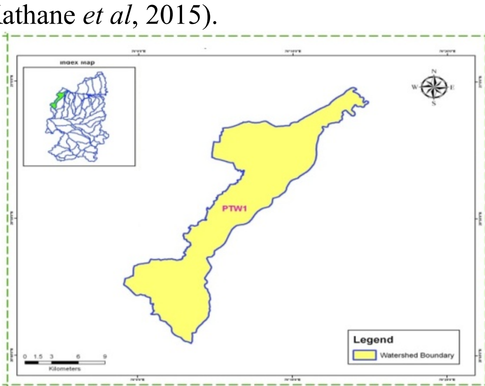


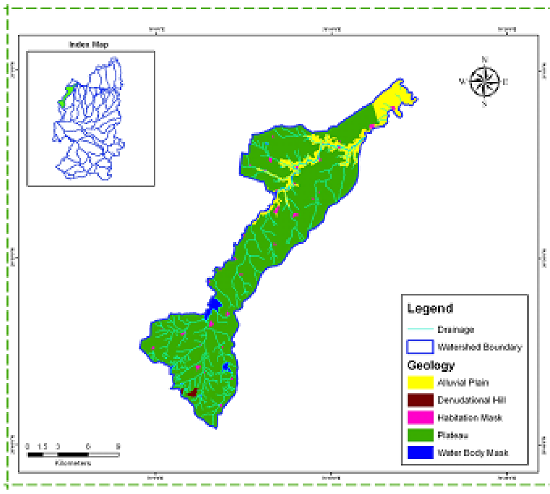
Figure 1: Location map of PTW-1 Watershed, dist. Buldhana

Drainage

The watershed PTW-1 is drained by the major river Wyaghra and its tributary. Wyaghra River is flowing from southwest to northeast direction. It is in mature stage. The main drainage is topographically controlled which exhibits meandering in various places like nearby the bridge on Malkapur– Devdabha road and due west corner of village Hingana Kazi. Various 2nd to 3rd order stream flowing from northwest to southeast direction. Most of it originates at high elevation part towards south east of studied area. Widths of the nallas are approx 10–15 m., while depth is around 2 – 3.5 m. All the drainages in the area are flowing along the principle slope direction. The drainage exhibits typical Deccan trap pattern i.e. dendritic drainage pattern. Width of river in study area is varies from 30 -35 m. and depth range is about 3.0 to 5.0 m. The width of Wyaghra river is increasing from South to North while its depth is decrease in same direction (Kathane *et al*, 2015). Depending on width and depth of river, the southern area in the village is more favour able to recharge rather than the northern area. Sand thickness in river bed is about 1.5 – 2.00 m in watershed PTW-1, Vyaghra is major drainage flowing from southwest to northeast, in some patches along the bank of Vyaghra river local alluvium formation is observed, total thickness of local alluvium varies from 2.5 m to 7.5m. this alluvium contain Sand, pebbles and sandy loam which is followed by tiny yellow colour clay or mud upghto the depth of 8 m to 12 m and its thickness is goes on increases towards north where Wyaghra meets the Purna river (Fig.2).

Geology and Hydrogeology

Deccan Trap lava flows and Purna Alluvium are the major water bearing formations of PTW-1 watershed (Fig.2) Major part of the area is covered by basaltic lava flows of upper Cretaceous to lower Eocene age. The Deccan lava sequence is grouped under Satpura group. Deccan Trap Basalt forms an important water bearing formation. The disposition of vesicular unit and massive unit of different lava flows has given rise to multi layered aquifer system. The water bearing capacity of Vesicular Basalt largely depends upon size and shape of vesicles, density of vesicles and the degree of inter connection of vesicles. Massive Basalt generally does not possess primary porosity. However, Massive Basalt, which is fractured, jointed and weathered posses' water bearing capacity (CGWB, 2007). The northern part of the area on either side of Purna River is underlain by thick alluvial deposits of Pleistocene to Recent age. In Alluvial deposits, inter pore spaces in sand and gravel renders them a high degree of porosity and permeability to make them a good ground water reservoir. However litho logical variation results in variable water yielding capacity depending upon the sand-clay ratio.



Figur.2. Map showing drainage and Geology of PTW-1 Watershed

MATERIALS AND METHOD

Twenty five groundwater samples representing dug wells and bore wells were collected in good quality polyethylene bottles of one-liter capacity. Prior to sampling all the sampling containers were washed and rinsed with the groundwater. The chemical characteristics were determined as per the standard methods for examination of water and wastewater (APHA, 2002). All results are compared with standard limit recommended by the Bureau of Indian Standards (BIS, 2003), and (WHO, 1993). Electrical conductivity (EC) and hydrogen ion concentration (pH) were measured using digital portable meters. Calcium, magnesium, bicarbonate and chloride were analyzed by volumetric titration methods, sodium and potassium were measured using the flame photometer, sulphate, and nitrate and fluoride were determined by spectrophotometric technique. The accuracy of the results was checked by calculating the ionic balance errors and it was generally within ±10%. Water quality secondary parameters name SAR, RSC, SSP; KR and PI were analyzed for IWQI. The statistical analysis of various quality parameters IWQI was classified into excellent to unfit condition of groundwater quality based on their Water Quality Index (WQI). Based on their severity of WQI the sub-basin further classified into good to pour good state of groundwater quality for sustainable development.

RESULTS AND DISCUSSION

Physic-chemical parameters of groundwater

The pH values of the groundwater vary from 7.10 to 8.20 with an average of 7.76, which indicates that, all other groundwater samples are alkaline in nature (Table1). The electrical conductivity (EC) in the study area varies from 435 to 3030 μS/cm with an average of 929.32 μS/cm at 25◦C (Table1). The Total Dissolved Solids (TDS) ranged from 283 to 1973 mg/L with an average of 604.8 mg/ in the study area (Table.1). Normally TDS in water may originate from natural sources and sewage discharges. The BIS specifies a desirable total dissolved solids limit of 500mg/L and a maximum permissible limit of 2,000 mg/L. In the study area none of the samples exceeding permissible limit prescribed by (BIS, 2003) (Table.2.). The total hardness (TH) of water is a measure of mainly calcium carbonate and magnesium carbonate dissolved in groundwater. The general acceptance level of hardness is 300 mg/L, although WHO has set an allowable limit of 600 mg/L. The total hardness in the study area ranges between 164 and 788 mg/L with mean 341.28 mg/L indicating all samples are within the prescribed limit. Calcium concentration ranged from 30 to 158 mg/L with an average of 80.76 mg/L. (Table.2) The desirable limit of Calcium (Ca^{2+}) for drinking water is specified by (BIS,2003) as 75 mg/L and a maximum permissible limit of 200 mg/L. It is observed that all the samples are within the maximum permissible limit. (Table.2). Calcium ion is necessary for proper mineralization of bones and bone strength. Deficiency in intake of calcium leads to eventual demineralization of bones for complementing the inadequate amounts of calcium in the body. Magnesium (Mg^{2+}) concentration varies from 19 mg/L to 104 mg/L with mean values of 33.4 mg/L (Table.1) content calcium and magnesium impart the hardness in water and is not good for drinking purposes. (Table.2) The principal sources of magnesium in the natural waters are various kinds of rocks and sewage. Sodium (Na^+) concentration in groundwater ranges from 14 to 99 mg/L with an average of 30.36 mg/L. According to (BIS,2003) and (WHO,1993) guidelines, the maximum admissible limit Na^+ content is 200 mg/L. Sodium regulates blood pressure levels in the human body and increased levels of sodium in blood leads to rise in blood pressure. Potassium (K^+) concentration in groundwater ranges from 0.4 to 2.5 mg/L with an average value of 0.76 mg/L.

Table1. Analytical data from the groundwater samples from the study area

Sample No.	Source	pH	EC (µS cm^{-1})	TDS (mg/L)	Na^+ (mg/L)	K^+ (mg/L)	Mg^{2+} (mg/L)	Ca^{2+} (mg/L)	Total Hardness (mg/L)	CO_3^- (mg/L)	HCO_3^- (mg/L)	SO_4^{2-} mg/L)	Cl^- (mg/L)	NO_3^- (mg/L)	F^- (mg/L)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	DW	7.9	561	365	19	0.5	27	45	224	0	112	37	84	21	0.2
2	DW	7.4	866	563	28	0.7	34	51	268	0	116	43	126	28	0.5
3	DW	7.7	988	642	33	0.8	41	54	308	0	136	51	142	34	0.3
4	DW	7.1	1077	700	37	0.9	36	70	324	0	112	66	144	43	0.2
5	DW	8.2	3036	1973	99	2.5	104	142	788	0	224	151	382	77	0.8
6	DW	7.9	1174	763	36	1	43	115	468	0	192	78	212	8	1.5
7	DW	7.7	1255	816	41	1	38	138	504	0	208	82	184	86	0.4
8	BW	7.9	736	478	22	0.6	26	75	296	0	168	50	102	15	0.2
9	BW	7.9	736	478	25	0.6	26	75	296	0	168	50	102	15	0.2
10	BW	8	540	351	17	0.4	19	67	248	0	84	83	60	50	0.2
11	BW	7.8	1423	925	45	1.2	41	158	568	0	208	96	248	72	0.1
12	DW	7.9	557	362	17	0.5	24	51	228	0	128	40	84	1	0.2
13	DW	7.5	1115	725	37	0.9	41	70	348	0	144	62	164	15	0.5
14	DW	7.4	435	283	14	0.4	21	30	164	0	52	22	74	14	0.3
15	BW	7.8	565	367	19	0.5	28	45	228	0	104	40	90	11	0.1
16	DW	7.9	852	554	27	0.7	21	101	340	0	176	56	126	18	0.4
17	DW	8	930	605	31	0.8	27	104	372	0	128	65	170	29	0.7
18	DW	8.1	700	455	22	0.6	32	61	284	0	124	45	118	14	0.3
19	BW	7.9	1020	663	35	0.8	36	104	412	0	144	70	168	80	0.2
20	DW	7.7	855	556	27	0.7	38	74	344	0	164	57	122	40	0.1
21	DW	7.8	575	374	21	0.5	20	53	216	0	112	30	62	60	0.3
22	BW	7.8	670	436	24	0.5	31	58	272	0	88	154	64	12	0.6
23	DW	7.8	565	367	18	0.5	25	51	232	0	100	58	64	45	0.4
24	BW	7.5	1225	796	41	1	20	150	460	0	168	101	172	70	0.4
25	BW	7.5	777	505	24	0.6	36	77	340	0	180	50	102	60	0.4
Minimum		7.1	435	283	14	0.4	19	30	164	0	52	22	60	1	0.1
Maximum		8.2	3036	1973	99	2.5	104	158	788	0	224	154	382	86	1.5
Mean		**7.764**	**929.32**	**604.08**	**30.36**	**0.768**	**33.4**	**80.76**	**341.28**	**0**	**141.6**	**65.48**	**134.64**	**36.72**	**0.38**

The European Economic Community (EEC, 1880) has prescribed the level of potassium at 10 mg/L in drinking water. As per EEC criteria, all samples are within the guideline level of 10 mg/L (Table1). Potassium controls body balance and maintains normal growth of the human body. Deficiency of potassium might lead to weakness of muscles and rise in blood pressure (Das and Nag, 2015). The Chloride (Cl^-) ion concentration varies between 60 to 382 mg/L with a mean value of 134.64 mg/L. Cl^- content in all samples were does not exceed maximum permissible limit (Table.2). The desirable limit of Chloride (Cl^-) for drinking water is specified by (BIS,2003) as 250 mg/L and a maximum permissible limit of 1000 mg/L. 96% samples are below the desirable limit and 4% samples exceeds desirable limit but within the maximum permissible limit (Table.2). The carbonate alkalinity (CO_3^-) is not found in the study area, whereas bicarbonate alkalinity (HCO_3^-) varies from 52 to 224 mg/L with an average value of 141.6 mg/L (Table 1).

Table 2: Assessment of groundwater quality for drinking purposes

Parameter	>DL %	>DL<MPL %	>MPL %
EC	96	0	4
TDS	44	56	0
Ca^{2+}	52	48	0
Mg^{2+}	48	48	4
HCO_3^-	88	12	0
TH	48	48	4
Cl^-	96	4	0
SO_4^{2-}	100	0	0
NO_3^-	76	0	24
F^-	**96**	**4**	**0**

DL- Desirable limit, MPL-Maximum permissible limit

The Sulphate (SO_4^{2-}) values of groundwater range from 22 to 154 mg/L with an average value of 65.48 mg/L. The highest desirable of sulphate is 300 mg/L, indicating that all samples are within the maximum permissible limit prescribed by (BIS, 2003) (Table1) (Table 2). The nitrate (NO_3^-) content in water samples of the study area varies from 1 to 86mg/L with an average value 36.72 mg/L (Table1), and 24% of samples crosses the maximum permissible limit prescribed by BIS (2003) and WHO (1993) (Table,2). The probably the cause for most of such occurrences, which can be assigned fairly definitely to drainage of water through soil containing domestic wastes, vegetable and animal matter. The fluoride content in the groundwater varies from 0.1 to 1.5 mg/L with an average value of 0.38 mg/L (Table 1). The desirable limit of Fluoride (F^-) for drinking water is specified by (BIS, 2003) as 1 mg/L and a maximum permissible limit of 1.5 mg/L. It is observed that all samples are within the maximum permissible limit Table2.

Water quality for irrigation purposes

To assess the overall agricultural water quality of the samples collected, water quality parameters have been considered; namely, Sodium Adsorption Ratio (SAR), Soluble Sodium Percentage (SSP), Permeability Index (PI), Residual Sodium Carbonate (RSC), Magnesium Adsorption Ratio and Kelly's Ratio. Table 3 represents evaluated values of these parameters for all 25 sampling locations. Table 4 shows classification of samples according to standards specified for different water quality parameters.

Sodium adsorption ratio (SAR)

Sodium adsorption ratio (SAR) is significant factor for determining the suitability of ground water for agriculture because it is a measure of alkali hazard to crops (Richard, 1954). SAR is calculated using the following formula where the concentration of all ions is in meq L^{-1}. Sodium adsorption ratio (SAR) = $Na^+/(\sqrt{Ca^{2+}+Mg^{2+}})/2)$ SAR classified into four categories as S_1 (SAR<10), S_2 (10-18), S_3 (18-26) and S_4 (>26), and in present study all the samples fall in excellent (S_1) category (Table 3and4), indicating that these groundwater sources are suitable for agricultural purpose.

Soluble sodium percentage (SSP)

Wilcox (1955) has proposed classification scheme for rating irrigation water for agricultural on the basis of soluble sodium percentage (SSP). The SSP was calculated by using following formula where the concentration of all ions is in meq L^{-1}. Soluble sodium percentage (SSP) = $Na^{++}K^+ / (Ca^{2+}+Mg^{2+}+ Na^++K^+)$ X100 in the present study SSP varies from 0.61 to 4.30 meq/L. The SSP < 60 represents safe water while it is unsafe if > 60. As per these criteria the groundwater is safe for agricultural use (Table 3 and 4).

Residual sodium carbonate (RSC)

The HCO_3^- and CO_3^- in the irrigation water tend to precipitate calcium and magnesium ions in the soil resulting in an increase in the proportion of the sodium ions. The Residual sodium carbonate (RSC) was calculated by using following formula where the concentration of all ions is in meq L^{-1}. Residual sodium carbonate (RSC) = $(CO_3^- + HCO_3^-) – (Ca^{2+} + Mg^{2+})$ Table 2 and 3 indicate that the calculated RSC dicating that in general groundwater is suitable for irrigation purposes.

Permeability index (PI)

The soil permeability is persuading by long term put into practice of groundwater for irrigation and supplementary reason. Calcium, magnesium bicarbonate and sodium, material of the groundwater are noteworthy donor which have an effect the soil permeability (Mohan *et al*, 2000;Aher, 2014). Permeability index is calculated by using the following formula: Permeability index (PI) = $(Na^+ + \sqrt{HCO_3}\text{-})$ x 100/ $Ca^{2+}+Mg^{2+}+ Na^+$ Where, all the values are in meq-1. The PI values >75 indicate excellent quality of water for irrigation. If the PI values fall in between 25 and 75, they indicate good quality of water for irrigation. However, if the PI values are <25, they reflect unsuitable nature of water for irrigation, indicating that all samples are suitable for irrigation.

Table 3: Water Quality Classification Based on Water Quality Index Value

Sample No.	SAR	RSC	KR	SSP	PI	MAR	CR	IWQI
1	0.55	-2.63	0.19	0.83	41.24	49.59	0.07	89.83
2	0.75	-3.44	0.23	1.22	39.61	52.22	0.10	90.69
3	0.82	-3.83	0.24	1.43	39.06	55.45	0.12	93.30
4	0.90	-4.61	0.25	1.61	36.77	45.74	0.12	80.78
5	1.54	-11.95	0.28	4.30	31.21	54.56	0.31	80.25
6	0.73	-6.13	0.17	1.57	30.81	38.00	0.17	65.32
7	0.80	-6.60	0.18	1.78	30.76	31.10	0.15	58.17
8	0.56	-3.13	0.16	0.96	38.26	36.24	0.08	73.13
9	0.63	-3.13	0.18	1.09	39.42	36.24	0.08	74.52
10	0.47	-3.53	0.15	0.74	33.87	31.74	0.06	63.50
11	0.82	-7.85	0.17	1.96	28.77	29.84	0.20	53.93
12	0.49	-2.42	0.16	0.74	41.62	43.55	0.07	84.22
13	0.87	-4.50	0.23	1.61	37.14	48.98	0.14	84.47
14	0.48	-2.37	0.19	0.61	40.00	53.44	0.06	92.41
15	0.55	-2.84	0.18	0.83	39.69	50.50	0.08	88.98
16	0.64	-3.89	0.17	1.17	36.15	25.42	0.10	59.78
17	0.70	-5.31	0.18	1.35	31.92	29.85	0.14	58.83
18	0.57	-3.64	0.17	0.96	35.93	46.24	0.10	80.32
19	0.75	-5.79	0.19	1.52	31.62	36.20	0.14	64.63
20	0.64	-4.13	0.17	1.17	35.22	45.71	0.10	78.88
21	0.62	-2.45	0.21	0.91	43.60	38.22	0.05	81.16
22	0.63	-4.00	0.19	1.04	34.61	46.70	0.07	79.26
23	0.52	-2.96	0.17	0.78	38.33	44.56	0.06	81.46
24	0.83	-6.39	0.20	1.78	31.52	17.94	0.14	46.02
25	0.57	-3.85	0.15	1.04	35.20	43.39	0.08	76.59
Minimum	0.47	-11.95	0.15	0.61	28.77	17.94	0.05	46.02
Maximum	1.54	-2.37	0.28	4.30	43.60	55.45	0.31	93.30
Mean	**0.70**	**-4.45**	**0.19**	**1.32**	**36.09**	**41.26**	**0.11**	**75.22**

Magnesium adsorption ratio (MAR)

Szobolces and Darab (1968), had given the equation to calculate Magnesium adsorption ratio (MAR) is as follows, Magnesium adsorption ratio (MAR) = Mg^{2+}X

100/ Ca^{2+}+Mg^{2+} MAR ratio of the groundwater varied from 17.94 to 55.45, with mean of 41.26 meq L-l.(Table-3). High MAR affects the soil unfavourably, a harmful effect on soils (Shirazi *et al*, 2011; Aher *et al*, 2015) appear when MAR exceeds 50. In the present study, most of the samples (80%) had MAR less than 50 which would cause no harm to soil and the rest were above 20 which might cause harm to soil.

Table 4: Classification of groundwater on the basis of SAR, SSP, KI and RSC.

Parameter	Range	Water Class	No. of Samples	Samples in (%)
SAR	<10	Excellent (S1)	25	100
	10-18	Good (S2)	-	-
	18-26	Doubtful (S3)	-	-
	>26	Unsuitable (S4)	-	-
RSC	<1.25	Good	25	100
	1.25-2.50	Doubtful	-	-
	>2.5	Unsuitable	-	-
SSP	<60	Good	25	100
	>60	Bad	-	-
KR	<1	Suitable	25	100
	>1	**Unsuitable**	-	-

Kelly's ratio (KR)

Kelly's ratio or Kelly's index was calculated by using the following expression Kelley index (KI) = $a^{+}/(Ca^{2+}+Mg^{2+})$ Where, concentrations are expressed in meq L-1. The Kelly's ratio or Kelly's index of unity or less than one is indicative of good quality of water for irrigation where as above one is suggestive of unsuitability for agricultural purpose due to alkali hazards (Karanth, 1987). Kelly's index the groundwater varied from 0.15 to 0.28, with mean of 0.19 meq L-l indicating that all samples are good for irrigation or agricultural use.

Corrosively ratio index (CRI)

The degree of the corrosiveness of groundwater know how to be assessed by using a perimeter known as corrosively ratio (CR) or corrositivity ratio Index (CRI), which can be determined by using the following formula.CR= $[(Cl/25.5+2SO_4)/\ 2(CO_2+(HCO_3/100\ )\ ]$ The water having the corrositivity ratio less than one is safe and non corrosive. Corrositivity ratio greater than two is suggestive of corrosiveness, and all samples are safe Table.3. In order to assess the irrigation groundwater quality in the study area, an attempt has been made to develop a model on Irrigation Water Quality Index (IWQI), (Anbazaghan, 2014; shashi *et al*, 2015). The assorted irrigation groundwater quality indices for instance SAR, SSP, RSC, PI, and KR are considered to assess the groundwater quality for irrigation. The indices value summed, then classified into excellent to unfit groundwater quality (Table,5) As per Irrigation Water Quality Index (IWQI) all samples falls in excellent to good quality of water and are sustainable for irrigation.

Table 5: Groundwater quality classification based on WQI Value

Groundwater Value Range	Groundwater quality	No.of Samples (IWQA)	Percentages (%)	Sustainable state
<50	Excellent	1	4	Sustainable
51-100	Good	24	96	Sustainable
101-200	Poor	Nil	Nil	Slightly unsustainable
201-300	Very poor	Nil	Nil	Unsustainable
>300	Very bad	Nil	Nil	Highly unsustainable

CONCLUSION

The groundwater quality of PTW-1 watershed has been assessed for its agricultural and domestic suitability purposes. The pH of water, both indicates that groundwater in the area is of alkaline nature. The electrical conductivity, total dissolved solids, calcium, magnesium, bicarbonate, chloride, sulphate, and fluoride of groundwater samples are all found to be within acceptable limits. The total hardness (4%) and nitrate (24%) of samples are exceeding maximum permissible limit indicating not suitability for their drinking uses. Due to this quality deterioration of some locations, an immediate attestation requires for sustainable development. Based on the water quality parameters analyzed like SAR, SSP, MAR, PI and KR, the groundwater samples are suitable for agricultural use. The results have shown that the groundwater of study area has been in excellent to good in IWQI. Overall quality of PTW-1 watershed is suitable for agricultural uses.

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