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Case Study on use of Irrigated Soil by Decant Water for Cultivation Near NTPC Ramagundam Super Thermal Power Plant Telangana (Andhra Pradesh)

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Figure 1

Abstract- The present study was conducted around the ash disposal sites of Ramagundam Super thermal power Plant (TPPs) Surrounding agricultural lands. It is situated in Peddapalli Telangana. Fly ash is produced as a result of coal combustion in thermal power station and discharged in ash ponds. Basically the releasing of huge amount of flay ash affects the soil quality. Detected higher concentration of Ca, Mg, Na, K and many more element in the sample of some sites while recorded minimum concentration in some site in all the collected samples.

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I. Introduction

Coal is the only natural resource and fossil fuel available in abundance in India. Consequently, it is used widely as a thermal energy source and also as fuel for thermal power plants producing electricity. Combustion process converts coal into useful heat energy, but it is also a part of the process that produce greatest environmental and health concerns. Disposal of such an enormous amount of FA is a massive problem, particularly if it must be deposited in areas that surround thermal power stations. Management of fly ash is a major environmental and economic concern for the coal fired power generators all over the world. Fly ash is rich in many macro and micro elements. Present study was conducted to evaluate the impact of fly ash incorporation on physico-chemical properties of soil for agriculture purpose. Based on the nature of coal and combustion conditions, fly ash may contain various levels of heavy metals such as antimony, arsenic, barium, boron, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, selenium, silver, and zinc. Large quantities of coal fly ashes are stored in the form of waste heaps or deposits, whose contamination poses a serious threat to the environment in general and can have deleterious effects on soils, surface water, and ground water Fly ash disposal and management of Ramagundam Super Thermal Power Plant, the current largest Thermal Power Plant in south India, it is a 2600 MW Thermal Power Station situated in Peddapalli district in the Indian state of Telangana, India has become a major issue of concern. The fly ash is dump in the dumping ponds and slurry from these ponds directly flows through canals into the surrounding land and water is used for the agriculture purpose, Blow-off the ash towards agricultural land is may causing unnecessary human exposure and has serious health risks. The villagers can even more affect as the ash is deposited in the fields and farmers use ash-laden water to irrigate, all the macro and micro elements (heavy metals) of fly ash are mixed in the soil and contaminate the quality of soil if it records in high concentration from the permissible limit.

Table 1: Chemical composition for fly ash produced from different coal types

Component (wt.%)	Bituminous	Sub-bituminous	Lignite
SiO2	20–60	40–60	15–45
Al2O3	5–35	20–30	10–25
Fe2O3	10–40	4–10	4–15
CaO	1–12	5–30	15–40
MgO	0–5	1–6	3–10
SO3	0–4	0–2	0–10
Na2O	0–4	0–2	0–6
K2O	0–3	0–4	0–4

Table 2: Chemical composition of fly ash

S.No.	Chemical Composition of Fly Ash	Formula	Percentage (%)
1	Silica	SiO2	
2	Iron oxide	Fe2O3	63
3	Aluminum	Al2O3	26
4	Titanium oxide	TiO2	1.8
5	Potassium oxide	K2O	1.28
6	Calcium oxide	CaO	1.13
7	Magnesium oxide	MgO	0.49
8	Phosphorus pentaoxide	P2O5	0.40
9	Sulfate	SO4	0.36
10	Disodium oxide	Na2O	0.28

Table 3: Diseases due to the presence of heavy metals in FA

Metal	Content (ppm)	Disease
Nickel (Ni)	77.6	Respiratory problem, lung cancer
Cadmium (Cd)	3.4	Anaemia, hepatic disorder
Antimony (Sb)	4.5	Gastroenteritis
Arsenic (As)	43.4	Skin cancer, dermatitis
Chromium (Cr)	136	Cancer
Lead (Pb)	56	Anaemia

II. Methodology

The soil samples collected from NTPC Ramagundam were brought to Govt. Science College and TFRI laboratories and oven dried in enamelled trays. Care was taken to maintain the identity of each sample at all stages of processing and analysis. During drying, the trays were numbered and a plastic tag was attached. Initially, the samples were allowed to dry in the air, and then the trays were placed in a hot air oven whose temperature did not exceed 50^0 C. Oven drying a soil at high temperature can cause profound change in the sample. Although, drying has negligible effect on total N content but the nitrate content in the soil changes with time and temperature.

The dried soil samples were grinded to powder and analysed for physico-chemical characteristics *viz.* pH, electrical conductivity, organic carbon, available N, P, K, exchangeable cations including Ca, Mg, Na, K, mechanical analysis (silt, clay, sand) and texture of the soil. The analysis of samples was done by the methods described by Piper (1950), Jackson (1965), Chopra and Kanwar (1976) and Black (1965).

1. Conducting modelling study to access the water usage in the agriculture field for short and long term.
2. The scope shall clearly conclude the impact of ash pond decant water due to usage in agriculture and shall come out with an implementable action plan both short term and long term for the mitigation actions, if required.
3. Sample collection, handling, transportation and analysis are to be carried out standard procedure defined by ICAR (Indian Council of Agriculture Research), USEPA/ MOEF/ CPCB/ BIS/ WHO etc and the following parameters are to be considered at least.
4. Soil for physical Texture soil type, pH, conductivity, SAR, CEC, Na, P, K, F, Cation (Ca, Na, P, K, Cation (Ca, Na, K), Anion (F, Cl, SO4, C3,) heavy Metals (As, Pb, Cd, Hg, Total Cr, Cr(6) Ni, As, Zn, Cu, B etc).
5. The scope inter alia also includes additional requirements of any kind, if observed necessary during the course of execution, without any additional cost implications.
6. Controlled experiments are also to be performed in the laboratory to assess the impact of ash pond decant water.

III. Selection of Sites

The selected sites beginning from ash ponds and throughout the course of decant water flow upto Godavari river at regular interval. A total of ten sampling locations were selected during the two tours conducted at NTPC Ramagundam:

Table 4

S.No.	Site	Geo-coordinates	Habitat/Surrounding features
1.	Ash ponds	$18^0 45'20.3"$ N $79^0 24'59.8"$ E Altitude – 198 m	4 Ash lagoons N1, N2, S1, S2, herbs and grasses coming on flyash
2.	Starting point of decant water canal	$18^0 45'15.3"$ N $79^0 25'41.1"$ E Altitude – 175 m	Vegetation mix of trees, shrubs and herbs, decant water from 4 ash lagoons coming and start of decant water canal
3.	Peddumpet village	$18^0 47'32.3"$ N $79^0 26'9.2"$ E Altitude – 155 m	A large number of trees, shrubs and herbs present, domestic waste adding to the canal
4.	Railway colony	$18^0 45'35.4"$ N $79^0 25'59.0"$ E Altitude – 171 m	A good number of shrubs and herbs present near the road bridge, partly waterlogged site
5.	Amijumbodu village (Decant water)	$18^0 47'34.4"$ N $79^0 26'46.9"$ E Altitude – 153 m	Agriculture land cultivating paddy using decant water
6.	Ramagundam Village (Decant water)	$18^0 47'50"$ N $79^0 27'9.2"$ E Altitude – 146.30 m	Near Amijumbodu village, agriculture land cultivating paddy using decant water
7.	Last point of decant water canal	$18^0 49'21.6"$ N $79^0 27'41.4"$ E Altitude – 122 m	Scattered vegetation comprising herbs and grasses, last point of canal before joining Godavari river
8.	Godavari river	$18^0 49'33.4"$ N $79^0 27'46.1"$ E Altitude – 126 m	Godavari river almost dry in May but sufficient water in September, herbs and grasses found on the bank of river
9.	Lingapur village (Normal water)	$18^0 48'04"$ N $79^0 27'45.1"$ E Altitude – 149.35 m	Control site. Agriculture land cultivating paddy and vegetables using normal water
10.	Lambadi tanda (Normal water)	$18^0 47'2.2"$ N $79^0 24'11"$ E Altitude – 187.76 m	Control site on upper side of ash ponds. Agriculture land cultivating paddy using normal water

IV. Collection of Samples

Following samples were collected in May and September 2016.

a) Soil and fly ash samples

Representative soil samples from the nearest possible site to the decant water, agricultural fields and control sites were collected and brought to Govt.

Science College and TFRI Laboratory Jabalpur for analyzing their physico-chemical properties. Fly ash samples were collected from ash lagoons/ ponds N1, N2, S1 and S2. Soil and fly ash samples were collected through grab sampling method. For surface soil sample the soil up to 15cm was taken through grab sampling method.

Soil, flyash, water and vegetation samples were analysed for trace elements and heavy metals by Inductively Coupled Plasma Emission Spectrometer (ICP) by following method:

0.5g sample (Soil/Fly-ash/) was taken and 5ml Conc. HNO_3 was added and covered with watch glass. Samples were heated at 125-130°C on hot plate, till (Plant samples – orange fumes stop emitting; Soil and Fly-ash samples – fumes stop emitting and only silica and crystals left, Effluent samples - Only crystals left). Care should be taken to not dry samples during heating. If samples become dry, then add few drops of distilled water or conc. HNO_3. Cool down the samples to room temperature and add 0.5ml H_2O_2.. After few minutes, filter the solution with Whatman filter paper and transfer the solution to 50 ml volumetric flask and make up the volume. Follow the similar procedure with 5 ml HNO_3, 0.5 ml H_2O_2 and distilled water, except adding the sample for blank.

The digested samples were injected to ICP, created lab book using Qtegra tool, selected analysts *viz*. Na, Mg, K, Ca, Cr, Mn, Fe, Ni, Cu, Zn, Cd, Hg, B, Al, As, Se, Pb. Selected two or three wavelengths of each element to avoid collision between two elements and minimize the error. Radial mode was selected for Na, Mg, Ca, Fe, K and Axial mode was selected for Cr, Mn, Ni, Cu, Zn, Cd, Hg, B, Al, As, Se and Pb

Fig. 2: Inductively Coupled Plasma Emission Spectrometer

Table 5: Soil and flyash samples analysed through ICP for micro and macro elements collected from NTPC Ramagundam (May 2016)

S.no	Sample	Site	ICP analysis																
			Mg	K	Na	Fe	As	Pb	Cd	Hg	Cr	Ni	Zn	Cu	Mn	B	Al	Se	Ca
Soil Sample And Fly Ash																			
1	N2 fly ash pond fly ash sample	4	1475.04	413.64	0	2869.43	3.70	4.71	0.01	0	19.69	9.86	21.01	13.63	112.32	56.14	7214.74	3.41	17620.57
2	Railway colony soil (nala)	3	8787.39	900.21	2162.24	8756.27	2.40	9.27	0.55	0	21.22	15.52	69.45	19.06	329.92	12.49	7305.06	3.41	67468.36
3	Near Godavari river pure decant water	5	2151.72	534.30	1448.36	6454.61	1.32	6.07	0.31	0	10.68	8.75	17.08	13.92	284.97	2.81	4440.66	5.98	18606.83
4	Amijumbo da village	7	4099.29	1285.45	1184.59	11468.71	1.69	7.09	0.21	0	43.38	21.64	25.50	14.56	250.58	2.10	8153.88	4.84	8735.27
5	Mix of bottom fly ash N2 ash lagoon		1262.98	402.37	1753.85	3512.17	1.21	3.30	0.15	0	8.19	9.42	12.36	8.95	98.95	14.72	4430.54	4.44	9729.35
6	S1 fly ash	4	22611.20	578.95	1485.09	4260.23	10.94	9.75	0.31	0	43.21	15.81	47.23	17.60	98.59	86.58	11489.47	7.69	13170.84
7	Peddempet pond		4143.00	1590.17	1387.29	11600.37	3.04	7.93	0.20	0	32.15	23.84	36.01	19.84	159.65	4.62	12030.75	5.73	10950.69
8	Godava-ri river	6	825.98	110.47	826.58	1674.23	0.56	2.66	0.06	0	11.55	3.10	7.42	79.00	137.67	4.65	946.20	1.77	15300.40

V. Result and Discussion

a) Analysis of Ramagundam soil and fly ash samples through ICP for micro and macro elements

The nutrient analysis for macro and micro-elements of soil and fly ash samples was done by using ICP.

The element magnesium (Mg) was found maximum (0.879 %) in Railway colony soil (nalla) samples while minimum in samples collected from Godavari river where it was found to be present in 0.083 percent.

Potassium (K) and iron (Fe) was found to be maximum and minimum in the samples collected from Peddumpet pond and Godavari river respectively. The macro element potassium was found in the range of 0.011 to 0.159 percent while iron was found to range between 0.167 to 1.16 percent.

The ICP analysis of the collected soil samples of Ramagundam showed that the maximum sodium (0.216 %) and calcium (6.747 %) was found in samples of Railway colony Nalla. Sodium was absent from the samples of N2 ash pond fly ash sample while minimum calcium (0.874 %) was found in the samples from Amijumboda village.

The estimation of the element aluminium in the soil samples showed that maximum aluminium was found in the soil and fly ash samples collected from Peddumpet pond (1.203 %) while least calcium was found in the samples collected from Godavari river soil samples (0.095 %).

Photographs

Decant water

Ash pond

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