Construction Materials and Thermal Power Plant Emissions: A Case Study of Physico-Chemical Interactions

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ABSTRACT

Fly ash disposal & utilisation is becoming of a national concern due to increasing pollution issues and its efficient management to prevent further degradation of environmental pollution. At present, generation of flyash is in tune of about 130 million tone and likely to be increased in future. Thermal power plants (TPPs) generate a huge amount of fly ash during combustion of coal and face fly ash management problems. Open dumping of fly ash can deteriorate the groundwater quality by runoff. In the present investigation, an attempt has been made to evaluate ground/surface water quality situated near thermal power plant (PTPP) located in eastern UP state in India. Water, flyash and coal samples from various locations in and around PTPP were collected and subjected to insitu and physico-chemical analysis. Coal samples found high ash content. pH values of ground water samples found acidic character with high conductivity values. Physico-chemical analysis of flyash and water extract indicated leaching tendency of soluble ions into water which enhance over a period of time. Urgent need towards flyash utilization & management is a cause of concern.

KEYWORDS: Fly ash; Leaching; Physico-chemical parameters; pH value; Ground water; acidity; Coal; Environmental pollution; Thermal power plant.

1. INTRODUCTION

Fly ash is a waste material generates on the combustion of coal in power stations throughout the world. The increasing amount of fly ash can pose a serious environmental threat. Fly ash is generally disposed off in ash pond by collecting it in the form of wet slurry. Contact of the slurry with fresh water streams deteriorates the surface as well as ground water quality. The water quality plays a vital role for the mankind as it directly affects the human health. To assess the effect of flyash on water quality, a case study was taken up. The study was undertaken near Parichha Thermal Power Station (PTPS) is located on the bank of river Betwa app. 25 km away from Jhansi in state of Uttar Pradesh. The power plant is being operated by Uttar Pradesh Rajya Vidyut Utpadan Nigam. In all six coal-fired thermal power units of the plant has a total generating capacity of 1140 MW (2 units of 110 MW, 2 units of 210 MW and 2 units of 250 MW). These units receive coal from Eastern Coalfields Limited. PTPS is connected to the national grid through NRLDC Delhi. The potential problem being faced by PTPS is fly ash disposal due to inadequate storing capacity of the existing ash dykes and possible danger of leaching of inorganic/heavy metal ions into the ground water over a period of time. The present study highlights the impact of fly ash on water quality.

2. SAMPLING LOCATIONS

Water samples were collected from seven sites (A to G); three fly ash (H to J) and two coal samples (K & L) from in and around PTPP. The details of samples collected are presented in Table 1.

Table 1: Sampling Locations

SAMPLE NOS..	LOCATIONS	
Water Samples		
A	**Hand Pump, Near Canal gate East to Ash dyke (2x110MW)**	

B	**Decantation Well, Compartment B, (2x110 MW)**	
C	**DM Plant, Intake Channel (2x210 MW)**	
D	**Hot Water Channel**	
E	**Hand Pump, Nr. Cremation Ground, Parichha Gaon**	
F	**Betwa River (Parichha reservoir)**	
G	**Hand Pump, Primary School, Parichha Gaon**	
Fly Ash Samples		
H	**Flyash at Compartment B**	
I	**Silos Flyash**	
J	**Flyash (randomly selected)**	
Coal Samples		
K	**Stacked Coal (Front)**	
L	**Stacked Coal (Back near Shed)**	

3. INSITU & LABORATORY INVESTIGATIONS

3.1 Water Samples (Sample Nos. A to G)

The water samples were analysed for in situ parameters like pH, conductivity, temperature, sulphide and ammonium before collection. Laboratory analysis was undertaken as per analytical procedure laid down in IS: 3025–1986 "Methods of Sampling and Test (Physical and Chemical) for Water used in the Industry"[5]. Wherever necessary, reference was also made to the procedure laid down in Standard Methods for the

Examination of Water and Waste Water" published by American Public Health Association and Water Pollution Control Federation, USA, 1985.[8]

Results of in situ tests for pH, Conductivity, Temperature, Ammonium and Sulphide & laboratory tests for Total Dissolved Solids, Inorganic Solids, Organic Solids, Acidity, Chlorides, Sulphates, Calcium, Magnesium, Carbonate, Bicarbonate were determined in the laboratory. Results of in situ and laboratory investigations are presented in Table 2&3 respectively.

Table 2: Results of in situ analysis of water samples

Sample No.	pH value	Conductivity µmhos/cm	Temperature (°C)	NH^{4+} mg/lit.	S^{2-} mg/lit.
A	7.52	504	27.2	0	0
B	7.73	300	31.9	0	0

C	8.23	226	30.8	0	0
D	8.09	232	37.9	0	0
E	6.50	1085	31.1	0	0
F	8.31	230	29.9	0	0
G	6.27	1113	28.0	0	0

Table 3 : Results of Laboratory Analysis of water samples

Sl No.	PARAMETER	WATER SAMPLES						
		A	B	C	D	E	F	G
1	Calcium, mg/lit	43.5	30.9	24	21.8	32	22	56
2	Magnesium, mg/lit	21.2	13.2	9.6	9.6	24	19	48
3	Sodium, mg/lit	22.4	15	10.6	13.1	198.5	13.9	107.7
4	Potassium, mg/lit	1.9	5.9	2.6	2.9	2.5	2.6	2.4
5	Carbonate, mg/lit	0	0	0	0	0	0	0
6	Bicarbonate, mg/lit	152.5	137.3	132	132	515.8	137.3	421.8
7	Chloride, mg/lit	26.4	10.4	7.6	8.3	48.7	7.7	127.0
8	Sulphate, mg/lit	82.1	43.5	6.1	6.4	117.7	42.1	47.2
9	Hydroxide, mg/lit	0	0	0	0	0	0	0
10	Acidity (as $CaCO_3$), mg/lit.	-	-	-	-	8.0	0	10.5

≡ Temperature of the water samples collected from the hand pumps varied between 27.2 to 31.1ºC, temperature of hot water channel and that of the Betwa river (Parichha reservoir) is found to be 37.9 and 29.9 °C respectively. Temperature of other collected samples varied between 30.8 to 31.9 °C. pH values found in acidic range for ground water samples (E & G) at around 6.1. pH values at other locations were found normal to slightly alkaline range.

≡ The conductivity of the ground water samples (Sample No. E&G) found exceeding 1000 µmhos/cm while remaining samples recorded conductivity values below 300 µmhos/cm. The high conductivity (>1000 µmhos/cm) values of ground water samples indicates very high dissolved salts content.

3.2 Staked Coal (Sample Nos. K & L)

Coal samples were analysed as per standard test methods given in IS : 1350 (PART 1) – 1984[4] standards. The results of the same are presented in Table 4.

Table 4 : Results of Chemical analysis of coal samples

Sl No.	Parameters	Sample Nos.	
		K	L
1	Moisture Content, % by wt.	0.94	0.35
2	Volatile matter, % by wt.	15.72	15.22
3	Ash content, % by wt.	46.75	40.49
4	Fixed carbon content, % by wt.	36.59	43.94

The results of chemical analysis of coal samples indicate high percentage of ash content and low values of fixed carbon content. The use of these types of coal tends to generate higher amount of coal ash content. [4]

3.3 Flyash samples (Sample Nos. H, I & J)

Fly ash samples were analysed in the laboratory as per standard test methods given in IS codes & ASTM standards. The result of chemical analysis of flyash is given Table 5.

Table 5 : Results of Chemical analysis of flyash samples

Sl. No.	**Parameters,** (% by wt.)	**H**	**I**	**J**
1.	Loss on Ignition	4.77	3.92	4.38

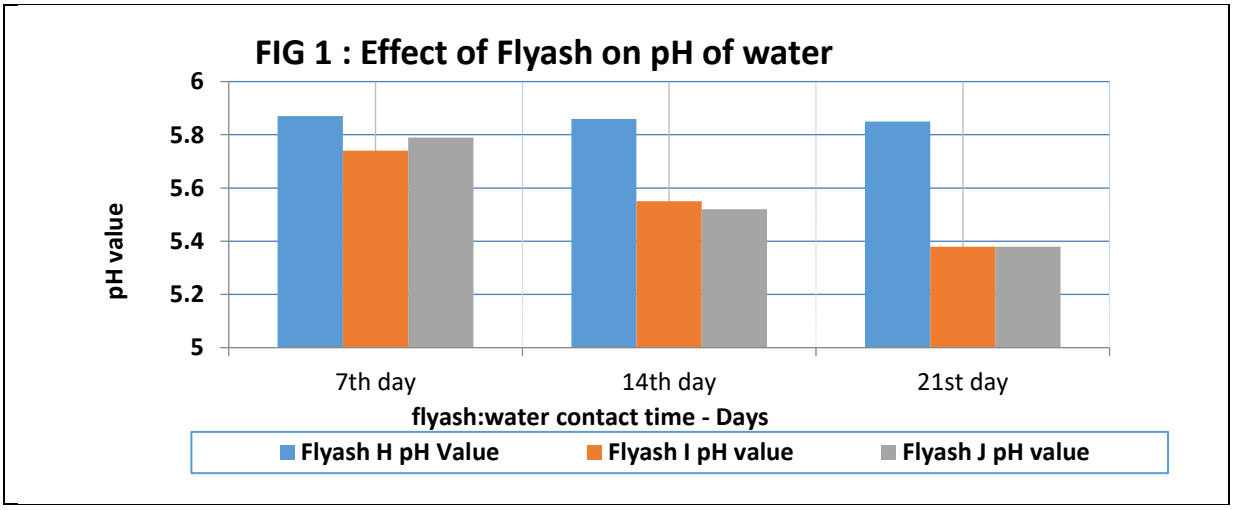
2.	Silica (as SiO_2)	59.70	63.72	61.01
3.	Silica (as SiO_2) + Iron Oxide (as Fe_2O_3) + Aluminium Oxide (as Al_2O_3)	92.87	96.21	95.43
4.	Magnesium Oxide (as MgO)	0.093	0.102	0.080
5.	Total sulphur content calculated as Sulphuric anhydride (SO_3)	0	0	0
6.	Total alkalis (as Na_2O)	0.096	0.071	0.072
7.	Total Chlorides (as Cl)	0.015	0.069	0.12

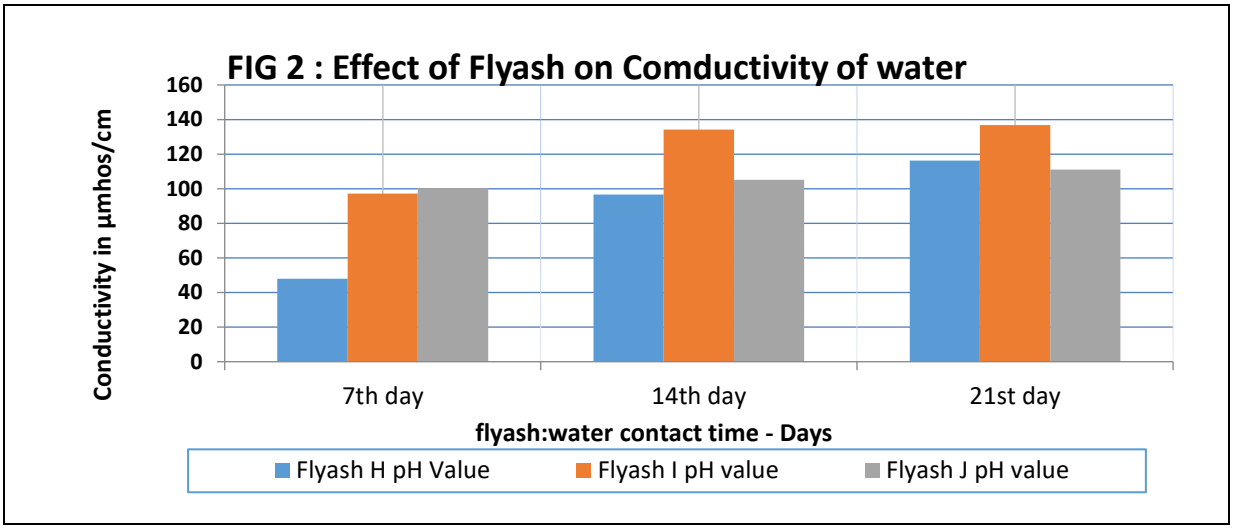
The results of chemical analysis of flyash samples indicate that the flyash samples are siliceous in nature. Fly ash samples conform to the relevant specifications given in IS:3812–2003 (Part 1&2) except chloride content, for flyash samples which recorded more than 0.05 %. [1][2]

4. PHYSICO CHEMICAL ANALYSIS

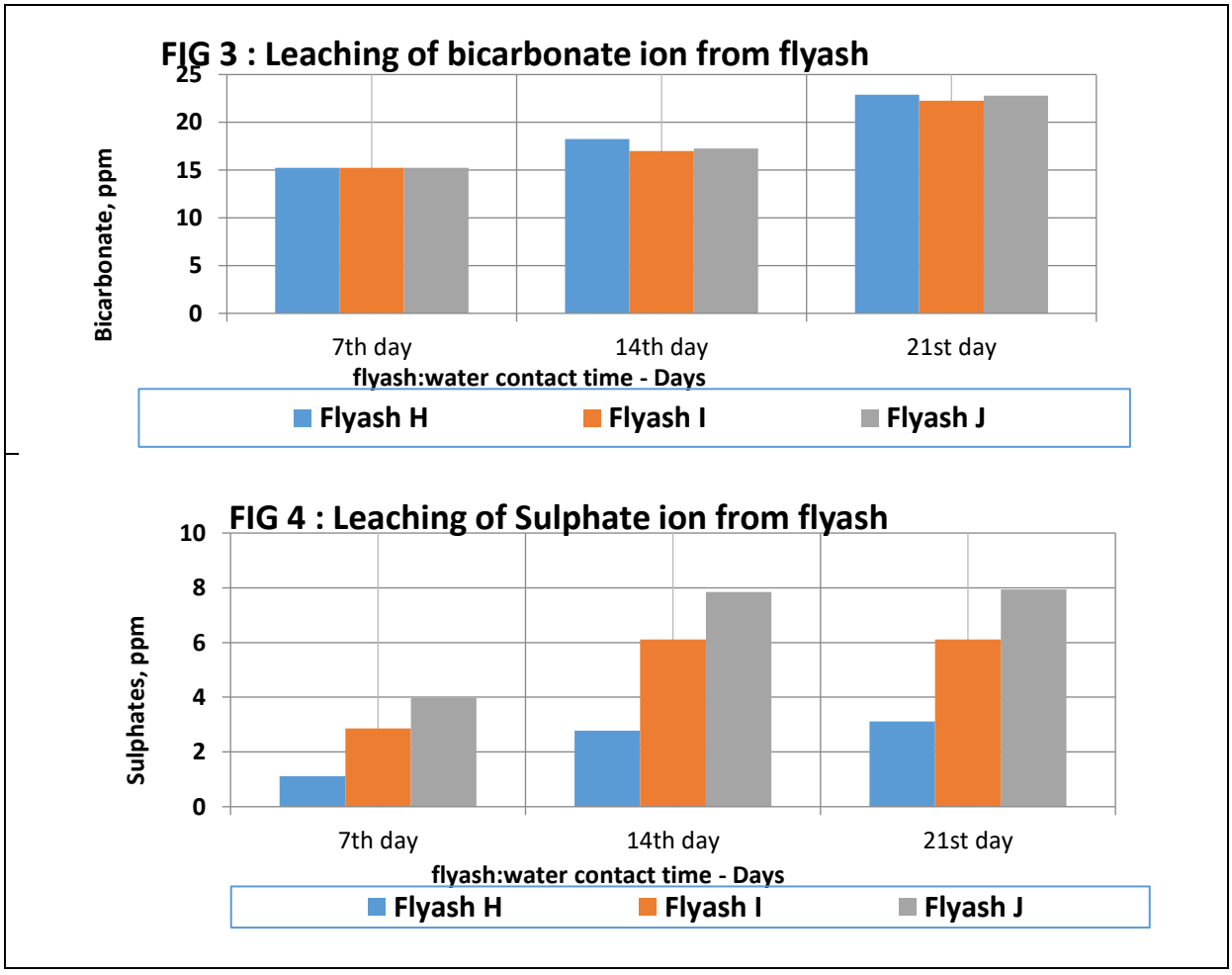
Three flyash samples collected from the project (Sample Nos H, I & J; Table 1) used to make 1:10 fly ash-distilled water suspensions. The suspensions were analysed for various physico-chemical parameters at different time intervals i.e. 7th, 14th and 21st day. Effect of flyash on pH and conductivity values of water are shown in Fig 1&2. The leaching of cations and anions from flyash into water have been represented in Fig. 3 to 9 for different interaction time intervals..

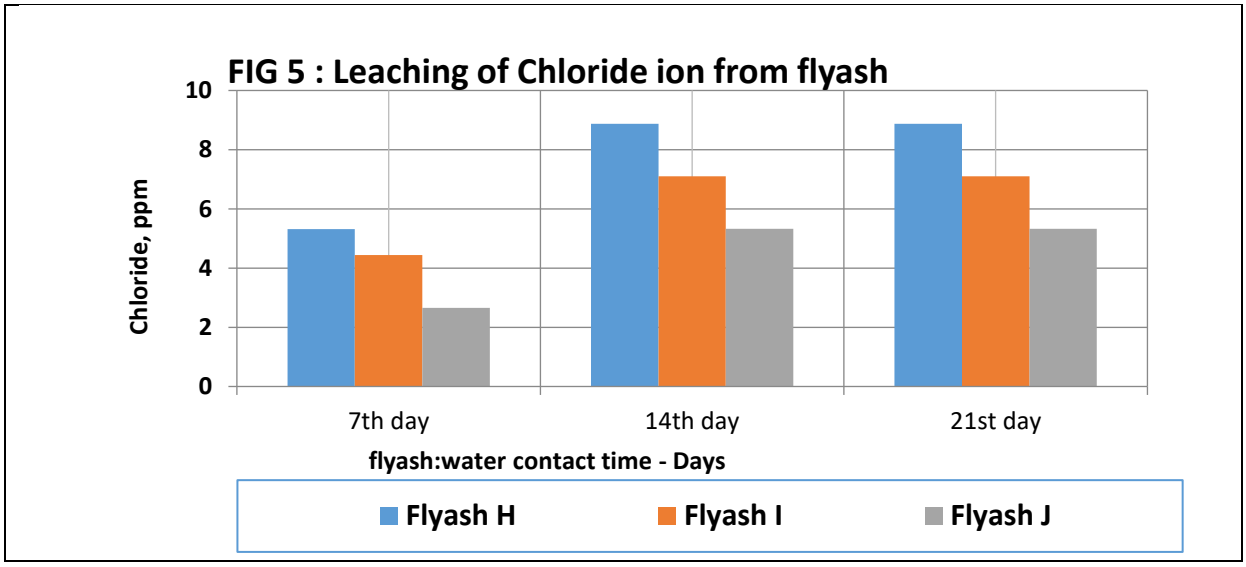
4.1 Impact of flyash on pH and conductivity of water



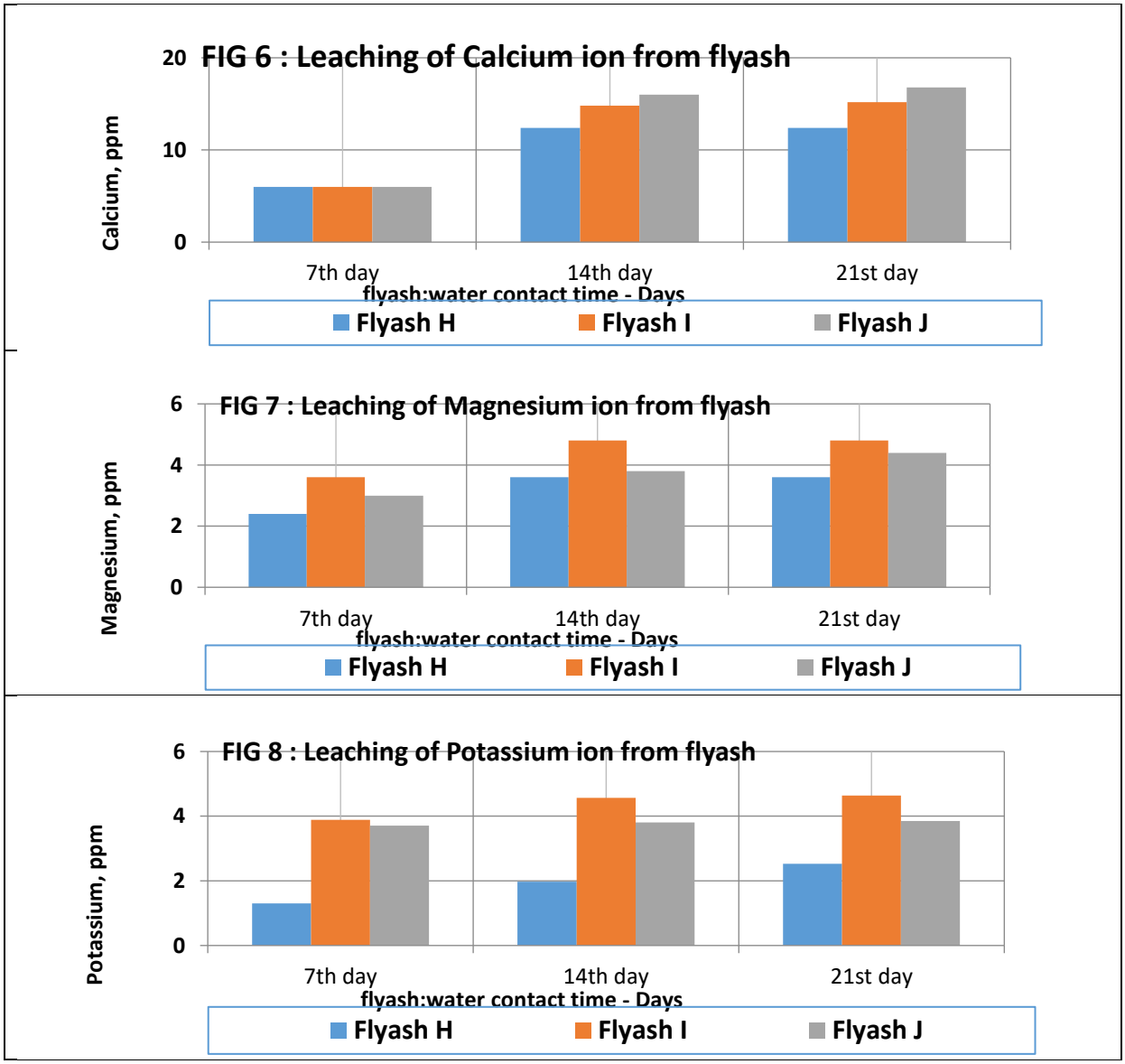


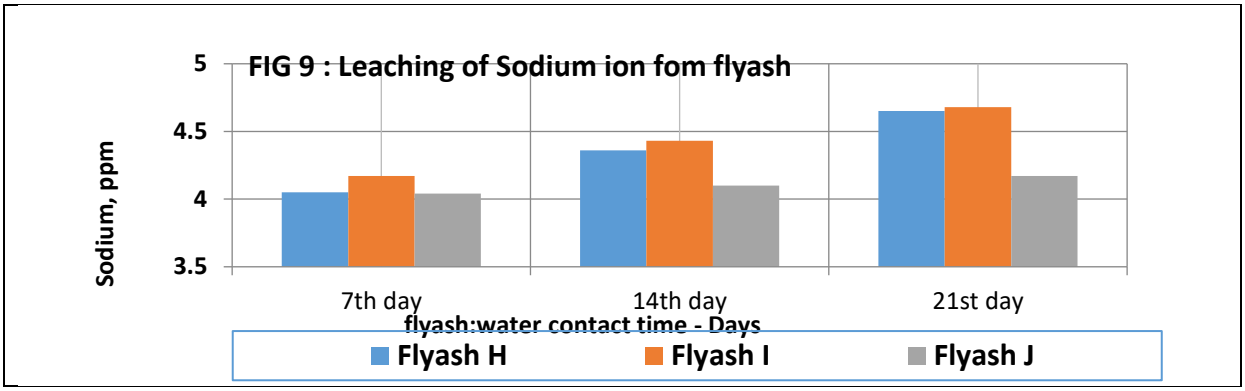
4.2 Impact of flyash contribution of anions in water





4.3 Impact of flyash contribution of cations in water





4.4 Interpretation of data

4.4.1 pH and conductivity (FIG 1&2): pH value falls sharply for fly ash samples I&J in initial stages and remains acidic through out of the period and contribute major acidity in water. General increase in conductivity was noticed for all flyash samples w.r.t. time indicate flyash contribute majority of inorganic ions in water. Further, in situ analysis of ground water samples indicate the high value of conductivity and low pH (Table 2) which correlate the possible effect of fly ash in ground water contamination.

4.4.2 Physico chemical parameters (Anions and cations): Fig. 3 to 5 indicates increase in leaching effect of major anions viz. bicarbonate, chloride and sulphate anions in water from flyash with respect to time. Fig. 6 to 9 indicates increase in leaching effect of major cations like calcium, magnesium, sodium and potassium in water from flyash with respect to time. The study generally shows that flyash tend to leach major anions and cations in water. [6][7]

5. CONCLUSION

The physic-chemical analysis study indicates that flyash contributes acidity in water which may turn the water unfit for drinking as well as for use in construction activity[3] . Apart from this, flyash also tend to leach the soluble ions (including heavy metal ions-study in process) which will further degrade the subsurface water in and around the area. in situ analysis of ground water samples indicate the high value of conductivity and low pH which correlate the possible effect of fly ash in ground water contamination. The chemical analysis of coal samples has shown the higher ash content and comparatively low fixed carbon content, storage of flyash required to be monitored either by raising the height of existing dykes or construction of new dykes. It is suggested for strict quality control of the construction materials to be used in the TPP as per IS specifications. Water quality of the area in the vicinity of thermal Power Plant is also required to be regularly monitored.

6. ACKNOWLEDGEMENT

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