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Influence of fly ash on soil characteristics of Kharland pond, Ratnagiri (Maharashtra)

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ABSTRACT

Fly ash is a powdery waste of coal-power generation and its management is a major environmental challenge. However, fly ash is useful ameliorant that may improve the physical and chemical properties of problem soil and is a source of readily available micro and macro nutrients**.** In the present investigation fly ash was incorporated in various proportions to study the influence on the acidic laterite soil on selected physico-chemical parameters. The seepage rate of soil was calculated by addition of fly ash with three different rates @ 25, 50 and 75%. While the maximum seepage was in control (100%) and minimum (25.33%) was observed in the soil with 75% fly ash. The physico-chemical properties of soil due to incorporation of different percentages of fly ash in soil were studied. Among the soil parameters the pH ranged from 4.40 to 10.05 in T_0 and T_3 respectively. The maximum bulk density of 3.69 gm/cm^3 was observed in T_2 (50%). The maximum organic carbon 1.92% was observed in the T_0. The values of soil NO_3-N and PO_4-P ranged from 126 to 879 mg/g and 50 to 4780 mg/g in T_0 and T_3 respectively. The silicate content ranged from 4015 to 8334 mg/g in the treatment T_2 and T_3 respectively. ANOVA showed a significant difference among the treatments in all these parameters. The sodium content was noted higher in T_2 (6.53 mg/g) at the end of experiment. The potassium content ranged from 1.49 to 3.29 mg/g in T_0 and T_3 respectively. The iron and aluminium showed increasing trend at the end of experiment i.e $T_3 > T_2 > T_1 > T_0$. Based on the present study it was concluded that fly ash has major impact on the parameters like pH, EC, OC, bulk density, sodium, potassium, NO_3-N, Silicate-silicon, iron and aluminium.

Keywords: Flyash, Nutrient level, soil characteristics, seepage

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1. INTRODUCTION

Fly ash is a very fine powdery material produced as by-product during the coal based power generation process. It is a mixture of fine, spherical particles with size ranging between 0-100 microns. In an industrial context, fly ash usually refers to the ash produced during combustion of coal (Shrivastavaet al., 2011). It is the residue of combustion of coal and comprises a wide range of inorganic particles, with low to medium bulk density and high surface area (Kumar, 2003). Fly ash is Ferro - aluminosilicate mineral with major elements like Si, Al and Fe together with significant amount of Ca, Mg, K, P and S (Aslam, 1998). Fly ash may often contain trace amounts of some heavy toxic metals like Molybdenum, Mercury, Selenium and Cadmium etc. Some metals enriched in fly ash include Cd, Cr, Ni, Pb Al, Fe, Mn, Mg, Si and Zn while other has intermediate enrichment. The micro and macro nutrients present in coal get generally concentrated in the ash (Adriano et al., 1980). It is by virtue of this and the ability of fly ash to modify the physical properties of soils, it works as a soil conditioner enhancing the yield of the crops. India ranks fourth in the world in the production of coal ash as by-product waste after USSR, USA and China, in that order. About 120 coals based thermal power stations in India are producing about 112 million tonnes fly ash per year (Alam and Akhtar, 2011). On account of its heterogeneous nature fly ash has the potential to be used as a soil-ameliorating agent in agriculture and forestry.

2. SCOPE OF STUDY

Few investigations on the influence of fly ash to improve agriculture soil from seepage and productivity have been attempted (Grewalet al., 2001; Mittraet al., 2003, Deshmukhet al., 2006; Bhattacharya et al., 2011). Similarly,the soil from fish farm from Konkan and such area also needs to be investigated since major expenditure is incurred on the manuring of pond and replenishing the water lost due to evaporation and seepage. So the current investigation was undertaken with the following objectives.

1) To investigate soil characteristics from selected localities of Ratnagiri.
2) To determine the effects of flyash on the soil characteristics.

2.1. Materials

Table 1
Quantities of fly ash and soil mixed in homogeneous method

Treatment % FA	Quantity of flyash (kg)	Quantity of soil (kg)
T_0 (Soil)	0	6
T_1 (25%)	1.5	4.5
T_2 (50%)	3	3
T_3 (75%)	4.5	1.5

Table 2
Physical and chemical characteristics of the fly ash and soil prior to the experiment

Initial parameters of soil/fly ash	Soil	Fly ash
pH	6.07	11.07
Electrical conductivity (mmhos/cm)	0.24	1.55
Bulk density (gm/cm³)	1.43	1.09
Organic carbon (%)	0.72	0.11
Sodium (mg/gm)	0.004	0.015
Potassium (mg/gm)	0.014	0.012
Iron (mg/g)	2010	0.71
Aluminium (mg/g)	2778	4.84
Nitrate-N (mg/g)	0.005	
Phosphate-P (mg/g)	0.030	
Silicate (mg/g)	654	

The Kharland ponds from the vicinity of College of Fisheries, Ratnagiri (Latitude 17°01'26.34"N and longitude 73°17'53.57"E) Maharashtra were selected for carrying out the research work. The soil samples were collected from four dyke corners of a pond and single composite sample was formed. Then the soil was analyzed for physico-chemical parameters.In the present research work the fly ash was procured from the thermal power plant located at Jaigad, about 40 km away from Ratnagiri. The fly ash was packed in to the large cartons and transported to laboratory. The dry fly ash was directly analyzed for selected physicochemical parameters.

2.2. Methodology

In the present experiment different quantities of fly ash and soil were mixed on weight basis to analyze the effect of fly ash on soil (Table 1). The required quantity of fly ash and soil were mixed homogenously. Four treatments namely control (T_0), 25% FA (T_1), 50% FA (T_2), 75% (T_3) were taken with five replicates for 75 days.Seepage test was conducted by homogeneous mixture method (Table 1). Soil was mixed with fly ash homogeneously using selected proportions. The PVC column of 30-cm height and uniform diameter (9 cm) was used to know the quantity of water flowing through the soil. Fine mesh sized muslin cloth was tied at the bottom of the pipe and plastic bottle was used for water collection.

2.3. Sample analysis

The soil samples were collected from each replicate fortnightly during experiment in the morning at about 10 hrs. for the analysis of different parameters.

2.3.1. Soil sample physico-chemical parameters

pH was recorded with the help of digital pH meter. (Equip-tronics, microcontroller pH meter model no EQ.621) with 0.01 precision. Bulk density was calculated as per Tondon (1993). The organic carbon content of sediment sample was determined by the method given by Jhingran et al. (1969). Electrical conductivity was measured with the help of EC kit by PHS - 3DpH meter CYBERLABTM. The phosphate, silicate, Nitrate-nitrogen content of soil sample was estimated following the procedure described by Tondon (1993).

2.4. Instrument used for metal analysis

2.4.1. Atomic absorption spectrophotometer

The AAS model used in the study for heavy metal level detection was AAnalyst 800 spectrophotometer system (AAS - Perkinelemer Analyst 800).

2.4.2. Preservation and digestion of samples

Dried soil sample was stored in cool/dark place in labeled polythene bags. The digestion ofsoil sample was done in Anton PaarMultiwave 3000 microwave digestion system. The digestion procedure required 2 hrs with pressure 25 bar 290 psi and temperature of 210º C. And further analysis was done on Atomic absorption spectrophotometer (Atomic absorption spectrophotometer Perkinelemer Analyst 800). The digested soil samples were aspirated to determine the content of metals namely Na, K, Fe, Al, Cu and Cd. Data obtained from the experiment was analyzed by one way ANOVA. Significant difference was indicated by $P < 0.05$. The Students Newman Kuel's multiple comparison tests was used to determine the significant difference between the treatments (Snedechor and Cochran, 1967; Zar, 2004).

3. RESULTS

The selected kharland pond soil was laterite in nature having redish brown in colour. The initial values of different parameters of soil and fly ashare given in Table 2.

4. DISCUSSION

4.1. Effect of fly ash on soil characteristics

In the present study, the fly ash was found to raise the pH to 7.72, 8.49, and 9.62 in treatments T_1, T_2 and T_3 respectively over the control of 6.07 significantly. The increase in pH depends primarily on soil buffering capacity; soils that are poorly buffered are expected to show the greatest increase in pH after ash treatment (Zhakiet al., 2002). Fly ash is generally highly alkaline due to low sulphur content of coal and presence of hydroxide and carbonates of calcium and magnesium (Maitiet al., 2005). This property of fly ash has the effect to neutralize acidic soils (Elseewi et al., 1978; Phung et al., 1978). Page et al. (1979) observed during experiments with calcareous and acidic soils that fly ash addition increased the pH of the former from 8.0 to 10.8 and that of the latter from 5.4 to 9.9.

Electrical conductivity of soil increased gradually with increase in percentage of fly ash. The highest electrical conductivity was observed in T_3 (75%). It varied significantly between the treatments but there was no significant difference between the days. Kalra et al., (1997) also observed increase in EC of soil from 0.467 to 0.746 as the proportion of fly ash increased. Kishor et al., (2010) also found that the EC of soil increased with fly ash application relating this to Fe content.

Bulk density decreased in the treatment of 50 and 75% fly ash. Sale et al. (1996) observed that bulk density increased as fly ash addition increased to 25%, and then decreasing with additional fly ash. Karla et al. (1998)

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Table 3
Effect of fly ash with different percentages on soil

Parameters	Treatments of fly ash			
	Control (T_0)	(T_1) 25%	(T_2) 50%	(T_3) 75%
pH	6.07	7.72	8.49	9.62
Bulk densitygm/cm^3	3.36	3.60	3.63	3.31
Organic carbon (%)	0.69	0.85	1.67	0.44
Electrical conductivity (mmhos/cm)	0.327	0.446	0.574	1.137
Nitrate-nitrogen (mg/g)	158	305	476	658
Phosphate-P (mg/g)	443	2059	1179	2139
Silicate-Si (mg/g)	7446	6348	6762	6944
Sodium (mg/g)	4.38	5.41	6.53	5.52
Potassium (mg/g)	1.49	1.55	2.85	3.29
Iron (mg/g)	0.319	0.651	0.691	0.897
Aluminium (mg/g)	1.14	6.597	6.412	24.72

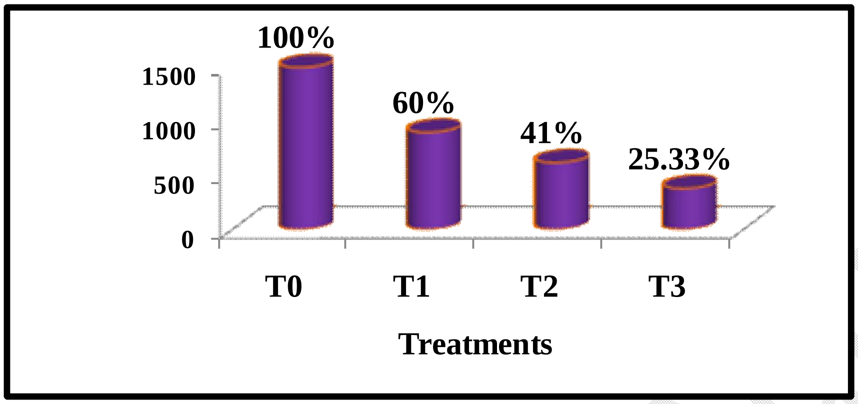

Figure 1
Effect on seepage rate

reported that fly ash addition to soil resulted in lower bulk density, although the differences compared with non-treated plots were not significant. The bulk density variation may be due to changes in the total porosity as well as modifications in pore size distribution as reported by Adriano et al. (1980) and Chang et al. (1977).

The highest organic carbon (1.67 %) was observed in 50% fly ash treatment. The marginal increase in OC content may be due to the fact that the soil initially had a very low OC content and it had not been supplemented with organic source (Prashanta et al., 2001). Kumar (2002) found that fly ash has its own carbon content i.e 0.11%. as it was applied to the soil having organic carbon 0.40%, it led to an increase in OC content by 0.55, 0.64 and 0.81 due to increase of fly ash proportion over the control (0.43%). Kalra et al. (2000) also observed that the OC value of soil-ash mixtures increased with ash content for sandy and sandy loam soil, whereas the reverse trend was noted for clayey and sandy-clay-loam soils. This can be attributed to relative changes in the soil texture.

The maximum PO_4-P content (2139 mg/g) was observed in the treatment T_3, whereas the minimum (443 mg/g) was in T_0. There was a significant difference among all the treatments. Phosphorous in soil increased as incorporation of fly ash increased, which can be attributed to fly ash itself and partly because of some native phosphate-solubilizers (Jala, 2005). Jala (2005) found that phosphorous increased in acidic soil as a result of fly ash amendment rangeing from 254 to1270 mg/gand reported that it may be due to an increase in population of phosphate-solubilizing bacteria observed with increasing fly ash percentage which was most favorable and also due to the presence of chemical fertilizers which augmented the nutrient supply for growth and proliferation of the bacteria by acting synergistically with fly ash. In acidic soil phosphorous though easily available as H2PO4 meets with interference fromiron, calcium, magnesium compounds (Brady, 1995).

In the present work the maximum NO_3-N (658 mg/g) was observed in T_3 (75%) on 75th day, whereas, the minimum (158 mg/g) was in T_0 on 30th day. ANOVA showed significant difference ($P<0.05$) in nitrate levels among the treatments. Effect of fly ash on soil nitrate showed an increasing trend in all the treatment between days. In T_0 it fluctuated (Figure 1 & Table 3). In the study made by Jala (2005) nitrogen content in the fly ash amended soil showed a significant increase ranging from 0.16 to 0.44 %. She reported that the native soil of Patiala was rich in nitrogen so the increased soil nitrogen can be attributed to decomposition of leaf litter, etc resulting in enzyme-aided nutrient mineralization carried out by the native microbial population. Nitrogen in soil is dominated by fertilizer-applied materials (Brady, 1995).

The maximum silicate (6944 mg/g) was in T_3, whereas, minimum (6348 ppm) was in T_1. It was also noted by Brady (1995) that silicate ranged from 1401 to 2712 mg/g markedly increasing with increase fly ash incorporation in acidic soil. This seemed to suggest that increase in silicate can be attributed to acidic pH and presence of silicate as a result of which SiO_3-Si increases in proportion to fly ash added. Na could associate with clays, which could account for their primary silicate distribution in fly ash (Kim and Kazonich, 2004).

In the present study small but consistent positive effect of fly ash application on available and exchangeable K was registered. The maximum concentration of potassium was 3.29 mg/g in T_3, while the lowest was 1.49 mg/g in T_0. Kumar (2002) found that potassium increased by 11.2, 15.3, 18.0 mg/gm as the incorporation of fly ash in soil increased over the control of 3.86 mg/gm. In fly ash available potassium is in small content and its addition in soil improves potassium level in the soil indicating the role of fly ash (Inthasan et al., 2002).

The initial sodium in soil was 0.004 mg/gm while in the fly ash it was higher i.e. 0.0014 mg/gm. At the end of experiment there was a significant increase in concentration of sodium from 4.38 to 5.52 mg/g in T_2. Similarly, Jala (2005) also found that sodium in soil increased as percentage of fly ash increased i.e from 11.1 to 54.8 mg/gm. Sodium in the coal may be precipitated from groundwater or infiltrating hydrothermal fluids, they are more likely to be associated with clays, which would account for their primary silicate distribution in fly ash (Kim and Kazonich, 2004)

The concentrations of iron and aluminium increased in soil as the percentage of fly ash increased. This is due to the fact that fly ash contained sufficient amount of these elements. At the end of experiment the observed maximum concentration of iron was 0.897 mg/g in T_3, while minimum was 0.319 in T_0 andmaximum concentration of aluminium was 24.72 ppm in T_3, against the minimum of 1.14 ppm in T_1. This is in agreement with many studies; Kishore et al. (2010) reported that iron in soil increased significantly with increase in percentage of fly ash. Jala and Goyal (2004) also reported that content of Fe in the soil increased substantially from 2180 to 7175 ppm with fly ash application up to 50%. Kumar and Singh (2003) similarly found that Fe and Al increased significantly, up to 4.5 percent of fly ash level due to low soil pH. Kumar (2002) also observed that

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the iron content of soil increased to 79.34, 99.58 and 110 % over the control of 6.21% at the rate of fly ash incorporation of 30, 45 and 60%. The increase in the available metals is not only due to fly ash addition, but also due to soil conditions like pH, EC and cation exchange capacity of soil (Dudas, 1981).

Seepage was reduced as the percentage of fly ash application increased which may be due to the reason that fly ash addition generally improves soil porosity, workability and water holding capacity due to decrease in soil bulk density (Rai et al., 2011). Increase in water holding capacity with fly ash addition into the soil was also found by Sharma et al. (1990). High water holding capacity due to application of fly ash was attributed to its dominant silt and clay fractions (Aggrawal et al., 2009).

5. CONCLUSION

Based on the present study it is concluded that fly ash has notable influence on the soil characteristics like seepage, pH, electrical conductivity, organic carbon, bulk density, Nitrate-nitrogen, silicate-silicon, sodium, potassium, Iron and aluminium.

SUMMARY OF RESEARCH

1. The present investigation has given the importance of usefulness of flyash on the brackishwatersoil of Ratnagiri, in view of the problems faced by Kokan fish farmers.
2. It has availed scientists the opportunity to research more on the usefulness of fly ash in aquaculture ponds with improving condition of soil to give the benefits to farmers

FUTURE ISSUES

There is a need to address the problems encountered during the disposal or reuse of fly ash in various fields. In aquaculture it will be useful where soil water holding capacity and productivity is less.

DISCLOSURE STATEMENT

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