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PHYSICO-CHEMICAL CHARACTERISTICS OF GROUNDWATER AROUND SINGRAULI COALFIELD AREAS, SINGRAULI DISTRICT OF MADHYA PRADESH (INDIA)

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ABSTRACT

Groundwater is contaminated around Singrauli coalfield area due to mining and industrial activities. The major cause of the contamination of ground water may be due to improper disposal of industrial waste. The aim of the present study was to assess the groundwater quality and also to have a statistical analysis of physicochemical parameters of groundwater around Singrauli coalfield region, Singrauli District of Madhya Pradesh (India).Eight groundwater samples were collected from the hand pump & Dug-wells located around Singrauli coalfields area during pre-monsoons and post monsoons seasons in the year 2018and analyzed for physicochemical parameters such aspH, TDS, EC, DO, Fluoride, Chlorides, Nitrate, Sulphate, Lithium, Sodium, Potassium, Magnesium and Calcium.A systematic calculation of the correlation coefficient has also been carried out between different analyzed parameters.
Keywords: Physicochemical Parameters, Correlation Co-efficient, Groundwater, Coalmines.

INTRODUCTION

Groundwater is one of the most significant water resources in India for drinking, domestic, irrigation and industrial uses. According to the WHO organization, about 80% of all the diseases in human beings are caused by water[1]. About 80% of the rural domestic water supply and 45% of the irrigation water supply in the country are met by the groundwater resources[3-4].Availability and occurrence of groundwater depends on the rainfall and recharge conditions of the area. Groundwater quality comprises the chemical, physical and biological characteristics of groundwater. The suitability of groundwater for various uses majorly depends on the quality of groundwater[2].Mining activity significantly affects the local environmental system in various ways, including land subsidence, lowering the groundwater table, Ground and Surface water quality and mine gas emissions. Open cast coal mining activities disturb the hydro-geological system and result in physical, chemical and environmental changes often resulting in pollution of both surface and groundwater[5].Degradation of the quality of water in the Singrauli coalfield due to toxic pollutants, acid mine drainage and disturbance in Hydrology.The present study was carried out to determine the physicochemical characteristics of groundwater during the pre and post- monsoon seasons in the study area and compared the results with WHO drinking water quality standards[6].Global Positioning System (GPS) was used to identify the sample location of groundwater around Singrauli coalfield area.

Study Area
The study area lies partly in Singrauli district of Madhya Pradesh and partly in Sonebhadra District of Uttar Pradesh[5].The study area bounded by the coordinates 24°00' to 24°15'N latitudes and 82°30' to 82°45'E longitudes[7].The climate of the study area is tropical monsoonal with extreme temperatures ranging from 47.2 to 6°C during summer and winter, respectively. Annual average rainfall in the study area is 1,119.65 mm. The study area is part of the Son-Rihand basin and the major streams draining the area are Matwani, Mayar, Mehrauli, Kachan, Bijul and Baliya nala. The drainage pattern of the study area

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is Dendritic drainage pattern developed which is totally controlled by topography and lithology.This coalfield stands as a high plateau over the surrounding plains covered by Talchir sediments.The Barakar sediments project over the Talchir outcrops as scarp faces. The Singrauli plateau rises to a height of over 500m above M.S.L.Location map of the study area are shown in Fig-1.
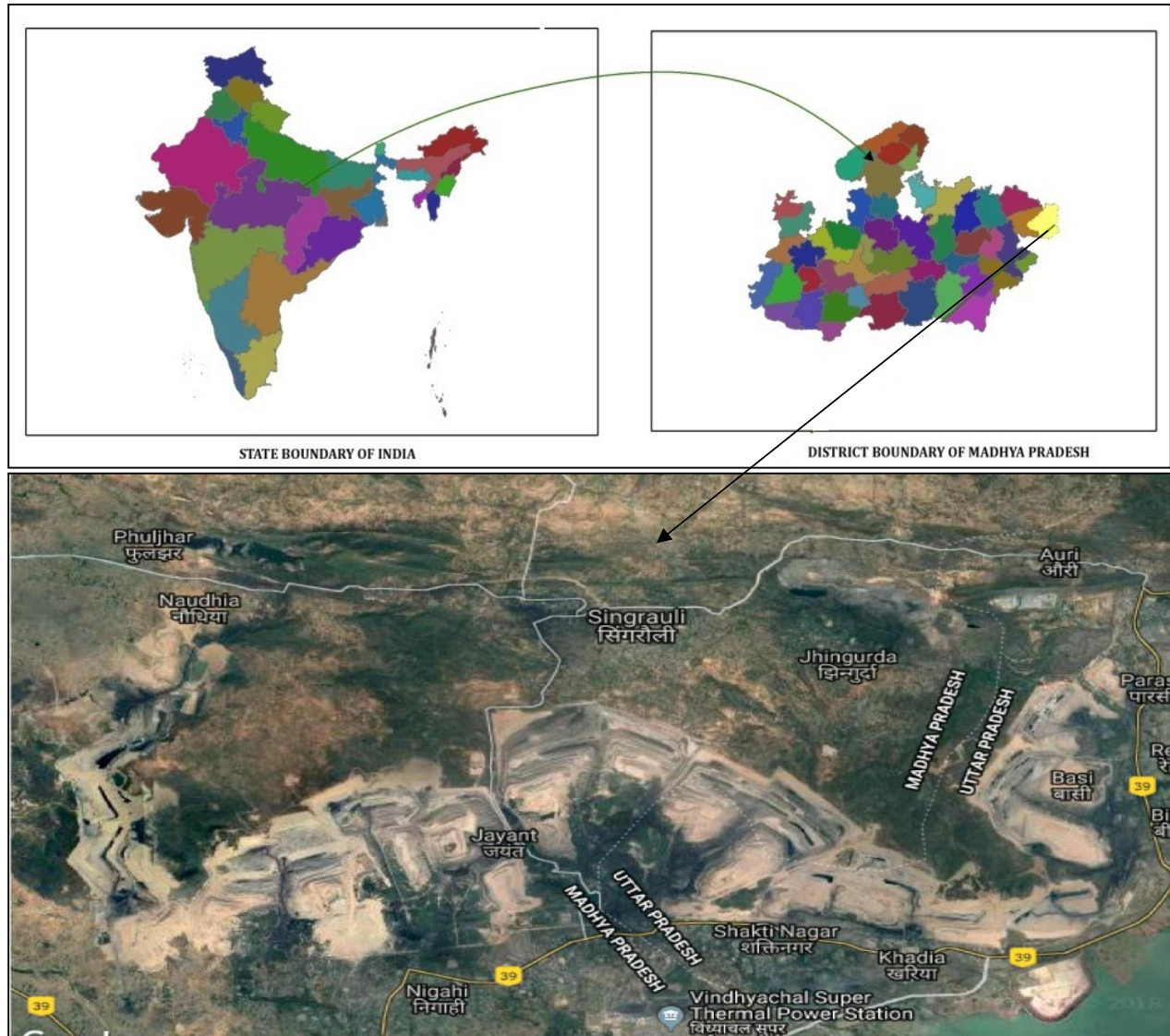

Fig.-1: Location Map of the Study Area

Table-1: Details of Sampling Locations of the Study Area

S.No.	Sample Code	Type of Water	Latitude(N)	Longitude(E)
1.	GW1	Hand Pump	24º12'15"	82º39'32"
2.	GW2	Hand Pump	24º11'25"	82º38'57"
3.	GW3	Hand Pump	24º07'29"	82º40'45"
4.	GW4	Dug Well	24º06'47"	82º37'06"
5.	GW5	Hand Pump	24º05'04"	82º39'29"
6.	GW6	Hand Pump	24º07'29"	82º40'44"
7.	GW7	Dug Well	24º07'08"	82º42'29"
8.	GW8	Dug Well	24º09'22"	82º46'07"

EXPERIMENTAL

Sampling Techniques

Groundwater Samples were collected in Polythene bottles of 1.0 liter. In the present investigation, groundwater samples were collected from the Dug-wells and hand pumps of Eight different stations around Singrauli coalfields region during pre-monsoon and post-monsoon seasonsin the year 2018(Fig.-2).It was ensured that the concentrations of various water quality parameters do not changes in time that elapse between the drawing of samples and the analysis in the laboratory.Groundwater samples wereimmediately transferred to the laboratory for the physicochemical analysis.The various water quality parameters such as pH, electrical conductivity, dissolved oxygen and total dissolved solids wereanalyzed at the sampling station by using the Multiparameterapparatusand other parameters like Fluoride, Chlorides, Nitrate, Sulphate, Lithium, Sodium, Potassium, Magnesium and Calcium were analyses in the laboratory.The details of sampling location along with their latitude and longitude are given in Table-1.

Fig.-2: Water Sampling of the Study Area

RESULTS AND DISCUSSION

The collected groundwater sample was analyzed in the laboratory for various water quality parameters viz. pH, TDS, EC, DO, Fluoride, Chlorides,Nitrate,Sulphate,Lithium,Sodium,Potassium,Magnesiumand Calcium.The physicochemical characteristics of the analyzed water sample of pre-monsoon and post-monsoon seasons have been presented in Table-2 & Table-5.Various statistical analysis of the experimental data was performed using Microsoft Excel 2016. The statistical analysis of physico

chemical parameters of groundwater quality of Singrauli coalfield region during the pre-monsoon and post-monsoon seasons is presented in Table-3 and Table-6.

pH
The pH value of groundwater samples varied between 7.18 to 7.98 during pre-monsoon and 6.85 to 7.34 during post-monsoon seasons. The sampling points-GW-3 showed high pH value in the pre-monsoon seasons.

Total Dissolved Solids (TDS)
Total dissolved solids (TDS) is the term used to describe the inorganic salts and small amounts of organic matter present in solution in water.In the present study TDS value ranged from 146 mg/l to 467 mg/l in the pre-monsoon season and 109 mg/l to 382 mg/l during post-monsoon season. The sampling points-GW-5 showed high TDS value in both monsoons.

Electrical Conductivity (EC)
Electrical conductivity (EC) is a measure of water capacity to convey electric current[12]. Electrical conductivity was found to be very high and ranges from 248- 933μs/cm in the pre-monsoon season and 212 – 831 μs/cm during post monsoon.The sampling points-GW-4, 5,6,7,8 showed high EC value in the pre-monsoon seasons and GW-5, 6, 7, 8 during post-monsoon.

Dissolved oxygen (DO)
The concentration of Dissolved oxygen of groundwater sample ranges (4.98-5.72) mg/l in the pre-monsoon season and (5.02-5.72) mg/l during post monsoon.

Fluoride (F^-)
Fluoride is a geochemical contaminant and natural sources account for most of the fluoride in surface and ground water. Its concentration is dependent on the solubility of fluoride-containing rocks. Intake of excess fluoride causes skeletal and dental fluorosis[8].Fluoride content of the study area is ranged from 0.342 mg/l to 0.958 mg/l in the pre-monsoon season and 0.314 mg/l to 0.701 mg/lduring post monsoon.

Chlorides (Cl^-)
Chloride is the most important parameter in assessing the water quality and higher concentration of chloride indicates a higher degree of organic pollution[5]. The concentration of Chlorides ion of groundwater sample ranges from (10.312-192.433) mg/l in the pre-monsoon season and (08.241-161.712) mg/l during post monsoon. The sampling points-GW-5 showed high Chlorides value in both monsoons.

Nitrate (NO_3^-)
The nitrate content of the groundwater samples ranges from (0.773 to 39.560) mg/lin the pre-monsoon season and (0.697to 32.743)mg/l during post monsoon.

Sulfate (SO_4^{-2})
The sulfate concentration of the groundwater samples varied between (5.947 to 95.246) mg/l in the pre-monsoon season and (5.242to 79.479) mg/lduring post-monsoon of the study area.

Lithium (Li^+)
The Lithium concentration of the groundwater samples varied between (0.069to 0.086) mg/l in the pre-monsoon season and (0.069 to 0.084) mg/lduring post monsoon.

Sodium (Na^+)
The concentration of Sodium ion of groundwater sample ranges (8.754-117.452) mg/lin the pre-monsoon season and (6.283 to 98.197) mg/lduring post monsoon. The permissible limit of magnesium is 70 mg/l.

Potassium (K^+)
Potassium content in the groundwater samples of the study area varied from (0.316to 5.294) mg/l in the pre-monsoon season and (0.259 to 4.178) mg/lduring post monsoon. Increase concentration of sodium and potassium may be seen in the groundwater of the mining area in comparison to the non-mining area.

Magnesium (Mg^{+2})
Potassium content in the groundwater samples of the study area varied from (0.316to 5.294) mg/l in the pre-monsoon season and (0.259 to 4.178) mg/lduring post-monsoon. Geochemistry of magnesium is quite similar to that of calcium.

Calcium (Ca^{+2})
The concentration of calcium ion of groundwater sample of the study area varied from (18.481-91.855)mg/lin the pre-monsoon season and (12.241-61.415) mg/l during post-monsoon. The acceptable limit of calcium is (75-200) mg/l, as per (WHO) recommendations. The sampling points-GW-6 showed high Calcium value in both monsoons.

Table-2: Physico-Chemical Parameters of Water Samples of Singrauli Coalfield During Pre-monsoon Season (2018).

Sample Code → / Parameter ↓	GW- 1	GW-2	GW-3	GW-4	GW-5	GW-6	GW-7	GW-8
pH	7.18	7.82	7.98	7.52	7.64	7.46	7.68	7.68
TDS	282	146	162	260	467	312	228	272
EC	456	248	272	319	933	619	453	523
DO	5.58	4.98	5.72	5.42	5.46	5.48	5.12	5.38
Fluoride	0.342	0.482	0.958	0.546	0.520	0.621	0.907	0.552
Chlorides	75.646	24.51	15.825	28.296	192.433	29.891	19.842	10.312
Nitrate	5.926	6.392	10.180	39.560	14.426	24.716	0.773	0.902
Sulphate	35.725	9.546	26.925	15.247	95.246	5.947	27.523	11.122
Lithium	0.070	0.080	0.070	0.084	0.086	0.079	0.073	0.069
Sodium	64.35	23.158	19.697	18.109	117.452	19.357	24.432	8.754
Potassium	5.294	1.784	0.316	4.182	1.869	2.107	1.113	2.476
Magnesium	21.185	9.468	4.581	17.686	19.825	18.592	11.512	5.876
Calcium	18.481	15.828	58.925	29.820	91.855	72.315	59.125	18.674

All parameters are given in mg/l, excluding pH and Electrical conductivity (µS/cm).

Table-3: Summary of Statistics of Groundwater parameter during pre-monsoon season.

Parameter	Min	Max	Mean	Median	S.D	Permissible limit by WHO and BIS
pH	7.18	7.98	7.62	7.66	0.2409	6.5-8.5
TDS	146	467	266.125	266	99.6457	500
EC	248	933	477.875	454.5	223.8165	300
DO	4.98	5.72	5.3925	5.44	0.2390	>5
Fluoride	0.342	0.958	0.616	0.549	0.2114	1.5
Chlorides	10.312	192.433	49.594	26.403	61.0869	250
Nitrate	0.773	39.560	12.859	8.286	13.3207	45
Sulphate	5.947	95.246	28.410	21.086	28.92386	150
Lithium	0.069	0.086	0.0763	0.076	0.06739	----
Sodium	8.754	117.452	36.913	21.427	36.51892	200
Potassium	0.316	5.294	2.392	1.988	1.616999	15
Magnesium	4.581	21.185	13.590	14.599	6.550172	30
Calcium	15.828	91.855	45.627	44.372	28.80853	75

Note: Min-Minimum, Max-Maximum, SD-Standard deviation

The correlation coefficients (r) among the various groundwater quality parameters of Singrauli coalfields for the pre-monsoon and post-monsoon seasons have been calculated and the numerical values are tabulated as shown in Table-4 and Table-7.

612

Table-4: Correlation Matrix of Groundwater Quality Parameters (Pre-Monsoon Season).

	pH	TDS	EC	DO	F⁻	Cl⁻	NO₃⁻	SO₄⁻²	Li⁺	Na⁺	K⁺	Mg⁺²	Ca⁺²
pH	1												
TDS	-0.435	1											
EC	-0.283	0.953	1										
DO	-0.197	0.277	0.182	1									
F⁻	0.658	-0.366	-0.228	0.083	1								
Cl⁻	-0.239	0.839	0.802	0.197	-0.374	1							
NO₃⁻	-0.231	0.219	0.005	0.261	-0.145	0.057	1						
SO₄⁻²	-0.049	0.741	0.730	0.234	-0.111	0.945	-0.082	1					
Li⁺	-0.035	0.472	0.370	-0.237	-0.288	0.524	0.663	0.373	1				
Na⁺	-0.279	0.773	0.740	0.202	-0.368	0.984	-0.045	0.948	0.418	1			
K⁺	-0.866	0.226	-0.009	0.167	-0.785	0.128	0.315	-0.051	0.054	0.161	1		
Mg⁺²	-0.822	0.666	0.510	0.165	-0.576	0.598	0.481	0.401	0.525	0.598	0.646	1	
Ca⁺²	0.169	0.582	0.675	0.275	0.432	0.541	0.175	0.599	0.389	0.486	-0.515	0.253	1

Table-5: Physico-Chemical Parameters of Water Samples of Singrauli Coalfield During Post-monsoon Season (2018).

Sample Code ⟶ / Parameter ↓	GW- 1	GW-2	GW-3	GW-4	GW-5	GW-6	GW-7	GW-8
pH	7.09	6.85	7.12	7.25	7.21	7.12	7.24	7.34
TDS	256	109	128	183	382	274	191	278
EC	432	212	198	285	831	549	325	417
DO	5.12	5.02	5.98	5.72	5.61	5.48	5.04	5.42
Fluoride	0.314	0.389	0.647	0.385	0.471	0.529	0.701	0.459
Chlorides	69.258	21.32	11.142	22.729	161.712	21.227	16.142	08.241
Nitrate	4.821	4.852	7.971	32.743	11.874	19.617	0.697	0.713
Sulphate	31.358	7.297	21.417	12.925	79.479	5.242	23.478	10.254
Lithium	0.069	0.070	0.070	0.070	0.084	0.070	0.070	0.070
Sodium	56.21	19.673	13.549	13.824	98.197	13.719	19.852	6.283
Potassium	4.178	1.249	0.259	3.271	1.247	1.847	0.986	1.879
Magnesium	18.451	7.917	3.463	11.493	13.549	13.253	09.741	3.651
Calcium	16.32	12.241	43.571	22.467	81.174	61.415	48.967	16.419

All parameters are given in mg/l, excluding pH and Electrical conductivity (μS/cm).

Table-6: Summary of Statistics of Groundwater Parameter during Post-monsoon Season.

Parameter	Min	Max	Mean	Median	S.D	Permissible limit by WHO and BIS
pH	6.85	7.34	7.152	7.165	0.1479	6.5-8.5
TDS	109	382	225.125	223.5	89.9244	500
EC	212	831	406.125	371	208.3859	300
DO	5.02	5.72	5.423	5.45	0.3459	>5
Fluoride	0.314	0.701	0.4868	0.465	0.1331	1.5
Chlorides	08.241	161.712	41.471	21.273	52.1848	250
Nitrate	0.697	32.743	10.411	6.4115	10.9683	45
Sulphate	5.242	79.479	23.931	17.171	24.14666	150
Lithium	0.069	0.084	0.071	0.070	0.0050	----
Sodium	6.283	98.197	30.163	16.748	31.4121	200

613

Potassium	0.259	4.178	1.8645	1.548	1.2784	15
Magnesium	3.463	18.451	10.189	10.617	5.1267	30
Calcium	12.241	81.174	37.821	33.019	25.0823	75

Note: Min-Minimum, Max-Maximum, SD-Standard deviation

Table-7: Correlation Matrix of Groundwater Quality Parameters (Post-monsoon Season).

	pH	TDS	EC	DO	F^-	Cl^-	NO_3^-	SO_4^{-2}	Li^+	Na^+	K^+	Mg^{+2}	Ca^{+2}
pH	1												
TDS	0.501	1											
EC	0.310	0.958	1										
DO	0.353	0.073	0.074	1									
F^-	0.265	-0.172	-0.128	0.212	1								
Cl^-	0.049	0.728	0.829	0.066	-0.268	1							
NO_3^-	0.124	0.039	0.085	0.518	-0.254	0.042	1						
SO_4^{-2}	0.191	0.655	0.741	0.159	-0.014	0.946	-0.077	1					
Li^+	0.167	0.686	0.810	0.240	-0.011	0.904	0.068	0.909	1				
Na^+	-0.014	0.672	0.770	-0.026	-0.266	0.986	-0.055	0.943	0.841	1			
K^+	0.092	0.214	0.080	-0.229	-0.772	0.100	0.338	-0.082	-0.244	0.133	1		
Mg^{+2}	-0.123	0.454	0.498	-0.318	-0.472	0.548	0.287	0.370	0.216	0.593	0.683	1	
Ca^{+2}	0.234	0.560	0.703	0.341	0.513	0.567	0.148	0.631	0.714	0.512	-0.455	0.194	1

Test of Significance of the Observed Correlation Coefficient
The correlation coefficient study is very useful to determine a predictable relationship which can be exploited in practice. It is used for the measurement of the strength and statistical significance of the relation between two or more water quality parameters. Hence, it is a helpful tool for the promotion of research activities[9-10].

In Pre-monsoon
In the period of Pre-monsoon season, out of 91 correlation coefficients,25 negative and 66 positive correlation coefficients. InTable-4, the highly positive correlation is observed between EC and TDS (0.953), Na^+ and SO_4^{-2}(0.948),$SO_4^{-2}$and Cl^- (0.945).where highly negative correlation is observed between K^+ and pH (-0.866),Mg^{+2} and pH (-0.822), K^+ and F^- (-0.785).Very poor positive correlation was observed between K^+ and Li^+(0.054), F^- and DO (0.083), K^+ and Cl^- (0.128),$Mg^{+2}$and DO (0.165),K^+ and DO(0.167),Ca^{+2} and pH (0.169),Ca^{+2} and NO_3^- (0.175), DO and EC (0.182), Cl^- and DO (0.197).while, there is almost no correlation was observed between NO_3^- and EC(0.005).

In Post-monsoon
In the period of Post-monsoon season, out of 91 correlation coefficients,19 negative and 72 positive correlation coefficients. In Table-7, the highly positive correlation is observed between Na^+ and Cl^- (0.986), EC and TDS (0.958), SO_4^{-2} and Cl^- (0.946),Na^+ and SO_4^{-2} (0.943), Li^+ and SO_4^{-2} (0.909), Li^+ and Cl^- (0.904).where highly negative correlation is observed between K^+ and F^- (-0.772), Mg^{+2} and F^- (-0.472). Very poor positive correlation was observed betweenNO_3^- and TDS (0.039), NO_3^- and Cl^- (0.042), Li^+ and NO_3^- (0.068), DO and TDS (0.073), DO and EC (0.074), K^+ and EC(0.080), NO_3^- and EC(0.085), K^+ and pH (0.092),While, there is almost no correlation was observed between Li^+ and F^- (-0.011).

CONCLUSION

In the present study,the ground water samples taken from eight villages present in and around Singrauli coalfield area were analyzed.The correlation of 13 physicochemical parameters of groundwater of the study area revealed that all the parameter were more or less correlated with one another. The groundwater

of the study area is alkaline in nature.EC found above maximum permissible limit prescribed by BIS in the pre-monsoon (933 μS/cm) and post-monsoon (831μS/cm).From correlation analysis it was observed that very strong correlation exit between EC and TDS (0.953), Na^+ and SO_4^{-2} (0.948), SO_4^{-2} and Cl^- (0.945) during pre-monsoon season and Na^+ and Cl^- (0.986), EC and TDS (0.958), SO_4^{-2} and Cl^- (0.946),Na^+ and SO_4^{-2} (0.943), Li^+ and SO_4^{-2} (0.909), Li^+ and Cl^- (0.904) during post-monsoon. The analysis shows that the groundwater of the study area needs some treatment before its consumption.

ACKNOWLEDGMENT

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