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Physicochemical Study of Kanhan River Water Receiving Fly Ash Disposal Waste Water of Khaperkheda Thermal Power Station, India

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Abstract

Fly ash resulting from coal- based thermal power plants is one of the alarming and continuously increasing sources of pollution leading to degradation of soil, water and air. Fly ash generated from thermal power plant and industrial waste discharged into the streams or dumped into surrounding land causes serious water and soil pollution problems. In the present study various parameters were studied to monitor the pollution of Kanhan River water due to water runoff from ash bund of Khaparkheda Thermal Power Station. These parameters produce various effects on environment and human being therefore their presence in water body is matter of concern. Values of conductivity, total dissolved solids, turbidity, chemical oxygen demand, alkalinity, hardness, and chlorides were very high in side stream water than the desirable values for drinking water. Concentration of copper, cadmium, zinc, lead, mercury and arsenic metals were observed within normal range posing no threats of pollution of heavy metals in water due to ash bund.

Keywords: Fly ash, thermal power plant, water pollution.

Introduction

In India, the natural resource and fossil fuel which is available in large quantity is coal. Coal is used extensively as a thermal energy source and also as fuel for thermal power plants for generating electricity. Power generating capacity has increased many times from 1362 MW to 147,403 MW from 1947 to 2008. More than 70 % of installed capacity for electricity generation i. e. 90,000 MW is produced by coal- based thermal power plants[1]. Fly ash is major by-product of any coal fired thermal power plants. Fly ash is defined as the fine residue resulting from the burning of ground or powdered coal in thermal power plants. In India, nearly 90 mt of fly ash is produced per year and is mainly responsible for environmental pollution[2]. Fly ash contains variety of substances of which trace metals are of special interest due to their cumulative build up, long life, and high toxicity to man, plants, and animals through air, water, and soil. The typical chemical composition of fly ash is given in table 1. Several estimates made by the Bureau of Mines suggest that the fly ash released into the atmosphere appears to be about 5 to 10% of the total ash in coal, and the solid waste produced in the form of ash after the combustion of coal is about 25 to 30%. Presently, less than 10% of the fly ash collected is utilized in some process other than direct burial. As there is no reliable way of successful utilization, the accumulation of fly ash has become a significant waste disposal problem[3].

Coal based thermal power plants are responsible for environmental pollution all over the world which affects the general aesthetics of surrounding in terms of land use, health hazards, quality of air, soil and water and thus pose environmental dangers[4].

Table-1
Chemical Composition of Fly Ash [3]

Name	Formula	Percentage
Silica	SiO_2	62
Iron oxide	Fe_2O_3	63
Aluminum	Al_2O_3	26
Titanium oxide	TiO_2	1.8
Potassium oxide	K_2O	1.28
Calcium oxide	CaO	1.13
Magnesium oxide	MgO	0.49
Phosphorus pentaoxide	P_2O_5	0.40
Sulfate	SO_4	0.36
Disodium oxide	Na_2O	0.28

Being very fine powder, fly ash enters in our body and deposits in pulmonary region of our body causing pulmonary disorders in case of long term exposure. The submicron particles from fly ash enter deep inside the lungs and are deposited on the alveolar walls where metals could be transported to the blood plasma across the cell membrane[1].

Fly ash resulting from coal- based thermal power plants is one of the alarming and continuously increasing sources of pollution leading to degradation of soil, water and air. Fly ash generated from thermal power plant and industrial effluent discharged into the streams or dumped into surrounding land causes serious water and soil pollution problems.

Solid waste is merely dumped on the ground at the selected sites called open dumps. These sites sometimes are ecologically valuable wetland. Those unsightly open dumps often contaminate ground water and surface water through leaching and run off. The dump also creates air pollution when strong winds blow. Usually thermal power plants used this open dump method for dumping fly ash. The atmospheric deposition of fly ash particularly deposits sulphur, increased quantities of aluminium and other toxic elements are leached out of the acidified solid and carried out to ground water and surface water. Fly-ash generated in thermal power station is rich in number of toxic trace elements which may usually add burden of pollutants to the river. Thermal power plants also produce thermal pollution due to discharge of hot water in to natural water bodies which in term decrease the DO content of water and also affects aquatic life[5].

Khaperkheda Power Plant is the oldest power station in Vidarbha. It is situated at Khaperkheda which is located 25 kilometers north–east of Nagpur on the bank of River Kahnan. It is a coal based power plant. Fly ash is dumped on dumping site located near the plant. The water runoff from the fly ash bund gets added to the river Kanhan.

In the present study various parameters were studied to monitor the pollution of water due to water runoff from ash bund of Khaparkheda Thermal Power Station. These parameters produce various effects on environment and human being therefore their presence in water body is matter of concern. The effect of these parameters and their impact on environment is also discussed.

Material and Methods

For this study total nine sampling sites were selected, 3 from the upstream, 3 from side stream, 1 from confluence point and two from downstream. The details of these sites are given in table 1 and also indicated on map (figure 1).

Table-2
Information of Sites

Sample code	Sample Site	Distance from Confluence point
W1	Rohna	8.0 Km Upstream
W2	Parshivani Bridge (Pulia)	6.0 Km Upstream
W3	Bina Sangam	3.0 Km Upstream
W4	Waregaon Waterfall	4.0 Km side stream
W5	Waregaon Pulia	3.0 Km side stream
W6	Waregaon Canal	2.0 Km side stream
W7	Waregaon Canal-Kanhan river Confluence point	0.0 Km (confluence point)
W8	Juni Kamptee	1.5 Km Downstream
W9	Mahadeoghat	3.0 Km Downstream
-	Ash Bund of Khaparkheda Thermal Power Station	-

Sampling was carried out by following the standard procedures and techniques[6]. Parameters like temperature, pH and colour are measured by using thermometer, pH meter and by visual observation respectively at the sampling site immediately after collection of samples. For Dissolved Oxygen, the samples were collected in glass BOD bottles and the D.O reagents were added at the site only in order to fix the Dissolved oxygen. Samples for metal analysis were collected in separate bottles and are acidified to pH 2 with HNO_3 and refrigerated at 40^oC and for rest of the parameters, sample were collected in virgin plastic cans and samples were analysed within 48 hrs.

Physical parameters like pH, Turbidity, Temperature, Total Dissolved Solid and Conductivity are determined by using standard procedures[6]. Colours of the samples are recorded by visual observation.

Chemical parameters like dissolved oxygen (Winkler method with Azide modification method), chemical oxygen demand, alkalinity, total hardness, calcium hardness, magnesium hardness, chlorides (Argentometric Method), sulphate, fluoride (Spadns Method), phosphate, silica, iron (Phenanthroline Method) are determined by using standard methods of water analysis[6]. Nitrate was tested by Brucine Method[7].

Analysis of manganese, copper, cadmium, zinc, lead, mercury and arsenic are carried as per BIS method IS: 3025 (part II) 2004 from outside laboratories, Anacon Laboratories Pvt. Ltd. and Enviro Techno Consult, Nagpur[8].

Results and Discussion

In the present study various parameters were studied to monitor the pollution of water due to disposal waste water (Ash Bund water) from Khaperkheda Thermal Power Station. These parameters produce various effects on environment and human being therefore their presence in water body is area of concern. The results of analysis of various parameters are given in table 2.

Total nine sampling sites were selected, 3 from the upstream, 3 from side stream, 1 from confluence point and two from downstream. pH of all the samples was within the normal range recommended for drinking water. Temperature of water samples was found in accordance with the ambient temperature in the range of 23.5^0C - 35.3^0C indicating that there is no thermal effect due to pollution of ash bund in side stream water. All the samples drawn from upstream were colourless except for rainy season. Milky white colour was observed in water samples from side stream and this colour was diluted as water move to downstream and gain colourless from site W9 onward. Turbidity followed the same trend of colour with turbidity more than 5 NTU was observed in the samples with milky white and muddy colour. Turbidity values for the samples from side stream were found in the range of 210-290 NTU which is much higher than the desired limit for drinking water 5 NTU. While for muddy water the turbidity was found in the range120 to180 NTU. Conductivity of samples from downstream was found to be more than the conductivity of samples collected from upstream, indicating the effect of addition of ash bund water from side stream to the downstream sites of Kanhan River. The same trend was found for total dissolved solids. Dissolved oxygen content of samples from downstream sites and Confluence point was comparatively low than DO content of upstream sites. This is due to depletion of oxygen at these sites because of addition of ash from side stream site. Site stream sites showed lowest values for DO. There is marginal variation in the COD of both upstream and downstream water samples but there is comparatively more COD in samples from side stream water. COD values do not reflect any significant organic pollution. Alkalinity of side stream was found higher than the desired limit for alkalinity. The alkalinity of downstream samples was high as compared to the samples from upstream thus showing the effect of addition of side stream water in the downstream sites. Similar type of trend was observed for total hardness of water. Total hardness of samples was found to be greater than the corresponding alkalinity for all the three seasons. This indicates that samples have alkaline as well as non-alkaline hardness. Ca^{2+} and Mg^{2+} ions in samples from Side stream sites were more than the desired limit for most of the samples. $Ca^{2+}$and Mg^{2+} ions at downstream sites was marginally higher than at upstream sites. This is probably due to leaching of these ions from ash to water. The samples from downstream sites showed the higher concentration of Cl^- ion than in samples from upstream sites. Chloride content of samples from side stream site was found to be much higher than the desired limit. This is obviously because of addition of Cl^- ions from ash to side stream water and this water further mix with the water of downstream. Higher concentration of Ca^{2+} and Chloride make water unsuitable for human use and making suitable for the growth of various algae[9].

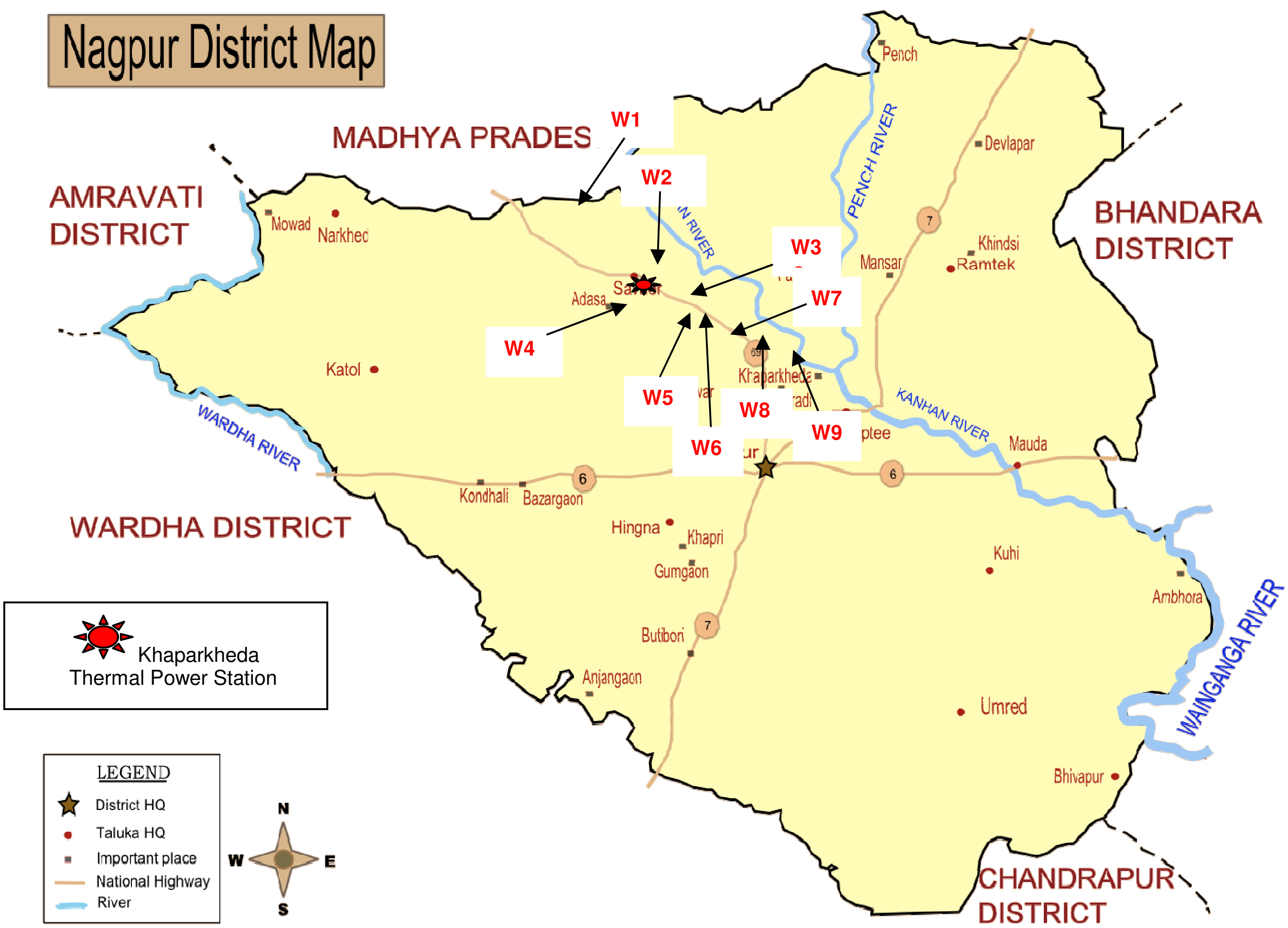

Figure-1
Map of Kahnan River (Dist. Nagpur, India) showing sampling Sites

Table-3
Season wise variation in Physico – Chemical Parameters at various sites

Sr. No	Parameter	Unit s	Seas on	Site1(W1)	Site2 (W2)	Site3 (W3)	Site4 (W4)	Site5 (W5)	Site6(W6)	Site7(W7)	Site8 (W8)	Site9 (W9)	Desirable limit
1	pH		W	8.3	7.9	8.1	7.9	7.9	7.9	7.9	8	8.1	6.5 to 8.5
			S	8	7.8	8.2	7.8	8.2	8.2	8.1	7.7	8.2	
			R	7.6	7.8	7.8	7.5	7.5	7.75	7.9	7.7	7.85	
2	Temp	^oC	W	26.5	23.5	25.6	24.2	24.9	24.2	24.9	26.8	26.5	
			S	27.3	29.1	29.5	33.9	29.3	29.5	30	29	35.3	
			R	28.3	28.3	31	30	28.7	28.7	29.2	28.7	28.7	
3	Colour		W	Colour less	Colourles s	Coiourless	Colourl ess	Colurle ss	milky white	Slightly milky	Colourles s	Colourles s	
			S	Colour less	Colourles s	Coiourless	milky white	milky white	milky white	Slightly milky	Slightly milky	Colourles s	
			R	Muddy	slightly muddy	Slightly muddy	milky white	milkyw hite	milky white	slightly muddy	slightly muddy	slightlym uddy	
4	Conductivit y	m S/cm	W	620	880	630	2310	2030	1990	1180	910	830	
			S	550	890	670	2330	1990	1970	1310	910	880	
			R	400	500	380	1750	2000	2000	1070	710	390	
5	TDS	mg/ L	W	419	619	430	1503	1383	1330	815	589	540	
			S	370	620	448	1627	1353	1357	849	599	588	
			R	263	330	255	1225	1356	1362	717	483	268	
6	Turbidity	NTU	W	1.1	1.2	1.2	260	260	240	50	1.7	1.5	5 NTU
			S	1.5	1.4	1	280	270	250	70	1.9	1.5	
			R	780	380	320	240	220	220	240	180	120	
7	Dissolved oxygen	mg/ L	W	7	6.9	6.8	5.6	5	5	5.8	6.3	6.5	
			S	7	5.6	6.7	5.2	4.5	5.1	6	6.8	7	
			R	7.2	7.2	7.1	5.7	5.8	5.3	6.7	6.8	7.1	
8	Chemical oxygen demand	mg/ L	W	25	75	32	50	154	151	84	42	79	500mg/L
			S	36	68	36	56	160	140	100	36	60	
			R	63	27	27	58	35	15	23	54	35	
9	Alkanity as $CaCO_3$	mg/ L	W	157	173	161	243	242	276	212	202	194	200mg/l
			S	154	184	153	271	250	239	200	186	166	
			R	104	93	91.5	215	244	232	215	184	104	
10	Hardness as $CaCO_3$	mg/ L	W	181	188	188	311	319	355	235	206	185	300 mg/l
			S	175	286	156	331	312	309	220	217	190	
			R	121	111	107	314	310	305	186	114	119	
11	Calcium as $CaCO_3$	mg/ L	W	119	127	116	177	185	206	130	116	98	
			S	107	160	95	206	194	166	126	118	99	
			R	75	93	64	160	175	159	103	71	89	
12	Magnesium as $CaCO_3$	mg/ L	W	62	61	72	134	134	149	105	90	87	
			S	68	126	61	125	118	143	94	99	91	
			R	46	18	43	154	135	146	83	43	32	
13	Calcium Ca^{2+}	mg/ L	W	47.6	50.8	46.4	70.8	74	82.4	52	46.4	39.2	75mg/L
			S	42.5	64	38	82.4	77.6	62	50.4	47.2	39.6	
			R	30	37.2	25.6	60	70	61.2	41.2	28.4	35.6	
14	Magnesium Mg^{2+}	mg/ L	W	15.12	14.88	17.57	32.7	32.7	36.36	25.62	21.96	21.23	30 mg/L
			S	16.59	30.74	14.88	30.5	28.79	32.45	22.94	24.16	22.2	
			R	11.22	4.39	10.49	30.26	32.94	34.16	20.25	10.49	7.81	
15	Chloride as Cl^-	mg/ L	W	20	26	21	504	435	427	180	35	26	250 mg/L
			S	22	175	72	617	442	452	203	90	112	
			R	9	60	27	401	472	468	185	11	9	
16	Sulphate SO_4^{--}	mg/ L	W	44	48	48	127	127	122	96	83	70	200 mg/L
			S	18	26	13	44	83	92	75	53	48	
			R	26	22	18	92	92	88	44	26	26	
17	Fluoride as F^-	mg/ L	W	1.05	1.14	1.06	1.1	1.14	1.1	1.05	1.13	1.1	1.0 mg/l
			S	1.1	1.17	1.1	1.14	1.18	1.23	1.21	1.13	1.12	
			R	0.73	0.83	0.7	0.85	1.06	1.13	0.84	0.76	0.77	
18	Phosphate as PO_4^{--}	mg/ L	W	0.75	0.83	0.5	0.83	1	0.75	1.08	0.416	0.83	
			S	3	2	4.33	2	2	2.33	1.66	3.66	4.66	
			R	0.83	0.58	0.83	1.08	1.41	1.33	1.08	1.41	0.83	
19	Nitrate as NO_3^-	mg/ L	W	8.57	11.42	8.57	11.42	14.28	14.28	20	20	18.57	45.0 mg/l
			S	2.85	8.57	5.71	7.14	7.14	10	18.57	8.57	5.71	
			R	5.71	7.14	5.71	11.42	11.42	14.28	20	11.42	5.71	
20	Sillica	mg/ L	W	13.04	7.24	5.79	5.79	7.24	5.79	5.79	8.69	8.69	
			S	26.08	10.87	8.69	6.52	6.52	6.52	8.69	6.52	4.66	

			R	14.49	10.14	5.79	7.24	7.24	7.24	8.69	8.69	7.24	
21	Iron	mg/L	W	0.345	0.345	0.46	0.69	0.805	1.15	1.38	1.725	1.38	0.3 mg/L
			S	0.345	0.345	0.345	0.805	1.265	1.38	2.415	2.07	1.725	
			R	0.805	0.345	0.805	1.38	0.92	0.92	0.805	1.725	1.495	
22	Manganese	mg/L	W	0.053	0.609	0.057	-	-	0.298	BDL	0.076	0.039	0.1 mg/l
			S	<0.05	0.11	-	-	0.41	-	-	-	0.06	
23	Copper	mg/L	W	BDL	0.008	0.002	-	-	0.013	0.002	0.004	0.001	0.05mg/L
			S	0.02	0.02	-	-	0.02	-	-	-	0.01	
24	Cadmium	mg/L	W	0.001	BDL	BDL	-	-	0.002	BDL	BDL	BDL	0.01mg/L
			S	<0.01	<0.01	-	-	<0.01	-	-	-	<0.01	
25	Zinc	mg/L	W	0.14	0.023	0.007	-	-	0.058	0.006	0.002	0.083	5mg/L
			S	0.1	<0.1	-	-	<0.1	-	-	-	0.1	
26	Lead	mg/L	W	0.364	0.011	BDL	-	-	0.012	BDL	BDL	BDL	0.05mg/l
			S	<0.01	0.01	-	-	0.02	-	-	-	0.01	
27	Mercury	mg/L	W	-	-	-	-	-	-	-	-	-	0.001mg/L
			S	-	-	-	-	<0.001	-	-	-	-	
28	Aresnic	mg/L	W	-	-	-	-	-	-	-	-	-	0.05mg/L
			S	-	-	-	-	<0.001	-	-	-	-	

Concentration of Sulphate SO_4^{2-} ions in all the samples was found within limit with comparatively higher in samples from side stream and downstream. Significant effect of ash pollution in water was not observed with respect to Sulphate SO_4^{2-} ions. Fluoride ion concentration of samples from all the sites for winter and summer season was found to be higher than the desirable limit. While fluoride ion content was below the desirable limit during rainy season except for sites W5 and W6 was basically due dilution effect. Concentration of PO_4^{2-} ion and NO^{3-} ion were observed within normal range as per Indian Standard indicating that ash bund do not exert any effect with respect to these ions. Silica concentration varies from of 4.66 to 26.08 mg/L. Limit for silica in water is not defined in Indian standard. Iron content was found more than the desirable limit for iron content is 0.3mg/L according to Indian standard drinking water specifications in all the samples. Interestingly the iron content was found to increase in the samples collected from side stream and downstream indicating the enrichment of iron in to the water from ash bund of thermal power station. Manganese content was found to be more than the desirable limit of 0.1mg/L for the side stream sites for both the summer as well as winter season. Manganese content in sample from both upstream and downstream sites was observed within desirable limit except site W2 which showed high concentration in winter and summer season. Concentration of copper, cadmium, zinc, lead, mercury and arsenic metals were observed within normal range posing no threats of pollution of heavy metals in water due to ash bund. In one of the studies on Water Quality Assessment in Reservoirs and Wastewater Treatment System of the Mae Moh Power Plant, Thailand, it was found that the heavy metals did not exceed both the surface water quality standards and the industrial effluent standards of Thailand. So the effluent from the Mae Moh power plant showed no significant effect on water pollution on the aquatic ecosystem[10]. Water Pollution occurs in local water streams, rivers and ground water from effluent discharges and percolation of harmful materials from the stored fly ash. Sanhita De *et al* have studied water pollution in the thermal power station effluents of Sarni, Betul, M.P. and noted that there is no major impact on water quality[11]. In our study, water of side stream was found more polluted with respect to certain parameters. Similarly the downstream water is more polluted than upstream water of river but this water is suitable for auxiliary purposes such as irrigation, washing, etc.

Conclusion

The side stream sites are highly polluted which then directly get mixed with the Kanhan River thus adding the load of pollution to the Kanhan River. Values of conductivity, total dissolved solids, turbidity, chemical oxygen demand, alkalinity, hardness, and chlorides were very high in side stream water than the desirable values for drinking water. Although main stream of Kanhan River showed these values within limits except few parameters exceed the desirable limit at confluence point. Concentration of these parameters were found comparatively more in downstream water than upstream water indicate the impact of ash bund side stream water on the quality of water of downstream of river. Even though most of the metals were found within the limits, metals like iron and manganese were found in high concentration. So some preventive steps should be taken in order to stop the addition of side stream water i.e. disposal waste water from thermal power plant to the fresh water bodies. Water near the confluence point is not suitable for drinking purposes although this water can be used for other auxiliary purposes such as irrigation, washing, etc.

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References

1. Shamshad A., Fulekar M.H.and Pathak B., Impact of Coal Based Thermal Power Plant on Environment and its Mitigation Measure, *International Research Journal of Environment Sciences,* **1(4),** 60-64 **(2012)**

2. Senapati M.R., Fly ash from thermal power plants – waste management and overview, *Current Science*, **100 (12)**, 25 **(2011)**

3. Sharma S., M.H.Fulekar, Jayalakshmi C.P. and Straub C.P., Fly ash dynamics in soil-water systems, *Critical Reviews in Environmental Control ,* **19(3)**, 251-275 **(1989)**

4. Ashoka D., Saxena M. and Asholekar S.R., Coal Combustion Residue-Environmental Implication and Recycling Potential, *Resource Conservation And Recycling,* **3**,1342-1355, **(2005)**

5. Asthana D. K., Asthana M., Environment, problems and solution **(2001)**

6. National Environmental Engineering Research Institute Nagpur, Manual on water and waste water analysis, **(1988)**

7. Chhatwal G.R., Mehra M.C., Satake M., Katyal T., Katyal M. and Magahiro T., Environmental Analysis, 130 **(1989)**

8. IS: 3025 (PART II) (**2004)**

9. Diwedi S. , World Academy of Science, Engineering and Technology, 71, **(2010)**

10. Junshum P., Menasveta P. and Traichaiyaporn S., *J. Agri. Soc. Sci.,* **3(3)**, (**2007)**

11. De S., Mishra D. D., Jain B, and Bajpai,A., poll.res.**26(3)**, 457-458, (**2007)**