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Research paper

Assessment of groundwater quality by using statistical analysis from kopargaon taluka, Ahmednagar, India

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Abstract

The study was conducted to evaluate the groundwater quality along the Kopargaon taluka. Thirty six ground water samples were collected from different sources in pre monsoon and post monsoon season, during the year 2013. The descriptive statistical analysis was carried out besides Pearson correlation. Correlation analysis revealed that very strong correlation exists between HCO_3 and Na (0.961), HCO_3 and Mg^{++} (0.935), HCO_3 and EC (0.927). Where highly negative correlation is observed between Na and pH (-0.537) during pre-monsoon season. During post monsoon season highly positive correlation is observed between Cl^- and Ca^{++} (0.973), Ca and EC (0.967), Cl^- and EC (0.966), SO_4 and EC (0.948). Where, highly negative correlation is observed between Ca and pH (-0.533).

Keywords: *Groundwater; Physico-Chemical Parameter; Statistical Analysis; Correlation Analysis.*

1. Introduction

Groundwater is considered as the major source of usable water, so that quality of water is the main key factor in management of groundwater in a sustainable manner. In the past few decades, reports of groundwater contamination have increased public concern; reports of ground water contamination have increased public concern about ground water quality (Kant et al 2015). In agro based industries, sugar cane industry plays important role in India. This sugar cane industry plays vital role in foreign exchange and helps Indian economy. The wastewater of these industries pollutes the water which becomes the threat for the environment and also affects the soil. In spite of the fact that sugar industry is the backbone of the rural economy of Maharashtra state the need has arisen to review and recognize environmental problem associated with it. , the sugar factory is a rural industry and continued operation of this industry, without environmental precautions, may lead to serious health problems in the area. In the Ahmednagar district alone, there are 13 such sugar factories with several types of allied units associated with them. Moreover, in majority of villages there is no organized water-supply facility. Instead, the rural population is dependent on traditional sources of water supply. Disposal of industrial waste is the major cause of soil & water pollution. Correlation coefficient is used to measure the strength of association between two continuous variables. This tells if the relation between the variables is positive or negative that is one increase with the increase of the other. Thus, the correlation measures the observed co-variation. The most commonly used measure of correlation is Pearson‘s correlation (r). It is also called the linear correlation coefficient because r measures the linear association between two variables (Khwaja and Agrawal, 2014).Description of the study area

The study area is situated in Ahmednagar district. Ahmednagar district lies between 18°02’ and 19°09’ North latitudes and 73°09’ and 75°05’ East longitudes. The district is bounded on the north by the districts of Nasik and Aurangabad, on the east by Beed & Osmanabad, on the south by Solapur and on the west by Thane and Pune Districts. Ahmednagar district covers an area of about 17, 0448 sq.km.Area wise largest district in the state covering 5.55 % area of the total area of Maharashtra state. The location map of study area is shown in figure 1.

2.1. Hydrogeology

The major part of the district is underlain by the basaltic lava flows, which were formed by the intermittent fissure type eruptions during of upper Cretaceous to lower Eocene age. The Deccan Trap has succession of 19 major flows in the elevation range of 420 to 730 m above mean sea level. These flows are characterized by the prominent units of vesicular and massive Basalt. The Alluvium of Recent age also occurs as narrow stretch along the course of major rivers deposited over the Traps. A map depicting the hydrogeological features is shown in figure 3.

2.2. Geomorphology and soil types

Physiographically the district forms part of Deccan Plateau. Part of Sahayadri hill ranges fall in the district. Western Ghat section in Akole taluka is hilly which extends to relatively flat areas in Shevgaon and Jamkhed talukas in the east. From the main Sahayadri range three spurs namely Kalsubai, Baleshwar and Hari shchandragad stretch eastwards. Physiographically the district can be broadly divided in four major characteristic landforms viz., hill and ghat section (7.6% area); foothill zone (19.4% area); plateau (3.71% area) and plains (occupy 69.30% area). The district lies partly in Godavari basin and partly in Bhīma basin. The northern part of the district is drained by Godavari River and its tributaries viz., Pravara, Mula, Adula and Mahalungi whereas the southern part is drained by Bhima River and its tributaries viz., Ghod and Sina. All the rivers have sub-parallel to semi-dendritic drainage pattern and the drainage density is quite high. Based on geomorphological setting and drainage pattern, the district is divided into 80 watershed

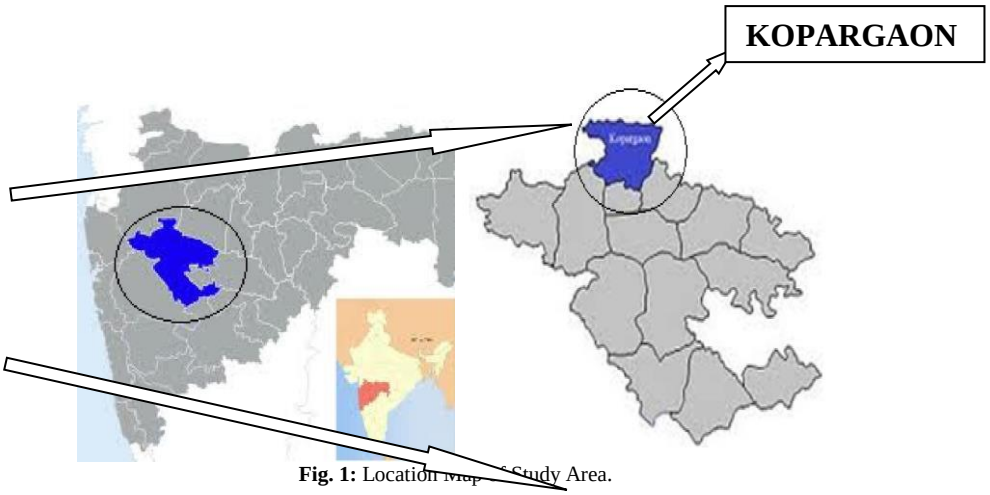

Fig. 1: Location Map of Study Area.

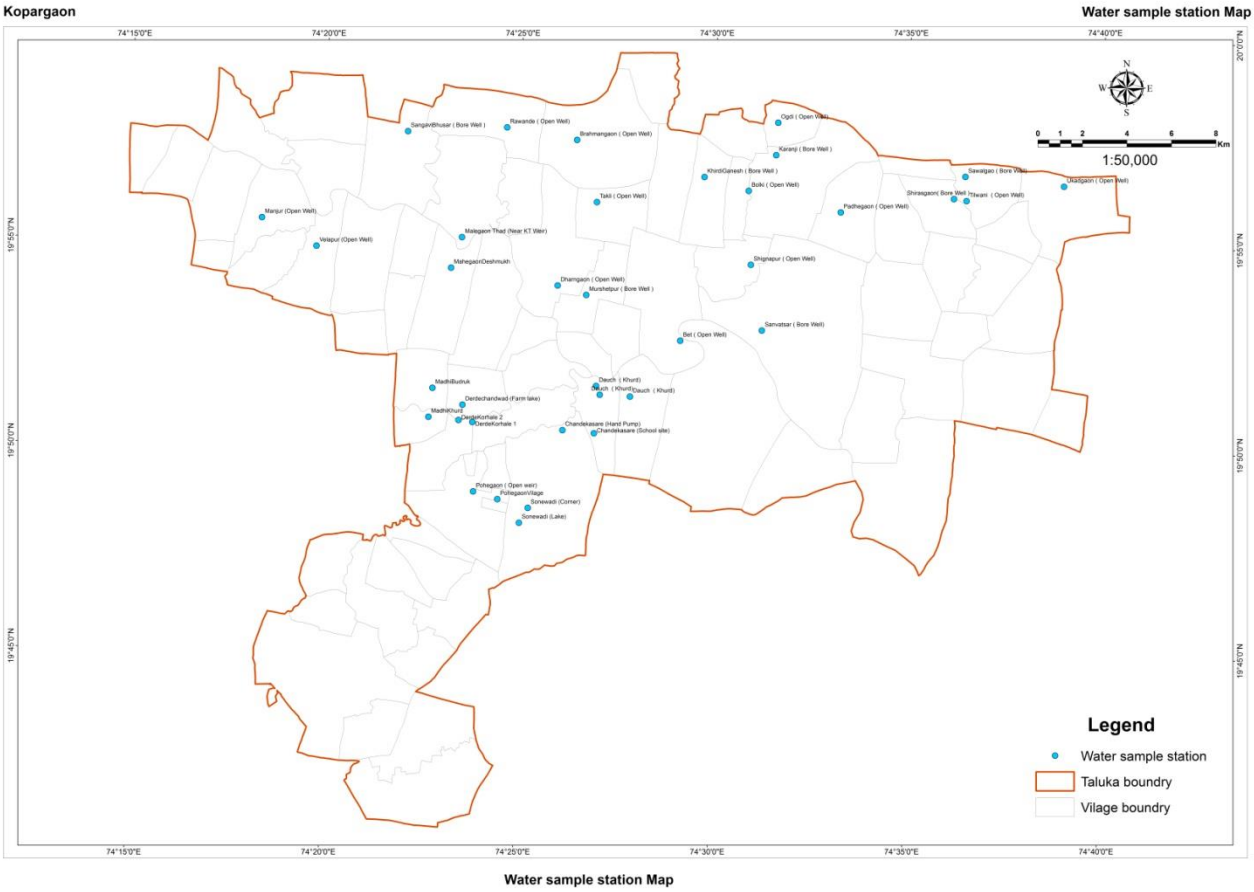

Fig. 2: Over View of Sampling Locations.

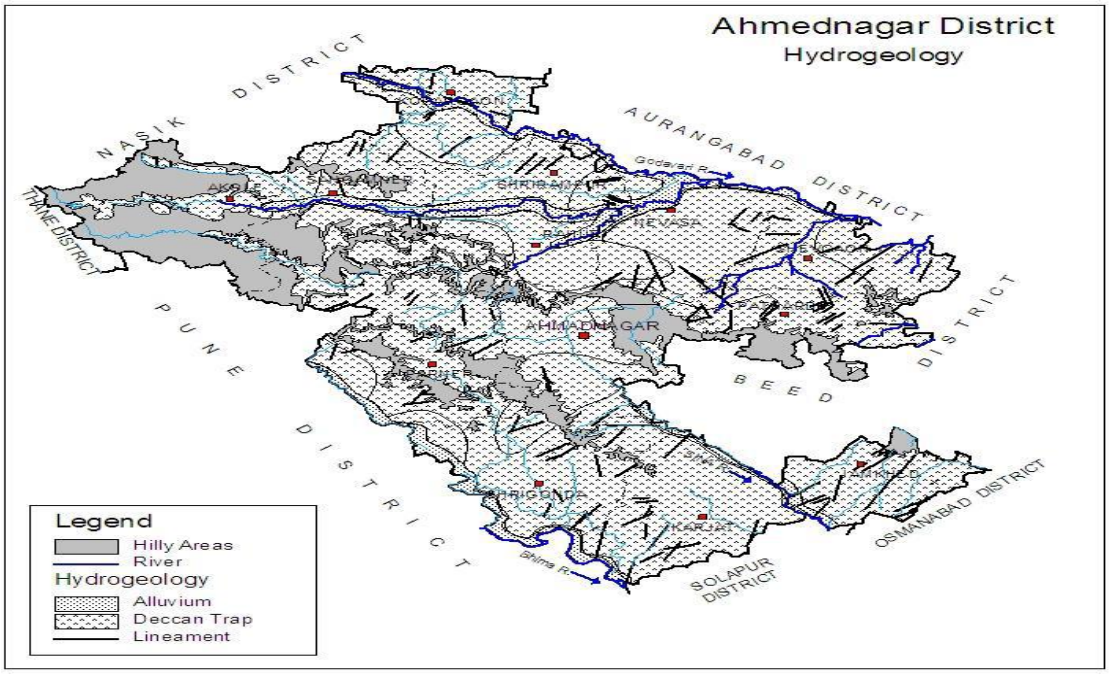

Fig. 3: Hydrogeological Map of the Study Area (CGWB 2014).

2. Materials and methodology

Ground water was sampled from 36 different stations during the pre-monsoon and post monsoon seasons in the year 2013. These collected samples were analyzed for water quality parameters viz. pH, Electrical conductivity (EC), Calcium, Magnesium, Sodium, Potassium, Ferrous, Manganese, Copper, Zink, Nickel, Chloride, Sulphate etc. All the tests were conducted in accordance with the techniques described by American Public Health (APHA 2005).Various statistical analysis of the experimental data were performed using Microsoft Excel 2010. The results of physico-chemical parameters as determined in samples collected from Kopargaon Taluka. The results of analysis obtained are summarized in Table 3. Normal statistic of water quality parameters of groundwater samples (pre-monsoon season) are summarized in Table 4.

Table 2: Instrumental Methods for Measurement of Different Water Quality Parameters

Parameter	Equipment
pH	Digital pH meter
Electrical conductivity	Electrical conductivity meter
Total hardness	Titrimetric method (EDTA)
Calcium	Flame- photometric method
Magnesium	Flame- photometric method
Chloride	color indicator titrimetric method
Sodium	Flame- photometric method
Potassium	Flame- photometric method
Sulphate	Digital Spectrophotometer

3. Result and discussion

3.1. Physico-chemical analysis of ground water quality parameters during pre-monsoon season

Ground water samples were collected from Kopargaon area. These samples were collected during summer season .The results of analysis are tabulated below in Table 3

In Pre- monsoon: Table 5shows highly positive correlation is observed between HCO_3 and Na (0.961), HCO_3 and Mg^{++} (0.935), HCO_3 and EC (0.927). Where highly negative correlation is observed between Na and pH (-0.538). Very poor positive correlation was observed between Fe and pH (-0.0008). While, there is almost no correlation was observed between Ni and Ca (0.004).

3.2. Physico-chemical analysis of ground water quality parameters during post-monsoon season

Ground water samples were collected from Kopargaon area. These samples were collected during post-monsoon season .The results of analysis are tabulated below.

Table 3: Physico-Chemical Analysis of Ground Water Quality Parameters during Pre-Monsoon Season

Parameter	pH	EC	Ca	Mg	Na	K	HCO3	Cl	SO4	Fe	Mn	Cu	Zn	Ni
S1	7.2	6.36	0.9	20.8	27.8	10.5	30.2	28	2.1	0.337	0.035	0.07	0.127	0.008
S2	7.4	4.28	0.8	11.2	24.9	6.7	24.5	17	2	0.327	0.018	0.064	0.123	0.004
S3	7.3	6.6	0.7	21.8	36.5	11.6	38.9	20.7	3.1	0.6	0.061	0.073	0.12	0.009
S4	7.2	4.33	0.8	10.1	25.6	7.8	24.2	17.7	0.9	0.515	0.172	0.065	0.104	0.003
S5	7.2	4.3	0.82	9.2	26	6.9	24.1	16.8	0.92	0.419	0.132	0.065	0.119	0.006
S6	7.7	1.68	0.6	4	10.8	1.2	9.5	6.2	0.1	0.366	0.022	0.058	0.135	Trace
S7	7.5	0.34	0.12	1.1	2.1	0.8	1.8	1.2	0.02	0.519	0.024	0.058	0.178	Trace
S8	7.8	0.97	0.3	2.5	6.8	1.2	4.1	3.6	0.09	0.82	0.034	0.065	0.071	Trace
S9	7.5	8.19	0.92	20.8	40.5	20.1	45.2	30.8	2.6	0.73	0.029	0.077	0.061	0.028
S10	7.7	3.99	0.65	15.8	18.2	5.5	26.5	10.8	2.5	0.351	0.228	0.065	0.043	0.007
S11	7.5	2.34	0.4	10.2	12	2.1	12.8	10.5	0.21	0.627	0.067	0.069	0.069	0.005
S12	8.1	6.06	0.7	16.8	20.3	18.7	28.2	21.9	3.7	0.826	0.045	0.07	0.111	0.018
S13	7.8	8.6	0.92	28.9	30.7		43.5	36.9	2.8	0.832	0.05	0.07	0.1	0.032
S14	7.7	2	0.2	4.8	10.7	21.5	9	11.2	0.09	425	0.03	0.067	0.207	0.01
S15	7.6	1.41	0.18	6.2	7.2	3.8	10.2	3.9	0.1	0.157	0.012	0.061	0.082	Trace

S16	7.5	5.5	0.7	18.5	31.2	1.1	27.8	26	0.4	0.173	0.013	0.077	0.074	0.014
S17	7.6	1.5	0.14	6	8.2	6.9	8.5	7	0.08	0.114	0.009	0.054	0.073	Trace
S18	7.4	5.04	0.7	24.8	22.5	1.8	30.1	18.9	0.1	0.212	0.008	0.069	0.059	0.011
S19	7.5	8.2	0.94	30.1	42.1	5.1	48.5	30.1	3	0.18	0.035	0.081	0.086	0.032
S20	7.4	1.94	0.18	4.74	11.9	7.8	11.2	7.9	0.08	0.127	0.006	0.061	0.068	Trace
S21	7.9	4.12	0.32	11.9	20.1	3.2	18.7	16	0.73	0.235	0.009	0.06	0.073	0.016
S22	8.2	1.3	0.4	5.7	8.6	8	6.5	5.2	1.1	0.111	0.004	0.064	0.19	Trace
S23	7.7	1.95	0.5	5.9	10.5	1.1	11.1	8	0.7	0.132	0.005	0.06	0.98	Trace
S24	7.8	1.95	0.52	6	10.4	3.1	11.3	7.8	0.72	0.162	0.006	0.069	0.078	Trace
S25	8.1	2.5	0.62	7.8	11.9	4.1	11.8	14	1.2	0.179	0.001	0.063	0.088	0.012
S26	7.8	3.39	0.7	12.9	13.4	6.2	20.1	11.2	1.4	0.118	0.005	0.073	0.062	0.011
S27	7.7	3.39	0.8	18.7	20.5	8.9	24.5	20.9	0.9	0.123	0.002	0.07	0.113	0.02
S28	8.1	4.81	0.3	4.2	6.8	1.1	3	7.1	1	0.151	0.009	0.067	0.049	Trace
S29	7.9	1.23	0.4	7	12.1	2.5	10.1	12.5	0.08	0.111	0.001	0.066	0.033	0.08
S30	8	2.23	0.25	6.8	3.4	0.9	5.2	5	0.1	0.098	0.001	0.062	0.078	Trace
S31	8	1.41	0.24	6.7	5.7	1.2	5.9	6.2	1.2	0.058	0.001	0.067	0.118	Trace
S32	8	1.11	0.24	5	4.5	1	5	4.9	1.1	0.1	0.008	0.06	0.087	Trace
S33	8.6	1.78	0.5	4.9	5.8	1.4	5.2	11.1	1.4	0.105	0.005	0.061	0.109	Trace
S34	7.4	3.86	0.7	14.9	17.8	5.9	18.8	16.9	0.9	0.082	0.01	0.063	0.107	0.02
S35	7.7	1.5	0.22	6.2	7.9	1.1	3.8	9	1.2	0.035	0.002	0.057	0.083	Trace
S36	7.7	4.07	0.72	14.9	20.5	6.2	18.5	15.1	2.7	0.069	0.007	0.066	0.066	0.24

Note: All units are in mg/l except pH & EC

Table 4: Normal Statistic of Water Quality Parameters of Groundwater Samples (Pre-Monsoon Season)

Parameter	pH	EC	Ca	Mg	Na	K	HCO3	Cl	SO_4	Fe	Mn	Cu	Zn	Ni
MIN	7.2	0.34	0.12	1.1	2.1	0.8	1.8	1.2	0.02	0.035	0.001	0.054	0.033	0.003
MAX	8.6	8.6	0.94	30.1	42.1	21.5	48.5	36.9	3.7	425	0.228	0.081	0.98	0.24
AVG	7.7	3.451	0.531	11.323	16.553	5.628	17.71	13.83	1.148	12.086	0.030	0.065	0.120	0.028
MED	7.7	2.945	0.56	8.5	12.05	4.1	12.3	11.2	0.91	0.176	0.009	0.065	0.086	0.012
SD	0.3125	2.229	0.260	7.599	10.671	5.431	12.78	8.696	1.044	70.78	0.049	0.006	0.152	0.041

MIN- Minimum, MAX- Maximum, AVG-Average, MED Median, SD- Standard deviation

Table 5: Correlation Matrix of Water Quality Parameters (Pre-Monsoon Season)

Parameter	Ph	EC	Ca	Mg	Na	K	HC03	CI	SO_4	Fe	Mn	Cu	Zn	Ni
pH	1													
EC	-0.33981	1												
Ca	-0.35033	0.79387	1											
Mg	-0.35701	0.891386	0.783346	1										
Na	-0.53775	0.90607	0.832361	0.86452	1									
K	-0.2104	0.474794	0.336593	0.344919	0.46746	1								
HC03	-0.46959	0.927398	0.842634	0.934807	0.96084	0.493368	1							
CI	-0.33927	0.917963	0.828901	0.899029	0.906606	0.499071	0.914682	1						
SO_4	0.014439	0.722184	0.640325	0.645154	0.625782	0.468514	0.680658	0.62975	1					
Fe	-0.0008	-0.11008	-0.21677	-0.14632	-0.09272	0.509664	-0.11565	-0.05063	-0.17244	1				
Mn	-0.36841	0.261768	0.327853	0.186956	0.3152	0.182708	0.334946	0.170351	0.264841	-0.00102	1			
Cu	-0.21048	0.73075	0.652941	0.731119	0.728883	0.374844	0.739268	0.702957	0.506255	0.037007	0.111606	1		
Zn	-0.00582	-0.15083	-0.3532	-0.16241	-0.11687	-0.05444	-0.11709	-0.13094	-0.07663	0.097481	-0.0975	-0.19528	1	
Ni	0.205779	-0.07434	0.00434	-0.00287	-0.06165	-0.08974	-0.13	-0.0656	0.204307	0.08061	-0.24907	-0.06553	-0.2767	1

Table 6: Physico-Chemical Analysis of Ground Water Quality Parameters during Post-Monsoon Season

Parameter	pH	EC	Ca	Mg	Na	K	HCO_3	Cl	SO_4	Fe	Mn	Cu	Zn	Ni
S1	7.65	4.44	26.1	16.2	1.8	0.18	6.7	25.7	12	0.244	0.09	0.077	0.017	0.038
S2	7.82	1.19	6.2	3.8	0.89	0.1	1.1	5.2	4.9	0.236	0.016	0.032	0.0015	0.042
S3	7.46	6.13	35	22.1	1.76	0.81	7.2	34.5	19.8	0.255	0.01	0.058	0.021	0.063
S4	7.66	3.5	19.8	12.5	1.5	0.45	4.7	20.2	10.8	0.229	0.02	0.035	0.092	0.047
S5	8.1	1.64	10.2	4.9	0.82	0.2	2.6	7.8	4.5	0.233	0.017	0.016	0.047	0.049
S6	7.84	1.4	9.8	3.4	0.9	0.15	2.1	6.2	4.1	0.127	0.012	0.015	0.055	0.047
S7	8.16	0.42	3	1.2	0.25	0.09	1	2.1	1.9	0.129	0.028	0.014	0.038	0.02
S8	7.99	0.81	4.2	2.9	0.1	0.12	0.7	6.2	2	0.245	0.009	0.008	0.025	0.02
S9	8.29	0.63	4.1	1.2	0.09	0.1	0.5	4.1	1.9	0.129	0.002	0.004	0.012	0.023
S10	7.11	2.66	15.1	8.1	1.1	0.7	4.4	12.7	10.1	0.24	0.005	0.016	0.057	0.044
S11	7.63	1.89	10.7	6.2	0.8	0.5	3.5	7.2	6.9	0.23	0.004	0.01	0.093	0.024
S12	8.3	0.66	3.1	2	0.4	0.15	1.2	2.4	1.1	0.145	0.013	0.013	0.052	0.061
S13	7.18	4.48	25.2	17	1.2	0.21	6.9	23.8	11.1	0.146	0.06	0.025	0.047	0.067
S14	7.14	2.49	11.9	10.1	0.7	0.24	3.4	12.2	7.2	0.15	0.014	0.013	0.052	0.061
S15	7.93	1.16	7.2	3.1	0.25	0.12	1.2	6.7	3.5	0.137	0.012	0.013	0.093	0.044
S16	7.13	1.17	8	2.9	0.2	0.15	1.4	6.6	3.4	0.232	0.012	0.007	0.027	0.048
S17	8.08	1.64	9	5.1	0.1	0.12	3.4	8.1	4	0.227	0.002	0.015	0.062	0.059
S18	7.15	5.1	28.1	15.6	1.16	0.89	6.9	30.1	14.9	0.26	0.011	0.003	0.018	0.086
S19	7.45	1.01	6.1	2.9	0.08	0.1	2.8	4.2	3.1	0.267	0.017	0.017	0.084	0.117
S20	7.12	1.52	11	4.2	0.1	0.12	3	8.1	4.2	0.267	0.011	0.031	0.054	0.128
S21	7.82	3.34	22.1	6.4	2.1	0.6	5.2	20.1	8.1	0.246	0.02	0.01	0.029	0.064
S22	7.9	2.38	14.9	6.2	0.9	0.2	3.4	12.1	8.9	0.232	0.025	0.012	0.049	0.036
S23	7.64	2.58	20.1	4.2	0.5	0.25	4	14.2	7.1	0.25	0.017	0.05	0.097	0.077
S24	7.18	1.86	14.5	3.2	0.7	0.14	3.9	9.5	4.2	0.24	0.004	0.012	0.051	0.042
S25	8.16	1.44	7.9	4.1	2.58	0.2	3.2	6.2	4.1	0.235	0.02	0.02	0.027	0.053
S26	7.11	2.81	18.1	9.8	0.7	0.19	4.8	19.2	6.3	0.238	0.03	0.08	0.071	0.06
S27	7.88	2.81	20.5	8.2	0.98	0.21	5.7	20.1	4.9	0.246	0.016	0.01	0.016	0.089
S28	7.95	1.94	14.2	4.9	0.95	0.25	2.1	12.5	6.2	0.25	0.007	0.01	0.07	0.046
S29	7.88	2.25	15.2	5.7	1.28	0.5	3.1	16.1	4.2	0.248	0.015	0.24	0.058	0.083

S30	7.81	1.55	7.5	8.1	0.8	0.1	2.9	8.1	4.1	0.134	0.009	0.09	0.1	0.034
S31	7.83	1.17	7	3.5	0.7	0.2	3.2	6.1	2.9	0.133	0.006	0.018	0.066	0.072
S32	7.89	2	14	5.1	0.5	0.21	4	12.1	7.2	0.138	0.014	0.011	0.081	0.068
S33	8.13	1.79	6	5.1	2.95	0.28	8.9	5.7	4.2	0.187	0.013	0.004	0.111	0.052
S34	7.56	3.03	20.1	9.2	0.95	0.7	6	16.1	8.1	0.144	0.014	0.05	0.066	0.096
S35	8.54	0.53	1.9	2.1	1.84	0.6	3.4	2	1.2	0.148	0.014	0.02	0.131	0.04
S36	7.18	2.39	18.5	12.1	0.9	0.7	4.1	20.1	9.2	0.155	0.013	0.02	0.036	0.038

Note: All units are in mg/l except pH & EC

Table 7: Normal Statistic of Water Quality Parameters of Groundwater Samples (Post-Monsoon Season)

Parameter	pH	EC	Ca	Mg	Na	K	HCO_3	Cl	SO_4	Fe	Mn	Cu	Zn	Ni
Min	7.11	0.42	1.9	1.2	0.08	0.09	0.5	2	1.1	0.127	0.002	0.003	0.002	0.02
MAX	8.54	6.13	35	22.1	2.95	0.89	8.9	34.5	19.8	0.267	0.09	0.24	0.131	0.128
AVG	7.713	2.161	13.231	6.758	0.931	0.301	3.683	12.063	6.175	0.204	0.017	0.029	0.056	0.057
MED	7.82	1.875	11.45	5.1	0.855	0.2	3.4	8.8	4.7	0.232	0.013	0.015	0.053	0.050
SD	0.403	1.315	7.940	4.916	0.695	0.236	2.029	8.108	4.011	0.051	0.016	0.042	0.031	0.025

Table 8: Correlation Matrix of Water Quality Parameters (Post-Monsoon Season)

Parameter	Ph	EC	Ca	Mg	Na	K	HC03	Cl	SO_4	Fe	Mn	Cu	Zn	Ni
pH	1													
EC	-0.50451	1												
Ca	-0.53341	0.966759	1											
Mg	-0.50948	0.936711	0.869756	1										
Na	0.152483	0.417972	0.327701	0.375489	1									
K	-0.266	0.596688	0.576468	0.551492	0.439325	1								
HC03	-0.33482	0.785863	0.725173	0.727647	0.652639	0.531902	1							
Cl	-0.50441	0.966315	0.973868	0.9148.3	0.343169	0.596896	0.715447	1						
SO_4	-0.5137	0.94783	0.906905	0.914573	0.364497	0.649377	0.683908	0.900884	1					
Fe	-0.30611	0.333804	0.372435	0.183854	0.131454	0.15554	0.205748	0.339897	0.307754	1				
Mn	-0.11617	0.409401	0.384323	0.450269	0.279814	-0.13227	0.363421	0.393856	0.311428	0.041928	1			
Cu	-0.05328	0.197615	0.223106	0.202715	0.131923	0.132868	0.095729	0.262135	0.089359	0.152835	0.20543	1		
Zn	0.17389	-0.24795	-0.27466	-0.22673	0.070478	0.007933	0.082375	-0.30875	-0.23838	-0.24947	-0.19863	0.073794	1	
Ni	-0.34464	0.23942	0.287547	0.129768	-0.06787	0.1282	0.31724	0.240316	0.119644	0.286241	-0.02933	0.187908	0.055865	1

In Post monsoon: Table 8 shows highly positive correlation is observed between Cl^- and Ca^{++} (0.974), Ca and EC (0.967), Cl^- and EC (0.966), SO_4 and EC (0.948). Where, highly negative correlation is observed between Ca and pH (-0.533). Very poor positive correlation was observed between Zn and K.

4. Conclusion

In the present study water quality has been calculated to assess the suitability of groundwater for drinking purpose along the periphery of, Kopargaon, Maharashtra, India. Better water quality was found in the post monsoon season than that of pre-monsoon season because of inflow of freshwater. The results shows that the concentration of alkalinity, total hardness, Ca, Mg, Cl at most of the sampling stations having higher values than the permissible limit prescribed by the Indian standards. In the present study, the correlation of physico-chemical parameters of groundwater revealed that all the parameters were more or less correlated with one another. Groundwater of the study area shows alkaline earth (ca and mg) exceeds than alkalis (Na and K), weak acids (HCO3) exceeds than strong acids (Cl, SO4 and NO3). The Ca, Mg and HCO3 indicate hardness is dominated by the alkaline earth and weak acids. The water increases its major ions and electrical conductivity in pre monsoon period as compared to post monsoon period due to over exploitation of groundwater. From correlation analysis it was observed that very strong correlation exist between HCO_3 and Na (0.961), HCO_3 and Mg^{++} (0.935), HCO_3 and EC (0.927). Where highly negative correlation is observed between Na and pH (-0.538) during pre-monsoon season. During post monsoon season highly positive correlation is observed between Cl^- and Ca^{++} (0.974), Ca and EC (0.967), Cl^- and EC (0.966), SO_4 and EC (0.948). Where, highly negative correlation is observed between Ca and pH (-0.533). The analysis shows that the groundwater of the study area need some treatment before it consumption. It is recommended that water analysis should be carried out from time to time to monitor the rate and kinds of contamination.

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