Utilization of Flyash and Sludge of Mysore Paper Mills for agriculture

Anusha.M.K[1] Dr.D.Istalinghamurthy[2]
[1,2]Department of Environmental Engineering
[1,2]Sri Jayachamarajendra college of Engineering, Mysuru, India

Abstract— Flyash is the main dust generated mainly from fluidized bed boilers, where coal is fired in a finely crushed form to improve the combustion efficiency. Sludge is a hazardous by-product which requires safe disposal either in landfill or incineration. These are the common waste generated mainly by thermal power plants and industries that cause un avoidable problems like ground water contamination, health hazards, environmental pollution etc., but by utilizing this waste for agriculture can reduce this problem to some extent and also it's economically feasible. Pot experiments were conducted at 10%,20%,30%,40%,50%,70%,90%,100% treatment levels with flyash and (10% FA + 10% ss + 80% soil), (20% FA + 20% ss + 60% soil), and (50% ss + 50% soil) treatment levels with sludge generated by Mysore Paper Mills, located at Bhadravathi. Two types of soil i.e. black soil and red soil and Lycopersicon Esculentum (Tomato) were used for this study. The physic-chemical parameters, heavy metal analysis, growth parameters were analyzed and checked for plant growth. The use of flyash in soil improved the plant growth by increasing the physic-chemical properties of soil. The Lycopersicon Esculentum showed a positive growth up to 30% amendment with flyash whereas the usage of sewage sludge did not give satisfactory results in turn it hindered the growth of plant.

Key words: Flyash, Sludge, Agricultural Use, Nutrient Status

I. INTRODUCTION

Agriculture on earth is as old as humans, it act as a principal component of livelihood for the major Indian population. It provides food security, rural employment and environmentally sustainable technologies like soil conservation, sustainable natural resource management and biodiversity protection. The paper mills are generating more quantities of solid waste such as press mud, ETP sludge, flyash, effluent, grits etc. day by day. Disposal of these waste is a major problem as they cause harm to the environment, as well as human health, hence there is a need to control pollution by adopting 3R's concept. Flyash is an end residue from combustion of pulverized bituminous or subbituminous coal in the furnace of thermal power plants or from fluidized bed boilers in industries that consists of mineral constituents of coal which is not fully burnt. Quantity of ash generated depends on the ash content in coal. Most than 95% of flyash generated is captured by electrostatic precipitators, which otherwise fly off into the atmosphere which in turn causes air pollution. Flyash is classified into two types based on residual carbon content i.e. class C and class F flyash. Class C flyash is almost white and has lower carbon content of 1-2% whereas class F flyash is black or dark grey color and has carbon content of 13-15%. Sludge is a hazardous byproduct which requires safe disposal either in landfill or incineration. Paper mill sludge produces majority of waste and disposal of this sludge is costly. A major determinant of the productivity of a soil is its nutritional status. Many industries produce waste containing essential plant nutrients in higher quantities. These wastes when reused for agricultural purpose at appropriate rates can improve the soil status as well as other properties.

This major issue requires an effective, economic and eco-friendly method to tackle with the disposal of residual industrial by-product. Though the beneficial use of flyash and sludge have been recognized in areas such as brick making, pavement construction, soil stabilization and in other applications only small quantity of total waste being generated is utilized currently in such applications, therefore recycling of these waste by reusing it for agricultural purposes reduces the pollution load and unavoidable problems like land barren, ground water contamination and thus it effectively manages the solid waste. Effect of flyash and sludge as a soil amendment in agriculture improves the soil characteristics like soil, water and nutrient holding capacity, enhances microbial activity. The flyash may enhance the fertility of soil but at the same time it may show some hindering effects if its application is not suitable for type of crop grown and soil used. Sewage sludge contains a number of potentially toxic substances and may cause environmentally pollution such as heavy metal accumulation if it is applied at higher rates than the normal levels. Flyash also contains essential plant nutrients such as N,P,K, Ca, Mg, Na, Fe, Cu, Cd, Mn, Zn, and also toxic metals like B, Mb, So. It increases physic-chemical characteristics of soil and also acts as a good soil conditioner, therefore it is necessary to use flyash and sludge on plant growth, nutrient uptake and heavy metal content in plant.

II. MATERIAL AND METHODS

A pot culture experiment was conducted with lycopersicon esculentum . Two types of soil were used in the study i.e. black soil and red soil. These soils were collected from nearby villages at Bhadravathi, Karnataka, India. The flyash and sludge were collected from the dumpyard of Mysore Paper Mills, Bhadravathi, Karnataka , India. The pot used was of 30cm dia and 20cm Ht. The soil and flyash samples were analyzed for pH, EC, OC, N,P,K, specific gravity, texture, porosity, water holding capacity. The soils were amended with flyash and sludge at different treatment levels on dry weight basis, such as,

Control = 2000g soil
10%= 1800g soil +200g FA
20%= 1600g soil + 400 g FA
30%= 1400g soil + 600 g FA
40%= 1200g soil + 800g FA
50%= 1000g soil + 1000g FA
70%= 600 g soil + 1400 g FA
90%= 200g soil + 1800 g FA
10%FA+10%SS+80%Soil
20%FA+20%SS+60%soil
50%SS+50%soil.

The amendments were done in duplicates. Each pot was planted with two 15 days old tomato plants. The pots were filled with water along with the amendments before 3 days of sowing. The plant growth was checked for each amendment after the complete growth on the basis of plant height, root length, no of leaves, germination rate. The post- harvest analysis was done for amended soils after the growth of tomatos.

The heavy metal analysis was checked by oven drying the soil and leaves of tomato plants. These samples were grinded in a stainless steel blender and sieved in a 2mm sieve and then kept at room temperature for further analysis. The samples were digested with a mixture of nitric, sulphuric and perchloric acid initially for 2 hours at 100oC temperature and further raised to 200oC. The digestion was done using 250ml Pyrex digestion tubes until white residue is achieved. Digested leaves was diluted with 50 ml double deionized water and used for heavy metal analysis. The heavy metal content in sample was found using atomic absorption spectrophotometer.

III. Results and Conclusions

A. *Physico-chemical*

Characteristics of flyash amended soils.

The selected physic-chemical characteristics of flyash amended soils such as pH, EC, OC, specific gravity, texture, available nutrients are shown below.

1) Texture:

When flyash is added to soil it modifies the soil texture. High rate of flyash application changes the surface texture of the soil by increasing silt content. The texture of red soil is sandy loamy and that of black soil is clayey soil. The addition of silty loamy texture flyash has altered the texture of red soil to silt clayey loamy at 70% amendment and that of black soil to clayey loamy at 30% amendment.

2) Specific Gravity:

It depends on the minerals and inorganic materials that are present in samples. Specific gravity of flyash was measured as 2.06 and that of soil ranges between 2.5-2.7.specific gravity of flyash was low compared to the soils.

Parameters	Red soil	Black soil	Flyash
Texture	Sandy loamy	Clayey	Silt loamy
Texture of FA soil	Silt clayey loamy	Clayey loamy	-
Specific gravity	2.67	2.6	2.06

Table 3.1(a): Results of specific gravity and texture.

3) pH:

The pH of both red and black soil took from nearby village near Bhadravathi was found to be acidic in nature while the flyash from dump yard of MPM was alkaline with pH 8.23. The pH of soil goes on increasing by the addition of flyash. The high levels of calcium and magnesium content found is responsible for increase in pH and due to alkaline nature of flyash, the pH of soil is neutralized, hence it can be used in agricultural soils. When the addition of flyash improves soil pH, it simultaneously adds plant nutrients to the soil. The pH of sludge took from dump yard was alkaline in nature with pH of 7.5. The pH of the soil increased when soils were amended with sludge. The pH is extremely alkaline which is not good for plant growth.

4) Electrical Conductivity:

The electrical conductivity of the flyash amended soil increase with the flyash content to both the soils. The EC ranges from 0.026-0.396ds/m in red soil and 0.014-0.391ds/m in black soil which is too low. The increase in electrical conductivity thereby increases the availability of soluble salts which might have detrimental effects on microbial respiration, enzyme activity, soil nitrogen cycling and also causes salinity problems, but due to low electrical conductivity it shows low salinity in soils. The EC of the sludge is 1.41. the electrical conductivity also been increased by the addition of flyash and sewage sludge mixture at different amendments to the soil.

5) Organic carbon:

The organic carbon values of flyash amended soils increased with the increasing ash content for both the soils. The maximum increase was found in 30 % amendment. The amount of organic carbon was found low in soil than flyash. The amount of soil organic carbon depends upon the soil texture. Soil with high clay content has high organic carbon. From the results it has been concluded that flyash amended soil contains sufficient organic carbon. The values obtained are shown in below table.

6) Available micronutrients:

The flyash contains all the nutrients such as Nitrogen, phosphorous and potassium that is necessary for plant growth. The available nitrogen was low in soil when compared to flyash and is gradually increased till 30% amendment by flyash application and then decreased. The phosphorous is very high in control and treated amendments and potassium is high till 30% amendment and again it has been gradually decreased. The available N,P,K values of flyash amended soils is shown in table below.

Treatments	Red soil		Black soil	
	pH	EC (ds/m)	Ph	EC(ds/m)
Control	6.70	0.026	6.78	0.014
10%	6.73	0.141	7.00	0.121
20%	6.89	0.147	7.14	0.221
30%	6.91	0.185	7.31	0.247
40%	7.07	0.236	7.42	0.308
50%	7.09	0.289	7.50	0.315
60%	7.12	0.328	7.50	0.328
70%	7.17	0.344	7.62	0.347
90%	7.32	0.396	7.65	0.391
100%	8.23	0.421	8.23	0.421

Table 3.1 (b): pH and EC of flyash amended soils

	Organic carbon	
Treatments	Red soil	Black soil
Control	0.38	0.40
10%	0.46	0.49
20%	0.58	0.67
30%	0.65	0.76

Table 3.1 (C): Organic carbon values of flyash amended soils.

Treatments	N(kg/ha)	P(kg/ha)	K(kg/ha)	N(kg/ha)	P(kg/ha)	K(kg/ha)
Control	169.34	100.44	219.52	225.4	93.65	208.32
10%	166.2	278.9	278.9	144.2	69.90	554.4

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20%	185.02	194.76	402.08	194.26	78.04	458.08
30%	175.62	193.41	405.04	78.04	99.76	481.60
40%	150.03	133.01	296.80	81.54	101.79	417.76
50%	119.17	131.65	420.00	109.76	108.58	392.00
70%	194.53	117.40	241.92	131.71	123.51	407.68
90%	128.58	96.36	249.76	169.34	119.44	309.12

Table 3.1 (d): Available N, P, and K in flyash amended soils

B. Post-harvest analysis of flyash amended soils:

Analysis of soil after the harvest showed that the application of flyash at 20% amendment increase the nutrient level, pH, EC without any change in soil texture. The pH of red soil increased slightly from 0 to 30% amendment whereas up to 20% amendment in black soil. The electrical conductivity remains unchanged even after the harvest but it slightly increased at 30% in red soil whereas in black soil it has increased only in control pot and rest remain unchanged.

The post-harvest analysis also showed that there is an increase in nitrogen content a control pot of red soil whereas the nitrogen, phosphorous and potassium increased in black soil. the overall results show that the nitrogen content is very low in both the soils and phosphorous and potassium have been increased with the addition of flyash.

C. Heavy metal analysis

The results of heavy metal analysis showed an increase in flyash amended soil as compared to control. There is no much difference between control and 10% amendment, however at 20% amendment there was increase in all the metal concentration over the control. The alkaline flyash increases the metal content, but in our study the flyash used has alkaline pH, hence the increment is due to higher inherent concentration in flyash. The metal concentration ranged as Fe>Mn> Ca >Zn>Cu>Na>Mg. Iron in flyash amended soil was greater when compared to other metals. The metals Fe, Cu, Zn, Mn were beyond the limits and rest of the metals were within the range. All the metals were present within the range. All the metal was greater in black soil compared to red soil. the iron ranges from (36.3-69.7), copper(0.52-0.85), manganese(2.34-8.54), zinc(2.34-6.54). the maximum increase of heavy metals was found at 30% amendment.

Treatments	Red soil		Black soil	
	Ph	EC(ds/m)	pH	EC(ds/m)
Control	6.70	0.026	6.78	0.014
10%	6.73	0.141	7.00	0.121
20%	6.89	0.147	7.10	0.221
30%	6.91	0.185	7.14	0.241
40%	7.07	0.236	7.31	0.308
50%	7.09	0.289	7.42	0.315
70%	7.17	0.344	7.62	0.347
90%	7.32	0.396	7.65	0.391

Table 3.2 (a) : pH and EC after post -harvest analysis.

	Red soil			Black soil		
Treatments	N (kg/ha)	P (kg/ha)	K (kg/ha)	N (kg/ha)	P (kg/ha)	K (kg/ha)
Control	170.35	100.44	219.52	225.4	95.71	211.32
10%	166.26	216.45	449.12	155.32	71.23	553.43
20%	185.02	191.42	402.11	201.04	78.42	458.08
30%	166.25	193.4	405.41	85.31	99.76	491.76
40%	155.36	136.54	290.14	81.55	100.42	433.05
50%	120.32	131.65	420.00	100.53	108.55	400.11
70%	194.53	112.45	241.92	129.26	123.54	407.56
90%	128.63	96.31	249.76	169.34	119.44	309.12

Table 3.2 (b): N,P,K during post- harvest analysis

Treatments	Red soil						
	Fe mg/kg	Cu mg/kg	Mn mg/kg	Zn mg/kg	Ca mg/kg	Mg mg/kg	Na mg/kg
Control	36.3	0.52	2.34	0.71	1.34	0.03	0.09
10%	37.1	0.57	2.56	0.76	2.16	0.05	0.12
20%	45.8	0.78	5.32	0.96	3.42	0.13	0.25
30%	56.7	0.85	6.54	1.01	3.51	0.27	0.29

Table 3.3(c): Heavy metal analysis

Treatments	Black soil						
	Fe mg/kg	Cu mg/kg	Mn mg/kg	Zn mg/kg	Ca mg/kg	Mg mg/kg	Na mg/kg
Control	42.5	0.61	3.52	0.85	0.61	0.12	0.91
10%	43.7	0.68	4.63	0.93	0.68	0.17	0.13
20%	57.3	0.75	7.13	1.84	0.75	0.25	0.28
30%	69.7	0.89	8.54	1.96	0.83	0.29	0.37

Table 3.3(d): Heavy metal analysis

D. Impact of Flyash on growth of Lycopersicon Esculentum:

The present study has been undertaken to find out environmentally safe recycling process of wastes, viz. fly ash and sewage effluents on land for disposal as well as to utilise them to increase the agricultural production. The soil mixed with flyash and sewage sludge were checked for plant growth, for this purpose lycopersicon esculentum (tomato) plants of 15 days old were planted in duplicates on dry weight basis. The results indicated that the addition of flyash to potting medium has positively impacted on growth of tomato. The addition of flyash at low levels i.e. up to 30% in both black and red soil enhanced tomato plants growth after 60 days of planting and no negative impact on fruit development, on the other hand flyash added at higher levels hindered the plant growth. The reason for this may be excess of heavy metals and nutrients affect the plant growth and also due to increase in salt content, siltation takes place that in turn because burning of the plant, whereas plant sown In complete flyash was completely burned within 30 days of planting, this may be due to high heat of hydration of flyash.

The germination rate was found to be 50% in both the soils. The germination rate decreased with the increase in flyash. The seed germinated only up to 40% treatment level in both the soils. Effect of flyash on root of *lycopersicon esculentum* showed that the length of root was observed maximum at 30% amendment at 90 days growth. The number of leaves has been increased from control to 30 %. There is no much difference between control and 10% amendment, but it has been gradually increased in 20% amendment and again slightly decreased in 30% amendment, therefore the good growth was found in 20% amendment. The tomato leaves along with the soil were checked for metal content and values were within the range the tomato leaves grown in soil with flyash had more metal content than control. The high phosphate content of flyash is one of the reasons for increase in productivity of plants upon flyash amendment.

The soil amended with flyash and sewage sludge did not show better results when compared to only flyash amended soil. the growth of *lycopersicon esculentum* was affected by the treatments with sewage sludge. The growth was better in control when compared to the plant grown in sewage sludge.

Treatment Levels	Plant height (cm)		Root length (cm)		No of leaves	
	Red soil	Black soil	Red soil	Black soil	Red soil	Black soil
Control	46	50	5	4.5	40	55
10%	50	54	5	5	50	56
20%	55	60	6.5	7.2	55	45
30%	40	45	5.6	6.7	40	45

Table 4.4 Morphological characteristics of plant grown in flyash amended soil.

Fig. 3.1: plant growth at 60 days of sowing lycopersicon esculentum under different treatment levels of flyash and sewage sludge.

Fig 3.2: complete growth of lycopersicon esculentum at 90 days.

IV. CONCLUSIONS

As per the study it has been concluded that, the good growth of plants has been seen in lower grades amendments i.e. upto 30% in flyash amended soil whereas at higher levels amendments the plants were hindered within 30 days of planting. The reason for this hindered growth is due to siltation that occurs due to addition of flyash at higher levels and also high level of metals. The physic-chemical properties of soil amended with flyash have been improved when compared to only soil. The addition of paper mill sludge showed a good growth at beginning and later it hindered the growth of plants, hence it dint give satisfactory results. The plants grown in control pot were better than the soil amended with flyash and sludge mixture. The plant growth parameters increase in flyash amended soil than the control. The results of post-harvest analysis showed a slight increase at lower amendments and also the nutrients increased in soil which in turn enhances the microbial population in soil. The flyash from Mysore paper mills can be used for agriculture as it contains all the essential nutrients required for soil whereas the sludge decreased the plant growth. The use of this industrial waste in large quantity can reduce the environmental pollution to some extent and in turn it's economical as it can be used as an admixture or soil conditioner or as substitute along with soil which in turn reduces the use of chemical fertilizers.

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