Int. J. Curr. Res. Biosci. Plant Biol. 2015, 2(8): 105-110

EXCELLENT PUBLISHERS

International Journal of Current Research in Biosciences and Plant Biology

ISSN: 2349-8080 Volume 2 Number 8 (August-2015) pp. 105-110

www.ijcrbp.com

Original Research Article

Long-Term Assessment of Fly Ash Disposal on Physico-Chemical Properties of Soil

Sudarshana Sharma[1], Vinit Kumar[1], Krishna Kumar Yadav[1]*, Neha Gupta[1] and Chanchal Verma[2]

[1]Institute of Environment and Sustainable Development, Bundelkhand University, Jhansi, India
[2]Department of Environmental Science, Gurukul Kangri University, Haridwar, India

**Corresponding author.*

Abstract

A huge and unmanageable amount of fly ash is being generated by thermal power plants and needs safe disposal and management. The study was initiated to assess the effect of fly ash on physical and chemical properties of soil. The seasonal investigation was done from 2010 to 2013. The soil samples were collected from five different locations and analyzed for pH, electrical conductivity, oxidation-reduction potential, organic carbon, bicarbonate, sulphate, chloride, total phosphorous, available phosphorous, calcium and magnesium content in soil. The result obtained clearly indicates that content of tested parameters are continuously and can be concluded that soil is significantly influenced by fly ash disposal on earth.

Keywords

Disposal
Fly ash
Physico-chemical
Soil characteristics

Introduction

Soil naturally occurs on earth, consist different horizons at different depth based on their parent material (Rai, 2002). The different type of soil support different type of land use depends on its potential. The physico-chemical and biological properties of soil affect the soil productivity (Patnaik et al., 2013). The physical characteristics of soil like shape, size and arrangement of particle directly affect the movement of water and air. The supply of water and air also vary from season to season. Chemical properties of soil regulate the nutrient supply to the plants (Haby et al., 2011). Fly ash is by-product material produces on the burning of coal in thermal power plants. The constituent of fly ash are silica, aluminum, iron, calcium, magnesium, potassium, phosphorous, sulphur, molybdenum, mercury, selenium and cadmium (Kanchan et al., 2015; Ivanova et al., 2011). The crop productivity of the soil increases on the addition of significant amount of fly ash due to the presence of micronutrient and macronutrient in it. Crop productivity may also reduce if the concentration of toxic metal is high in the fly ash (Murugan and Vijayarangam, 2013). The objective of the present investigation was to assess the impact of fly ash deposition on physicochemical properties of soil.

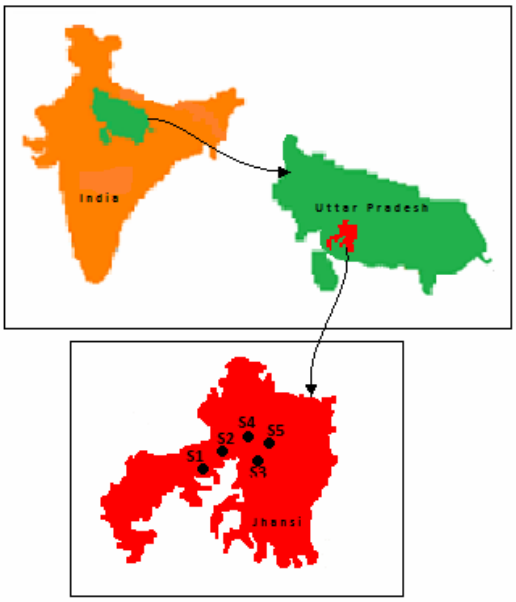
Materials and methods

Study area

Locality near Parichha Thermal Power Plant was chosen to carry out the present study. The selected site is suitable for the present investigation as the fly ash

generated from thermal power plant is disposed off in nearby area and affects the soil properties significantly. Parichha thermal power plant is located at 25°30'51.16"N and 78°45'37.40"E in Jhansi.

Fig. 1: Map showing the sampling sites.



Methodology

The samples were collected from five different locations around Parichha Thermal Power Plant, Jhansi. Location map is depicted as Figure-1. Five replicate of each sample was collected from each site to analyze the physicochemical parameters in soil. Seasonal sampling was done in pre-monsoon, monsoon and post-monsoon for three years consecutively i.e. from 2010-2013. The samples were collected at a surface level of 0-10 cm of soil but contaminated surface soil material was removed up to a depth of 0-2 cm prior to collect the sample using spade. The collected samples were stored in polyethylene bags, labeled accordingly and taken to the laboratory for analyses. The collected samples were dried in air and sieved prior to analysis.

Soil pH, Electrical Conductivity (EC) and Oxidation-Reduction Potential (ORP) were determined using water analyzing kit by preparing 7 g soil sample mixed with 35 ml distilled water in 1:5 ratio. Organic Carbon is a source of plant nutrient in soil and maintains soil integrity (Solanki and Chavda, 2012). The organic carbon was estimated by Walkley and Black Method, 1934. Bicarbonate was determined by potentiometric titration method. Chloride was estimated by Mohr's method. Sulphate content in soil was determined by turbidimetric method. Total phosphorous was determined by ascorbic acid method and available phosphorous was determined by Olsen's, 1954 method.

Results and discussion

An examination of soil samples for consecutively three years is shown in Table 1, 2 and 3 respectively. pH value shows that soil around Parichha Thermal Power Plant is alkaline and vary between 7.19 to 8.41 (2010 - 11), 7.35 to 8.79 (2011- 12) and 7.56 to 8.99 (2012- 13). It can be observed that alkalinity is regularly increasing year to year. It might be due to alkaline nature of fly ash which is continuously depositing on this area and making the area more alkaline. In almost all the samples, pH was found greater in post-monsoon than pre-monsoon which may be due to addition of rain water in soil. Alkaline soil decreases the solubility of minerals and creates nutrient deficiencies in the soil by which plant growth is limited (Wagh et al., 2013).

Electrical conductivity in soil depends on moisture content present in soil and affects soil salinity, soil texture, subsoil characteristics, drainage condition and cation exchange capacity. The electrical conductivity greater than 4 µmhos/cm in soil indicates that soil is saline in nature. EC values ranges from 1.00 to 1.50 (2010-2011); 0.79 to 1.25 (2011-2012); 0.70 to1.15 (2012-2013). It remains almost static in all seasons.

Oxidation Reduction Potential (ORP) is the tendency of a chemical species to be reduced by attaining new electrons. Each species has its own intrinsic reduction potential; the more positive the potential, the greater the species affinity for electrons and tendency to be reduced. The value of ORP was found 30 to 84.33 during 2010-2011, 32 to 88 during 2011-2012 and 33 to 88 during 2012-2013.

Organic carbon is the amount of carbon hold by soil organic matter. It enters into the soil through animal manure, green manure, crop residue, living and dead organism etc. (Raut and Ekbote, 2012). It provides energy to microorganisms in soil and improves soil health. It was found between 2.63 to 5.16 during 2010-2011, 2.75 to 5.88 during 2011-2012 and 2.78 to 5.78 during 2012-2013 by which it can be observed that organic carbon is increasing annually. It might be due to the regular deposition of fly ash in the soil (Sharma et al., 2002). Organic carbon content in soil was highest in post-monsoon followed by monsoon and pre-monsoon respectively.

Table 1. Physico-chemical properties of soil samples in different season during 2010-2011.

Season	Sampling Site	pH	EC	ORP	%OC	Cl^-	HCO_3^-	SO_4^{2-}	AV P	TP (%)	Ca^{2+}	Mg^{2+}
PRE MONSOON	S1	8.20	1.17	46.00	2.69	45.97	211.47	11.51	0.15	0.26	136.33	47.61
	S2	7.40	1.00	84.33	2.64	48.67	214.07	19.53	0.15	0.78	145.11	55.00
	S3	8.20	1.40	39.67	2.67	50.70	255.23	15.58	0.18	0.22	122.15	75.54
	S4	7.19	1.10	51.00	2.64	47.47	258.27	15.45	0.14	0.42	130.48	62.39
	S5	7.62	1.10	66.00	2.63	54.00	265.97	24.14	0.17	0.20	130.48	55.84
MONSOON	S1	7.19	1.10	75.00	2.75	78.53	103.70	9.58	0.23	0.25	124.04	23.92
	S2	7.48	1.13	51.67	2.68	52.83	149.33	15.99	0.20	0.77	122.71	17.34
	S3	8.07	1.10	30.00	2.71	52.26	115.67	12.93	0.16	0.27	121.91	11.52
	S4	7.45	1.10	56.00	2.68	52.83	141.93	12.22	0.28	0.42	115.87	11.48
	S5	7.39	1.13	58.00	2.72	48.42	155.43	19.56	0.30	0.27	120.54	12.38
POST MONSOON	S1	8.64	1.40	40.67	4.68	157.07	359.40	12.25	0.11	0.32	203.67	33.77
	S2	7.43	1.50	38.67	4.64	151.40	430.13	24.27	0.11	0.84	176.09	19.15
	S3	7.65	1.23	32.67	5.16	162.83	643.47	19.28	0.21	0.32	180.79	41.43
	S4	8.41	1.40	46.67	4.74	172.10	547.40	19.49	0.12	0.48	206.69	14.19
	S5	7.97	1.47	54.00	4.79	175.67	569.40	34.59	0.14	0.32	192.11	14.67

Table 2. Physico-chemical properties of soil samples in different season during 2011-2012.

Season	Sampling Site	pH	EC	ORP	%OC	Cl^-	HCO_3^-	SO_4^{2-}	AV P	TP (%)	Ca^{2+}	Mg^{2+}
PRE MONSOON	S1	8.32	0.98	48.00	2.75	47.43	225.47	12.51	0.13	0.24	117.63	48.61
	S2	7.49	0.88	88.00	2.75	48.90	229.07	22.53	0.16	0.74	118.51	57.00
	S3	8.35	1.12	40.00	2.78	51.05	268.23	18.58	0.19	0.25	115.21	72.54
	S4	7.35	0.99	52.00	2.88	49.17	269.27	18.45	0.15	0.45	116.04	64.39
	S5	7.89	0.88	68.00	2.78	54.89	278.97	25.14	0.18	0.22	112.04	56.84
MONSOON	S1	7.78	0.89	78.00	2.75	80.53	115.70	12.58	0.16	0.21	118.40	23.92
	S2	8.05	0.79	52.67	2.79	56.83	152.33	16.99	0.28	0.72	114.27	18.34
	S3	8.25	0.85	32.00	2.79	53.55	128.67	14.93	0.18	0.26	114.19	12.52
	S4	7.95	0.85	58.00	2.82	53.28	154.93	15.22	0.19	0.41	113.58	12.48
	S5	7.85	0.89	59.00	2.82	48.43	169.43	22.56	0.15	0.26	115.05	14.38
POST MONSOON	S1	8.79	1.12	42.00	4.78	158.04	375.40	14.25	0.12	0.30	124.36	36.77
	S2	7.78	1.20	41.00	4.77	153.44	442.13	26.27	0.14	0.79	120.60	21.15
	S3	8.12	1.05	34.00	5.48	165.31	659.47	21.28	0.13	0.28	120.07	43.43
	S4	8.78	1.20	48.00	4.88	173.24	559.40	21.49	0.19	0.46	122.66	16.19
	S5	8.25	1.25	55.00	4.88	176.34	575.40	36.59	0.16	0.33	123.21	16.67

Table 3. Physico-chemical properties of soil samples in different season during 2012-2013.

Season	Sampling Site	pH	EC	ORP	%OC	Cl^-	HCO_3^-	SO_4^{2-}	AV P	TP (%)	Ca^{2+}	Mg^{2+}
PRE MONSOON	S1	8.45	0.90	49.00	2.78	42.37	149.97	13.67	0.18	0.34	119.63	50.61
	S2	7.88	0.80	88.00	2.79	51.45	152.67	18.56	0.19	0.83	118.51	59.00
	S3	8.45	1.01	41.00	2.85	56.89	152.70	17.91	0.19	0.44	116.21	75.54
	S4	7.56	0.89	51.00	2.88	50.09	149.47	21.08	0.18	0.36	117.04	66.39
	S5	7.99	0.80	69.00	2.85	53.56	158.00	23.12	0.11	0.20	116.04	58.84
MONSOON	S1	7.99	0.80	77.00	2.85	47.07	182.53	12.05	0.14	0.28	119.40	25.92
	S2	8.25	0.70	51.67	2.85	52.44	156.83	17.44	0.24	0.72	116.27	20.34
	S3	8.42	0.75	33.00	2.85	58.32	155.26	18.56	0.19	0.27	116.19	15.52
	S4	8.56	0.72	57.00	2.95	46.76	156.83	24.04	0.23	0.41	114.58	14.48
	S5	8.08	0.81	58.00	2.95	48.81	152.42	27.46	0.13	0.28	116.05	16.38
POST MONSOON	S1	8.99	1.01	44.67	4.95	121.34	162.07	16.01	0.15	0.30	125.36	38.77
	S2	7.98	1.10	42.67	4.88	123.28	158.40	22.08	0.22	0.85	121.60	22.15
	S3	8.28	0.92	35.67	5.78	137.59	168.83	18.45	0.25	0.35	122.07	44.43
	S4	8.98	1.01	149.67	4.95	123.49	176.10	24.65	0.16	0.41	124.66	18.19
	S5	8.45	1.15	156.00	4.95	128.27	179.67	29.21	0.18	0.35	125.21	17.67

Major anions like bicarbonate, sulphate and chloride in soil was found high in post-monsoon followed by pre-monsoon and monsoon. It was high in post-monsoon may be due to the deposition of anions through rain in monsoon and less in pre-monsoon due to the uptake of them by soil organisms and plants (Solanki and Chavda, 2012). Available phosphorous in soil is important for the growth of plant and metabolism. It was ranged in analyzed samples from 14.56 to 30.23 in 2010-2011, 18.15 to 33.21 in 2011-2012 and 19.18 to 34. 19 in 2012-2013 and availability of total phosphorous was 0.20 to 0.84 in 2010-2011, 0.21 to 0.79 in 2011-2012 and 0.20 to 0.85 in 2012-13.

Calcium is soluble positively charged ion occurs in largest amount in soil (Bache, 1984) held by clay and organic matter particles. It makes up about 3.6% of earth's crust. Calcium is held more tightly than magnesium, potassium and other exchangeable ions. It was found 115.87 to 206.69 mg/l during 2010-2011, 112.04 to 124.36 mg/l during 2011-2012 and 114.58 to 125.36 mg/l during 2012-2013. Magnesium makes up about 2.7% of the earth's crust. Soil developed from rocks and fine-textured soil contains high amount of magnesium. It was ranged 11.48 to 75.54 mg/l in 2010-2011, 12.48 to 72.54 mg/l in 2011-2012 and 14.48 to 75.54 mg/l in 2012-2013. The calcium and magnesium content was continuously increasing on passing time may be due to continuous amendment of fly ash in soil. The content of both mineral was found higher in pre-monsoon and lower in monsoon.

Conclusion

The study indicates that the effect of fly ash disposal on soil was significant. pH, organic carbon, bicarbonate, sulphate, chloride, available phosphorous, total phosphorous, calcium and magnesium was increased regularly while electrical conductivity and oxidation-reduction potential was almost static. Fly ash contains silica, aluminum, iron, calcium, magnesium, potassium, phosphorous, sulphur, molybdenum, mercury, selenium and cadmium itself and hence increasing physical and chemical properties of soil on disposed off on it.

Acknowledgement

The authors are thankful to University Grants Commission, New Delhi, India for their financial assistance of this study. Authors are also thankful to Department of Biochemistry, Bundelkhand University, Jhansi to provide necessary facilities to complete this study.

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