



Assessment of Ground Water Quality in Umaria District, Vindhya Pradesh, India

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ABSTRACT

The Physico-chemical analysis of ground water samples from eight hand pumps in 3 tehsil, 2 crop field and 3 village place of the Umaria district under Vindhya Pradesh, M.P. India results indicated that during the seasons (rainy, winter and summer). The samples were analyzed for temperature, pH, turbidity, DO, BOD, COD, nitrate, nitrite, chloride, sulphate, phosphate and heavy metals. The ground water samples from all the location in the Umaria District are found to be within the prescribed limits as physico-chemical characteristics are concerned except sulphates concentration. The content of Cd and Cu in the analyzed water samples were below the permissible limit set by BIS (1992) as 1.5 and 0.01 mg L⁻¹. The mean values of each parameters together with its standard deviation (SD) and coefficient variation (CV) were calculated. The present study deals with the various relationship derived statistically by calculation 'r' and 't' among the physico-chemical parameters.

Keywords: Umaria District, diffuse pollution, ground water, heavy metals, t - test, Vindhya Pradesh.

INTRODUCTION

The quality of ground water is highly related with the local environmental and geological conditions. The quality of soil and rock and the water table determines the quality of ground water. The ground water source levels change by the regular withdrawal and hence the quality of ground water reported seasonal as well as annual change in the ground water quality [1-4]. Ground water is a part of hydrological cycle and 50% of the world's population depends on ground water for their drinking purposes. Due to anthropogenic activities such as urban development industrialization, agricultural runoffs, domestic activities leads to wastes disposal and discharges, chemical spills and even individual house hold sewage systems have coursed significant ground water contamination in areas that previously had clean potable ground water. The Vindhya Pradesh plateau is environmentally very important to understand the rich Indian biodiversity and diffuse chemical pollution. Umaria District is located to the north east of Madhya Pradesh. Mathematically the co-ordinates of the district extent from 23^o 38' to 24^o20' North and 80^o28' to 82^o12' east. It has geographical area of 4548sq km this district has extensive forests. About 42% of the total area is covered by forests only. The district is rich in minerals. The most important mineral found in the district

is coal and as a result 8 mines are being operated by south eastern coal field limited in the district. The famous bandhogarh National Park (Tala) and sanjay Gandhi Thermal Power Station Mangthar(Pali) are located in the district. (Census- 2011)

Watershed management for any city requires the estimation of both point and non-point sources of water pollution. An effective land-use planning plays a crucial role in efficient management of water resources of any area. Both diffuse and point source pollution is dependent upon the land use pattern of a city. The total amount of runoff generated from an area depends upon the land use type of that area. High impervious area in a city results in more runoff generation thereby allowing more pollutants to enter into the surface water bodies directly and indirectly. Similarly the point source pollution of water is also dependent upon the land use pattern of the city. Densely populated city like National Capital Territory (NCT) of India will generate more domestic sewage. Also, urban runoff on percolation results in salinization of the groundwater [5]. The poor quality of surface waters can also be attributed to the runoff generated from both dry and wet weather [6-9]. Different factors contributing to the quality of urban runoff have been studied and it has been concluded that surface water quality is indeed affected by urbanization and industrialization [10-14].

MATERIALS AND METHODS

Eight sampling locations consisting of bore wells and hand pumps were selected in the study area. Sampling was done during summer, rainy and winter seasons (of year 2009 to 2010). The month of April-May, July-August and December-January, were selected as representative month of summer, rainy and winter seasons respectively. Sampling was done in accordance with grab sampling methods in polyethylene bottles of one liter capacity. To avoid leaching of metals and interaction with the surface wall of the container, bottles were first cleaned with detergent and then with 1:1 HNO₃ for 24 hours. Finally bottles were cleaned and rinsed with the distilled water. During sampling bottles were rinsed two to three times with the sample to be examined before finally filling with it. Samples were collected by immersing the rinsed bottles in river water [15,16]. During sampling from hand pumps and bore wells, the water pumped to waste for about five minutes and sample was collected directly. All the samples were refrigerated at 4°C in the laboratory [15-17], and procedures were followed as per the standard methods [18,19], and different physicochemical parameters like, temperature, pH, turbidity, dissolved oxygen, BOD, COD, nitrate, nitrite, chloride, sulphate, phosphate and heavy metal were analyzed. The digested samples were analyzed for heavy metals using Atomic Absorption Spectrophotometer. The locations of sampling stations are shown in figure 1.

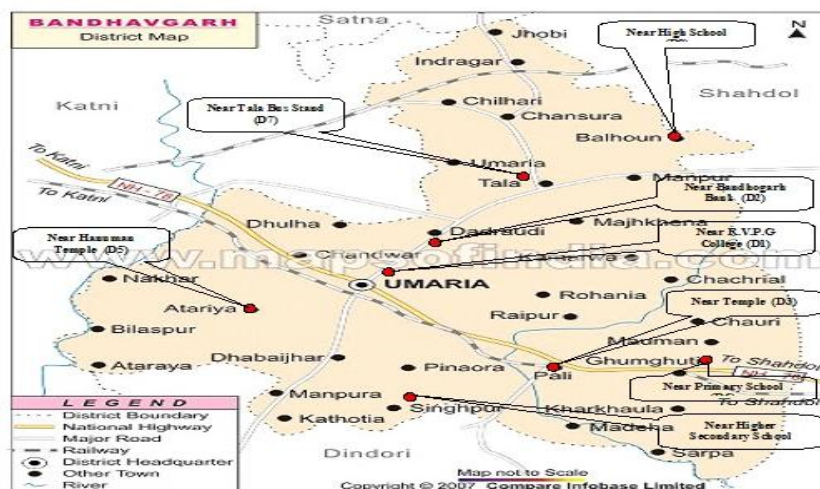


Figure 1 Sampling locations of Umaria District

The coefficient of variation (CV) was determined using the formula-

$$CV = \frac{SD}{Average} \times 100$$

Where CV = coefficient of variation, SD = Standard Deviation.

The correlation coefficient 'r' was calculated using the equation

$$r = \frac{\sum xy - \sum x \cdot \sum y}{\sqrt{(\sum x^2 - (\sum x)^2/n) (\sum y^2 - (\sum y)^2/n)}} \times 100$$

where x and y represents two different parameters.

The t- test (t) was calculated by using the following formula-

$$t = \frac{r}{\sqrt{1 - r^2}} \sqrt{n - 2}$$

at degree of freedom = n - 2

RESULTS AND DISCUSSION

In the present study ground water samples were collected from Umaria District. These water samples were subjected for the analysis of parameters like temperature, pH, turbidity, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), nitrates, nitrites, sulphates chlorides, phosphates and heavy metals like lead, cadmium, nickel, Iron, chromium and copper

Ground water samples collected from 8 different location, and analyzed for the physicochemical characteristics, correlation coefficient and heavy metal content in it. The physicochemical characteristics of the ground water sample of Umaria during the three seasons are presented in **table 1**. Heavy metals concentrations in the ground water samples of Umaria District in different seasons and average values with their standard deviation are presented in **tables 3 and 4**. The graphical representation of average individual metals concentrations from different location are depicted in **figures 2a and 2b**.

Characteristics of ground water samples of Umaria District: Ground water samples were collected from eight different locations in Umaria District, the details of the locations are depicted in the **Figure 1**. The ground water samples were collected during the three seasons (Monsoon, winter and summer) to know the seasonal variation in characteristics. The physicochemical characteristics of the ground water sample of Umaria during the three seasons are presented in **Tables 1**.

The mean values of eleven parameters of ground water analyzed in eight station together with their SD and CV are presented in **Table 1**. The water temperature averaged 27.21⁰C which was lower than the average value of ground water of Singhpur (27.7⁰C) at location D₅ and higher than those of Bandhogarh (27.1⁰C) at location D₂ in Umaria District during monsoon season.

pH was ranging from 6.5-7.9 within mean value of 7.162 . WHO (1984) prescribed the desirable limit of pH range between 7 and 8.5. The turbidity of water was found to be 1.6-3.8 NTU and the mean value was 2.287 NTU. Dissolved oxygen was ranging from 1.8-5.3 with an mean value of 3.125. The mean values of BOD and COD in the ground water of Umaria District during monsoon season were 3.2mg L⁻¹ and 7.671mg L⁻¹ respectively. The BOD and COD values observed in the present study were well within the limit (6.0mg L⁻¹ for BOD and 10mg L⁻¹ for COD) prescribed by WHO for drinking water. The CV values of temperature (1.2), pH (6.5), turbidity (31.3), dissolved oxygen (40.6), BOD (9.7) and COD (11.5) showed wide fluctuation of there for relation of these parameters did not occur between stations. The nitrates and nitrites values observed in the present study were well within the permissible limit. The chloride ion concentration is used as an important parameter for detection of extent of contamination. The concentration of chloride ions varied from 15-152mg L⁻¹, which was found lowest in R.V.P.S College Umaria at location D₁ highest in Bandhogarh Samples at location D₂.

It was found that amount of sulphate ranged from 5.0-398mg L⁻¹. Values of sulphates at Atariya (398) Chumghouti (268) and Tala (278) are higher than the permissible limit prescribed by WHO and BIS. The

phosphates content of water was found to be 0.04-1.0mg/l. the highest value of 1.0mg L⁻¹ was recorded at location D₈ while the minimum value 0.04mg/l was recorded at location D₆ as show in the **table -1**. Value of phosphate at Umaria (0.27) Bandhogarh (0.25), Pali (0.28), Singhpur (0.95) and Balhon (1.0) mg L⁻¹ are higher than permissible limit prescribed by WHO and BIS. The CV values of nitrites (60.1), sulphates (79.5), chlorides (103.8), phosphates (95.9) indicated their significant variation from one station to another.

The correlation coefficient (r) among various water quality parameters are given in **table-1a**. The temperature of ground water during monsoon showed positive relationship with pH, BOD, COD, nitrites, sulphates, chlorides and negative relationship with turbidity, DO, nitrates and phosphates. The pH of the ground water showed significant positive relationship between temperature, turbidity, DO, BOD, nitrates, sulphates and chlorides and negative relationship with COD, nitrites and phosphates. Turbidity showed significant positive relationship pH, BOD, COD, nitrites and chlorides and negative relationship with temperature, DO, nitrates, sulphates and phosphates.

Dissolved oxygen (DO) showed positive relationship with pH, BOD, COD, nitrite, chlorides, phosphates and negative relationship with temperature, turbidity, nitrates and sulphates. Biochemical oxygen demand (BOD) showed positive relationship with temperature, pH, turbidity, COD, nitrites, sulphates and chlorides and negative relationship with DO, nitrates and phosphates. Chemical oxygen demand (COD) showed positive relationship with temperature, turbidity, BOD, nitrites, chlorides and phosphates and negative relationship with pH, DO, nitrates and sulphates. Nitrates showed significant positive relationship with pH, DO and phosphates and negative relationship with temperature, turbidity, BOD, COD, nitrites, sulphates and chlorides. Nitrites showed positive relationship with temperature, turbidity, BOD, COD and phosphates and negative relationship with pH, DO, nitrates, sulphates and chlorides. Sulphates showed significant positive relationship with temperature, pH and BOD, and negative relationship with turbidity, DO, COD, nitrates, nitrites, chlorides and phosphates. Chlorides showed significant positive relationship with temperature, pH, turbidity, BOD, COD and negative relationship with DO, nitrates, nitrites, sulphates and phosphates. Phosphates showed significant positive relationship between ground water DO, COD, nitrates, nitrites and negative relationship with temperature, pH, turbidity, BOD, sulphates and chlorides.

The various relationship during statistically by calculation 'r' and 't', among the physicochemical characteristics the r value was negative 28 times and positive 27 times showed that positive relationship in the present study. During monsoon season, correlated different parameter each other statically which shows great variation negative to positive for 1% significant value (3.148) and 5% significant value (1.948). In case of COD and turbidity, nitrates and DO and sulphates and temperature we established a relationship which were positive and values were 2.45, 1.9 and 2.04 respectively which was grater than 5% significant level. While DO and temperature, phosphate and COD shows negative relationship i.e - 3.128 and -2.906 respectively with each other at 1% significant level. It showed that COD, turbidity, nitrates, DO, sulphates, temperature, nitrites play major role in the physico-chemical characteristics of ground water of Umaria District during monsoon season.

The mean values of eleven parameters of ground water analyzed in eight station together with their SD and CV are presented in **table-1**. The water temperature averaged 22.96⁰C which was lower than those of Balhoun (24.8⁰C) at location D₈ and higher than those of Pali (20.7⁰C) at location D₃ in Umaria District during winter season. pH was ranging from 6.5-7.8 with an mean value of 7.2, WHO (1984) prescribed the desirable limit of pH range between 7 and 8.5 mg/l. The turbidity of water was found to be 1.0-3.0 NTU and the mean value was 2.287 NTU. Dissolved oxygen was ranging from 1.6-5.1 with an mean value of 3.125mg/l. The mean values of BOD and COD in the ground water of Umaria District during winter season were 3.0mg/l and 7.171mg/l respectively. The BOD and COD values observed in the present study were well within the limit prescribed by WHO for drinking water. The CV values of temperature (6.1), pH (6.5), turbidity (44.1), dissolved oxygen (44.1), BOD (10.2) and COD (11.9) showed wide fluctuation of

there for relation of these parameters did not occur between stations. In the case of nitrates, nitrites, sulphate and chloride, the mean values were recorded as 3.988, 1.918, 114.375 and 49.013 mg L⁻¹ and all the results are within the permissible limit. The phosphates content of water was found to be 0.04-1.0mg/l. the highest value 1.0 mg L⁻¹ was recorded at location D₈ as show in the **table-1**. Values of phosphate at Umaria(0.27) Bandhogarh (0.25), Pali(0.28) Singhpur(0.95) and Balahoun ((1.0) mg/l are higher than the permissible limit. The high coefficient variation values of Chloride (104.2) and phosphates (95.9) indicated their significant variation from one station to another.

The correlation coefficient (r) among various water quality parameters and given in **table -1a**. The temperature of ground water in Umaria District during winter showed positive relationship with pH, dissolved oxygen, COD, nitrates and sulphates, and negative relationship with turbidity, BOD, nitrites, chlorides and phosphates. The pH of the ground water showed significant positive relationship between temperature, turbidity, BOD, nitrates, sulphates and chlorides and negative relationship with DO, COD, nitrites and phosphates. Turbidity showed significant positive relationship with pH, BOD, COD, chlorides and phosphates and negative relationship with temperature, DO, nitrates, nitrites and sulphates.

Dissolved oxygen (DO) showed positive relationship with temperature, nitrates and phosphates and negative relationship with pH, turbidity, BOD, COD, nitrites, sulphates and chlorides. Biochemical oxygen Demand (BOD) showed positive relationship with pH, turbidity, nitrates, nitrites, sulphates and chlorides and negative relationship with temperature, DO, COD and phosphates. Chemical oxygen demand (COD) showed positive relationship with temperature, turbidity, nitrites, chlorides and phosphates and negative relationship with pH, DO, BOD, nitrates and sulphates. Nitrates showed significant positive relationship with temperature, pH, DO, BOD and phosphates and negative relationship with turbidity, COD, nitrites, sulphates and chlorides. Nitrites in present investigation showed positive relationship with BOD, COD and phosphates and negative relationship with temperature, pH, turbidity, DO, nitrates, sulphates and chlorides. Sulphates showed significant positive relationship with temperature, pH, BOD and negative relationship with turbidity, DO, COD, nitrates, nitrites, chlorides and phosphates. Chlorides showed significant positive relationship with temperature, pH, turbidity, BOD, COD and negative relationship with DO, nitrates, nitrites, Sulphates and phosphates.

The present study deals with the various relationship derived statistically by calculation 'r' and 't' among the physicochemical characteristics, the r value was negative 30 times and positive 25 this showed positive relationship in the present ground water studied. During winter season, we have investigated the different physico-chemical characteristics of ground water of Umaria district and stabilized the correlation by using ANOVA statistical software. The table value of 5% significant level were 1.948 and at 1% significant level were 3.148. In case of DO and temperature, BOD and pH, nitrates and DO, Nitrites and BOD and nitrites and COD we established a correlation ship which were positive and values were 2.448, 2.646, 2.770, 2.453 and 2.176, while nitrate and COD, chloride and sulphate, and phosphate and pH shows negative relationship i.e -2.151,-1.941 and 2.248 respectively with each other at 5% significant level. For chloride and turbidity we have found positive value of co-relationship at 1% significant level i.e 4.412. It showed that DO, temperature, BOD, pH, nitrates, DO, COD, nitrites, chloride, sulphate and phosphates play major role in the physico-chemical characteristics of ground water of Umaria district during winter season. The mean values of eleven parameters of ground water analysed in eight station together with their SD and CV are presented in **table-1**. The water temperature averaged 31.187 which was lower than those of Bandhogarh (34.1⁰C) at location D₂ and higher than those of Ghumghouti (25.9⁰C) at location D₃ in Umaria District during summer season.

The value of pH was found in the range of 6.0-8.0 (mean values of pH 7.1 and turbidity of water was found to be 0.5-1.5 NTU (mean value was 0.925 NTU). Dissolved oxygen was ranging from 1.4-4.8mg L⁻¹, with an mean value of 2.675mg L⁻¹, which is within permissible limit prescribed by WHO for drinking

water. The mean values of BOD and COD in the ground water of Umaria District during summer season were 2.7mg L^{-1} and 6.8mg L^{-1} respectively. The BOD and COD values observed in the present study were well within the limit (6.0mg L^{-1} for BOD and 10mg L^{-1} for COD) prescribed by WHO for drinking water. The CV values of temperature (8.9), pH (10), turbidity (41.5), dissolved oxygen (45.9), BOD (11.8) and COD (14.1) showed wide fluctuation of there for relation of these parameters did not occur between station. The concentration of nitrate ion was found to be between from $2.0\text{-}6.55\text{mg L}^{-1}$. The nitrite content of water was found to be $0.7\text{-}4.9\text{mg/l}$. the highest value of 4.9mg L^{-1} was recorded at location D₁, while the minimum value 0.7mg L^{-1} was recorded at location D₇ as show in **table-1**. It was found that amount of sulphate ranged from $12.0\text{-}210\text{mg L}^{-1}$ and all samples were below the permissible limit as per WHO standard. The mean values of chloride and phosphates in the ground water of Umaria District during summer season were 46.5mg L^{-1} and 0.195mg L^{-1} respectively. The chloride ion concentration in used as an important parameters for detection of extent of contamination. The concentration at chloride ion varied from $22.0\text{-}157\text{mg L}^{-1}$. The highest value of 157mg L^{-1} was recorded at location D2 (Bandhogarh) while the minimum value 22.0mg L^{-1} at location D4 (Singhpur). The phosphate content of water was found to be $0.02\text{ - }0.53$, the highest value of phosphate 0.53 was recorded at location D4 while minimum value 0.02 was recorded at location D6 (**Table-1**). Values of phosphate at Umaria (0.24), Bandhogarh (0.23) and Singhpur (0.53) are higher than the permissible limit prescribed by WHO and BIS. The CV values of nitrates (43.3), nitrites (60.6), sulphates (70.3), chlorides (100.1) and phosphates (80) indicated their significant variation from one station to another.

The correlation coefficient (r) among various water quality parameters are given in **table 1b**. The temperature of ground water during Summer showed positive relationship with pH, BOD, chlorides and phosphates and negative relationship with turbidity, DO, COD, nitrates, nitrites and sulphates. The pH of the ground water showed significant positive relationship between temperature, turbidity, DO, BOD, sulphates and chlorides and negative relationship with COD, nitrates, nitrites and phosphates. Turbidity showed significant positive relationship between pH, DO, nitrates and sulphates and negative relationship with temperature, BOD, COD, nitrites, chlorides and phosphates. Dissolved oxygen (DO) showed positive relationship with pH, turbidity, nitrates and negative relationship with temperature, BOD, COD, nitrites, sulphates, chlorides and phosphates. Biochemical oxygen demand (BOD) in present investigation showed positive relationship with temperature, pH, nitrates, sulphates, chlorides and phosphates and negative relationship with turbidity, DO, COD, nitrites. Chemical oxygen demand (COD) showed positive relationship with nitrites, chlorides, phosphates and negative relationship with temperature, pH, turbidity, DO, BOD, nitrates and sulphates. Nitrates showed significant positive relationship between water turbidity, DO with BOD and negative relationship with temperature, pH, COD, nitrites, sulphates, chlorides and phosphates. Nitrites showed positive relationship with COD, sulphates and phosphates and negative relationship with temperature, pH, turbidity, DO, BOD, nitrates and sulphates. Sulphates of the ground water summer showed significant positive relationship with pH, turbidity, BOD, nitrites and negative relationship with temperature, DO, COD, nitrates, chlorides and phosphates. Chlorides showed significant positive relationship with temperature, pH, BOD, COD and phosphates and negative relationship with turbidity, DO, nitrates, nitrites and sulphates. Phosphates showed significant positive relationship between ground water temperature, BOD, COD, nitrites and chloride and negative relationship with pH, turbidity, DO, nitrates and sulphates.

The present study deals with the various relationship derived statistically by calculation 'r' and 't' among the physic-chemical characteristics. The r value was negative 32 times and positive 23 times this showed that positive relationship in the present study. During summer season, correlated different parameter each other statically which shows great variation negative to positive for 1% significant value (3.148) and 5% significant value (1.948). In the case of DO and turbidity, BOD and temperature, phosphate and DO and phosphate and nitrites we established a correlation ship which were positive and values were 2.786 , 2.112 , 2.129 and 2.271 , while COD and turbidity, nitrites and COD and phosphates and turbidity shows negative relationship i.e -3.023 , -1.998 and -2.400 respectively with each other at 5% significant level. The value of

t is slightly exceeded from the calculated value of 1% significant level in the case of nitrates and DO i.e 3.154, while nitrite and turbidity, nitrite and DO shows negative relationship i.e -3.510 and -3.874 respectively with each other at 1% significant level. It showed that turbidity, DO, BOD, temperature, COD, nitrites, phosphates play major role in the physico-chemical characteristics of ground water of Umaria district during Summer season.

Table 1- Seasonal variation in Physico-chemical characteristics of ground water samples at different locations in Umaria District

Parameters		Sampling Locations										
		D1	D2	D3	D4	D5	D6	D7	D8	Mean	S.D	C.V.
Temperature (°C)	Monsoon	27.3	27.1	27	27.6	27.7	27.3	27	26.7	27.212	0.331	1.2
	Winter	23.4	22.5	20.7	21.2	23.2	23.7	24.2	24.8	22.962	1.421	6.1
	Summer	30.3	34.1	33.5	31	33.6	25.9	32.2	28.9	31.187	2.795	8.9
pH	Monsoon	6.5	7.5	7.1	7	7.5	7.2	7.9	6.6	7.162	0.471	6.5
	Winter	6.7	7.6	7	7	7.6	7.4	7.8	6.5	7.2	0.469	6.5
	Summer	6.6	8	6.9	6	8	7.6	7.5	6.7	7.162	0.722	10
Turbidity (NTU)	Monsoon	2.4	2.75	3.8	2	1.75	1.8	2.2	1.6	2.287	0.717	31.3
	Winter	1	3	1	1.8	1.7	1	1.2	1.6	1.537	0.678	44.1
	Summer	0.5	0.5	1	0.5	1.2	1	1.2	1.5	0.925	0.384	41.5
Dissolved Oxygen	Monsoon	2.2	2.5	2.8	1.8	2.2	3.5	4.7	5.3	3.125	1.271	40.6
	Winter	2	2.3	2.5	1.6	1.8	3.3	4.3	5.1	2.862	1.263	44.1
	Summer	2	2	2.3	1.4	1.7	3	4.2	4.8	2.675	1.229	45.9
BOD	Monsoon	3.5	3.5	3	3.1	3	3.2	3.6	2.7	3.2	0.311	9.7
	Winter	2.8	3.4	3	3	2.8	2.9	3.5	2.6	3	0.307	10.2
	Summer	2.5	3.2	2.8	2.8	2.7	2.5	3.3	2.4	2.775	0.328	11.8
COD	Monsoon	9.2	8.3	6.7	7.9	6.8	7.6	7.2	-	7.671	0.886	11.5
	Winter	8.6	7.9	6.5	7.3	6.5	7.2	6.2	-	7.171	0.859	11.9
	Summer	8.4	7.7	5.8	6.7	6.1	7	6	-	6.814	0.961	14.1
Nitrates	Monsoon	2.6	3.5	5.3	6.5	2.98	4.01	7.22	6.81	4.865	1.831	37.6
	Winter	2.12	3.17	3.66	4.23	3.17	2.56	6.76	6.24	3.988	1.681	42.1
	Summer	2	2.89	3.25	4.12	2.76	2.81	6.55	6	3.797	1.644	43.3
Nitrites	Monsoon	2.5	1.3	1.7	2.15	1.05	ND	0.3	0.5	1.357	0.816	60.1
	Winter	4.7	1.9	2.4	4.61	0.015	0.52	0.4	0.8	1.918	1.865	97.2
	Summer	4.9	2.5	2.7	4.22	ND	ND	0.7	1.2	2.703	1.639	60.6
Sulphates	Monsoon	190	5	60	152	398	268	278	32	172.875	137.466	79.5
	Winter	150	10	40	130	150	200	200	35	114.375	75.755	66.2
	Summer	120	12	50	122	200	210	198	20	116.5	81.987	70.3
Chlorides	Monsoon	15	152	25	24	69	18	25	30	44.75	46.475	103.8
	Winter	19	165	43	20	50	20	27	32	47	49.013	104.2
	Summer	23	157	51	22	52	23	20	24	46.5	46.558	100.1
Phosphates	Monsoon	0.27	0.25	0.28	0.95	0.19	0.04	0.12	1	0.387	0.371	95.9
	Winter	0.27	0.25	0.28	0.95	0.19	0.04	0.12	1	0.387	0.371	95.9
	Summer	0.24	0.23	0.17	0.53	0.17	0.02	0.15	0.05	0.195	0.156	80

Table 1a. Correlation coefficients (r) among various water quality parameter
(Physico chemical characteristics of ground water in Umaria district during Monsoon and Winter)

(Monsoon) Parameters	Temp	pH	Turbidity	DO	BOD	COD	Nitrates	Nitrites	Sulphates	Chlorides	Phosphates
Temperature (°C)	1										
pH	0.140 0.345	1									
Turbidity (NTU)	-0.245 -0.619	0.065 0.159	1								
Dissolved Oxygen	-0.787 - 3.128**	0.066 0.161	-0.285 -0.727	1							
BOD	0.096 0.236	0.427 1.155	0.201 0.502	-0.194 -0.484	1						
COD	0.018 0.044	-0.598 -1.827	15 2.454*	-0.332 -0.862	0.59 1.789	1					
Nitrates	-0.469 -1.300	0.119 0.293	-0.088 -0.237	0.613 1.9*	-0.249 -0.629	-0.397 -1.059	1				
Nitrites	0.490 1.377	-0.531 -1.534	0.339 0.882	-0.812 - 3.409**	0.149 0.356	0.601 1.841	-0.488 -1.370	1			
Sulphates	0.640 2.040*	0.393 1.046	-0.463 -1.278	-0.130 -0.320	0.156 0.387	-0.316 -0.815	-0.241 -0.608	-0.122 -0.300	1		
Chlorides	0.025 0.061	0.400 1.068	0.146 0.360	-0.244 -0.616	0.236 0.594	0.1 0.245	-0.369 -0.972	-0.155 -0.383	-0.289 -0.738	1	
Phosphates	-0.159 -0.394	-0.549 -1.609	-0.280 -0.713	0.135 0.333	-0.598 -1.827	0.182 0.452	0.536 1.554	0.055 0.134	-0.476 -1.295	-0.165 -0.409	1
(Winter) Parameters	Temp	pH	Turbidity	DO	BOD	COD	Nitrates	Nitrites	Sulphates	Chlorides	Phosphates
Temperature (°C)	1										
pH	0.021 0.051	1									
Turbidity (NTU)	-0.121 -0.298	0.278 0.708	1								
Dissolved Oxygen	0.707 2.448*	-0.122 -0.300	-0.208 -0.520	1							
BOD	-0.167 -0.414	0.734 2.646*	0.356 0.932	-0.022 -0.054	1						
COD	0.035 0.085	-0.556 -1.637	0.237 0.597	-0.453 -1.244	-0.24 -0.605	1					
Nitrates	0.370 0.975	0.017 0.041	-0.014 -0.034	0.749 2.770*	0.232 0.600	-0.66 - 2.151*	1				
Nitrites	-0.540 -1.571	-0.522 -1.5	-0.021 -0.052	-0.559 -1.650	16 2.453*	0.664 2.176*	-0.358 -0.938	1			
Sulphates	0.313 0.807	0.363 0.953	-0.561 -1.660	-0.029 -0.073	0.061 0.149	-0.204 -0.510	-0.051 -0.130	-0.122 -0.300	1		
Chlorides	-0.167 -0.414	0.383 1.015	0.874 4.412**	-0.193 -0.481	0.483 1.350	0.228 0.573	-0.178 -0.442	-0.117 -0.288	-0.621 -1.941*	1	
Phosphates	-0.066 -0.172	-0.676 - 2.248*	0.198 0.493	0.167 0.414	-0.421 -1.136	0.167 0.414	0.411 1.104	0.354 0.926	-0.412 -1.106	-0.178 -0.442	1

Table 1b - Correlation coefficients (r) among various water quality parameter
(Physico chemical characteristics of ground water in Umaria district during Summer)

(Summer) Parameters	Temp	pH	Turbidity	DO	BOD	COD	Nitrates	Nitrites	Sulphates	Chlorides	Phosphates
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Temperature (°C)	1											
pH	0.258 0.653	1										
Turbidity (NTU)	-0.183 -0.455	0.229 0.575	1									
Dissolved Oxygen	-0.390 -1.038	0.040 0.097	0.751 2.786*	1								
BOD	0.653 2.112*	0.386 1.024	-0.209 -0.523	-0.054 -0.139	1							
COD	-0.284 -0.725	-0.124 -0.305	-0.777 -3.023*	-0.296 -0.758	-0.282 -0.719	1						
Nitrates	-0.059 -0.153	-0.164 -0.406	0.595 1.814	0.790 3.154**	0.283 0.722	-0.559 -1.650	1					
Nitrites	-0.087 -0.234	-0.543 -1.584	-0.820 -3.510**	-0.845 -3.874**	-0.385 -1.021	0.632 - 1.998*	-0.82 - 3.510**	1				
Sulphates	-0.281 -0.717	0.251 0.634	0.147 0.364	-0.064 -0.137	0.0005 0.0012	-0.287 -0.733	-0.043 -0.109	0.032 0.078	1			
Chlorides	0.570 1.699	0.546 1.597	-0.372 -0.981	-0.325 -0.841	0.499 1.411	0.253 0.640	-0.323 -0.836	-0.055 -0.142	-0.516 -1.475	1		
Phosphates	0.357 0.935	-0.537 -1.559	-0.700 -2.400*	-0.656 -2.129*	0.253 0.640	0.123 0.303	-0.131 -0.322	0.680 2.271*	-0.090 -0.243	0.057 0.139	1	

1% Level of significance = **,5% Level of significance = *

The average physicochemical characteristics of Umaria District are presented in **table -2**. The variation of temperature in this District was observed to be 20.7^oC minimum to 34.1^oC maximum. pH was ranging from 6.0 to 8.0 with an average of 6.6-7.7. The range of turbidity was found to be 0.5 to 3.8 NTU and dissolved oxygen was ranged between 1.4 to 5.3 mg L⁻¹. BOD and COD were in the range of 2.4, 5.8, to 3.6, 9.2 mg L⁻¹ respectively. In the case of nitrates, nitrites, sulphates, chlorides and phosphates, the values were ranged between 2.0, 0.015, 5.0, 15.0 and 0.02 to 7.22, 4.9, 398, 165 and 1.0 mg L⁻¹ respectively.

Table 2- Average physico-chemical characteristics of ground water in Umaria District and standards for Drinking Water

Parameters	Sampling locations									BIS (10500 : 1991) mg/l		WHO (1994) mg/l	
	D1	D2	D3	D4	D5	D6	D7	D8	Desirable	Permissible	Excessive	Permissible	
Temperature(°C)	27	27.9	27.1	26.6	28.2	25.6	27.8	26.8	-	6.5	8.5	6.5	
SD (±)	3.5	5.8	6.4	5.0	5.2	1.8	4.1	2.1					
pH	6.6	7.7	7	6.7	7.7	7.4	7.7	6.6	-	6.5	8.5	6.5	
SD (±)	0.1	0.3	0.1	0.6	0.3	0.2	0.2	0.1					
Turbidity (NTU)	1.3	2.1	1.9	1.4	1.6	1.3	1.5	1.6	-	-	10	5.0	
SD (±)	1.0	1.4	1.6	0.8	0.3	0.5	0.6	0.1					
Dissolved Oxygen	2.1	2.3	2.5	1.6	1.9	3.3	4.4	5.1	3.0	-	6.3	4.0	
SD (±)	0.1	0.3	0.3	0.2	0.3	0.3	0.3	0.3					
BOD	2.9	3.4	2.9	3.0	2.8	2.9	3.5	2.6	-	2.0	-	6.0	
SD (±)	0.5	0.2	0.1	0.2	0.2	0.4	0.2	0.2					
COD	8.7	8.0	6.3	7.3	6.5	7.3	6.5	ND	-	-	-	10.0	
SD (±)	0.4	0.3	0.5	0.6	0.4	0.3	0.6	-					
Nitrates	2.2	3.2	4.1	5.0	3.0	3.1	6.8	6.4	100	45	10	10	
SD (±)	0.3	0.3	1.1	1.3	0.2	0.8	0.3	0.4					
Nitrites	4.0	1.9	2.3	3.7	0.5	0.5	0.5	0.8	-	-	40	10	

SD (±)	1.3	0.6	0.5	1.3	0.7	-	0.2	0.4				
Sulphates SD (±)	153	9	50	135	249	226	225	29	1000	-	400	250
Chlorides SD (±)	19.0	158.0	39.7	22.0	57.0	20.3	24.0	28.7	1000	250	600	250
Phosphates SD (±)	0.3	0.2	0.2	0.8	0.2	0.0	0.1	0.7	-	-	0.3	0.1
	0.02	0.01	0.06	0.24	0.01	0.01	0.02	0.55				

D1: Near R.V.P.G. College, Umaria, **D2:** Near Bandhogarh Bank, **D3:** Near Pali Temple, **D4:** Near higher secondary school, Singhpur, **D5:** Near Atariya Hanuman Temple., **D6:** Near Ghumghouti primary school, **D7:** Near Tala Bus stand, **D8:** Near Balhoun high school. All the parameters except temperature, pH and turbidity are expressed in mg/l, ND=Not detected

The heavy metals concentrations in the ground water samples of Umaria District in different seasons and the average values with their standard deviations are presented in **tables 3 and 4**. The lead concentration was recorded maximum during the winter season (0.127 mg L⁻¹) and minimum of 0.01 mg L⁻¹ in summer season. Cadmium concentration was found to be 0.012 mg L⁻¹, maximum in monsoon and minimum of 0.0037 mg L⁻¹ during summer. Maximum concentrations of nickel, iron, chromium and copper are observed to be 0.042, 4.65, 0.056 and 0.123 mg L⁻¹, while minimum values were recorded as 0.012, 0.37, 0.022, 0.0052 mg L⁻¹, respectively. The average individual metals concentrations from different locations in Umaria District are appended as **figure 2a and 2b**. All the results were compared with the standard set by bureau of Indian standards (100500 1991), world health organization (1994) as given in **tables 2 and 3**.

Table 3- Metal concentrations of ground water samples at different locations in Umaria District and standards for Drinking Water

Metals (mg L ⁻¹)		Sampling Locations								BIS (10500 : 1991) mg L ⁻¹		WHO (1994) mg L ⁻¹	
		D1	D2	D3	D4	D5	D6	D7	D8	Desira ble	Permiss ible	Excess ive	Permiss ible
Lead	Mons oon	0.09	0.01	0.01	0.01	0.12 3	ND	0.0 53		0.05	No relaxati on	0.01	0.05
	Winte r	0.03	0.01	0.02	0.03	0.12 7	ND	0.0 62	0.02 9				
	Summ er	0.01	0.02	0.02	0.01	0.09 8	ND	0.0 47	0.03 1				
Cadmium	Mons oon	0.00 52	0.00 55	0.00 68	0.00 43	0.00 41	ND	ND	0.01 21	0.01	No relaxati on	0.003	--
	Winte r	0.00 48	0.00 53	0.00 59	0.00 58	0.00 52	ND	ND	0.01 12				
	Summ er	0.00 42	0.00 47	0.00 48	0.00 47	0.00 37	ND	ND	0.01 10				
Nickel	Mons oon	ND	ND	0.02 4	0.01 2	0.02 1	0.0 25	0.0 42	0.01 8	--	--	--	0.02
	Winte r	ND	ND	0.02 8	ND	0.03 1	0.0 36	0.0 32	0.01 3				
	Summ er	ND	ND	0.02 3	ND	0.02 4	0.0 26	0.0 38	0.01 5				
Iron	Mons oon	0.49	4.40	0.67	0.85	0.39	0.5 9	0.8 7	0.49	0.3	1.0	0.3	--

	Winter	0.56	4.65	0.55	0.55	0.46	0.61	0.91	0.54				
	Summer	0.47	4.32	0.53	0.78	0.37	0.46	0.76	0.38				
Chromium	Monsoon	0.026	0.029	0.034	ND	0.044	0.027	0.056	0.035	No relaxation	0.05	--	0.05
	Winter	0.028	0.038	0.038	ND	0.046	0.029	0.052	0.041				
	Summer	0.022	0.032	0.032	ND	0.041	0.023	0.057	0.033				
Copper	Monsoon	0.009	0.0152	0.0257	0.0123	ND	0.033	0.091	0.0257	1.5	0.05	1.00	--
	Winter	0.0052	0.0123	0.0194	0.0103	0.011	0.027	0.07	0.0194				
	Summer	0.0176	0.0243	0.0322	0.0158	0.018	0.056	0.123	0.0322				

D1: Near R.V.P.G. College, Umaria, **D2:** Near Bandhogarh Bank, **D3:** Near Pali Temple, **D4:** Near higher secondary school, Singhpur, **D5:** Near Atariya Hanuman Temple, **D6:** Near Ghumghouti primary school, **D7:** Near Tala Bus stand, **D8:** Near Balhoun high school. Concentration of metals are expressed in mg/l, ND=Not detected.

Table 4- Average metals concentration of ground water in Umaria District

Metals	Sampling Locations							
	D1	D2	D3	D4	D5	D6	D7	D8
Lead	0.043	0.013	0.017	0.017	0.116	ND	0.054	0.028
SD (±)	0.042	0.006	0.006	0.012	0.016	-	0.008	0.004
Cadmium	0.005	0.005	0.006	0.005	0.004	ND	ND	0.011
SD (±)	0.001	0.000	0.001	0.001	0.001	-	-	0.001
Nickel	ND	ND	0.025	0.012	0.025	0.029	0.037	0.015
SD (±)	-	-	0.003	-	0.005	0.006	0.005	0.003
Iron	0.507	4.457	0.583	0.727	0.407	0.553	0.847	0.470
SD (±)	0.047	0.172	0.076	0.157	0.047	0.081	0.078	0.082
Chromium	0.025	0.033	0.035	ND	0.044	0.026	0.055	0.036
SD (±)	0.003	0.005	0.003	-	0.003	0.003	0.003	0.004
Copper	0.011	0.017	0.026	0.013	0.015	0.039	0.095	0.026
SD (±)	0.006	0.006	0.006	0.003	0.005	0.015	0.027	0.006

D1: Near R.V.P.G. College, Umaria, **D2:** Near Bandhogarh Bank, **D3:** Near Pali Temple, **D4:** Near higher secondary school, Singhpur, **D5:** Near Atariya Hanuman Temple, **D6:** Near Ghumghouti primary school, **D7:** Near Tala Bus stand, **D8:** Near Balhoun high school. Concentration of metals are expressed in mg/l, ND=Not detected.

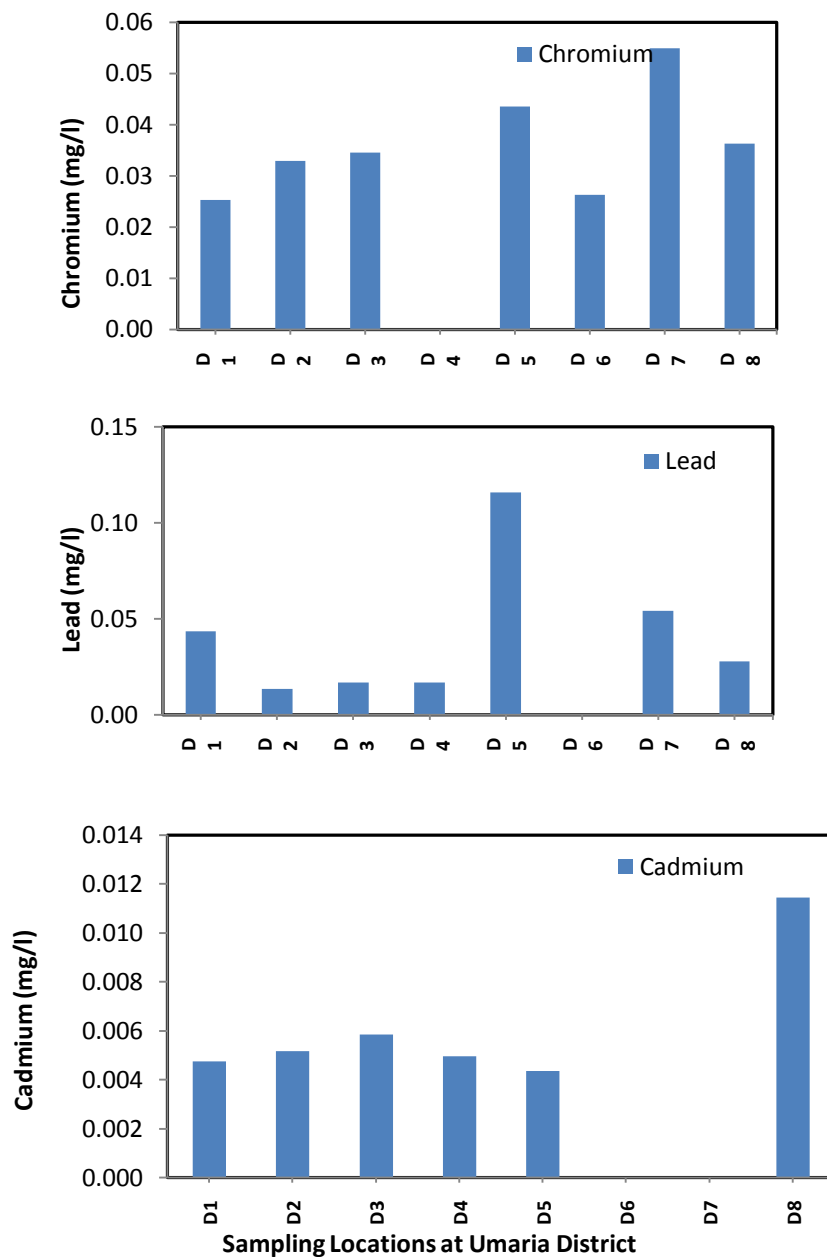
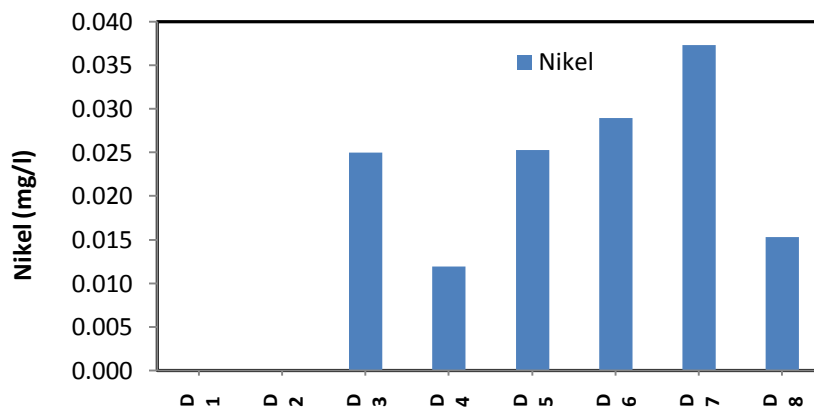


Figure- 2a Metals content in the ground water samples of Umara District



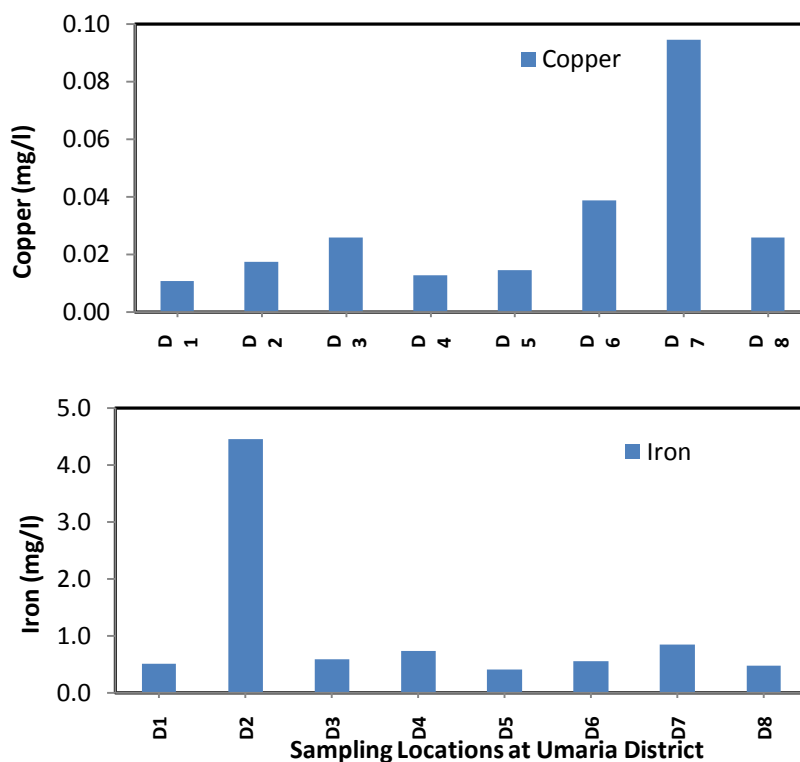


Figure 2b Metals content in the ground water samples of Umaria District

APPLICATIONS

These results are useful to know the quality of water in this region.

CONCLUSIONS

The maximum nitrate and chloride concentrations were observed during the monsoon season, but in the case of sulphate and phosphates the maximum values were observed in all the season. With compared to WHO prescribed limits for drinking water, the ground water samples from all the locations in the Umaria district are found to be within the prescribed limits as physico-chemical characteristics are concerned except sulphates concentration. The content of Cd, Cr and Cu in the analyzed water sample were below the Permissible limit, while lead concentration at sampling station D5, D7 and nickel concentration at sampling station D3, D5, D6 and D7 are higher than the permissible limit. Iron concentration were found more than the permissible limit during all the season, which may be attributed to the geological strata present in the area.

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