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Physical and chemical properties of Koradi fly ash of Maharastra for its utilization in agriculture

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Abstract

The fly ash collected from Koradi Thermal Power Station, Nagpur, Maharashtra was characterised for its physical, chemical and nutrient capacity. The particle size distribution showed wide variation in the <0.25 mm size fraction. Bulk density lies between 0.85-1.16 g/cm^3. The available water holding capacity ranges between 40.1 to 55.6%. The organic carbon content lies between 1.9 to 4.5 kg^{-1}. The fly ash is slightly alkaline in reaction. Cation exchange capacity was 2.8-4.1 cmol(p+) kg^{-1}. The presence of various elements was in the order of Si > Al >Fe > Ca , Ti > Mg > K. The DTPA extractable micronutrients were in the order of Fe>Mn>Zn>Cu where as available N, P, K show the trend as N>K>P. Physical and chemical properties of fly ash are discussed.

Additional keywords: macronutrient, micronutrient.

Introduction

Fly ash, an industrial waste product from coal based power station, is yet to find its proper application as per its physical and chemical properties. Attempts are being made for its useful application in many fields including agriculture. Use of fly ash in agriculture has been reported by many workers in India and abroad (Chang *et al.* 1977; Adriano *et al.* 1980; Ferraiolo *et al.* 1990; Maiti *et al.* 1990; Matte *et al.* 1995; Lal *et al.* 1996; Jambagi *et al.* 1995; and Chatterjee *et al.* 1988).

Fly ash being an amorphous ferro-alumino silicate could be a good amendement for problem soils. Properties of fly ash vary depending on the grade and quality of coal as well as the technology employed in the power station. This study on physical, chemical and nutritional status of fly ash collected from Koradi Thermal Power Plant presents its possible utilisation in agriculture.

Materials and methods

Fly ash samples were collected from 8 disposal sites of the Koradi Thermal Power Station (KTPS), Nagpur, Maharashtra. Samples were processed by air drying and sieving to remove the very coarse residues. Physical properties like moisture content, particle size distribution, water holding capacity and bulk density

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were determined (Piper, 1950). Chemical properties like pH, electrical conductivity, organic carbon, free lime, cation exchange capacity and exchangeable cations were also determined (Black 1965; Jackson 1973). The samples were digested for elemental composition by fusion with sodium carbonate. The alkali metals were analysed by wet digestion using triple acid mixture, and hydrofluorization of the silica (Jackson, 1973). The extracts were analysed for elemental analysis by the Inductively Coupled Plasma Emission Spectrometer (ICP). Extractable micronutrients (Cu, Fe, Zn and Mn) were also estimated following the method of Lindsay and Norvell (1978).

Results and discussion

Some physical properties of the fly ash samples are presented in table 1. Particle size distribution showed narrow variation in their size fraction. The finer fractions less than 0.25 mm varied from 54.19 to 62.41%. The moisture content of the samples is low (0.10-0.32 %) which might be due to low content of organic matter. Bulk density (B.D.) of the samples ranged from 0.85-1.16 g cm^3. The slightly higher bulk density in samples 4,5 and 6 could be due to the dominance of coarse fractions. The bulk densities are slightly less than that of a good average soil (1.48 g cm^3) and hence can be used to improve texture of heavy as well as light soils. The water holding capacity of the fly ash is fairly good ranging from 40.1 to 55.6 %. Application of the fly ash can improve the physical conditions specially drainage and porosity of soils having light as well as heavy texture. Amendment of sandy soils with fly ash has been reported by Aitken *et al* (1984).

Table 1. Some physical properties of fly ash from Koradi Thermal Power Station

Sr. No.	Moisture content (%)	Particle size distribution (%)					Available water holding capacity (%)	Bulk density g/cm^3
		>2 mm	2-1 mm	1-0.5 mm	0.5-0.25 mm	<0.25 mm		
1.	0.18	1.06	2.04	6.04	31.45	59.41	43.12	0.85
2.	0.11	1.20	1.95	5.90	28.54	62.41	52.69	0.90
3.	0.10	0.98	2.40	6.13	35.01	55.48	40.10	0.95
4.	0.20	1.10	2.36	5.25	37.10	54.19	41.04	1.01
5.	0.22	1.43	2.60	7.09	29.70	59.18	50.07	1.16
6.	0.25	1.25	1.98	8 00	31.00	57.77	55.60	1.04
7.	0.32	1.27	2.60	6 59	30.50	59.04	48.55	0.99
8.	0.20	1.18	2.57	6 90	28.98	60.37	49.06	1.10

The pH of the fly ash samples ranges from 7.3 to 7.9, indicating that they are slightly alkaline in reaction which might be due to the presence of oxides of alkali metals. The electrical conductivity of the samples lies between 0.27 to 0.36 dS m^{-1}. Results indicate that the application of the fly ash to soil system will not

cause any adverse effect in terms of soil salinity and sodicity when used for a long period of time. The organic carbon (OC) of the fly ash samples is low and it ranges from 1.9 to 4.5 g kg^{-1}. The low content of OC may be due to the absence of organic source in the fly ash other than unburnt coal and its complexes. Low content of OC is also responsible for negligible contribution of soil nitrogen. Free lime content was also found to be low (0.05 to0.45 %). The cation exchange capacity (CEC) of the fly ash samples ranges from 2.8 to 4.1 cmol (p+) kg^{-1}. The exchangeable cations namely, Na, K, Ca and Mg range from 0.23 to 1.01, 0.20 to 0.36, 0.92 to 1.31 and 0.62 to 1.13 cmol (p+) kg^{-1} respectively (Table 2).

Table 2. Physical and chemical properties of fly ash

Sr. No.	pH (1:2 Ash/water ratio)	E.C. dSm^{-1}	O.C. g kg-1	Free lime (%)	C.E.C. cmol (p+) kg-1	Exchangeable Cations Na	K	Ca	Mg
						----------cmol (p+) kg^{-1}----------			
1.	7.5	0.36	3.8	0.20	3.1	0.48	0.30	1.28	0.62
2.	7.4	0.29	3.4	0.19	2.8	0.61	0.35	1.12	0.68
3.	7.9	0.28	2.9	0.26	2.9	0.23	0.20	1.31	0.90
4.	7.6	0.36	4.5	0.05	3.2	0.30	0.28	1.06	0.04
5.	7.8	0.27	3.0	0.12	3.7	0.36	0.28	1.24	1.13
6.	7.5	0.29	2.8	0.18	3.3	0.62	0.35	0.84	1.00
7.	7.3	0.30	1.9	0.21	3.8	0.65	0.34	1.08	1.12
8.	7.5	0.31	2.4	0.45	4.1	1.01	0.36	0.92	1.04

Total chemical composition of fly ash samples are presented in table 3. The major constituent of the fly ash are found to be silica (SiO_2) which ranges from 60.1 to 68.8 followed by aluminium and iron. Similar composition of fly ash was also observed by Rajendran *et al* (1989). Low grade coal generally contains appreciable amount of quartz and/or glass particles including soil materials which when burnt give rise to ferro-aluminosilicates with high content of silica, aluminium and iron. The total iron content varied from 4.3 to 8.7 per cent, whereas total aluminium ranges between 20.6 to 27.5 per cent showing wide variation in its content in the fly ash. Total sodium, potassium, calcium, magnesium and titanium range from 0.38 to 0.66%, 0.31 to 0.65, 0.57 to 1.88, 0.53 to 1.32 and 0.98 to 1.52%, respectively.

Some trace elements like boron, molybdenum, copper, zinc and manganese are present in small quantity, (Table 3). These elements are present in the range of 165 to 250, 0.76 to 1.2, 40 to 109, 47 to 136 and 100 to 700 ppm, respectively. Fly ash samples contain fairly high amount of boron and this would be useful in soils having boron deficiency.

Table 3. Composition of fly ash from Koradi Thermal Power Station

Sr. No.	Total									Total (ppm)				
	LoI	SiO_2	Fe_2O_3	Al_2O_3	Na_2O	K_2O	CaO	MgO	TiO_2	B	Mo	Cu	Zn	Mn
	%									ppm				
1	2.48	61.49	4.32	27.52	0.58	0.65	1.18	0.79	0.98	165	1.00	68.0	102.0	610.0
2.	3.11	58.56	8.72	25.55	0.38	0.96	0.98	0.56	1.17	200	1.20	74.0	108.0	700.0
3.	0.85	64.38	4.28	26.98	0.65	0.31	0.57	0.70	1.27	210	0.95	76.0	88.0	500.0
4.	1.51	68.19	5.76	20.64	0.60	0.48	1.01	0.53	1.27	109	0.76	48.0	90.0	300.0
5.	1.47	62.92	5.11	25.21	0.58	0.45	1.88	0.85	1.52	250	0.78	40.0	50.0	200.0
6.	0.80	67.16	6.52	20.80	0.38	0.49	1.25	0.99	1.16	245	0.80	66.0	136.0	100.0
7.	1.47	63.20	4.28	26.22	0.49	0.60	1.25	1.32	1.17	220	1.10	64.0	60.0	200.0
8.	1.52	62.33	5.07	26.45	0.66	0.41	1.33	1.08	1.14	180	0.95	109.0	47.0	650.0

The total nitrogen content is low to medium (0.03 to 0.10 %). The available nitrogen of all the samples is in the range of 95 to 130 ppm. The total 'P' content ranges between 0.15 to 0.29 % whereas available 'P' is in the range of 65 to 90 ppm. In all cases total K is in the range of 0.26 to 0.80 per cent and the available K content is quite high ranging from 72 to 98 ppm (Table 4).

Table 4. Macronutrient status of fly ash

S.No.	Total nutrients (%)			Available nutrients (ppm)		
	Nitrogen (N)	Phosphorus (P)	Potash (K)	N	P	K
1	0.03	0.18	0.51	126	80	90
2.	0.07	0.22	0.80	130	65	98
3.	0.08	0.15	0.26	119	70	76
4.	0.07	0.20	0.40	122	72	80
5.	0.08	0.22	0.37	130	66	85
6.	0.09	0.28	0.41	128	70	96
7.	0.05	0.29	0.50	101	75	90
8.	0.10	0.19	0.34	95	90	72

DTPA extractable micronutrient status of the fly ash is appreciable (Table 5). The available Cu, Fe, Zn and Mn are in the range of 0.80 to 2.60; 10.20 to 22.20; 0.80 to 3.20 and 1.52 to 4.20 ppm, respectively. Thus application of fly ash in soil, deficient in Fe, Zu, Cu and Mn could increase their availability.

Table 5. Available micronutrient status of fly ash

Sr.No.	DTPA extractable (ppm)			
	Cu	Fe	Zn	Mn
1.	1.4	10.2	2.2	2.6
2.	2.2	14.0	1.6	2.4
3.	2.4	18.0	1.6	2.2
4.	1.6	16.8	1.8	2.6
5.	1.4	17.6	3.2	4.0
6.	0.8	19.6	1.2	4.2
7.	1.6	20.2	1.0	1.5
8.	2.6	22.2	0.8	1.6

Application of fly ash in agriculture has been reported by many researchers to be beneficial (Warambhe *et al* 1992, Taylor *et al* 1988, Gupta *et al* 1995 and Campbell *et al* 1983) in improving nutrient status along with soil physical conditions. The present study demonstrates the physical and chemical properties of Koradi fly ash as the basic data base for experimental study to find its usefulness in agriculture.

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