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Effect of Fly Ash Disposal on Ground Water Quality near Parichha Thermal Power Plant, Jhansi: A Case Study

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ABSTRACT

Thermal power plant generates a huge amount of fly ash on combustion of coal which is becoming a major environmental issue. Thermal power plants are greatly facing a fly ash management problem. Open dumping of fly ash can deteriorate the groundwater quality by runoff. In the present investigation, the ground water samples were collected from nearby areas of Parichha Thermal Power Plant at six locations during the period of Jan 2014 to May 2014. The samples were taken to the laboratory and analyzed for physico-chemical properties and heavy metal content. The physico-chemical analysis was done for the parameters like pH, Turbidity, Temperature, Electrical Conductivity, Alkalinity, Total Dissolved Solids, Total Hardness, Calcium Hardness and Magnesium Hardness. The concentration of Turbidity, EC and Alkalinity was exceeding the standard at all locations and shows that the groundwater of the area is not fit for drinking. The ground water samples were also analyzed for the presence of lead and cadmium and it was found that lead was exceeding the limit although cadmium was found within the limit.

Key words: Fly ash, Heavy metal, Physico-chemical parameters, Thermal power plant.

INTRODUCTION

Fly ash is a waste material generates on the combustion of coal in power station throughout the world. The increasing amount of fly ash being generated from thermal power plants can pose a serious environmental threat (Nalawade *et al*., 2012). Fly ash contains major elements like Silica, Aluminum and Iron with significant amount of Calcium, Magnesium, Potassium, Phosphorous and Sulphur (Ivanova *et al*., 2011; Aswar, 2001). It also contain trace amount of some heavy metals like Molybdenum, Mercury, Selenium and Cadmium etc. (Adriano *et al*., 1980). Fly ash in itself is a waste product and contains a huge problem for disposal. Fly ash is disposed off in ash pond by collecting it in the form of wet slurry (Singh *et al*., 2010). Disposal of fly ash in surface water bodies can damage the aquatic life. Mosquitoes and bacteria may grow in large number in slurry disposal lagoons/settling tank (Nawaz, 2013). The soil and water contamination from ash ponds has been a major subject of research all over the world (Theis *et al*., 1978; Theis and Richter, 1979; Theis and Gardner, 1990; Carlson and Adriano, 1993; Deshmukh *et al*., 1994; Deshmukh *et al*., 1995; Gulec *et al*., 2001; Praharaj *et al*., 2002; Singh *et al*., 2010; Ramya *et al*., 2013; Nawaz, 2013). The water quality plays a vital role for the mankind as it directly affects the human health. More than 90% population in India is dependent on groundwater for drinking purpose (Yadav *et al*., 2012; Ramachandraiah, 2004; Tank and Singh, 2010). The present study was done to assess the impact of fly ash disposal on groundwater quality near Parichha Thermal Power Plant at Jhansi.

Study Area

Locality near Parichha thermal power plant at Jhansi was selected as the study area. Parichha thermal power plant is located at 25°30’51.16"N and 78°45’37.40"E. Jhansi is located at 24°11' and 25°57' N and 78°10' and 79°25 E’. Jalaun lies on North to

Jhansi, Mahoba and Hamirpur on East, Tikamgarh of Madhya Pradesh on South and Lalitpur on southwest which joins the Jhansi District by a narrow corridor. A map showing the sampling location of study area is depicted as figure-1.

Collection of Sample

Groundwater samples were collected from 6 different locations near Parichha Thermal Power Plant during January to May 2014. The water samples were collected in polyethylene bottles which were pre-cleaned by nitric acid and distilled water in the laboratory. The pre-cleaned polyethylene bottles were also washed twice by water sample prior to collect the samples. The water samples were immediately taken to the laboratory and analyzed to minimize the physicochemical changes.

Physico-Chemical Analysis

Physico-chemical parameters like pH, turbidity, temperature, electrical conductivity, alkalinity, total hardness, calcium hardness, magnesium hardness and heavy metals like Lead and Cadmium were determined using standard methods of APHA (1995) and the methods by Trivedi and Goel (1986). The reagents of analytical grade were used for analysis and the instruments were calibrated.

RESULT AND DISCUSSION

The result of physico-chemical and heavy metal analysis of groundwater collected near Parichha Thermal Power Plant is given in Table-1.

pH value of studied samples ranges from 6.99 to 7.55 which conform to the IS 10500:2012 drinking water standard. High temperature may raise the alkalinity of water because it reduce solubility of CO_2. Temperature was ranges from 22ºC and 24.5ºC.

The turbidity was varied between 14.63 NTU to 15.78 NTU. It was found greater than the IS 10500:2012 standard in all the samples.

Conductivity is a carrying capacity of electrical current of a solution through the water (Gupta *et al.*, 2013). EC values were varied between 614 to 1317 µmhos/cm. It is directly proportional to the ionizable solids.

Alkalinity of water may be due to either the always presence of strong bases like sodium hydroxide or potassium hydroxide in water or the extreme low concentration of them. Maximum alkalinity of 455.5 mg/l was recorded in GW-1 and

Table 1: Average Results Of Tested Parameters

Sampling Location	pH	Temp	Turb	EC	Alk	TH	CH	MH	TDS	Pb	Cd
GW1	7.45	24.0	15.73	757.0	455.5	151.30	55.94	95.36	300.0	0.04	0.004
GW2	7.55	24.0	15.78	618.0	331.5	143.84	39.91	103.90	369.0	0.04	0.004
GW3	7.25	24.0	15.63	710.5	387.0	246.95	73.84	173.08	681.5	0.03	0.004
GW4	7.25	22.0	14.63	614.0	323.5	273.95	123.86	150.08	703.5	0.03	0.003
GW5	7.00	23.5	15.25	1317.0	397.0	725.20	84.42	640.78	958.5	0.03	0.002
GW6	6.90	24.5	15.70	874.5	289.5	407.23	188.57	218.65	209.5	0.02	0.003
Mean	7.23	23.67	15.45	815.17	364.0	324.75	94.43	230.34	537.0	0.03	0.00
SD (δ)	0.25	0.88	0.45	264.21	60.39	218.45	54.24	206.14	289.11	0.01	0.00
CV	0.035	0.037	0.029	0.324	0.166	0.673	0.574	0.895	0.538	0.238	0.245

All parameters are in mg/l except pH, temperature, turbidity and EC. Temperature in ºC, Turbidity in NTU and EC in micromhos/cm.; Temp- Temperature, Turb- Turbidity, EC- Electrical Conductivity, Alk- Alkalinity, TH- Total Hardness, Ca- Calcium, Mg- Magnesium, TDS- Total Dissolved Solids, Pb- Lead, Cd- Cadmium SD- Standard Deviation, CV- Co-efficient of Variation

minimum i.e. 289.5 mg/l was recorded in GW-6 which exceeds the standard value. It may be due to the minimum rate of decomposition of salts caused by low temperature and low water table (Mahananda *et al.*, 2010). The water is well buffered if it has high alkalinity.

The range of hardness analyzed is 143.84 – 725.20 mg/l. Some samples were within the standard of drinking water and some was exceeding the limit. Hardness caused excessive soap consumption and formation of scum due to the presence of calcium and magnesium in water.

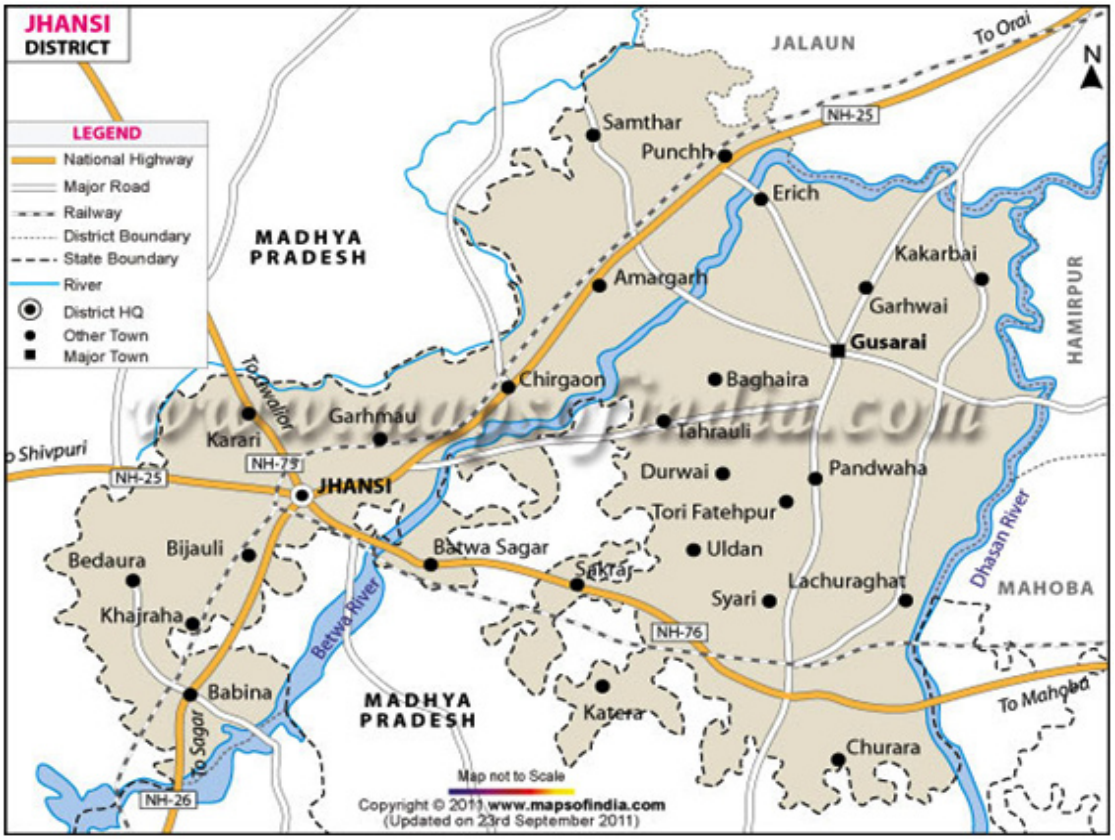

Fig. 1: Location Map showing Sampling Locations of Study Area

Different type of rocks, sewage and industrial waste are responsible for the calcium and magnesium in water (Trivedy and Goel, 1984). The values of calcium varied from 39.91 – 188.57 mg/l and the values of magnesium ranged from 95.56 – 640.78 mg/l.

Total Dissolved Solids and conductivity usually related with each other. The water is not considered good for drinking if TDS of water is more than 500 mg/l (Jain, 2002). The values of investigated samples were ranged between 209.5 – 958.5 mg/l. Half samples were within the drinking water standard of IS 10500:2012 and half were exceeding the limit.

The value of lead was ranged from 0.02 to 0.04 mg/l and the range of cadmium was 0.002 to 0.004 mg/l. Use of mineral phosphate fertilizer is important source of cadmium (Lambert *et al.*, 2007). Both parameters were detected within the permissible limit of IS 10500:2012.

Correlation and Regression Analysis

The correlation study reduces the uncertainty range associated with decision making. The correlation co-efficient 'r' is used to know the

Table 2: Comparison Of Groundwater Quality With Drinking Water Standard

Parameters	IS (10500:2012)	Percent (10500:2012)
pH	6.5-8.5	100
Temperature	—	—
Turbidity	1	0
Electrical Conductivity	—	—
Alkalinity	200	0
Total Hardness	200	33
Calcium	75	50
Magnesium	30	0
Total Dissolved Solids	500	50
Lead	0.01	100
Cadmium	0.003	100

relationship among the parameters. The co-efficient was calculated by using the below given formula:

$$r = \frac{N\sum(XY) - (\sum X).(\sum Y)}{\sqrt{[N\sum X^2 - (\sum X)^2][N\sum Y^2 - (\sum Y)^2}}$$

Where, X and Y represents investigated parameters, N= Number of total observation.

In the present study, the correlation coefficient (r) between two different parameters was calculated by considering the average values as shown in table 1. Correlation coefficient was

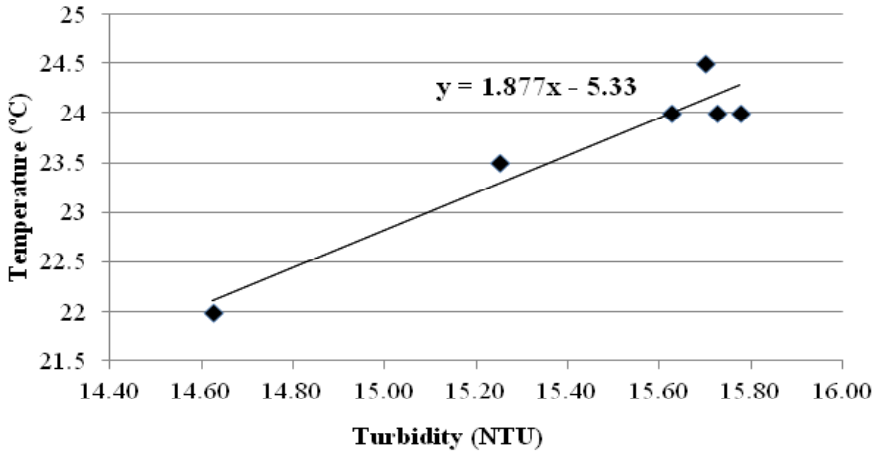

Fig. 2: Regression Line for Turbidity and Temperature

Table 3: Correlation Co-efficient Of Different Parameters

Parameter	pH	Temperature	Turbidity	EC	Alkalinity	TH
pH	1					
Temperature	-0.076	1				
Turbidity	0.206	0.960	1			
EC	-0.656	0.157	-0.030	1		
Alkalinity	0.349	0.103	0.199	0.238	1	
TH	-0.797	-0.060	-0.283	0.935	-0.040	1
Ca	-0.803	-0.029	-0.253	0.137	-0.657	0.344
Mg	-0.633	-0.056	-0.233	0.955	0.131	0.969
TDS	-0.245	-0.559	-0.617	0.498	0.214	0.613
Cl	-0.268	0.439	0.355	0.263	-0.609	0.299
Pb	0.920	-0.051	0.208	-0.316	0.587	-0.531
Cd	0.766	0.326	0.535	-0.799	0.199	-0.934

Parameter	Ca	Mg	TDS	Cl	Pb	Cd
Ca	1					
Mg	0.102	1				
TDS	-0.189	0.699	1			
Cl	0.244	0.252	-0.262	1		
Pb	-0.917	-0.322	-0.071	-0.249	1	
Cd	-0.468	-0.866	-0.578	-0.269	0.542	1

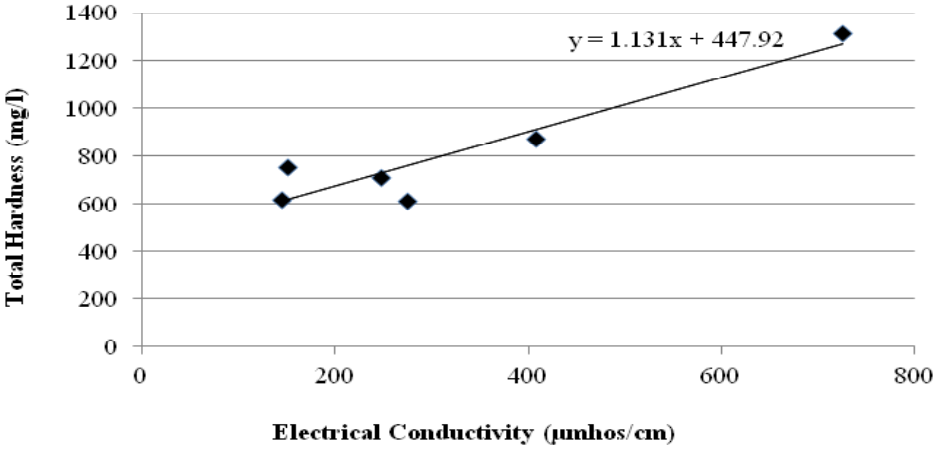

Fig. 3: Regression Line for Total Hardness and Electrical Conductivity

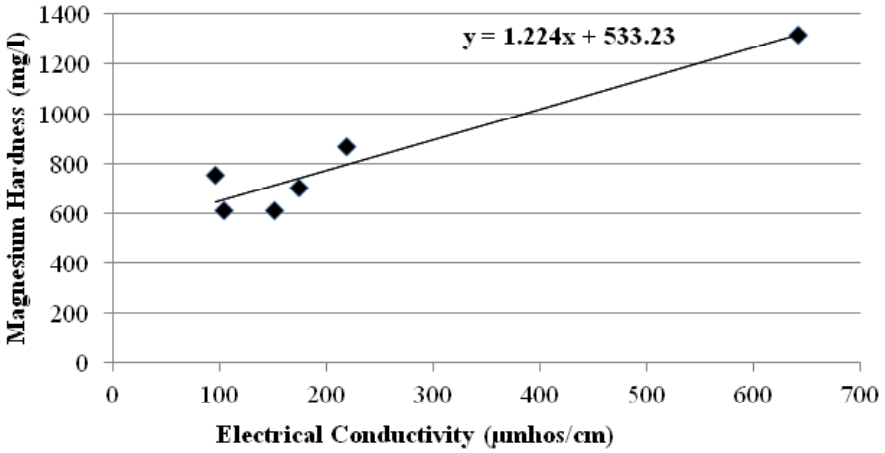

Fig. 4: Regression Line for Magnesium Hardness and Electrical Conductivity

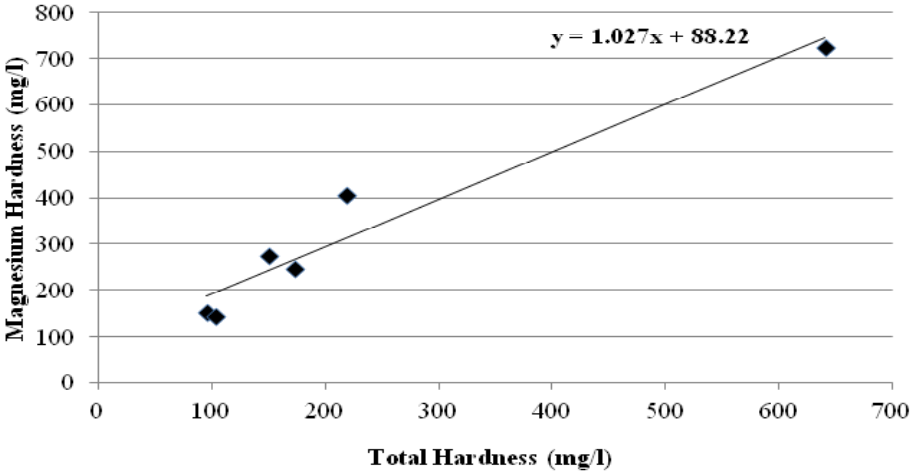

Fig. 5: Regression Line for Magnesium Hardness and Total Hardness

calculated for pH, Turbidity, Temperature, EC, Alkalinity, Total Hardness, Calcium, Magnesium, Total dissolved solids, Lead and Cadmium of groundwater. The highest positive correlation (r = 0.960) was found between turbidity and temperature and the highest negative correlation (r = -0.803) was found between calcium hardness and pH. High values of the correlation coefficient between TH & EC (0.935), Mg & EC (0.955), Mg & TH (0.969), TH & pH (-0.797) as shown in table 3, were observed for the regression analysis, regression equations were formed and regression lines are drawn as shown in figures 2, 3, 4, 5, 6 and 7.

CONCLUSION

After the analysis and interpretation of numerical data, it can be concluded that the groundwater is contaminated in terms of Turbidity, alkalinity, magnesium, total hardness, calcium and TDS. This may be due to the disposal of fly ash near Parichha Thermal Power Station. The study shows that the groundwater needs attention for certain degree of treatment before drinking. Perfect positive correlation evolved between Turbidity and Temperature (0.960), TH & EC (0.935), Mg & EC (0.0.955), Mg & pH (0.969) and perfect negative

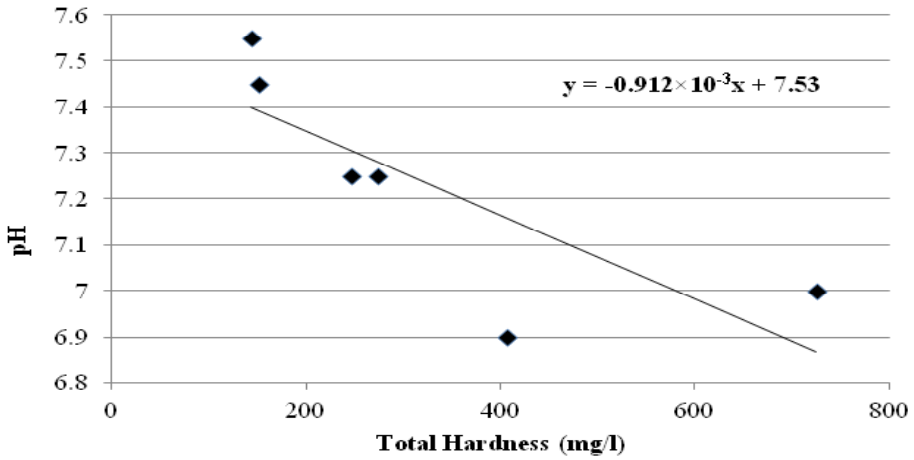

Fig. 6: Regression Line for pH and Total Hardness

Table 4: Computation Of Regression Line For Various Samples

Sample	X-axis	Y-axis	N	X	δ X	Y	δ Y
Turb & Temp	Turb	Temp	6	15.45	0.45	23.67	0.88
TH & EC	TH	EC	6	324.75	218.45	815.17	264.21
Mg & EC	Mg	EC	6	230.34	206.14	815.17	264.21
Mg & TH	Mg	TH	6	230.34	206.14	324.75	218.45
TH & pH	TH	pH	6	324.75	218.45	7.23	0.25
Ca & pH	Ca	pH	6	94.43	54.24	7.23	0.25

Sample	Correlation coefficient(r)	$Y = r\frac{\delta Y}{\delta X}(X - \overline{X}) + \overline{Y}$
Turb & Temp	0.960	1.877X - 5.33
TH & EC	0.935	1.131X + 447.92
Mg & EC	0.955	1.224X + 533.23
Mg & TH	0.969	1.027X + 88.22
TH & pH	-0.797	0.91×10^{-3}X + 7.53
Ca & pH	-0.803	3.70×10^{-3}X + 7.58

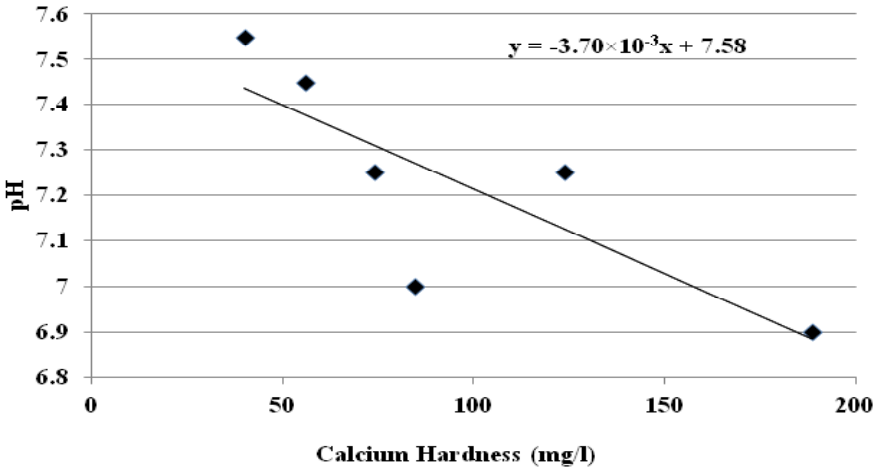

Fig. 7: Regression Line for pH and Calcium Hardness

correlation evolved between TH & pH (-0.797) and Ca & pH (-0.803). It shows that Turbidity, Total Hardness and Magnesium is permanent in nature however there is no relation between TH & pH and Ca & pH. Regression lines were drawn to get the value of one parameter from another parameter.

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