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Physico-chemical characteristics of groundwater in some villages of Jaitpur Tahsil, Shahdol district M.P., India

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Abstract
Physico-chemical characteristics of groundwater of Jaitpur tahsil of Shahdol district have been studied. Water is an elixir of life and it is a basic need for all humans. The major sources of water are surface water and groundwater. Groundwater is the basic requirement of rural and urban areas and it is essential for a healthy society and sustainable development. The problem of groundwater quality is acute. The possibility of groundwater contamination is due to the mixing of toxic chemicals, fertilizers, waste disposed site. Hence monitoring of groundwater has become indispensable. The aim of the study was to assess the groundwater quality and also to have a statistical analysis of physico-chemical parameters of groundwater quality of some villages of Jaitpur Tahsil, Shahdol District of India. The various water quality parameters such as pH, Electrical Conductivity (E.C), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^{+}), Potassium (K^{+}), Sulphates (SO_4^{2-}), Chloride (Cl^{-}), Nitrate (NO_3^{-}), Total Dissolved Solids (TDS), Total Hardness (TH), were determined using standard APHA methods and compared with WHO standards. The Correlation analysis provides a rapid method of monitoring of water quality. The different significant correlations have been worked out between the parameters in both the post and pre monsoon seasons.

Keywords: physico-chemical parameters, groundwater quality, correlation studies, WHO standards

1. Introductions
Water is important to the mechanics of the human body and the body cannot survive without it. Water quality is essential for the well being of all people, the quality of water can be affected by different pollutants such as, chemical, biological and physical. Contaminates such as bacteria, viruses, heavy metals, nitrate and salt have found their way into water supplies, the water pollution occurs when a body of water is adversely affected due to the addition of large amounts of materials to the water (Atta and Razzak, 2008) [3].

In rural arid and semi arid regions, where well managed water transportation system and related infrastructures are not available, groundwater serves as chief source of drinking water. Groundwater is an excellent reservoir of water but as rivers, lakes and streams are influenced by natural and human factors, groundwater is also facing the same situation around the world. Human activities, hydrological aspects and characteristics of recharged water affect the quality of groundwater. As groundwater is used in high extent, some troubles are created such as water logging, land subsidence, lowering of water table, sea water intrusion in coastal aquifers and deterioration in water quality (Mehta, 2011) [8].

Water is one of the indispensable natural resources in our environment which is a basic need for human being and also an essential thing for the survival of all living organisms (Prashat, *et al.* 2013) [11]. The earth's surface contains about 2.8% of fresh water in which 20% of water constituent's groundwater (Senthilnathan, *et al.* 2011) [14]. About 95% of the population in India depending on groundwater for domestic purpose (Moharir, *et al.* 2002) [9] which occurs in weathered portions along the joints and fractures of rocks and also a major source for drinking purpose in both the rural and urban areas. The quality of groundwater gets affected due to dumping of municipal waste and industrial waste over the land surface, use of fertilizers in agriculture. The problem of water quality is due to improper management of water system (Subbarao and Subbarao, 1995, Sharma, 2015, Kashyap, 2015, Borkar and Tembhre, 2018 and Namdeo and Singh, 2021) [16, 15, 7, 4, 10]. In order to minimize the groundwater pollution and to have a control on pollution causing agents, the continuous monitoring of groundwater is essential (Arya, *et al.* 2011) [2].

Hence an attempt is made on the analysis of physico-chemical characteristics of groundwater during the post and pre monsoon seasons in the study area and compared the results with WHO drinking water quality standards (WHO, 2007) [17].

2. Experiments

For the present study the area was selected is Jaitpur Tahsil which is located in Shahdol district of (M.P.), India. The water samples were collected from 20 different stations from five villages Kamta, Sakhi, Biraudi, Kadaudi and Bhathiya the study area during pre-monsoon and post-monsoon seasons in a clean one litre polyethylene bottles from both dug well and bore well which was immediately transferred to the laboratory for the physico-chemical analysis. The physical chemical recordings like Electrical conductivity (EC) and hydrogen ion concentrations (pH) was determined by using potable meter like Conductivity meter and pH meter respectively and the other physico-chemical parameters were analysed by the standard method given in APHA as provided in Table-1.

3. Results and Discussion

The statistical analysis of the study area during the pre-monsoon and post monsoon seasons is presented in Tables-2-3 and Graph-1. Electrical conductivity was found to be very high and ranges from 448-2953 µs/cm in the pre-monsoon season and 414–2583 µs/cm during post monsoon season respectively. As per WHO standards, around three numbers of wells are exceeding the allowable limits of EC during both the seasons. The pH values ranged from 7.5 to 8.4 and 7.1 to 8.3 during the pre-monsoon and post monsoon seasons respectively and it was within the maximum allowable limits of WHO standards. The pH of water of the study area is found to be alkaline in nature and from the point of view of human consumptions all the samples are considered as fit. An important parameter for determining the water quality of domestic purpose is electrical conductivity and it a measure of water capacity to conduct electrical current which is a direct function of TDS (Harilal, *et al.* 2004) [6].

Total Dissolved solids (TDS) indicated the nature of groundwater quality and salinity behaviour of groundwater. In water TDS are composed mainly of carbonates, bicarbonates, chlorides, phosphates and nitrates of calcium, magnesium, sodium and potassium. The maximum allowable limit of TDS of groundwater is 500mg/l as per WHO standard and the water containing more than 500mg/l of TDS is not suitable for drinking purpose. The TDS value ranged between from 221-1685mg/l during pre-monsoon season with an average value of 952.0mg/l and during post monsoon season it ranges from 222-1462mg/l. Most of the samples are within the permissible limits of WHO standards during both the seasons (14 samples during pre-monsoon and 13 samples during post monsoon seasons). According to Freeze and Cherry (Freeze, *et al.* 1979) [5] classification, the fresh water is found to be 76% and 80% during the pre and post monsoon seasons respectively as given in Table-4. Hardness of water is often referred as the amount of dissolved calcium and magnesium. The Total Hardness (TH) in the study area ranged from 214-904mg/l during the pre- monsoon season and 112-783mg/l in the period of post monsoon. Even though the hardness has no adverse effects on the health of the human beings, around 13 samples are higher than the desirable limits (>300mg/l) for drinking purpose during both the seasons. According to Sawyer and McCartly (1967) [13] classification as given in Table-5, the groundwater of the study area is found to be very hard (52%). Detailed information about various species along with diseases and drug preparation is given in Table 1.

Table 1: Methods for determining the physical- chemical analysis of groundwater

S. No.	Parameters	Methods adopted
1.	pH	pH Meter
2.	Electrical Conductivity	Conductivity meter
3.	Calcium (Ca^{+})	EDTA Titration
4.	Magnesium (Mg^{+})	EDTA Titration
5.	Sodium (Na+)	Flame Photometric titration
6.	Potassium (K+)	Flame Photometric titration
7.	Sulphate (SO_4^{2-})	Spectro photometric titration
8.	Chlorine (Cl-)	$AgNO_3$ Titraion
9.	Nitrate (NO_3^{-})	Spectro photometric titration
10.	Total Dissolve Solids(TDS)	Gravimetric Titration
11.	Total Hardness (TH)	(Ca^{+} + Mg^{+}) X 50

Table 2: Summary of statistics of chemical parameter during pre-monsoon season.

S. No.	Parameters	Min.	Max.	Mean	Median	SD	WHO standards, 2005 (max. allowable limits)
1.	E.C. (µs/cm.)	448	2953	1700.5	1700.5	1769.89	1500
2.	pH	7.5	8.4	7.95	7.95	0.49	7.0-8.5
3.	Ca (mg/l)	15	102	58.5	58.5	61.52	75
4.	Mg (mg/l)	37	190	113.5	113.5	108.19	50
5.	Na (mg/l)	10	353	181.5	181.5	242.54	200
6.	K (mg/l)	1	94	47.5	47.5	65.76	12
7.	SO_4 (mg/l)	5	409	207	207	285.67	200
8.	Cl (mg/l)	17	396	206.5	206.5	267.99	200
9.	NO_3(mg/l)	1	217	109	109	152.74	100
10.	TDS (mg/l)	221	1685	952	952	1035.20	500
11.	T.H. (mg/l)	214	904	556.5	556.5	487.20	300

Table 3: Summary of statistics of chemical parameter during post-monsoon season.

S. No.	Parameters	Min.	Max.	Mean	Median	SD	WHO standards, 2005 (max. allowable limits)
1.	E.C. (µs/cm.)	414	2583	1496	1496	1534.42	1500
2.	pH	7.1	8.3	7.8	7.8	0.57	7.0-8.5
3.	Ca (mg/l)	19	113	66	66	66.47	75
4.	Mg (mg/l)	16	125	70.5	70.5	77.07	50
5.	Na (mg/l)	15	342	178.5	178.5	231.22	200
6.	K (mg/l)	2	39	20.5	20.5	26.16	12
7.	SO_4 (mg/l)	1	218	109.5	109.5	153.44	200
8.	Cl (mg/l)	24	494	259	259	332.34	200
9.	NO_3(mg/l)	1	191	96	96	134.35	100
10.	TDS (mg/l)	222	1462	841	841	876.86	500
11.	T.H. (mg/l)	112	783	446.5	446.5	474.47	300

Table 4: Nature of groundwater based on TDS values

S. No.	TDS in mg/l	Nature of water	Pre-monsoon	Post-monsoon
1.	< 1000	Fresh water	19	20
2.	1000-10000	Brackish water	6	5
3.	10000-100000	Saline water	Nil	Nil
4.	>100000	Brine water	Nil	Nil

Table 5: Groundwater classification based on TH

S. No.	Total hardness (mg/l)	Water class	Pre-monsoon	Post-monsoon
1.	< 75	Soft	Nil	Nil
2.	75-150	Moderately hard	Nil	1
3.	150-300	Hard	12	11
4.	>300	Very hard	13	13

4. Statistical Analysis

The statistical analysis is an attractive option in the environmental studies. For the prediction of parametric parameter, Correlation becomes an important tool with a reasonable degree of accuracy (Sanchez-perez and Tremolieres, 2003). If X and Y are the two variables then the correlation "r" between the variables is calculated using the following relations,

$$Correl\,(X,Y) = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sqrt{\sum(x-\bar{x})^2(y-\bar{y})^2}}$$

The correlation coefficients (r) among the various water quality parameters for the pre-monsoon and post monsoon seasons have been calculated and the numerical values are tabulated as shown in Table-6 and Table-7.

Table 6: Correlation Coefficient (r) among the various water quality parameters during pre-monsoon season.

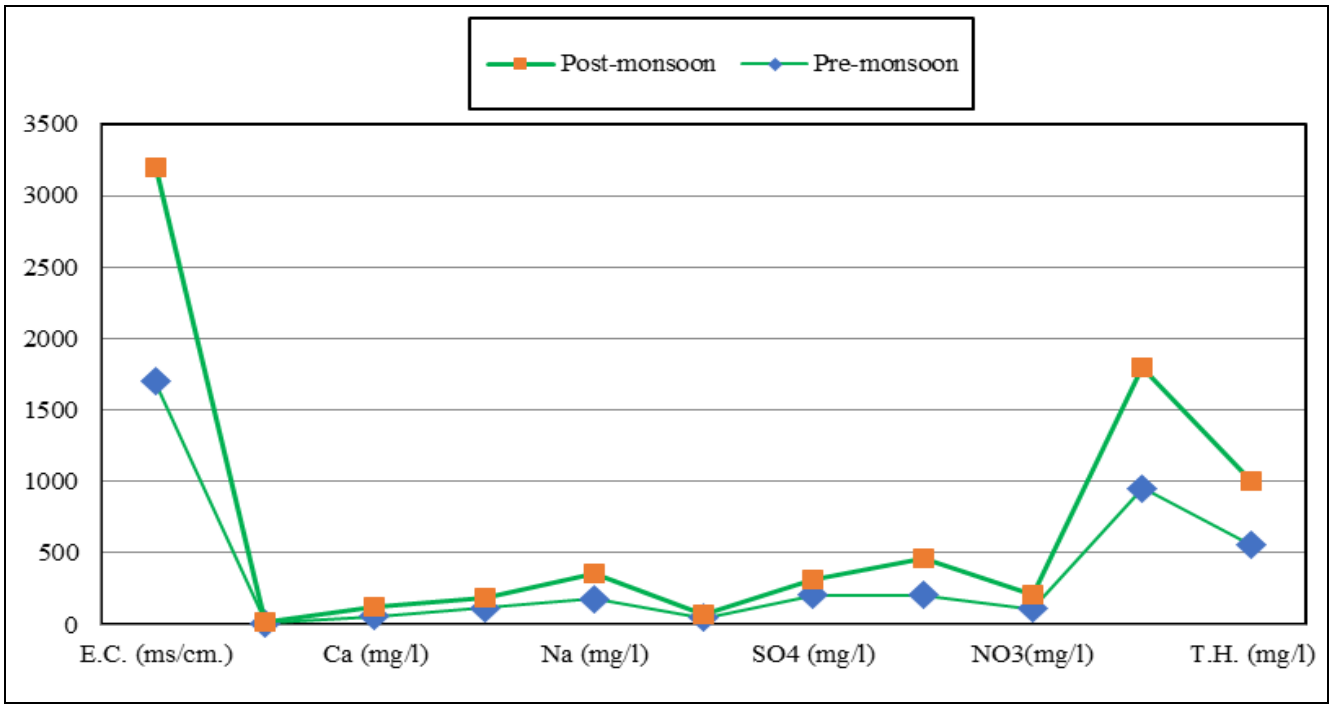
	EC	pH	Ca	Mg	Na	K	SO_4	Cl	NO_3	TDS	TH
EC	1.00										
pH	-0.22	1.00									
Ca	0.56	-0.31	1.00								
Mg	0.81	-0.14	0.47	1.00							
Na	0.75	-0.15	0.36	0.39	1.00						
K	0.06	-0.05	-0.17	0.03	-0.08	1.00					
SO_4	0.81	-0.06	0.68	0.74	0.62	-0.16	1.00				
Cl	0.92	-0.30	0.60	0.82	0.67	-0.71	0.84	1.00			
NO_3	0.57	-0.13	0.30	0.68	0.18	0.07	0.32	0.51	1.00		
TDS	0.99	-0.21	0.60	0.80	0.81	0.05	0.84	0.92	0.57	1.00	
TH	0.83	-0.18	0.69	0.96	0.42	-0.04	0.81	0.85	0.65	0.84	1.00

Table 7: Correlation Coefficient (r) among the various water quality parameters during post-monsoon season.

	EC	pH	Ca	Mg	Na	K	SO_4	Cl	NO_3	TDS	TH
EC	1.00										
pH	-0.32	1.00									
Ca	0.61	-0.26	1.00								
Mg	0.76	-0.17	0.81	1.00							
Na	0.82	-0.25	0.31	0.28	1.00						
K	0.37	-0.26	0.03	0.11	0.41	1.00					
SO_4	0.75	-0.32	0.36	0.59	0.67	0.27	1.00				
Cl	0.86	-0.28	0.72	0.74	0.59	0.22	0.41	1.00			
NO_3	0.59	-0.23	0.48	0.47	0.48	-0.12	0.23	0.67	1.00		
TDS	0.99	-0.31	0.59	0.74	0.84	0.35	0.76	0.86	0.64	1.00	
TH	0.73	-0.22	0.93	0.97	0.24	0.07	0.52	0.77	0.51	0.73	1.00

4.1 Test of significance of the observed correlation coefficients during Pre Monsoon season and Post Monsoon season

In the period of Pre-monsoon season, out of 66 correlation coefficients, 14 correlation coefficients between EC and Total Dissolved Solids (R=0.99), EC and Chloride (R=0.92), EC and TH (R=0.83), EC and Magnesium (R=0.81), EC and Sulphate (R=0.81), Magnesium and Total Hardness (R=0.96), Magnesium and Chloride (R=0.82), Sodium and Total Dissolved Solids (R=0.83), Sulphate and Chloride (R=0.84), Sulphate and Total Dissolved Solids (R=0.84), Sulphate and Total Hardness (R=0.81), Chloride and Total Dissolved Solids (R=0.92), Chloride and Total Hardness (R=0.85), Total Dissolved Solids and Total Hardness (R=0.84) are found to be highly significant level (0.8< r <1.0) and in the period of post – monsoon seasons 08 correlation coefficients between EC and Sodium (R=0.82), EC and Chloride (R=0.86), EC and Total Dissolved solids (R=0.99),Calcium and Magnesium (R=0.81), Calcium and Total Hardness (R=0.93), Magnesium and Total Hardness (R=0.97), Chloride and Total Dissolved Solids (R=0.86), Sodium and Total Dissolved Solids (R=0.84).



Graph 1: Graphics analysis of average physio-chemical parameters during pre and post monsoon seasons at Jaitpur tehsil, district Shahdol

5. Conclusion

Water is indispensable not only for the existence of the mankind but also for human development and healthy functioning of eco-system. The ground water samples taken from five villages (Kamta, Sakhi, Biraudi, Kadaudi and Bhathiya) present in and around Jaitpur tahsil were analysed. The major conclusions derived from this study are as follows. Higher values of EC are recorded in the study area during pre-monsoon (2953 µs/cm) and post monsoon seasons (2583 µs/cm). The pH of water in the study area is found to be alkaline in nature. Based on the Freeze and Cherry classification, the water was found to be freshwater during both the season and nature of the water is hard water. The results of correlation analysis shows that EC and Chloride, EC and TDS, Mg^{2+} and TH, Chloride and TDS are perfectly have strong relationship during pre-monsoon season and during the post monsoon season EC and TDS, Calcium and TH, Magnesium and TH have strong relationship with each other parameters. The results also revealed that most of the parameters of the groundwater quality are well within the permissible limits of WHO standards and the water is good for drinking purpose.

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