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EFFECT OF FLYASH INCORPORATION IN SOIL ON GERMINATION AND SEEDLING CHARACTERISTICS OF RICE (*Oryza sativa L.*)

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ABSTRACT

Fly ash is a waste product of Industrial plants that pose serious environmental hazards. The possibility of using fly ash as a soil amendment in the reclamation of disturbed areas is a research topic of growing interest. The present study evaluated effects of fly ash on germination of rice crops to work out the optimum level of ash addition and relate germination effects with early seedling vigour characteristics caused by mixing ash with the soil. Increase in concentration of fly ash decrease in seed germination and least germination was seen in 100 % fly ash while seedling growth in terms of both shoot length and root length was found to be significantly more in low concentration (25%) of fly ash in compared to the control and higher concentrations of Fly ash. There was no significant difference of leaf Chlorophyll a and Chlorophyll b in control and different treatments, but the total chlorophyll found to be more in 25% of fly ash concentration followed by 100 % of fly ash and least was observed in control condition, while SPAD index was decreased with the increase of fly ash concentration in the incorporated soil. The study revealed that the fly ash in low concentration could be beneficial in improving plant growth and early seedling vigour of rice plants can be used as soil amendment and, while adverse effects was observed at higher levels. This finding is encouraging for an agro-friendly disposal of this potential multiple-pollutant in rice cultivation and soil-fertilization as well.

Key Words: Chlorophyll**;** Fly ash; Germination; Seedling vigour; Rice.

INTRODUCTION

Fly ash is a waste product of Industrial plants that pose serious environmental hazards. Disposal of the huge amount of ash produced by burning of coal for energy purpose in different industry is a major concern today (Gautam et al. 2012). Fly ash, though, finds a use in the manufacture of cement, bricks and other construction materials, but this is not so popular in India on cost considerations. Countries like USA, Germany and The Netherlands utilize 70% of fly ash as building material and for other constructional purposes, but in India its utilization is less than 5% (Mandal and Sinha, 1988). It can also be used as a land fill material, or for reclaiming acidic or sodic soils (Plank and Martens, 1974; Taylor and Schuman, 1988). Because of the restricted use of ash in such activities, thermal power stations have to provide adequate storage space and check associated environmental pollution problems (Pathak et al. 1996).

The disposal of fly ash by conventional methods leads to degradation of arable land and contamination of ground water therefore, development of proper technologies for disposal of this solid waste in an eco-friendly manner becomes essential to derive maximum benefit from its heterogeneous nature, since it is a store house of readily available plant macro and micronutrients (Gupta et al 2002). In combustion with organic manure, microbial inoculants or fertilizers, fly ash can be used to design a soil benefaction strategy, which can help in improving soil properties and enriching its nutrient status. The presence of almost all essential plant nutrients in ionic form and the ameliorating effect on the physical, chemical and microbial nature of soil makes fly ash and important input for biomass production, especially on various degraded soils and waste land (Gupta et al 2002).

Germination and crop stand establishment are prime plant-growth processes, which play a major role in deciding subsequent growth and yield, and so need to be evaluated under varying levels of ash incorporation within the soil. The present study evaluated fly ash incorporation effects on germination of rice crops to work out the optimum level of ash addition and relate germination effects with early seedling vigour characteristics caused by mixing ash with the soil. Lower amendment levels of Fly ash caused enhancements of both growth and yield while adverse effects at higher levels were observed for several crops including maize, soybean barley, cabbage, apple, alfalfa, beet (Kumar et al, 2002; Marten, 1971). However, there is no report on growth, yield or leaf metabolism of the rice plant. Keeping view of the above information the present study evaluated ash incorporation effects on germination of rice crops to work out the optimum level of addition are relate germination effects with changes in seedling vigor characteristics.

MATERIALS AND METHODS

Site of Collection and Characterization of Fly ash:

The fly ash used in this study was collected from National Aluminum Corporation Limited, is situated at Damanjodi in Koraput district of Odisha. The fly ash were collected from ash pond, in plastic containers and brought to the laboratory for analysis. The freshly collected fly ash was observed for pH and moisture content. Soil samples were collected from gardens of Central University of Orissa in a large plastic bag and brought to the laboratory. Both the Soil and Fly ash dried for 5 days used for the experiments. Different amendments of fly ash and soil were prepared by mixing these two in different ratio that is 0%, 25%, 50%, 75%, 100% fly ash on dry weight basis in a soil- ash mixer these different ratio of soil- ash mixture were placed in half-Kg polythene bags perforated at the bottom to allow air passage.

Growth conditions:

The study was conducted by taking a popular high yielding *Indica* rice variety Lalata during summer season in the month of April- May 2014 at Central University of Orissa Campus.

The experiments were carried out in polythene bags filled with different concentration of fly ash and soil mixture (Control, 25%, 50%, 75% and 100% Fly ash). The bags were filled with water to field capacity, 30 good quality seeds were sown directly in each bag. The experiments were carried out in three replications in a complete randomize block design and were statistically analyzed. Plants were grown in an open shade at Central University of Orissa, Koraput Campus regularly irrigated with tap water and subjected to natural solar radiation, with daily maximum photosynthetic photon flux density, air temperature and relative humidity being about 1660 μ mol m^{-2} s^{-1} and 30.6 ^{o}C and 70-75% respectively. The plants were maintained up to 12 days after sowing. The seed germination percentage was recorded every alternate day 3, 5 and 7 days after sowing.

Measurement of chlorophyll index by SPAD meter:

Chlorophyll index were made on the fully expanded leaf of 5 different plants using an SPAD 502 chlorophyll meter (KONIKA MINOTA SENSING JAPAN) calculate the SPAD value on the intensity of light transmitted 650nm under ambient environmental condition.

The 2nd and3rdleaf from the top were selected and kept inside the chamber until stable reading was recorded.

Estimation of Photosynthetic pigments:
Photosynthetic pigments like Chlophyll (Chl) a and Chl b and Total Chl and also Chlorophyll Index was measures after 9 days after sowing. For Chl estimation, 100 mg of finely chopped fresh leaves were placed in a 25 mL capped-measuring tube containing 10mL of 80 % cold acetone, and kept dark inside a refrigerator (4°C) for 48 h .The Chl was measured spectrophotometrically by taking optical density at 663.6 and 646.6 nm following Panda et al 2008. The Chl a and b contents were calculated using the following equation of Porra, 2002.

Chlorophyll a (mg/ml) =[12.25(A663.6)-2.55(A646.6)]
Chlorophyll b (mg/ml) = [20.31(A646.6)-4.91(A663.6)]
Total Chlorophyll =Chlorophyll a + Chlorophyll b

Statistical Analysis:
Differences between various parameters were compared by ANOVA using CROPSTAT (International Rice Research Institute, Philippines) software's least significant difference (LSD*$p<0.05$), as this is a good test for determining whether means were significantly different. Correlation coefficients and regression analysis were done following the standard procedure using CROPSTAT.

RESULTS

Effect of Fly ash on germination:
Germination is a prime plant-growth process, which play a major role in deciding subsequent growth and yield. The effect of different concentrations of fly ash incorporation soil on germination of rice was presented in Fig.1. Germination of rice seeds starts after 3 days of sowing in every treatment and gradually increased up to 7 days. Germination percentage of rice seeds was more (94 %) in control condition *i.e*. normal soil in compared to other treatments. Increase in concentration of fly ash decrease in seed germination and least germination was seen in 100 % fly ash (58 %) where as germination was 68 %, 71 %, 84% in 75 %, 50 % and 25 % fly ash incorporation respectively (Fig 1).

Effect of fly ash on photosynthetic pigment and SPAD Chlorophyll index:
The impact of different concentration of fly ash in soil on leaf photosynthetic pigments chlorophyll a, Chlorophyll b and total chlorophyll content was presented in Table 1. The result sowed that there were no significant differences of leaf Chlorophyll a and Chlorophyll b in control and different treatments, but the total chlorophyll found to be more in 25% of fly ash concentration followed by 100 % of fly ash and least was observed in control condition without fly ash.

SPAD chlorophyll index of 12 days old rice seedlings under different concentration of Fly ash and control were presented in Table 1. The SPAD index was found to be statistically significant different among control and different concentration of fly ash incorporation. The SPAD index was decreased with the increase of fly ash concentration in the incorporated soil. The rice plant grown in without fly ash *i.e* control seedlings showed significantly more value (17.6± 1.4) compared to 25% (19.1± 1.5), 50 % (11.8± 1.4), 75% (7.5± 0.1) and least in 100% (4.0± 0.1).

Effect of fly ash on early seedling growth and Vigour:
Early seedling growth and seedling vigour in terms of plant height, fresh weight, dry weight and dry matter accumulation in rice plant in different concentrations of fly ash along with the control conditions was presented in Table 2. The seedling growth in terms of both shoot length and root length was found to be significantly more in low concentration (25%) of fly ash in compared to the control and higher concentrations of Fly ash. The root growth was less in 100 % fly ash and more in 25% of fly ash in compared to the other treatments, where as shoot growth was decreased in 75 % fly ash.

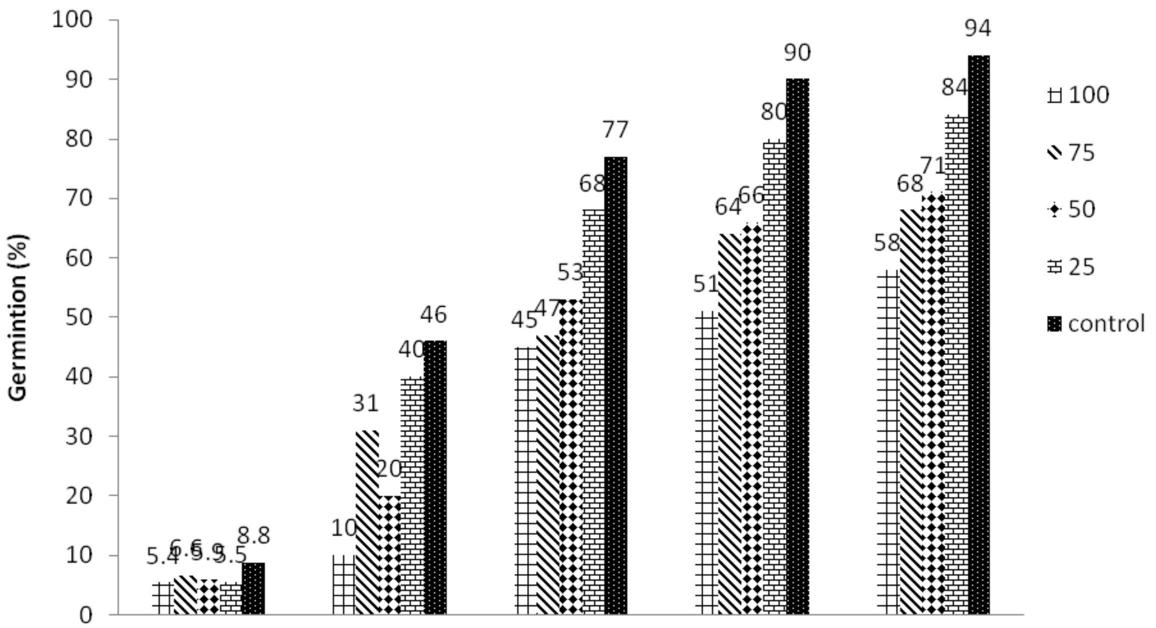
Table-1: Effect of different concentration of fly ash on photosynthetic pigments and SPAD chlorophyll index in rice of 12 days old seedlings. Data are the mean of Five replications ± Standard deviation; LSD, Least significant deviation; CV, Coefficient of variation.

Concentration of fly ash	Chlorophyll a (mg/gm fwt)	Chlorophyll b (mg/gm fwt)	Total Chlorophyll (mg/gm fwt)	SPAD Index
Control	0.610± 0.01	1.018± 0.01	1.628± 0.03	17.655± 1.49
25 %	0.631± 0.01	1.065± 0.06	1.697± 0.06	19.133± 1.58
50 %	0.621± 0.01	1.029± 0.02	1.651± 0.02	11.866± 1.47
75%	0.638± 0.01	1.078± 0.04	1.716± 0.06	7.500± 0.12
100%	0.625± 0.01	1.062± 0.02	1.687± 0.03	4.044± 0.07
LSD*P<0.05	0.025	0.060	0.069	2.27
CV (%)	2.1	3.1	2.2	10.0

Table-2: Effect of different concentration of fly ash on seedling growth, plant height in rice after 12 days old seedlings. Data are the mean of five replications ± Standard deviation; LSD, Least significant deviation; CV, Coefficient of variation.

Concentration of fly ash	Fresh weight (g/pl)	Dry weight (g/pl)	Dry matter accumulation (%)	Root Length (cm)	Shoot length (cm)
Control	0.253 ±0.020	0.73 ±0.01	71.04 ±2.3	4.63 ±1.11	15.72±1.24
25	0.335 ±0.027	0.64 ±0.01	80.54 ±3.1	14.47±3.99	18.63±0.46
50	0.295 ±0.034	0.62 ±0.01	78.78 ± 0.79	6.43 ±2.69	17.83±2.50
75	0.173 ±0.014	0.62 ±0.01	63.95 ± 4.7	3.68 ±1.10	7.68 ±7.07
100	0.129 ± 0.013	0.63 ± 0.01	50.89 ± 5.5	3.60 ± 0.83	15.83±1.38
LSD*P<0.05	0.049	0.013	7.76	6.9	7.16
CV (%)	10.9	6.0	5.6	5.6	2.5

Figure-1. Germination percentage of rice cultivar grown in different concentration of fly ash during different days after sowing.

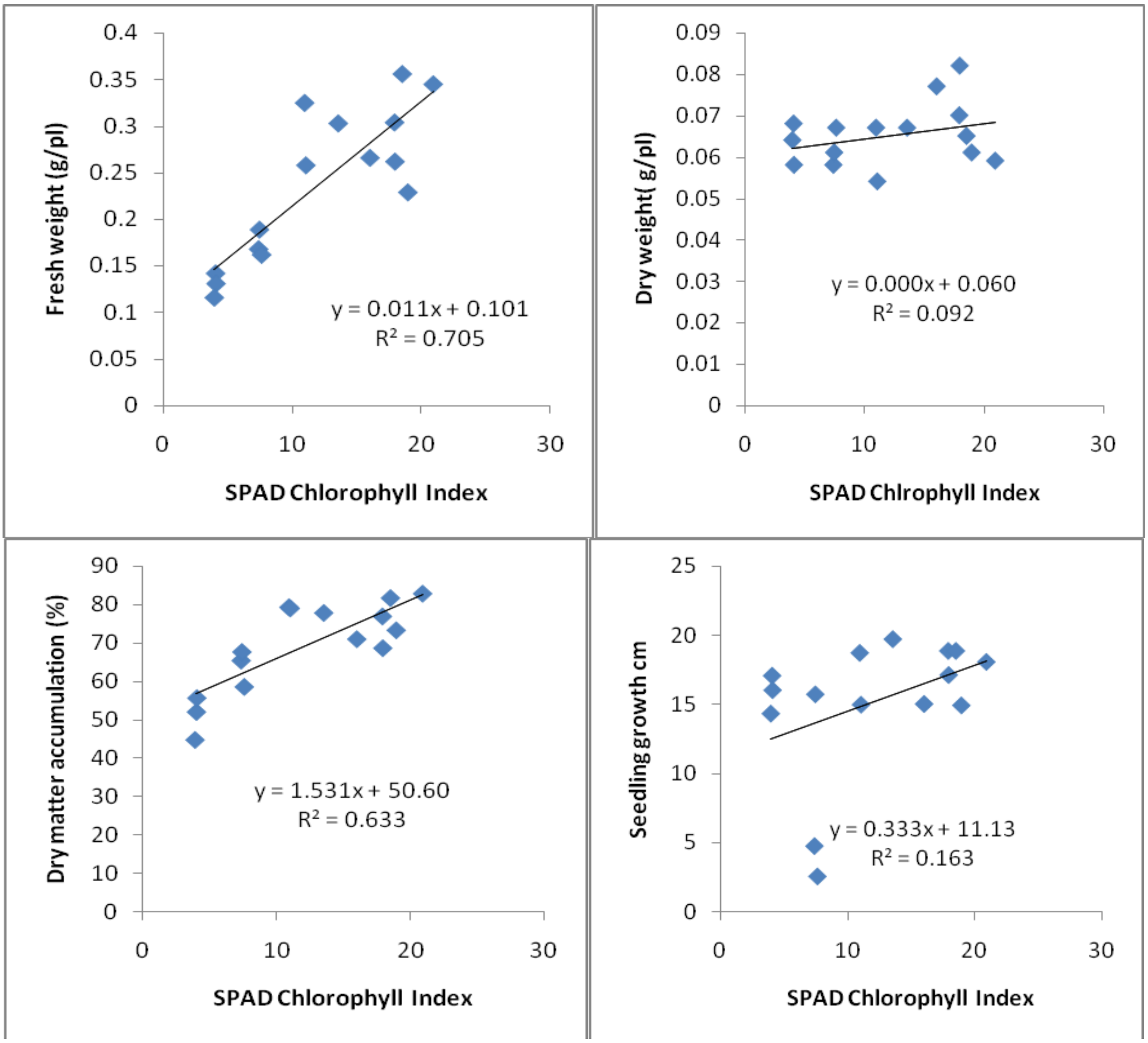


Fresh weight and dry weight of rice seedlings of 12 days old in different treatments were presented in Table 2. Fresh weight of rice seedlings were significantly higher in 25 % of fly ash in compared to other treatments and control seedlings (Table 2). The fresh weight of rice seedlings was maximum in 25 % (0.335 ±0.027 g/pl) followed by control (0.253 ±0.020 g/pl) and minimum was observed in 100 % (0.129 ± 0.013 g/pl) of fly ash. But in the dry weight of seedlings was found to be more in Control condition in compared to other treatments. Dry matter accumulation (%) was found to be significantly more in 25 % of fly ash (80.537) flowed by 50 % (78.780) and least in 100% (50.888) Table 2. The dry matter accumulation also increased with lower concentration of fly ash in compared to normal soil.

Relationship between SPAD Chlorophyll Index with early Seedling growth:

Relationship between SPAD Chlorophyll Index with early Seedling growth parameters are presented in figure 2. SPAD Chlorophyll Index of 12 days old rice seedlings was found to be significantly positive correlated with fresh weight (0.705 at *P<0.05) and Dry matter accumulation (0.663 at *P<0.05) but statistically insignificant with fresh Wight and seedling growth.

Figure-2. Relationship between SPAD Chlorophyll Index with Fresh weight, Dry weight , Dry matter accumulation and Seedling growth in rice cultivar grown in different concentration of fly ash.



DISCUSSIONS

Fly ash incorporation in soil delays germination of crops, most likely because of increased impedance offered by the soil/ash matrix to germinating seeds. This causes reduced growth of crops in the earlier stages, which subsequently may lead to poor seedling establishment. A good amount of research has already been done all over India and elsewhere on the yield of agricultural crops after fly-ash application and yield increases of 15–25% have been found (Kumar et al. 2001). Detrimental effects of higher applications of fly-ash on plants are primarily due to a shift in the chemical equilibrium of the soil (Singh and Yunus 2000). Both the high alkaline pH and the excess levels of soluble elements released from fly-ash induce hazardous effects in plant roots and the rhizosphere. Fly ash added to soil significantly increases the electrical conductivity of the soil mixture by increasing the levels of soluble major and minor inorganic constituents (Adriano et al. 1980; El-Mogazi et al. 1988; Eary et al. 1990). Fly-ash itself is not effective in retaining water, but it significantly increases water holding capacity of the soil mixture (Chang et al. 1977).

Changes in soil properties caused by fly-ash may directly or indirectly affect microbial activity and the root growth f plants. Fly-ash increases water-holding capacity of soil Mixtures, but this capacity does not appear to significantly increase the available water to plants (Chang et al. 1977). Field and greenhouse studies both indicate that many chemical Constituents of fly-ash benefit plant growth and can improve the agronomic properties of the soils (Chang et al.1977). A lower application of fly-ash (5–10%) in soils enhances seed germination as well as seedling growth, although higher application (20–30%) either delays or drastically inhibits plant growth, development and other specific parameters (Singh et al. 1997). Significant increase in growth and seedling vigour parameters(including plant pigment and dry matter accumulation) in lower fly ash levels 25 % could be due to ready-availability of Fly ash nutrients, but in higher Fly ash levels the same parameters decline for absorption of toxic elements as reported earlier in similar crops (Korcak, 1995).

The study revealed that the fly ash in low concentration could be beneficial in improving the soil quality and plant growth. The most suitable treatment for improved rice plant growth is 25% of fly ash with soil as it gives the maximum dry matter and seedling growth, while adverse effects was observed at higher levels. This finding is encouraging for an agro-friendly disposal of this potential multiple-pollutant in rice cultivation and soil-fertilization as well.

REFERENCES

1. Adriano D. C., Page A. L., Elseewi A. A., Change A. C., Straughan I. 1980. Utilization andDisposal of fly-ash and other residues in terrestrial ecosystems: review. Jornal ofEnviron. Qual. 9: 333-334.
2. Chang A. C, Lund L. J., Page A. L., Warneke J. E. 1977. Physical properties of fly ash amended soils. J. Environ. Qual. 6: 267-270.
3. Eary L.E., Rai D., Mattigod S. V., Ainsworth C.C. 1990. Geochemical factors controlling the mobilization of inorganic constituents from fossil fuel combustion residues. J Environ. Qual. 19: 202–214.
4. El-mogazi D., Lisk D.J., Weinstin L.H. 1988. A review of physical, chemical and biological properties of fly-ash and effects on agricultural ecosystems. Sci Total Environ. 74:1–37
5. Gautam S., Singh A., Singh J. and Shikha. 2012. Effect of Flyash Amended Soil on Growth and Yield of Indian Mustard (*Brassica Juncea*). Advances in Bio. Res.3: 39-45.
6. Gupta D. K., Rai U. N. Tripathi R. D. Inouhe M. 2002. Impacts of fly-ash on soil and plant responses. J Plant Res. 115:401–409
7. Kumar A., Vajpayee P., Ali M. B., Tripathi R. D., Singh N., Rai U. N., Singh S. N. 2002 Biochemical responses of *Cassia siamea* Lam. grown on coalcombustion residue (fly-ash). Bull Environ Contam. Toxicol. 68: 675–683.

8. Kumar V., Goswami G., Zacharia A. K. 2001. Fly ash use in agriculture: issues and concerns. Technology demonstration projects commissioned by fly-ash mission under technology information forecasting assestment council (TIFAC) News and Views, pp 1-6.
9. Mandal P. K. and Sinha A. K. 1988. Potential utilization of fly ash from thermal power stations-Magnitude of problems and remedies thereof, Nat Workshop Coal Ash Utilization India. Sponsored by Department of Science and Technology, New Delhi, 1-18.
10. Martens D. C. 1971. Availability of plant nutrients in fly-ash. Compost Sci. 12: 15–19.
11. Pathak H., Kalra N., Sharma S. and Joshi H.C. 1996. Use of fly ash in agriculture: Potentialities and constraints. Yojana, 40: 24-25.
12. Panda D., Sharma S. G. and Sarkar R.K. 2008. Chlorophyll fluorescence parameters, CO_2 photosynthetic rate and regeneration capacity as a result of complete submergence and subsequent re-emergence in rice (*Oryza sativa* L.). *Aquatic Botany*. 88: 127-133.
13. Plank C. O., Martens D. C. 1974. Boron availability as influenced by application of fly ash to soil. Soil Sci Soc. Am. Proc. 38: 974-977.
14. Porra R.J. 2002. The Chequered history of the development and use of simultaneous equations for accurate determination of chlorophyll a & b. Photosynth. Res. 73; 149-156.
15. Singh N. and Yunus M. 2000. Environmental impacts of fly-ash. *IN: Iraq* J Environ boil. Srivastava, P. S. Siddiqui T. O. (eds) Environmental hazards: plant and people. CBS, New Delhi, pp 60-79.
16. Singh S. N., Kulshreshtha K., Ahmad K. J. 1997. Impact of fly ash soil amendment on seed germination, seedling growth and metal composition of *Vicia faba* L. Eco. Eng. 9: 203-208.
17. Taylor E. M., and Schuman G. E. 1988. Fly ash and lime amendment of acid coal spoil to acid re vegetation. Environ. Qual., 17: 120-124.

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