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Assessment of ground water quality in and around of Madhyabharat paper mills, Janjgir-Champa, C.G, India

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Abstract
Water is the most abundant precious and essential compound to sustain the life on the earth. Analytical studies of some selected physicochemical parameter with metallic elements were made on the underground water bodies of Paper mills industrial areas Janjgir-Champa Chhattisgarh. Water samples were collected from four different selected spot in the month of Oct'2012 to Dec'2012. Temperature, pH, E.C, Turbidity, TDS and D.O were analyzed instantly at the sampling spot while T.S, TSS, TH, Total Alkalinity, BOD, COD, Cl^-, F^-,SO_4^{2-}, NO_3^-, PO_4^{3-}, Na, K, Ca, Mg, Fe, Cu, Zn, Mn and Phenol by the standard method as per IS procedure. The statistical parameters like mean, SD, SE, %CV and Correlation coefficient(r) and WQI were systematically calculated. Around 60% of these parameters were above the maximum permissible limit of IS: 10500 and WHO standard of drinking water. The elevated values of these parameters are of great concern to public health when the water from these bore wells are consumed by people without treatment.

Keywords: Water quality, Industrial effulent, Physico-chemical parameter, Statistical value and public health.

INTRODUCTION

Water is essential for the survival of any form of life. Pure drinking water resources are dwindling due to deforestation, mining and industrialization. Approximately 71% of the earth surface is covered with water, mainly in the form of oceans. The actual fresh water is available for human consumption is around 1% of the total earth water. Ground and surface water used by man are of different characteristics. Ground water contains dissolved minerals from the soil layers through which it passes[1-3]. Owing to natural weathering and anthropogenic activities all these parts of universe becoming deteriorated the water quality. Moreover, considerable part of this limited quantity of water is polluted by sewage, industrial wastes and a wide array of synthetic chemicals. Thus, the quality as well as the quantity of clean water supply is of vital significance for the welfare of mankind[4-7].

Study area

Champa city is situated on the banks of Hasdeo river and 12 km. away from in Janjgir-Champa district headquarter in the state of Chattisgarh, India. It is located between 22.05° N to 82.65° E latitude. The study area is surrounded by small mild forest, topographically height of the area is 253 meters from means sea level and average temperature 49°C and average rain fall 1157.1 mm, geologically the study field is high grade area and metamorphic stone of archean age. Many companies big or small have their manufacturing/ production units are located in an around Champa viz. Madhya Bharat Paper Limited (MBPL), Prakash Industries Ltd., CSPGCL's Marwa Power Plant and many mega power projects are in under construction[8-9]. Due to rapid industrialization; Cement, steel, paper, urbanization and over using of fertilizer, pesticides, have undoubtedly affected different water system. The main causes for the deterioration of water quality in water bodies are entering of pollutants due to discharge of untreated or partially treated waste water from steel plant, paper factory, municipal sewage and domestic effluents, so it is necessary to analyze the extent of pollutant present in the water of this area. We have taken Post -Monsoon (Oct –Dec 2012) assessment of water quality status to check the pollutants. In the present paper we have presented the analysis of post monsoon observations in reference of physicochemical parameters; however coefficient of correlation matrix, % CV and WQI were used for grading water sources.

MATERIAL AND METHOD

In our study, we have selected total four sampling spots (shown in Fig.1) as the basis of environmentally significant in which four from the borewell of Birgahani (MG_1), Deoraha (MG_2), Pithampur (MG_3) and Garapali (MG_4) respectively.

Ground water samples were collected every month of the post monsoon season (Oct'2012 to Dec'2012). In two liter capacity of polyethylene jerry canes and (one for physical and chemical analysis and another for metal analysis) previously soaked with 8M HNO_3 and clean with detergent followed by rinsing with double distilled water. The collected water sample was preserved in ice cooled chamber and kept in dark room[17,20] Analysis was carried out by the standard protocol[10-22] as per standard method within a short period of time, so as to get more reliable and accurate results.

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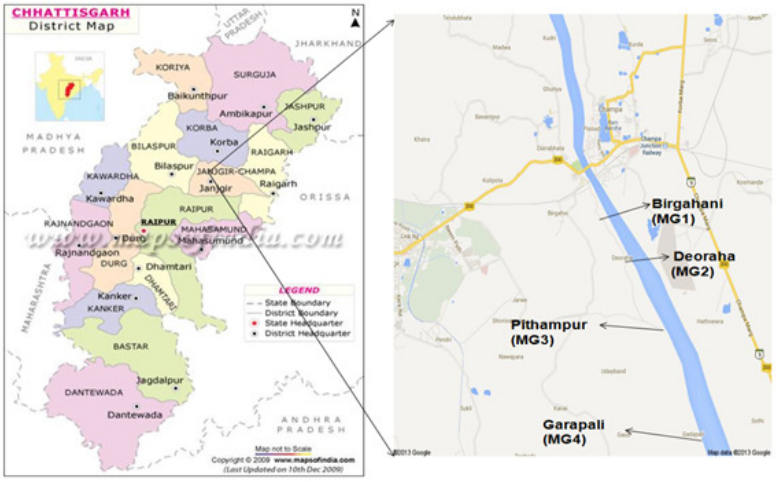

Fig 1. Location of study area

RESULT AND DISCUSSION

The results are given in the Table-1while Statistical parameters-Mean, SD, SE, WQI and Correlation matrix are displayed in Table-2 to 4.

P^H : In our investigation P^H ranges was noted 7.01 at the sampling spot MG_1 (Nov'2012) to 7.8 at the Site of MG_4 (Nov'2012). The above ranging P^H indicate water is nutral to basic in nature, which is under the range of acceptable for drinking water suggested by WHO, 1993 and BIS, 1991; 6.5 -8.5.

Table 1. Average value of Physico-chemical and metallic element analysis.

Parameters / Sampling Spot	MG1	MG2	MG3	MG4
Temperature	24.466	24.566	24.533	24.633
PH	7.376	7.300	7.386	7.690
Conductivity	1100.333	1083.333	954	1013.666
Turbidity	12.000	22.333	8.333	5.000
TS	418.333	413.000	414.667	632.000
TDS	294.666	236.666	302.666	522.333
TSS	123.666	176.333	112.000	109.666
Alkalinity	623.000	665.000	488.000	336.333
Total Hardness	384.000	391.333	284.666	341.333
Chloride	161.770	487.233	193.866	227.263
Fluoride	0.990	0.760	0.940	0.926
Sulphate	264.666	277.000	219.333	270.666
D.O	4.756	4.970	4.640	4.836
BOD	4.280	4.340	4.716	4.736
COD	112.333	64.666	72.333	47.000
Nitrate	24.973	30.793	26.990	23.913
Phosphate	0.123	0.133	0.116	0.106
Sodium	400.000	533.333	473.333	430.000
Potassium	6.000	5.333	9.666	5.666
Calcium	111.936	121.656	106.333	93.596
Magnesium	21.733	10.743	25.926	15.443
Iron	0.316	0.310	0.316	0.353
Copper	0.030	0.027	0.028	0.029
Zinc	0.096	0.080	0.093	0.096
Manganese	0.063	0.256	0.163	0.033
Phenol	0.012	0.013	0.013	0.240

* All parameters in mg/Lit. except Conductivity (µ mhos/cm), Turbidity (NTU) and P^H

MG_1– Birgahani (Borewell Water), MG_2–Deoraha(Borewell Water), MG_3– Pithampur(Borewell Water), MS_4– Garapali (Borewell Water).

Table 2. Statistical Parameter of water Quality

Parameters	N	MEAN	S.D	S.E	%CV	MIN	MAX	RANGE	Indian Drinking water Std. IS: 10500, 1993, Edition 2.2 (2003-09)	WHO Rec.1999
Temperature	4	24.550	0.069	0.035	0.283	24.466	24.633	24.466 -24.633	***	27-28
PH	4	7.438	0.172	0.086	2.317	7.300	7.690	7.3 -7.69	6.5-8.5	6.5-8.5
Conductivity	4	1037.833	67.302	33.651	6.485	954.000	1100.333	954 -1100.333	***	1000
Turbidity	4	11.917	7.510	3.755	63.020	5.000	22.333	5 -22.333	5-8 NTU	5 NTU
TS	4	469.500	108.356	54.178	23.079	413.000	632.000	413 -632	520-2050	***
TDS	4	339.083	125.657	62.828	37.058	236.666	522.333	236.666 -522.333	500-2000	1000
TSS	4	130.416	31.218	15.609	23.937	109.666	176.333	109.666 -176.333	20-50	***
Alkalinity	4	528.083	148.470	74.235	28.115	336.333	665.000	336.333 -665	300-600	***
Total Hardness	4	350.333	49.016	24.508	13.991	284.666	391.333	284.666 -391.333	300-600	500
Chloride	4	267.533	148.887	74.444	55.652	161.770	487.233	161.77 -487.233	200-1000	200-1000
Fluoride	4	0.904	0.100	0.050	11.046	0.760	0.990	0.76 -0.99	1-1.2	1.5
Sulphate	4	257.916	26.211	13.105	10.162	219.333	277.000	219.333 -277	200-400	250
D.O	4	4.801	0.139	0.069	2.890	4.640	4.970	4.64 -4.97	5	***
BOD	4	4.518	0.242	0.121	5.347	4.280	4.736	4.28 -4.736	5	***
COD	4	74.083	27.618	13.809	37.280	47.000	112.333	47 -112.333	10	***
Nitrate	4	26.667	3.032	1.516	11.370	23.913	30.793	23.913 -30.793	45	50
Phosphate	4	0.120	0.011	0.006	9.529	0.106	0.133	0.106 -0.133	0.1	***
Sodium	4	459.167	57.887	28.944	12.607	400.000	533.333	400 -533.333	***	200
Potassium	4	6.666	2.018	1.009	30.276	5.333	9.666	5.333 -9.666	10	***
Calcium	4	108.380	11.714	5.857	10.808	93.596	121.656	93.596 -121.656	75-200	200
Magnesium	4	18.461	6.711	3.355	36.351	10.743	25.926	10.743 -25.926	<30	***
Iron	4	0.324	0.020	0.010	6.086	0.310	0.353	0.31 -0.353	0.1-1.0	0.3
Copper	4	0.029	0.001	0.001	4.530	0.027	0.030	0.027 -0.03	0.05	2
Zinc	4	0.091	0.008	0.004	8.364	0.080	0.096	0.08 -0.096	5	3
Manganese	4	0.129	0.101	0.051	78.771	0.033	0.256	0.033 -0.256	0.1	0.5
Phenol	4	0.070	0.114	0.057	163.551	0.012	0.240	0.012 -0.24	0.001	***

Electrical Conductivity: For good aquatic life the conductivity value of 150-500 µS cm^{-1}. Minimum conductivity was observed 852 µ mhos/cm at the sampling site MG_3 in the month of Nov' 2012, while maximum EC was found on the sampling point MG_2; 1220 µ mhos/cm, which is slightly above the maximum permissible level as per WHO, 1993 standard. The high value of the EC in water sample suggested the dissolve of inorganic and organic salt in water in high concentration.

Turbidity : It was detected 3 NTU as low on the investigation site MG_4 in the month of Nov'2012 which is within permissible limit, while 29 NTU reported as the higher value on the MG_2 in Dec'2012. The Maximum value was beyond the acceptable range i.e., 5-25 NTU as set by WHO, 1993 and BIS, 1991.

Suspended and Dissolved Solid : TS was noted in the ranges from 394 to 643 mg/L on the sampling point MG_3 (Dec-2012) and MG_4 (Oct 2012) respectively. TDS only measure of filtrate water sample. 220 mg/L on the sampling spot MG_2 in the month of Nov' 2012 and 535 mg/L of the location site MG_4 in the month of Nov 2012. TSS was noted in the ranges from 88 to 180 mg/L on the sampling point MG_4 (Nov-2012) and MG_2 (Nov' 2010) respectively. The values of TS and TDS were within the permissible unit while Maximum TSS value crossed the maximum allowable limit. Although high suspended dissolved particles have not serious health hazard, but those peoples who are suffering from kidney and constipation problems mere affected of these parameters.

Alkalinity : The cause of alkalinity in water is due to the presence of various dissolve ions such as OH^-, HCO_3^-, PO_4^{3-}, BO_3^- etc (Verma, 2000). The desirable and maximum permissible unit is suggested by various water monitoring agencies such as WHO, 1993 and BIS, 1991; 300mg/L to 600 mg/L. In our study minimum and maximum both values were noted in Dec' 2012 as 330 mg/L at the sampling location MG_4 and 672 mg/L of the sampling spot MS_2 (Nov'2012).

Total Hardness : Total hardness is computed by sum of temporary hardness and permanent hardness. The sources of hardness of water is chiefly due to the dissolve of OH^-, HCO_3^-, Cl^- and SO_4^- ion of Ca^{2+}, Mg^{2+}, Fe^{2+} and Mn^{2+} (De, 2006). In study region its ranges was recorded 180 mg/L to 564 mg/L from sampling point MG_3 (Nov' 2012) and MG_1 (Nov'2012). The highest value was crossed the ranges according to WHO, 1993 standard drinking water; 500 mg/L hardness of water does not create adverse effect on human

health.

DO : Dissolve oxygen is important water quality parameter which determine organic pollution of water (Orebiyi E.O et al., 2010). According to various water monitoring agencies its desirable value is 5 mg/L. In our study 3.46 mg/L to 6.59 mg/L reported as low and high values at the sampling spot MG_4 (Oct'2012) and MG_4 (Nov'2012).

BOD : It was noted on ranging from 4.02 mg/L on the sampling point MS_2 in the month of Nov-2012 to 4.98 mg/L in the month of Oct-2012 at the sampling point MS_3. Some water samples were showed below the permissible limit prescribed by ISI, 1993, 5mg/L.

COD: The ranging was obtained from 48 mg/L (MG_4) in the month of Dec'2012 to 120 mg/L (MG_1) in the month of Dec 2012. The higher value is too hold greater than the above permissible value according to standard drinking water agency as per BIS, 1991; 10mg/L. The high value may cause the presence of high content of carbonaceous particle and suspended particles in different water bodies.

Chloride : The potentially of Cl^- in microbes killing is depended upon the P^H and people accustomed to higher chloride in water are subjected to laxative effect (Verma, 2006). In our minor assessment the ranging was found from 127.79 mg/L to 500 mg/L from in MG_4 (Nov'2012) and MG_2 (Oct'2012) respectively under the desirable limit.

Fluoride : Its desirable amount spread from 1 to 1.5 mg/L is useful for human being. Its concentration is increased beyond the permissible limit 1 to 1.5 mg/L (WHO, 1993) causes health hazardous. In this work ranging was obtained from 0.72 mg/L to 1. mg/L for MG_2 (Nov'2012) and MG_1 (Oct'2012) respectively. The observed value was within the standard range.

Sulphate : The minimum and maximum value was calculated as 210 mg/L and 305 mg/L from MG_3 (Oct'2012) and MG_2 (Oct'2012) respectively.

Nitrate : In study area minimum value was recorded 23.81 mg/L on the sampling point MG_4 in the month of Nov (2012) while 31.22 mg/L as maximum on the location spot MG_2 in the month of Oct-2012.

Phosphate : Domestic sewage and chemical fertilizer are chief source of phosphate in water. In this research work phosphate was obtained in the range of 0.1 mg/L from MG_4 sampling point in the month of Nov and Dec-2012 to 0.14 mg/L on MG_2 in the month of Dec-2012.

Sodium : Domestic sewage is chief source for increase the amount of sodium in water. In our investigation observed value was 380 mg/L to 600 mg/L from MG_1 (Dec-2012) and MG_2 (Dec-2012) respectively.

Potassium : Its permissible range in drinking water is 10mg/L as per BIS, WHO and ICMR standard. 4 mg/L was detected as minimum on sampling spot MG_2 in the month of Nov'2012 while 10 mg/L at the sampling spot MG_3 in the month of Nov and Dec'2012.

Calcium : Its compound makes water hard due to high dissociation in water. In our research work the ranging was observed from 80 mg/L to 131.81 mg/L from MG_1 (Oct-2012) and MG_1 (Dec-2012) respectively. The range was under permissible according to standard value.

Magnesium : 10.5 mg/L was reported on the sampling spot MG_2 in the month of Dec'2012 while 26.23 mg/L was noted on the sampling location MG_3 in the month of Dec'2012.

Iron : In our study 0.3 mg/L (MG_1, Oct-2012) to 0.37 mg/L (MG_4, Oct-2012) were reported. The amount of iron is high which is above the permissible limit as per drinking water standard.

Copper : In our study minimum amount was detected as 0.026 mg/L on the sampling spot MG_2 in the month of Dec-2012 while 0.03 mg/L was reported in the month of Oct - Dec (2012) & Oct-2012 on the sampling location MG_1 & MG_4 respectively.

Zinc : In our study minimum amount was detected as 0.07 mg/L on the sampling spot MG_2 in the month of Oct-2012 while 0.1 mg/L was reported on MG_1 & MS_4 (in the month of Oct & Dec), MG_4 (Nov & Dec -2012) and MG_3 (Dec -2012) sampling location respectively.

Manganese : In our study minimum amount was detected as 0.011 mg/L on the sampling spot MG_1 in the month of Oct-2012 while 0.27 mg/L was reported on MG_4, Dec -2012 sampling location respectively.

Phenol : In our study minimum amount was detected as 0.009mg/L on the sampling spot MS_1 in the month of Dec-2012 while 0.29 mg/L was reported on MS_4 (in the month of Oct'2012).

Correlation Matrix : The value of 'r' was calculated on the monthly basis as follows:

253 correlation coefficient 'r' among various water quality parameters were observed in which 153 positive (+) while 100 negative (–) correlation. Higher positive correlation was found between TDS and P^H (r = 0.998) while higher negative correlation was seen between Cu and PO_4^{3-} (r = –0.989). Minimum positive r value was detected between Na and SO_4^{2-} (r = + 0.021) while minimum negative correlation was occurred between TSS and Temperature (r = –0.017). Near about 62 correlations were found above the significant at 5% level (r > 0.649).

Water Quality Index: Water quality index was calculated for different sampling locations, the results were found in the ranges of 97.866 at the sampling point MG_1 to 98.533 at the MG_4. The high value of this statistical parameter indicated high loading of various kinds of pollutant. Another investigating points such as MG_1 **(**97.866), MG_2 (98.266), MG_3 (98.133**),** MG_4 **(**98.533) showed less than maximum WQI (<100) but greater than 76 -100 WQI values (very poor water quality) indication of intrusion of pollutants through leaching or percolation of surface water via domestic garbage and paper mill industrial effluent.

Table 3. Correlation Matrix of water Quality

	Temp.	PH	Cond.	Turb.	TS	TDS	TSS	Alk.	T.H	Cl–	F–	SO42-	D.O	BOD	COD	NO3–	PO43–	Na	K	Ca	Mg	Fe	Cu	Zn	Mn	Ph
Temp.																										
PH	0.690																									
Cond.	-0.364	-0.342									Significant at 5% level, r > 0.649															
Turb.	-0.226	-0.773	0.624																							
TS	0.789	0.978	-0.233	-0.623																						
TDS	0.684	0.998	-0.347	-0.780	0.975																					
TSS	-0.017	-0.631	0.589	0.977	-0.454	-0.640																				
Alk.	-0.679	-0.925	0.672	0.868	-0.861	-0.928	0.745																			
T.H	-0.176	-0.260	0.979	0.659	-0.119	-0.268	0.665	0.603																		
Cl–	0.332	-0.391	0.350	0.841	-0.196	-0.401	0.932	0.463	0.486																	
F–	-0.399	0.353	-0.234	-0.789	0.164	0.363	-0.889	-0.387	-0.379	-0.993																
SO42-	0.266	0.160	0.797	0.422	0.324	0.151	0.520	0.202	0.890	0.496	-0.417															
D.O	0.419	-0.047	0.626	0.669	0.161	-0.058	0.793	0.301	0.768	0.845	-0.800	0.878														
BOD	0.633	0.672	-0.919	-0.752	0.596	0.676	-0.651	-0.899	-0.852	-0.346	0.236	-0.519	-0.434													
COD	-0.969	-0.547	0.496	0.159	-0.638	-0.541	-0.037	0.618	0.310	-0.397	0.482	-0.092	-0.346	-0.683												
NO3–	-0.041	-0.750	0.198	0.889	-0.621	-0.756	0.888	0.681	0.260	0.866	-0.868	0.083	0.495	-0.395	-0.118											
PO43–	-0.480	-0.900	0.632	0.962	-0.795	-0.905	0.882	0.968	0.611	0.668	-0.606	0.273	0.467	-0.833	0.401	0.829										
Na	0.290	-0.490	-0.069	0.704	-0.355	-0.496	0.765	0.371	0.045	0.877	-0.917	0.021	0.494	-0.064	-0.458	0.933	0.576									
K	-0.236	-0.175	-0.809	-0.391	-0.332	-0.166	-0.483	-0.194	-0.893	-0.447	0.365	-0.998	-0.849	0.528	0.053	-0.035	-0.251	0.035								
Ca	-0.524	-0.937	0.573	0.940	-0.846	-0.940	0.848	0.972	0.541	0.628	-0.571	0.182	0.389	-0.805	0.428	0.833	0.996	0.578	-0.161							
Mg	-0.554	-0.083	-0.516	-0.569	-0.289	-0.071	-0.718	-0.156	-0.678	-0.824	0.793	-0.856	-0.988	0.291	0.479	-0.437	-0.341	-0.491	0.825	-0.261						
Fe	0.728	0.997	-0.293	-0.717	0.992	0.996	-0.565	-0.902	-0.200	-0.319	0.284	0.231	0.036	0.640	-0.579	-0.707	-0.862	-0.445	-0.243	-0.905	-0.165					
Cu	-0.372	0.399	0.212	-0.590	0.278	0.404	-0.663	-0.241	0.091	-0.818	0.874	0.071	-0.415	-0.086	0.550	-0.874	-0.453	-0.989	-0.128	-0.462	0.433	0.360				
Zn	-0.135	0.599	-0.309	-0.907	0.431	0.608	-0.951	-0.609	-0.409	-0.966	0.961	-0.316	-0.702	0.408	0.247	-0.965	-0.788	-0.927	0.267	-0.769	0.658	0.539	0.863			
Mn	-0.046	-0.751	0.055	0.814	-0.645	-0.756	0.805	0.624	0.108	0.800	-0.818	-0.070	0.370	-0.287	-0.140	0.988	0.768	0.943	0.118	0.786	-0.320	-0.718	-0.903	-0.921		
Ph	0.803	0.974	-0.242	-0.613	0.995	0.972	-0.442	-0.862	-0.124	-0.178	0.144	0.323	0.171	0.604	-0.657	-0.603	-0.790	-0.332	-0.329	-0.841	-0.301	0.989	0.254	0.412	-0.627	1

Table 4. Water Quality Index

Sampling Spot	∑QiWi	∑Wi	WQI = ∑QiWi / ∑Wi
MG1	19.18	0.196	97.866
MG2	19.26	0.196	98.266
MG3	19.23	0.196	98.133
MG4	19.31	0.196	98.533

CONCLUSION

We have taken minor but deeply month wise monitoring of Ground water in the Four sampling spots MG_1 to MG_4 in and around the Madhyabharat Paper Mill industry. From the results of experiment it may be concluded that the Ground water is polluted in references of EC (1120 µ mhos/cm), turbidity (29), TSS (180 mg/L), BOD (4.98 mg/L), COD (120 mg/L), Phosphate (0.14 mg/L), Sodium (600 mg/L), Iron (0.37 mg/L) phenol (0.27 mg/L). These qualities were marginally higher than the standard values of drinking water. Higher Positive correlation of significant was calculated out between TDS vs. P^H (r = + 0.998) indication that of both parameters are significantly correlated and follow similar kind of pattern together (increasing or decreasing). WQI reported 98.533 at the sample site MG_4, more loading of pollutant in this water source. We have suggested to peoples by comparing prior treatment is necessary before human Consumption for especially potable purpose.

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