

Physico Chemical Properties of Groundwater around Ash Pond of Parichha Thermal Power Plant, Jhansi, U.P., India

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Abstract: Groundwater quality was assessed in terms of their physico chemical parameters around ash pond of Parichha thermal power plant, Jhansi. The study was carried out in three seasons i.e. summer, monsoon and winter. Groundwater samples were taken from six bore wells near the ash pond. The obtained results revealed the range of pH as (7.3-8.2), electrical conductivity (0.76-2.03 mS/cm), total dissolved solid (504-1275 mg/l), alkalinity (280-2280 mg/l), chloride (17.75-273.35 mg/l), hardness (110.11-790.79 mg/l), bicarbonate (134.2-2775.5 mg/l), sodium (105-245 mg/l), sulphate (5-60 mg/l), calcium (8.01-52.10 mg/l) and magnesium (19.45-160.51 mg/l). These parameters were also compared with BIS and observed that total dissolved solids, alkalinity, hardness, bicarbonates and magnesium were exceeding the prescribed limit of BIS.

Keywords: Ash pond, fly ash, groundwater, physico chemical properties, thermal power plant.

1. INTRODUCTION

Groundwater is one of the earth's most important, renewable and widely distributed resource [1]. The properties of groundwater depend on the chemistry of water in recharge area as well as the different geochemical processes that are occurring in the subsurface [2]. Groundwater chemically evolves by interacting with aquifer minerals or internal mixing among different groundwater along flow paths in the subsurface [3]. It is generally considered as safer than surface water under normal conditions, as its natural protection from the contamination by the infiltration of recharge water through soil cover. However the subsurface soil cover should be free from contamination load. But in present days soil is getting contaminated by the influence of human activities due to not following the strict environmental norms [2].

In case of thermal power plants, the fly ash is generally disposed in a site that has no liners [4]. Fly ash is mixed with water to make slurry and is directly dumped on open lands or ash lagoons which are not properly constructed, contaminating the groundwater by seepage of pollutants. This type of contamination is a matter of much concern as huge amounts of ash is generated on a daily basis and the continuous input of it affects the physico chemical properties of groundwater [5]. In the present study, focus has been made to assess the physico chemical properties of groundwater around ash disposal site of Parichha Thermal Power Plant, Jhansi.

2. METHODS

Parichha is a small town located at an elevation of 25°30'48.25"N-78°45'23.01"E in Jhansi district of Bundelkhand region. Groundwater samples were collected from bore wells located around ash pond of Parichha Thermal Power Plant. Total numbers of six bore wells were selected for sampling purpose. Groundwater samples were collected in September, 2013 (monsoon), January, 2014 (winter) and May, 2014 (summer). Samples were analysed in terms of their physico

chemical properties by referring standard method (“APHA, 2005) [6]. pH, electrical conductivity and total dissolved solids were measured at site by using portable Biocraft water analyzing kit (Model NPC 362D). Alkalinity and Bicarbonate was measured by potentiometric titration method, chloride by argentometric titration method, hardness by versenate titration method. Sulphate was estimated by turbidmetric method.

3. RESULTS AND DISCUSSION

Physico chemical parameters of groundwater in monsoon, summer and winter season is given in table 1, 2 and 3 respectively. Correlation between parameters is also assessed in table 3. All the parameters are showing positive correlation with each other except sulphate. Sulphate is found to be negatively correlated with all parameters.

pH: The parameter pH (the negative base-10 logarithm of hydrogen ion activity, measured in moles per liter) indicates whether a substance will behave as an acid or base. It is one of the most important parameters that describe groundwater quality, because pH largely controls the amount and chemical form of many organic and inorganic solutes in the groundwater [7]. pH was ranged between 7.3-7.6 in monsoon, 7.8-8.2 in summer and 7.5-7.9 in winter season. pH of groundwater samples were found within the acceptable limit of BIS.

Electrical conductivity: Electrical conductivity of groundwater samples were 0.76-1.12 mS/cm in monsoon, 0.89-2.03 mS/cm in summer and 0.82-1.89 mS/cm in winter season. Electrical conductivity is a measure of material's ability to conduct an electric current due to the enrichment of salts in the groundwater [8]. Electrical conductivity is exceeding the desirable limit of BIS i.e. 1.4 ms/cm in summer and winter season. Higher conductivity of groundwater is due to downward percolation of ions from ash pond through soil strata.

TDS: Total dissolved solid is a measure of combined content of all organic and inorganic substances contained in a liquid in molecular, ionized and micro granular suspended form [9]. Total dissolved solid was ranged between 504-740 mg/l in monsoon, 553-1275 mg/l in summer and 526-1249 mg/l in winter season. TDS value was found to be exceeding the acceptable limit of BIS (500 mg/l) throughout the study period.

Alkalinity: The alkalinity of water is mainly caused due to OH^- , CO_3^{2-} , HCO_3^- ions [10]. The value of alkalinity provides an idea in water of natural salts present in water. The cause of alkalinity is the minerals which are dissolved in water from soil [11]. Alkalinity was observed as 280-490 mg/l in monsoon, 1020-2280 mg/l in summer and 400-810 mg/l in winter season. Alkalinity in groundwater samples was higher than the prescribed limit of BIS as 200 mg/l.

Chloride: Chloride is a widely distributed element in all types of rocks in one or other form. Its affinity towards sodium is high. Soil porosity and permeability also has a key role in building up the chloride concentration [12]. The chloride concentration in groundwater was ranged as 17.75-85.2 mg/l in monsoon, 28.4-273.5 mg/l in summer and 21.3-241.4 mg/l in winter. Chloride was observed within the range of BIS i.e. 250-1000 mg/l.

Hardness: Total Hardness is caused primarily by the presence of cations such as calcium and magnesium and anions such as carbonate and bicarbonate, chloride and sulphate in water [2]. Hardness of groundwater in monsoon was 110.11-480.48 mg/l, in summer 190.19-790.79 mg/l and in winter 160.16-660.66 mg/l. Hardness in groundwater of BW3, BW5 and BW6 was exceeding the acceptable limit of BIS i.e. 300 mg/l throughout study period.

Sodium: The primary source of sodium in natural water is from the release of the soluble products during the weathering of minerals. Groundwater of the surrounding thermal power plant comes under the non safe zone for drinking with reference for drinking with reference concentration of sodium which is more than 300 mg/l [2]. Sodium concentration in groundwater samples was ranged between 105-197 mg/l in monsoon, 120.5-245 mg/l in summer and 112.7-232 mg/l in winter season.

Sulphate: Combustion of fossil fuels releases large quantities of sulfur to the atmosphere. Sulphur in the atmosphere is oxidized to sulphate and eventually deposited with precipitation or through dry deposition. Because sulphate occurs as dissolved ion, it is mobile in groundwater. Sulphate concentration in groundwater was observed as 5-54 mg/l in monsoon, 5-45 mg/l in summer and 8-60 mg/l in winter season. Sulphate concentration was found within the range of acceptable limit of BIS (250 mg/l).

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Bicarbonates: Bicarbonate ions are mainly released by the coal combustion residue from thermal power plants contaminating the groundwater passing through the soil. Bicarbonate concentration was found to be exceeding the BIS limit (500 mg/l) in summer and winter season. The bicarbonate concentration was ranged between 134.2-280.6 mg/l in monsoon, 1207.8-2775.5 mg/l in summer and 329.4-683.2 mg/l in winter season.

Calcium and Magnesium: Calcium and magnesium are directly related to the hardness [13]. Calcium was observed as 8.01-32.06 mg/l in monsoon, 20.04-52.10 mg/l in summer and 12.02-44.08 mg/l in winter. Calcium was found within the range of BIS as 75 mg/l. Magnesium was found to be exceeding the acceptable limit of BIS i.e. 30 mg/l in all samples except at BW2. It was observed as 19.45-102.14 mg/l in monsoon, 34.04-160.52 mg/l in summer and 29.18-133.76 mg/l in winter.

Table1. Physico chemical parameters of groundwater around ash pond of Parichha Thermal Power Plant during monsoon season.

	pH	EC (mS/cm)	TDS (mg/l)	Alkalinity (mg/l)	Chloride (mg/l)	Hardness (mg/l)	Bicarbonate (mg/l)	Sodium (mg/l)	Sulphate (mg/l)	Calcium (mg/l)	Magnesium (mg/l)
BW-1	7.5	1.12	728	290	42.6	370.37	170.8	105	20	24.048	75.392
BW-2	7.5	0.76	504	280	21.3	110.11	134.2	118.6	5	12.024	19.456
BW-3	7.3	1.1	740	340	85.2	390.39	146.4	126.5	18	32.064	75.392
BW-4	7.5	1.02	665	310	17.75	220.22	176.9	117	6	8.016	48.64
BW-5	7.5	0.99	669	380	71	450.45	195.2	134	18	20.04	97.28
BW-6	7.6	1.01	680	490	28.4	480.48	280.6	197	54	24.048	102.144

Whereas; EC=electrical conductivity, TDS= total dissolved solids.

Table2. Physico chemical parameters of groundwater around ash pond of Parichha Thermal Power Plant during summer season.

	pH	EC (mS/cm)	TDS (mg/l)	Alkalinity (mg/l)	Chloride (mg/l)	Hardness (mg/l)	Bicarbonate (mg/l)	Sodium (mg/l)	Sulphate (mg/l)	Calcium (mg/l)	Magnesium (mg/l)
BW-1	7.8	1.36	870	1350	124.25	790.79	1567.7	120.5	15	52.104	160.512
BW-2	8.2	0.89	553	1020	42.6	190.19	1207.8	148.6	7	20.04	34.048
BW-3	7.8	2.03	1275	1880	145.55	480.48	2287.5	133.5	13	44.088	89.984
BW-4	7.8	1.41	910	1960	28.4	390.39	2330.2	202.1	5	40.08	70.528
BW-5	7.9	1.93	1246	2090	273.35	710.71	2513.2	230	15	44.088	145.92
BW-6	7.9	1.96	1275	2280	88.75	730.73	2775.5	245	45	48.096	148.352

Whereas; EC=electrical conductivity, TDS= total dissolved solids.

Table3. Physico chemical parameters of groundwater around ash pond of Parichha Thermal Power Plant during winter season.

	pH	EC (mS/cm)	TDS (mg/l)	Alkalinity (mg/l)	Chloride (mg/l)	Hardness (mg/l)	Bicarbonate (mg/l)	Sodium (mg/l)	Sulphate (mg/l)	Calcium (mg/l)	Magnesium (mg/l)
BW-1	7.6	1.36	839	430	106.5	660.66	341.6	112.7	25	44.088	133.76
BW-2	7.9	0.82	526	400	31.95	160.16	329.4	141.8	16	16.032	29.184
BW-3	7.5	1.7	1077	660	134.9	410.41	549	130.4	26	36.072	77.824
BW-4	7.6	1.16	760	700	21.3	350.35	616.1	170.4	8	12.024	77.824
BW-5	7.6	1.86	1160	720	241.4	520.52	646.6	217	22	36.072	104.576
BW-6	7.6	1.89	1249	810	110.05	550.55	683.2	232	60	36.072	111.872

Whereas; EC= electrical conductivity, TDS= total dissolved solids.

Table4. Correlation matrices among physico chemical parameters of groundwater around ash pond of Parichha Thermal Power Plant.

	pH	EC	TDS	Alkalinity	Chloride	Hardness	Bicarbonate	Sodium	Sulphate	Calcium	Magnesium
pH	1.000										
EC	0.891	1.000									
TDS	0.900	1.000	1.000								
Alkalinity	0.984	0.794	0.807	1.000							
Chloride	0.845	0.996	0.994	0.735	1.000						
Hardness	0.988	0.950	0.957	0.944	0.918	1.000					
Bicarbonate	0.981	0.785	0.799	1.000	0.725	0.939	1.000				
Sodium	0.912	0.999	1.000	0.823	0.990	-0.368	0.815	1.000			
Sulphate	-0.508	-0.061	-0.083	-0.655	0.031	-0.368	-0.666	-0.111	1.000		
Calcium	0.992	0.940	0.947	0.954	0.905	1.000	0.949	0.956	-0.398	1.000	
Magnesium	0.986	0.954	0.960	0.940	0.922	1.000	0.935	0.967	-0.359	0.999	1.000

Whereas; EC= electrical conductivity, TDS= total dissolved solids.

4. CONCLUSION

The ash residues after coal burning may contain significant level of ions of calcium, magnesium, chloride and bicarbonates may cause serious groundwater pollution when disposed off through ash pond due to leaching effect. The groundwater samples taken from bore wells around the ash disposal site of thermal power plant showed higher concentration of electrical conductivity, total dissolved solids, alkalinity, hardness, bicarbonates and magnesium ions exceeding the desirable limits prescribed by BIS. Other parameters like pH, chloride, calcium and sulphate were within the limit. From the present study it can be concluded that there is major effect of ash pond on groundwater contamination.

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