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Study of Groundwater Quality for Drinking Purpose in Anjana Sub Basin, Chhatrapati Sambhajinagar (Aurangabad), M.S., India

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Abstract:
This study based on groundwater quality assessment in Anjana sub river basin in Chatrapati Sambhajinagar (Aurangabad). Total 30 groundwater samples were collected from different dug well and borewells within the study area. All groundwater samples were analysed in laboratory for measured physicochemical parameters with standard methods. All the physicochemical parameters were correlates with BIS and WHO standard for drinking water. The result of this study 76.67% groundwater samples is revealed that the alkaline earth, 10% groundwater samples revealed that the alkaline earth exceed alkalis and remaining groundwater samples are exhibited in low concentration of non-carbonate hydro chemical facies in piper trilinear diagram. Hydro chemical facies of this study the maximum groundwater samples are suitable or use for the drinking purpose for the society.

Keywords: *Groundwater, pH, Piper trilinear diagram, Water quality, Anjana sub river basin***.**

INTRODUCTION

Groundwater is typically viewed as a reliable source of drinking water because it is less impacted by surface pollution. However, other factors can still contaminate it (Mondal et al., 2010, 2011; Rahman et al., 2021). The chemical concentration in groundwater and soils is influenced by various factors, including like composition of precipitation, human activities, the geological and anthropogenic activities (Kadam et al., 2023) or drinking well (Andre et al., 2005; Adewoya and Oludura, 2007). The hydrogeochemical processes in the groundwater system offer important insights into the effects of rock and soil-water interactions, as well as human activities, on groundwater quality. These geochemical processes significantly contribute to the spatial and temporal variations in groundwater chemistry (Matthess 1982; Kumar et al. 2006; Kadam et al., 2023). The quality of groundwater changes based on its location, the depth of the water table, and seasonal variations. This is largely influenced by the amount and type of dissolved solids it contains. In recent years, the impact of human activities on groundwater quality has become a significant concern so its need to analysed water quality (Kamble and Sirsat, 2024). Groundwater quality is shaped by subsurface geological processes, atmospheric precipitation, inland water bodies, and the quality of recharged water. Periodic changes in groundwater quality can occur due to hydrological, human-induced, and temporal factors affecting the source and composition of the replenished water. Besides impacting water quality, pollution poses risks to human health, economic development, and social well-being

(Deshpande et al., 2022). The water quality pollution is also harmful crop or agriculture purpose in rural area (Kamble et al., 2024). The quality of groundwater changes as it moves through the hydrological cycle, influenced by various processes including evaporation, transpiration, absorption by plants, oxidation/reduction, cation exchange, mineral dissociation, precipitation of secondary minerals, mixing of different water sources, leaching of fertilizers and manure, and pollution (Appelo and Postma, 1993; Samson and Elangovan, 2017).

This study aims to assess the physico chemical investigation of thirty groundwater samples in Anjana sub river basin area of Kannad taluka of Chhatrapati Sambhajinagar (Aurangabad), Maharashtra, India.

STUDY AREA

The Anjana sub-basin is part of the Purna basin, located in the Aurangabad district, with latitudes ranging from 20°13′9′′ N to 20°20′34′′ N and longitudes from 75°10′00′′ E to 75°33′88′′ E (Fig. 1), covering an area of approximately 350.5 km². It occupies a strategic position on the Deccan Plateau. The region experiences a hot summer and remains generally dry throughout the year, except during the southwest monsoon season, which lasts from June to September, with October and November marking the post-monsoon season. Temperatures range from 24 to 40°C during the hottest months (April/May) and from 13 to 28°C during the winter months (December/January). The average annual rainfall is about 660 mm.

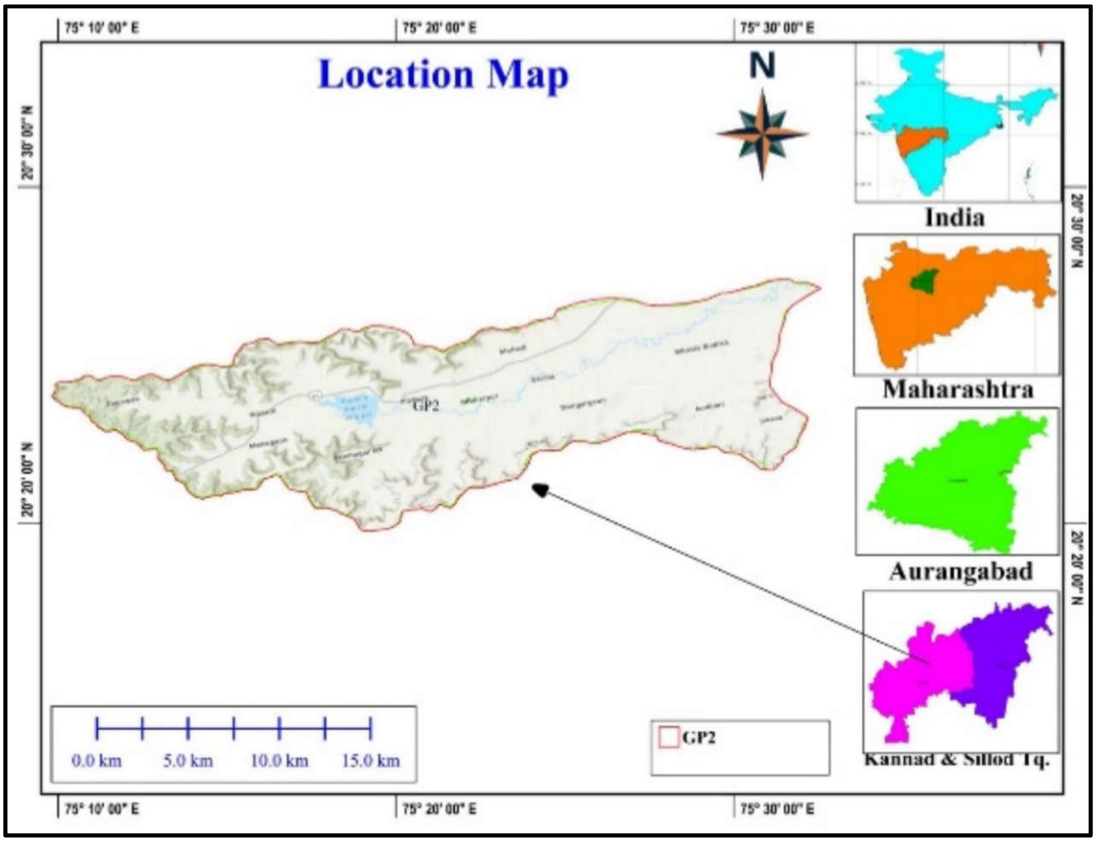

Figure 1: Location map of the study area

Geologically, the Deccan Volcanic Province (DVP) consists of basaltic flows dating from the Up. Cretaceous to L. Eocene period and is a distinct geological formation in Peninsular India. The DVP is renowned for its pronounced horizontal layers, distinctive flat-topped hills, and step-like terraces. The study area primarily comprises basaltic rocks, which appear as horizontal flows that vary in thickness and can extend over considerable distances. A typical spheroidal weathering pattern is prevalent throughout the DVP. On the gentle slopes of the hills, these rocks are often covered by residual and/or colluvial soils, while alluvial deposits are found along the banks of streams. The exposed rock types in the area showcase a variety of basalts, including Compact basalt, vesicular basalt, amygdaloidal basalt, and combinations of vesicular amygdaloidal basalt.

MATERIALS AND METHODS

To evaluate the physicochemical parameters, a total of 30 groundwater samples were collected from various dug wells and bore wells using one-liter polyethylene bottles of high quality. Before sampling, all containers were thoroughly washed and rinsed with groundwater. The physical parameters, including pH and electrical conductivity, were measured on-site during sample collection. The chemical characteristics were analyzed promptly in the laboratory following standard methods for the examination of water and wastewater (APHA, 2002) and Trivedi and Geol.

All results were compared against the standard limits given in Table 1 recommended by the Bureau of Indian Standards (BIS, 2012) and the World Health Organization (WHO, 2011).

Table 1 Drinking water standards for physical chemical parameter

Physical and chemical parameter	Unit	WHO international standards, 2011		Bureau of Indian Standards, Ref.IS 10500:2012	
		Acceptable Desirable limit	Maximum Permissible Limit	Acceptable Desirable limit	Maximum Permissible Limit
pH	---	6.5-8.5	8.5-9.2	6.5-8.5	No Relaxation
EC		750		750	
Total Dissolved Solids	mg/l	500	1500	500	2000
Calcium (Ca^{++})	mg/l	75	200	75	200
Total Hardness (CaCO3)	mg/l	100	500	200	600
Magnesium (Mg)	mg/l	30	150	30	100
Chloride (Cl^{-})	mg/l	200	600	250	1000
Total Alkalinity (HCO_3)	mg/l	200	600	200	600
Sodium (Na)	mg/l	-	-	200	200
Potassium (K)	mg/l	No relaxation	No relaxation	No relaxation	No relaxation
Sulphate (So_4)	mg/l	200	400	200	400

The EC and pH were measured in the field by portable EC and pH meters. In the laboratory, the water samples were analyzed for major ion chemistry using the methods recommended by APHA (2002). Total dissolved solids were estimated by ionic calculation method. Total alkalinity (TA); Carbonate (CO3) and Bicarbonate (HCO3) were estimated by titrating with 0.1N HCL. Total hardness (TH) and Calcium (Ca) were determined by titration method. Na and K+ were measured by flame photometer, Cl- was estimated by standard AgNO3 titration and SO4 was determined by UV visible spectrophotometer. Results of chemical analysis and comparison of physical parameters along with standards are represented in Table 1. While some samples exceeded the desirable limits, they remained within the maximum permissible limits.

RESULTS AND DISCUSSIONS

pH: The pH values for the groundwater sample within the study area vary between 7.05 to 7.71 with 7. 39 average values (Table 2). These values are indicating that the all the groundwater samples are below permissible limit as per BIS & WHO standard.

Electrical Conductivity (EC): EC values vary between 630 to 5850 µmhos/cm with an average value 1588.97 µmhos/cm (Table 2). According to WHO and BIS standards, the maximum allowable EC for drinking water is 1500 µmhos/cm. A sample No 5,12,13,15,16,18,20,27 are exceeding the permissible limits and except theses sample no other sample are observed the values below the permissible limits as per WHO & BIS standard (Table 1). As per BIS and WHO standard 8 samples (26.67%) are exciding the permissible limit out of 30 sample within the study area.

Total Dissolved Solids (TDS): The groundwater samples value of TDS for study area is varies from 403 to 3744 mg/l with an average value 1016.94 mg/l (Table 2). A per BIS and WHO standard acceptable limit 500 mg/l and 2000 mg/l for groundwater quality parameters. TDS values for samples no 13 and 21 exceed the permissible limits and other sample are below the permissible limit.

Calcium (Ca): The Ca++ values are observed between the 48.10 to 464.93 mg/l with an average value 120.186 mg/l. The acceptable and permissible limit for Ca++ is 75 mg/l and 200 mg/l respectively for BIS and WHO standard. Sample no 6,15,16,22 show value below the acceptable limits and sample no 3 and 9 revealed the high values than the permissible limits as per BIS and WHO standard.

Total Hardness ($CaCo_3$): 2, 10, 14 these three samples are also exciding the permissible limits as per BIS standard. It is observed that 10 samples (66.66%) are exceeding the permissible limit.

Table 2: Drinking water standards for physical chemical parameter

Sr. No.	Latitude	Longitude	Ph	EC	TDS	Ca	Ca CO_3	Mg	Cl	HCO_3	Na	K	SO_4
01	20°17'59"N	75°19'15"E	7.30	990	633.60	124.25	428	50.00	198.80	520	24	0	61.66
02	20°18'03"N	75°19'16"E	7.40	850	544.00	168.34	840	52.33	355.00	345	94	4	33.38
03	20°18'24"N	75°17'32"E	7.30	1090	697.60	336.67	290	187.05	211.58	695	43	1	31.17
04	20°19'06"N	75°12'13"E	7.12	1500	960.00	90.58	270	38.95	42.60	230	39	7	32.55
05	20°18'55"N	75°14'18"E	7.26	2520	1612.80	87.37	390	29.89	99.40	510	70	1	45.38
06	20°18'55"N	75°14'18"E	7.57	650	416.00	63.33	500	8.78	55.38	325	89	1	60.69
07	20°16'49"N	75°14'27"E	7.57	850	544.00	129.86	416	54.12	163.30	335	92	2	58.34
08	20°17'42"N	75°14'14"E	7.46	1410	902.40	121.84	510	43.68	117.86	335	52	1	39.72
09	20°16'55"N	75°14'39"E	7.37	1140	729.60	464.93	570	248.26	49.70	450	96	3	38.48
10	20°17'42"N	75°15'45"E	7.39	1200	768.00	104.21	830	14.02	49.70	215	90	2	42.76
11	20°18'07"N	75°15'47"E	7.50	1020	652.80	90.58	398	31.36	120.70	505	59	2	41.93
12	20°07'09"N	75°22'23"E	7.61	1950	1248.00	112.22	510	37.85	49.70	295	61	1	28.28
13	20°17'17"N	75°22'22"E	7.69	5850	3744.00	128.26	570	44.02	49.70	285	68	4	59.17
14	20°17'58"N	75°22'30"E	7.54	740	473.60	104.21	830	14.02	72.42	200	52	4	15.86
15	20°16'57"N	75°19'47"E	7.37	1650	1056.00	58.52	398	11.91	49.70	255	95	1	19.45
16	20°18'03"N	75°38'56"E	7.21	1710	1094.40	63.33	510	8.18	35.50	350	139	1	42.34
17	20°15'54"N	75°18'36"E	7.38	1380	883.20	78.56	510	17.42	59.64	215	37	1	36.28
18	20°15'33"N	75°18'14"E	7.48	3090	1977.60	76.15	480	17.74	63.90	195	34	7	51.31

19	20°18'53"N	75°23'25"E	7.24	1160	742.40	108.22	323	46.50	106.50	245	38	2	24.28
20	20°18'53"N	75°23'25"E	7.37	1560	998.40	48.10	750	-15.28	62.48	250	47	0	40.69
21	20°18'05"N	75°23'28"E	7.38	3150	2016.00	104.21	500	33.58	187.44	265	112	1	34.76
22	20°16'58"N	75°23'29"E	7.05	1450	928.00	72.14	388	20.77	59.64	275	33	2	23.72
23	20°17'01"N	75°23'34"E	7.29	980	627.20	138.68	500	54.49	21.30	360	31	0	38.48
24	20°'17'27"N	75°22'19"E	7.49	1680	1075.20	81.76	380	27.08	99.40	280	60.	1	80.97
25	20°16'18"N	72°22'27"E	7.47	1410	902.40	118.64	330	52.41	120.70	400	148	15	18.62
26	20°14'47"N	75°22'34"E	7.18	630	403.20	97.80	470	31.47	61.06	250	53	17	60.28
27	20°14'01"N	75°22'20"E	7.35	1820	1164.80	112.22	460	40.81	42.60	260	60	1	46.76
28	20°14'01"N	75°22'20"E	7.36	1170	748.80	100.20	500	31.15	51.12	380	51	2	42.34
29	20°'17'42"N	75°25'16"E	7.71	1480	947.20	100.20	330	41.22	38.34	350	117	1	44.83
30	20°17'38"N	75°25'04"E	7.30	1080	691.20	76.15	460	18.93	120.70	215	85.	0	78.62
Min	-	-	7.05	630	403.2	48.1	270	8.18	21.3	195	24	0	15.86
Max	-	-	7.71	5850	3744	464.93	840	248.26	355	695	148	17	80.97
Avg	-	-	7.39	1588.97	1016.94	120.19	489	44.98	92.94	330.17	68.41	2.93	41.19

Magnesium (Mg): The Mg^{++} values vary from 8.18 to 248.26 mg/l with an average value 44.9772mg/l (Table 2), sample number 3 and 9 excide the permissible limit and sample number 5,6,10,11,14,15,16,17,18,20,22,24 and 30 are below the acceptable limit. It is observed that most of the sample are below the permissible limits as per BIS and WHO standard (Table 1). It is observed that only two sample are exciding the permissible limit and 96.66 % sample are below the permissible limits.

Chloride (Cl): The Cl^- values vary from 21.30 mg/l to 355 with an average value 92.9366 mg/l. Sample no 2 is revealed that the value exciding the permissible limit. It is observed that only one sample (3.33%) is exciding the permissible limit and all the samples (96.67%) are observed the value below the permissible limit as per BIS & WHO standard.

Total Alkalinity (HCO_3): The alkalinity standard for drinking water according to BIS and WHO acceptable and permissible limits are 200 mg/l and 600 mg/l respectively (Table 1). Sample no 3 revealed that the value above the permissible limits i.e., 695 mg/l and sample no 18 revealed the HCO_3 value below the acceptable limits i.e., 195 mg/l (Table 2). The average value of 330.172 mg/l for groundwater samples are observed in between acceptable and permissible limits as per BIS 2012 and WHO 2011 standard. Alkalinity measures the water's capacity to neutralize strong acids. It is primarily due to the presence of carbonate, silicate salts, and free hydroxyl ions.

Sodium (Na) and Potassium (K): Sodium concentrations ranged varies from 24 to 139 mg/l with a 68.41 mg/l average value, while potassium (K+) concentrations ranged varies from 0 to 17 mg/l, with average values of 2.93 mg/l and (Table 2). Sodium and potassium are found in various minerals, and the rising pollution of groundwater has led to a significant increase in sodium levels in drinking water. As per BIS and WHO standard all the sample are below the permissible limits for sodium and potassium water quality parameters.

Sulphate (SO_4): Sulphate content in groundwater results from processes such as oxidation, precipitation, dissolution, and concentration as water moves through rocks. The sulphate (SO_4) observed values varies between 15.86 mg/l to 80.97 mg/l with an average value 41.19 mg/l (Table 2). All the groundwater sample within study area is observed below the permissible limits as per standard for drinking water by WHO 2011 and BIS 2012.

Piper trilinear diagram for classification of groundwater

To understand the relationship between water and chemical elements dissolved ions, the concept of hydrogeochemical facies for the study area is analyzed using the Piper trilinear diagram (Piper, 1944, 1953). The water type is influenced by the lithological characteristics of the aquifer, the retention time, and the flow pattern of the groundwater (Baghvand et al., 2010). Chadha's plot is frequently used by researchers to interpret major ion data in groundwater (Herojeet et al., 2013; Kumar et al., 2009; Singh et al., 2011; Thakur et al., 2016; Thilagavati et al., 2012). The system can also be influenced by chemical processes, including cation exchange, the adsorption of dissolved ions, and biological factors (Shekhar and Sarkar, 2013). Groundwater classifications are employed to understand variations in groundwater bodies based on their chemical properties and compositions (Mahlnecht et al., 2004). The hydrochemical properties of groundwater vary based on lithology, regional water flow patterns, and residence time (Domenico, 1972). Chemically, all waters can be classified into three main categories: chloride, sulphate, and bicarbonate types (Chebotarev, 1955; Islam et al., 2017).

The Piper diagram shows that groundwater samples belong majority to Ca-Mg -HCO3- and remaining three ground water samples falls in mixed Ca-mg type. Piper trilinear diagram show 76.67 % (23 groundwater samples) are observed in alkaline (Ca + Mg) in nature out 30 groundwater samples. 10% (3 groundwater samples) are observed in Na + K) i.e. alkalis in nature (Fig. 2). Bicarbonate in groundwater is observed in very low quantity and lower concentration of calcium and bicarbonate (HCO3-) in groundwater indices like recharge, mixing weathering and leaching from sewage sources is not mixing in groundwater sample within study area. Maximum water sample within study area is alkaline earths class, it suggests that the strong acids are more prevalent than the weak acid and non-carbonate group.

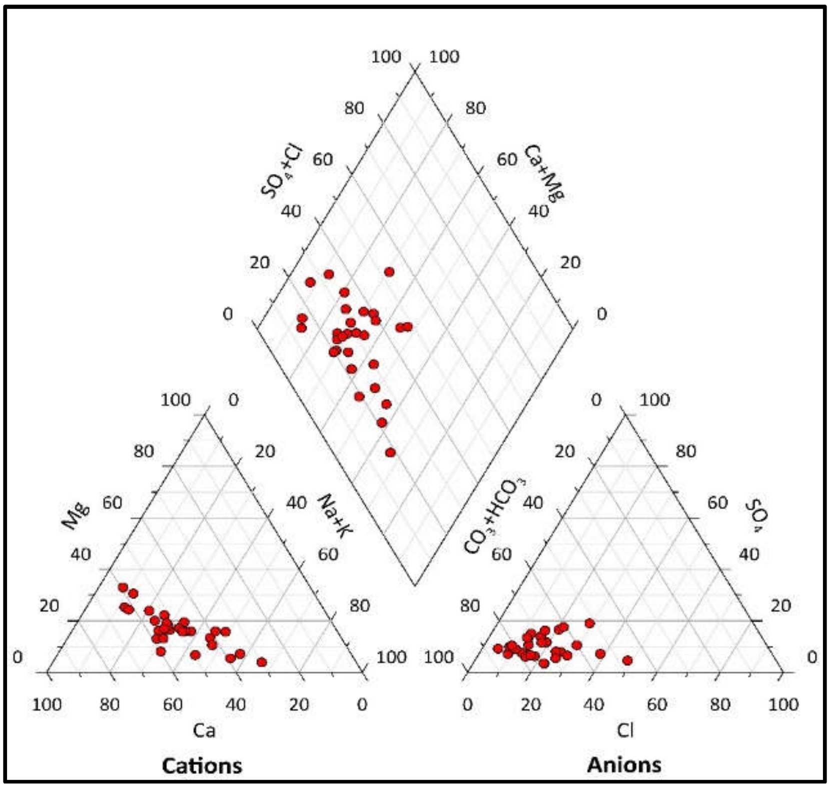

Figure 2: Piper trilinear diagram for pre-monsoon-2022.

CONCLUSIONS

This study is based on water quality analysis of 30 groundwater samples from Anjana river sub basin in Kannad, Chhatrapati Sambhajinagar, Maharashtra, India. The hydro chemical parameters like Ph, EC, TDS, Ca, $CaCO_3$, Mg, Cl, HCO_3, Na, K and SO4 were analyzed in laboratory and correlates their results with WHO 2011 and BIS 2012. The physio chemical analysis of 30 groundwater samples revealed that 76.67 % (23 groundwater samples) of Ca+Mg (alkaline earth) hydrogeochemical facies in pre monsoon season. 10% of groundwater samples are revealed that the Na + K (alkaline earth exceeds alkalis) and remaining groundwater samples are exhibited in low concentration of non-carbonate class. Hadrochemical facies of this study is under the weak acid exceed strong acid). Based on these hadrochemical facies and groundwater quality analysis data maximum water sample is suitable or use for the drinking purposes.

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CONFLICT OF INTERESTS

No conflict of interests among all the authors.

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