Interpretation of Groundwater Quality Using Statistical Analysis from Kopargaon, Maharashtra, India

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Abstract-   The study was conducted to evaluate the groundwater quality along the periphery of Sanjivani sugar factory Kopargaon. Twelve ground water samples were collected from different sources in pre monsoon and post monsoon season, during the year 2014. The descriptive statistical analysis was carried out besides Pearson correlation. Correlation analysis revealed very strong correlation between NO_3^- and Mg^{++} (0.9223), Mg^{++} and TDS (0.0.8644) and total hardness and TDS (0.8624) during pre- monsoon season. During post monsoon season Cl^- and Ca^{++} (0.9037), TDS and alkalinity (0.8479), NO_3^- and Cl^- (0.8470), total hardness and TDS (0.8416) indicated strong correlation. The alkalinity, magnesium and total hardness concentration in all samples were found more than maximum permissible limit prescribed by BIS in both season. In pre-monsoon season concentration of Calcium and TDS also crossed maximum permissible limit prescribed by BIS.

Keywords – Ground Water Quality, Physico-Chemical Parameters, Statistical Analysis, Pearson Correlation Model

I. INTRODUCTION

Ground water is the major source of water for drinking, agricultural, and industrial desires. The availability of water determines the location and activities of humans in an area and our growing population is placing great demands upon natural fresh water resources. (Pathak and Limaye,2012; Sasane and Patil, 2013). It is estimated that approximately one third of the world's population uses groundwater for drinking purposes and today more than half the world's population   depends on groundwater for survival (Mohrir A.,2002; Khwaja and Aggarwal 2014). Groundwater is one of the earth's most important, renewable and widely distributed resources. It is generally considered least polluted compared to other inland water resources. However studies indicate that groundwater is not absolutely free from pollution though it is likely to be free from suspended solids. Therefore, a systematic statistical study of correlation coefficient of the water quality parameters not only helps to assess the overall water quality but also quantify relative concentration of various pollutants and provide necessary cue for implementation of rapid water quality management programmes. Many workers (Gajendran et al.,2013; Aravinda, 1991; Biswal *et al.,* 2001; Gajendran and Thamarai, 2008; 2008a; Keshvan and Parameswari, 2005; Mishra *et al.,* 2003; MorSuman *et al.,* 2002; Patowary *et al.,* 2005; Prajapati and Mathur, 2005; Srivasthava and Sinha, 1994) . In this study statistical techniques were used to analyze the water quality data collected from along the periphery of Sanjivani sugar factory, Kopargaon.   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 (Halsel and Hirsch, 2002; Khwaja and Aggrawal, 2014).

II. STUDY AREA

The study area is situated at a distance of 18 km from the holy town of Shirdi. Kopargaon is situated at 19.88°N 74.48°E . It has an average elevation of 493 metres (1617 feet) and lies at the banks of the Godavari river, here are around 79 villages in Kopargaon tehsil of Ahmednagar district of state of Maharashtra. The annual rainfall in the area of operation ranged between 326 mm to 630mm. This area falls under rain shadow & scarcity track of agro-climatic zones of Maharashtra which adversely affects the irrigation water supply in summer. However the average rain fall is satisfactory for the growth of cane in the area of operation of the factory. During the rains water is stored in perennial wells, bandhars, storage tanks, K.T. weirs etc. facilitating irrigation during summer months.
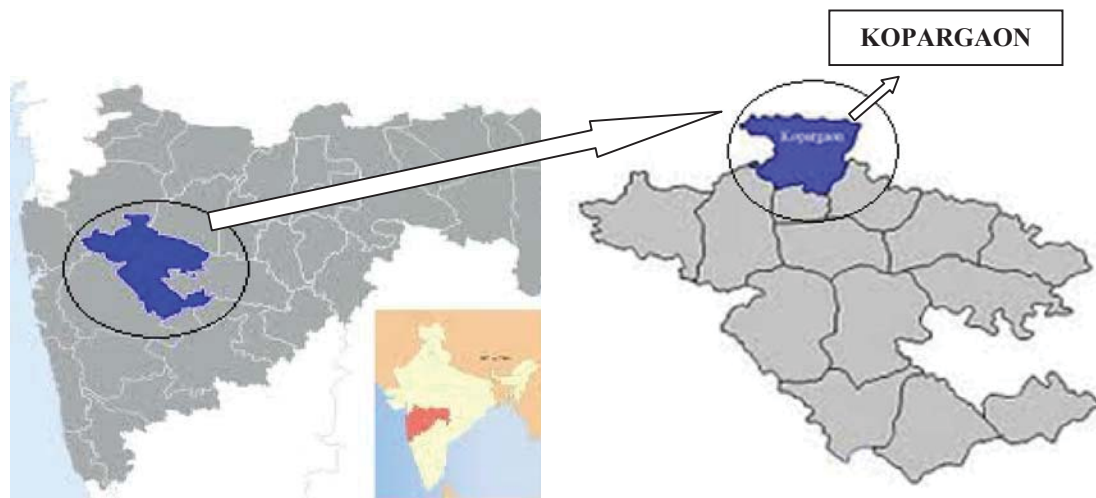

Figure 1: Location map of Kopargoan Taluka

For the present study the samples to analyze groundwater parameters were collected along the periphery of Sanjivani Sugar factory, Kopargaon. The samples were collected from 7 dug wells, 3 tube wells and 2 hand pumps. The sampling locations are shown in figure 2.
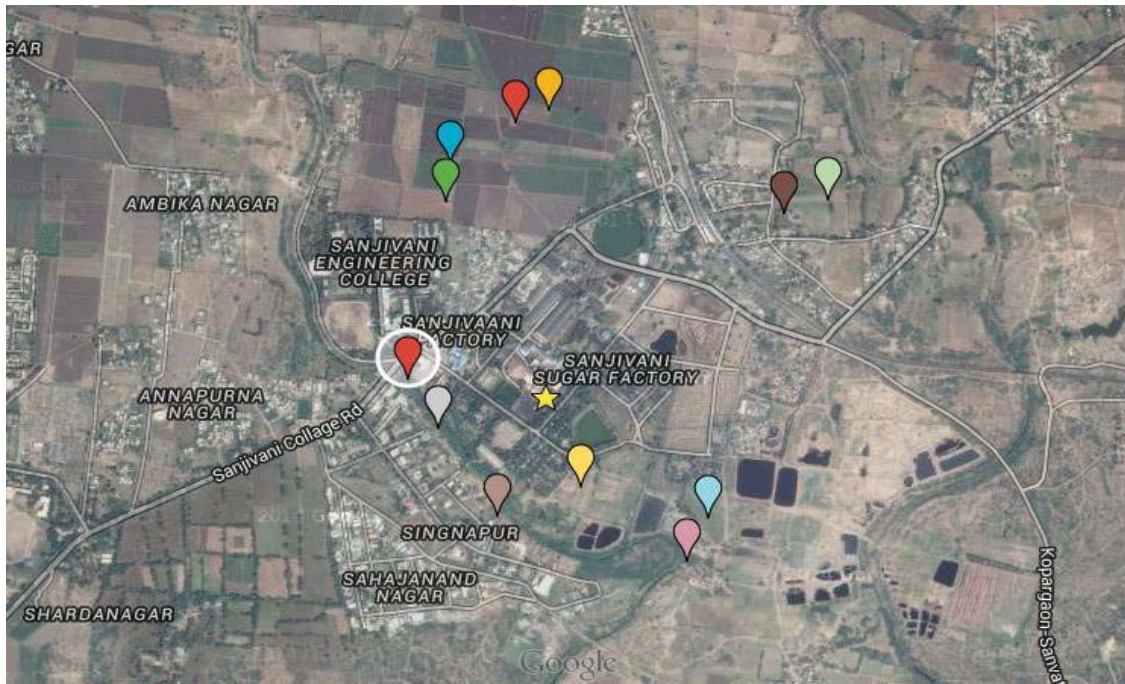
Figure 2: Sampling Locations in study area

Table 1: LATITUDES AND LONGITUDES OF SAMPLING LOCATIONS:

SR. NO.	LOCATION	LATITUDE (N)	LONGITUDE (E)	SOURCE
1	S 1	19°54'16.1" N	74°29'49.9" E	Dug Well
2	S2	19°54'19.8" N	74°29'46.4" E	Dug Well
3	S3	19°54'24.1" N	74°29'53.0" E	Dug Well
4	S4	19°54'25.5" N	74°29'56.4" E	Dug Well
5	S5	19°54'14.8" N	74°30'20.5" E	Hand Pump
6	S6	19°54'16.2" N	74°30'24.9" E	Dug Well
7	S7	19°53'40.1" N	74°30'12.0" E	Hand Pump
8	S8	19°53'46.6" N	74°30'12.4" E	Dug Well
9	S9	19°53'46.6" N	74°29'59.5" E	Tube Well
10	S10	19°53'43.4" N	74°29'51.3" E	Dug Well
11	S11	19°53'52.4" N	74°29'45.5" E	Tube Well
12	S12	19°53'58" N	74°29'41.8" E	Tube Well

III. EXPERIMENT AND RESULTS

Ground water was sampled from 12 different stations during the pre-monsoon and post monsoon seasons in the year 2014. These collected samples were analyzed for various water quality parameters viz. Temperature, pH, Alkalinity, Dissolved Oxygen (DO), Total Dissolved Solids (TDS), Total Hardness (TH), Calcium, Magnesium, Chloride, Fluoride, Nitrates 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.

Table 2: Instrumental methods for measurement of different water quality parameters

Parameter	Equipment
Temperature 0C	Thermometer
pH	Digital pH meter
Alkalinity	colour indicator titrimetric method
DO	colour indicator titrimetric method
TDS	Titrimetric method (EDTA)
Total hardness	Titrimetric method (EDTA)
Calcium	Flame- photometric method
Magnesium	Flame- photometric method
Chloride	colour indicator titrimetric method
Fluoride	Spectro photometric method
Nitrate	Spectro photometric method

The results of physico-chemical parameters as determined in samples collected from along the periphery of Sanjivani (Takli) Sahakari Sakhar Karkhana Ltd. Kopargaon. 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.

3.1 Physico-chemical analysis of ground water quality parameters during Pre-Monsoon season:

Ground water samples were collected from periphery of Sanjivani (Takli) Sahakari Sakhar Karkhana Ltd. Kopargaon. These samples were collected during summer season .The results of analysis are tabulated below.

Table 3: Physico-chemical analysis of ground water quality parameters during Pre-Monsoon season:

Parameter	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Temperature	25.2	24.3	23.8	24.6	25.1	24.7	25.2	24.9	24.8	25.1	25.3	24.8
pH	8.10	7.42	7.80	7.32	8.12	7.64	7.48	7.82	7.46	7.60	7.86	7.65
Alkalinity	265.54	225.38	285.10	313.48	252.25	620.24	605.16	546.84	610.8	394.56	236.00	295.5
DO	6.35	6.24	6.84	5.92	6.15	5.86	6.10	6.21	6.14	5.98	6.14	6.18
TDS	748	845.4	585.8	854	1360	1250.4	1925	2045.2	2016.5	2120	985.4	896.2
Total hardness	545.4	510	595.8	564.25	625.4	704.62	865.4	712.8	716.4	784.5	576	554.4
Calcium	78.35	94.3	135.25	146.85	185.2	174.4	165.75	198.5	210.15	208.45	87.50	86.54
Magnesium	44.25	73.25	58.45	46.30	46.85	93.4	112.50	122.35	118.3	103.8	57.6	64.25
Chloride	354.25	230.55	195.73	246.62	354.2	295.84	458.62	410.42	305.52	268.56	246.58	315.3
Fluoride	0.48	0.58	0.42	0.41	0.43	0.49	0.43	0.44	0.46	0.57	0.36	0.38
Nitrate	25.4	37.8	30.2	24.5	30.16	48.26	54.24	46.6	49.82	45.84	34.5	24.8

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

Table 4: Normal statistic of Water Quality Parameters of Groundwater samples (Pre-monsoon season)

	Min	Max	AM	SD	CV	Median
pH	7.32	8.12	7.689	0.2575	3.350	7.645
Alkalinity	225.38	620.24	387.5708	160.5888	41.43469	304.49
DO	5.86	6.84	6.175833	0.250326	4.053308	6.145
TDS	585.8	2120	1302.658	573.6713	44.03851	1117.9
TH	510	865.4	646.248	109.423	16.932	610.6
Ca^{++}	78.35	210.15	147.6033	50.26957	34.05721	156.3
Mg^{-++}	44.25	122.35	78.44167	29.8572	38.06295	68.75
Cl$^-$	195.73	458.62	306.846	77.0704	25.117	300.68
F$^-$	0.36	0.58	0.45417	0.06748	14.8584	0.435
NO$_3^-$	24.5	54.24	37.67667	10.84072	28.77304	36.15

Note: All units except pH are in mg/L Min- Minimum, Max- Maximum, AM- Arithmetic Mean,
SD- Standard deviation, CV- Coefficient Variation, Med- Median

Table 5: Correlation matrix of water quality parameters (Pre-monsoon season)

	pH	Alk.	DO	TDS	TH	Ca	Mg	Cl-	F	NO$_3^-$
pH	1									
Alk.	-0.3494	1								
DO	0.3757	-0.3757	1							
TDS	-0.1840	0.7232	-0.4242	1						
TH	-0.2122	0.8074	-0.3270	0.862338	1					
Ca^{++}	-0.1761	0.6840	-0.3238	0.8199	0.7554	1				
Mg^{-++}	-0.3916	0.8559	-0.2681	0.86437	0.8012	0.6743	1			
Cl$^-$	0.2096	0.5199	-0.2404	0.5621	0.5687	0.2912	0.4386	1		
F$^-$	-0.2330	0.0883	-0.1507	0.2407	0.1453	0.2265	0.298	-0.1396	1	
NO$_3^-$	-0.3466	0.8439	-0.32824	0.8121	0.8479	0.6564	0.9223	0.4084	0.3529	1

In Pre- monsoon: Table 5shows highly positive correlation is observed between NO_3^- and Mg^{++} (0.9223), Mg^{++} and TDS (0.0.8644), Total hardness and TDS (0.8624). Where highly negative correlation is observed between TDS and DO (-0.4242). Very poor positive correlation was observed between F^- and total hardness (0.1453). While, there is almost no correlation was observed between F^- and alkalinity (0.0883).

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

Ground water samples were collected from periphery of Sanjivani (Takli) Sahakari Sakhar Karkhana Ltd. Kopargoan. These samples were collected during post monsoon season .The results of analysis are tabulated below:

Table 6: Physico-chemical analysis of ground water quality parameters during Post-Monsoon season

Parameter	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Temperature	18.5	19.3	19.2	19.7	20.1	18.8	19.4	19.7	18.8	19.2	19.2	19.9
pH	7.86	7.65	7.1	6.94	6.86	6.68	6.84	6.67	6.54	7.2	6.95	6.21
Alkalinity	248.5	246.48	316.24	214.6	342	390.4	374	365	398	324	224	210.8
DO	6.45	6.34	6.21	5.98	6.76	6.95	5.87	5.78	6.3	5.64	6.52	6.8
TDS	445.5	464.75	482.5	454	452.3	548.4	536	585.43	654.4	562	358.5	368.7
Total hardness	355.45	480.14	325	445.8	438.2	518	654.6	618.3	610.4	485.7	285.4	314.5
Calcium	45.5	65.25	85.32	82.15	92.2	85.62	102.84	125.65	135.46	110.94	75	68.4
Magnesim	32.5	50.4	42.36	54.45	38.6	55.6	68.50	78.43	65.4	76.88	38.8	35.6
Chloride	135.4	110	224.85	165.46	176.2	214.46	248.65	265.4	288.5	286.46	187	164
Fluoride	0.36	0.38	0.41	0.42	0.42	0.49	0.43	0.44	0.46	0.47	0.36	0.38
Nitrate	20.14	23.8	23.5	18.4	26.46	38.2	46.4	36.6	45.82	45.84	24.5	19.58

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

Table7: Normal statistic of water quality parameters of groundwater samples (post-monsoon season)

	Min	Max	AM	SD	CV	Median
pH	6.21	7.86	6.9584	0.456226	6.556545	6.9
Alk.	210.8	398	304.502	71.5924	23.5113	320.12
DO	5.64	6.95	6.3	0.4219	6.6968	6.32
TDS	358.5	654.4	492.707	87.4665	17.7522	473.625
TH	285.4	654.6	460.958	124.847	27.0843	462.97
Ca ++	45.5	135.46	89.2775	26.08385	29.2166	85.47
Mg.++	32.5	78.43	53.12667	16.15718	30.41256	52.425
Cl-	110	288.5	205.532	58.7047	28.5623	200.73
F-	0.36	0.49	0.41833	0.0426	10.1844	0.42
NO_3^-	18.4	46.4	30.77	11.0274	35.8383	25.48

All units except pH are in mg/L Min- Minimum, Max- Maximum, AM- Arithmetic Mean, SD- Standard deviation, CV- Coefficient Variation, Med- Median

Table 8: Correlation matrix of water quality parameters (post-monsoon season)

	pH	Alk.	DO	TDS	TH	Ca	Mg	Cl-	F	NO$_3^-$
pH	1									
Alk.	-0.2899	1								
DO	-0.1912	-0.1466	1							
TDS	-0.1435	0.8479	-0.4468	1						
TH	-0.2047	0.7516	-0.4567	0.8416	1					
Ca^{++}	-0.5218	0.7496	-0.4846	0.8069	0.7209	1				
Mg^{++}	-0.2043	0.6084	-0.7347	0.8087	0.8338	0.8066	1			
Cl$^-$	-0.4471	0.7420	-0.5097	0.7630	0.5735	0.9037	0.7674	1		
F$^-$	-0.3921	0.7980	-0.2281	0.8095	0.6769	0.7343	0.7299	0.7353	1	
NO$_3^-$	-0.2640	0.8287	-0.4120	0.8258	0.7918	0.7900	0.8151	0.8470	0.766	1

In Post monsoon: Table 8 shows highly positive correlation is observed between Cl$^-$ and Ca^{++} (0.9037), TDS and alkalinity (0.8479), NO$_3^-$ and Cl$^-$ (0.8470), total hardness and TDS (0.8416). Where , highly negative correlation is observed between Mg^{++} and DO (-0.7347). Very poor positive correlation was observed between Cl$^-$ and Ca^{++}.

IV.CONCLUSION

In the present study, the correlation of 10 physico-chemical parameters of groundwater revealed that all the parameters were more or less correlated with one another. In all places alkalinity, total hardness and magnesium found above maximum permissible limit prescribed by BIS in both season , reveals that the groundwater of the study area is alkaline and hard in nature. From correlation analysis it was observed that very strong correlation exist between NO$_3^-$ and Mg^{++} (0.9223), Mg^{++} and TDS (0.0.8644), Total hardness and TDS (0.8624) during pre- monsoon season and Cl$^-$ and Ca^{++} (0.9037), TDS and alkalinity (0.8479), NO$_3^-$ and Cl$^-$ (0.8470), total hardness and TDS (0.8416) during post monsoon season. 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.

V.ACKNOWLEDGEMENTS

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