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ORIGINAL ARTICLE

A Preliminary Report on Natural Metal Tolerant Plants around Talcher Thermal Power Station, Talcher, Odisha, India

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ABSTRACT
Fly ash disposal creates problems in the form of land use, health hazards and hazards to entire ecosystems in the form of heavy metal pollution. These hazards are more pronounced in the vicinity of disposal sites where Fly ash particles become airborne and are inhalable. Since plants can play an important role in reducing air pollution, the concept of green belt development in and around industrial areas has gained much attention in the recent past. In the present studies 64 species belonging to 33 families comprising of herbs, shrubs and trees were described. Among the plants observed Mangifera indica, Acacia arabica, Emblica officinalis, Azadirachta indica were found tolerant to Fly ash pollution. Some aquatic plants Eichhornia, Jussiea, Anhydra, Vernonia observed around thermal power stations can be used for filtering of heavy metals from the aquatic environment. The tolerant plants can be used for green belt development in similar Fly ash polluted areas.
Keywords: *Talcher, Thermal power plant, Fly ash, Metal tolerant plants*

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INTRODUCTION

Electrical energy is the basic input for an industry and industrial growth. Adequate coal is undoubtedly a prime source in India to generate electrical energy. The two words energy and electricity have become nearly synonymous and thus energy means mostly the electrical energy. At present about 55% of total electrical power stations which convert coal into electric power and Fly ash. The latter is its byproduct which poses problems for its disposal as it is not used at present in other industries on large scale for useful purposes. Around 12.21 million tones of Fly ash is produced every year [1] and about 0.35 m^3 space is required to dump one tone of Fly ash, thus enormous area of land is required to store this byproduct of thermal power stations.

Physical, mineralogical and chemical properties of Fly ash depend on the composition of parent coal, condition during coal combustion efficient of emission control devices, storage handing of fly ash and climate (Tab.1). The combustion temperature affects the degree of volatilization of many mineral elements present in coal physical and chemical weathering processes proceed as the ash is stored particularly under moist condition where leaching of soluble constituents take place [2]. Fly ash in thermal power station is transported as water slurry to long distances at ash ponds. Fly ash there is bound to suffer physical and chemical weathering.

Fly ash consists of many small (05.100/m) glasses like spherical particles. Indian fly ash consist particles equivalent to the sand (>50/m) silt (2 to 50/m) and clay (<2/m) are found to the extent of 30.5, 66.0 and 3.5% respectively. Chemically Fly ash consists largely of Silica Alumina Iron Oxides together with significant content of Ca, Mg, K, Na, Ti and variable amount of trace elements [3,4]. Fly ash is usually considered as Ferro Aluminum silicate Minerals [5,2].

General electrical power is undoubtedly one of the major emission sources heavy metals in most countries. New coal technologies have decreased environmental contamination but in developing countries, thermal power stations still burn brown coal (Lignite) that produce emissions that are rich in heavy metals and create substantial aerial heavy metal burdens. Talcher Industrial complex situated in between 20-29'' N latitude and 84-16'' E longitude constitutes the largest industrially concentrated area of Odisha (Fig. 1). With increasing demand of power requirement, a huge amount of solid waste Fly ash was generated near the plant sites. In 2013-14 only TTPS has generated 1.217million tonns of Fly ash. The adverse impact of fly ash is contamination of surface and subsurface water with toxic heavy metals and loss off soil fertility around plant sites.

The thermal power plants generate more than 100 million tones of fly ash each year, and close to 90% of this year is dumped in landfills or settling ponds. Fly ash disposal poses problems in the form of land use, health hazards, and hazards to entire ecosystems. Toxic trace metals present in the as leach out of the ash ponds and contaminate the soil, ground water and surface water, limiting the survival and growth of plants and microbial population [6-13].

Studies on vegetation around power stations have been done mainly concerning effects of gaseous emissions, particularly Fly ash. Fly ash from uncolonized mound is freely dispersed by wind and adversely affects plant communities. The impact of such emission on terrestrial ecosystems around smelters has been well documented [14]. For example around zinc smelter at Pennsylvania, there was an area of 50ha devoid of vegetation or sparsely ascribes to toxic levels of Zn, Pb, Cd and Cu [15]. High concentrations of metals may lead to the poor growth of vegetation. Despite extensive research on the restoration of PFA to agriculture [9,16,17] but very little work has been published on the natural revegetation process on PFA. The present study is a preliminary investigation of natural metal tolerant plant populations growing on aerial Fly ash emissions from coal based thermal power station at Talcher, Odisha, India.

MATERIALS AND METHODS

Talcher-Anugul industrial complex situated in between 20-29'' N latitude and 84-16'' E longitude constitutes the largest industrially concentrated area of Odisha (Fig. 1). Plant specimens are collected from the surrounding areas of thermal power station at Talcher, particularly from the Fly ash deposits. Plants were collected during serial exploration trips in Different seasons of the year. Collected plants were identified, documented and preserved in the post-graduate department of Botany, Berhampur University Berhampur. Correct names were ascertained in consultation with the international code of Botanical Nomenclature. Families were arranged in accordance with modified Bentham and Hooker's system of classification while the genera within a family and species within a genus follow an alphabetical sequence.

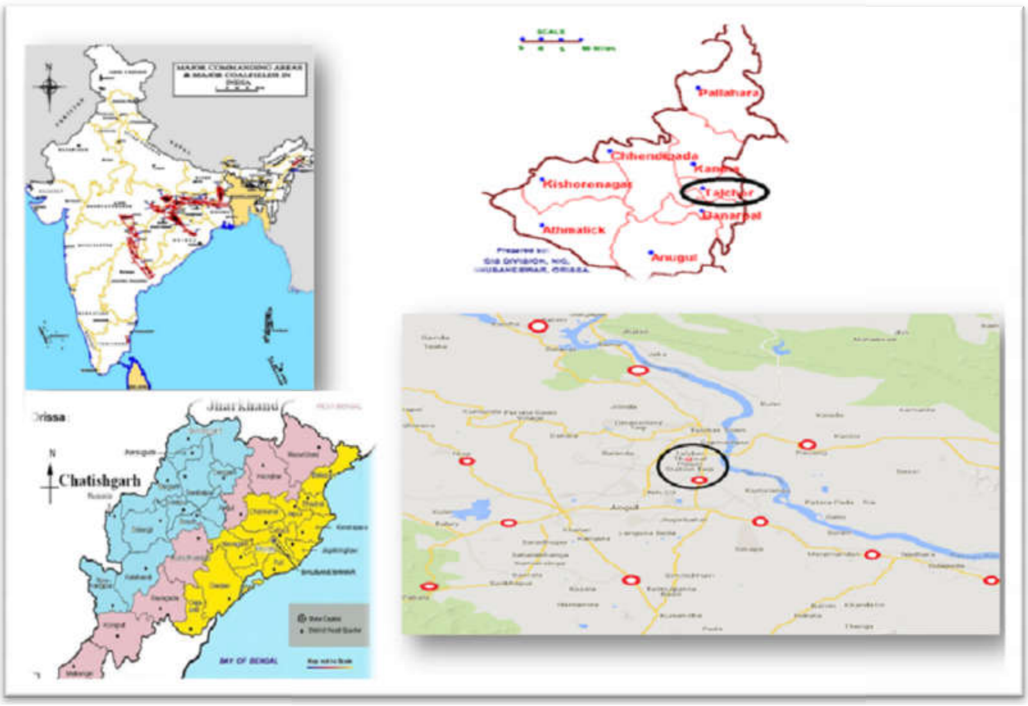

Figure 1: Talcher Thermal power station (TTPS) and its surroundings

RESULTS AND DISCUSSION

The present study describes 64 species, belonging to 33 families comprising of herbs, shrubs, climbers and tree (Tab. 2). A large number of herbs, shrubs, under shrubs belonging to families Fabaceae and poaceae occur predominantly around TTPS. The tree species such as *Pongamia pinnata, Mangifera indica, Ailanthus excelsa, Syzygium cumini, Shorea robusta and Ficus benghalensis* occur in patches. *Plantation* has been also raised at few places with *Acacia auriculifomis, Cassia siamea, Delonix regia* etc. Shrubs like *Streblus asper, Cltropis gigantean, Ipomoea carnea, Latanta camara, Vitex negundo, Ziziphus nummularia* are notable due to their profuse occurrence along the Nandira River. Many plans of aquatic habit such as *Typha angustata, Ottelia alismoides, Marsilea anthelmintica* and *Ludwigia perennis* found to occur along the Jheels, marshy places and compounded polluted water. These plants are remarkable due to their tolerant nature with polluted water which can be considered as indicator species. No morphological peculiarities were detected, except that the plants exhibit stunted growth with extremely long tap root system.

Table 1: Normal range of chemical composition for fly ash produced from different coal types (expressed as percent by weight)

Component	Bituminous	Sub-bituminous	Lignite
SiO_2	20-60	40-60	15-45
Al_2O_3	5-35	20-30	10-25
Fe_2O_3	10-40	4-10	4-15
CaO	1-12	5-30	15-40
MgO	0-5	1-6	3-10
SO_3	0-4	0-2	0-10
Na_2O	0-4	0-2	0-6
K_2O	0-3	0-4	0-4
LOI	0-15	0-3	0-5

Table 2: Natural and cultivated plant species around Talcher Thermal Power Station, Talcher, Odisha

SL NO.	*BOTANICAL NAME*	HABIT	Family
1	*Achyranthes aspera*	H	Amaranthaceae
2	*Acacia auriculiformis*	T	Misosaceae
3	*Ailantthus excelsa*	T	Simaroubaceae
4	*Alternanthera sessilis*	H	Amaranthaceae
5	*Amaranthys viridis*	H	Amaranthaceae
6	*Anacardium occidentalis*	T	Anacardiaceae
7	*Andrographis paniculata*	H	Acanthaceae
8	*Annona squamosa*	S	Annonaceae
9	*Argemone mexicana*	H	Papaveraceae
10	*Anhydra fluctuans*	H, AQ	Asteraceae
11	*Azadirachta indica*	T	Meliaceae
12	*Bixa orellana*	S	Bixaceae
13	*Calotropis gigantea*	S	Asclepiadaceae
14	*Cassia occidentalis*	H	Caesalpiniaceae
15	*Cassia siamea*	T	Caesalpiniaceae
16	*Cereus hexagonolobus*	H	Cactaceae
17	*Chromolena odoratus*	US	Asteraceae
18	*Commelina benghalensis*	H	Commelinaceae
19	*Combretum roxburghii*	S	Combretaceae

20	*Croton sparciflorus*	H	Euphorbiaceae
21	*Cuscuta reflexa*	C	Cuscutaceae
22	*Cyperus rotundus*	H	Cyperceae
23	*Datura staramonium*	S	Solanaceae
24	*Dentella asiatica*	H	Rubuaceae
25	*Digitaria longiflora*	H	Poaceae
26	*Echinochola colunum*	H	Poaceae
27	*Eichhornia carssipes*	H, AQ	Potenderiaceae
28	*Emilia sanctifolia*	H	Asteraceae
29	*Euphorbia furformis*	H	Euphorbiaceae
30	*Euphorbia tirucalli*	S	Euphorbiaceae
31	*Evolvulus elsinoides*	H	Convolvulaceae
32	*Fius bengalensis*	T	Moraceae
33	*Ficus religiosa*	T	Moraceae
34	*Ipomoea carnea*	S	Convolvulaceae
35	*Justicia diffusa*	S	Acanthaceae
36	*Jussiea repens*	H, AQ	Hydrophyllaceae
37	*Lantana camara*	S	Verbenaceae
38	*Leonotis nepetaefolia*	H	Lamiaceae
39	*Ludwigia perennis*	H	Onagraceae
40	*Mangifera indica*	T	Aanacardiaceae
41	*Mariscus pariceous*	H	Cyperceae
42	*Mitracarpus verticiplatus*	H	Rubiaceae
43	*Mimosa pudica*	H	Momosaceae
44	*Mollugo pentaphylla*	S	Molluguinaceae
45	*Moringa Oleifera*	T	Moringaceae
46	*Nerium odorum*	H	Euphorbiaceae
47	*Nerium odorum*	S	Apocyanaceae
48	*Pongamia pinnata*	T	Fabeceae
49	*Scoparia dulcis*	H	Scorphulariaceae
50	*Shorea robusta*	T	Dipterocarpaceae
51	*Sida cordate*	H	Malvaceae
52	*Sterculia villosa*	T	Sterculiaceae
53	*Streblus asper*	S	Moraceae
54	*Syzygium cumini*	T	Myrtaceae
55	*Tabernaemontana coronaria*	S	Apocyanaceae
56	*Tamarindus indica*	T	Caesalpiniaceae
57	*Tephrosia purpurea*	H	Fabaceae
58	*Tridax procumbens*	H	Asteraceae
59	*Typha angustata*	H	Typhaceae
60	*Verbena officinalis*	H	Verbenaceae
61	*Vernonia anthelmintica*	H, AQ	Asteraceae
62	*Vitex negundo*	S	Verbenaceae
63	*Woodfordia fruiticosa*	S	Lythraceae
64	*Ziziphus jojoba*	S	Rhamnaceae

H= Herbs, S=Shrubs, US= Under Shrubs, T= Trees, AQ= Aquatic, C=Climber

The vegetation of Talcher falls under the category of dry deciduous forests. However due to biotic interference like industrialization and urbanization many atomically important tree species have vanished. Shaw [18] described vegetation cover and soil development on abandoned PFA lagoons in the Lee Valley, southern England. The plants succession resembled that found on colliery spoil with a mixed radial community leading to wood land dominated by birch (Betula sp) and willow (Salix sp). Ader [29] studied plant communities on abandoned PFA in Manchester and found that succession resulted in Birch/Willow scrub woodland after 30 years. Geonsoulin [20] surveyed vegetation on three abandoned Fly ash patches in Tennessee and found a small number of rudeal species including Polygonum sp. *Erigeron Canadensis*, *Melilotus alba* and *Salix populous* etc. Brieger *et al* [21] describes a total 48 plant species with 35 species on Fly ash species slurry pond site and 20 on dry deposited site. They conclude that in general plants did not accumulate toxic metal but 16 plants have process of colonization of metalliferous solid by plants is more complex than a simple selective screening process for tolerance genotypes from seed population. The initial selection may occur at seedling stage, Walley *et al* [22] but a successful colonization of a plant species on the contaminated soils relies on continuous evolution through evolutionary change rather than simply being accomplished by any physiological tolerance.
In our study site large number of herbs and shrubs belonging to Fabaceae, Asteraceae and Poaceae predominate and there is a gradual abolition of tree species due to industrial and mining activity in the area. Aquatic weeds like *Eichhornia crassipes*, *Ludwigia perennis* and *Marsila quadrifollia* growing luxuriously in coal Fly ash slurry water can be considered as indicator species and have a great potential needs are to be exploited. Fly ash deposits represent structurally simple environments which combined with their newness result in low pH, salinity and abrasiveness. Such structurally simple environment with low species diversity if given adequate moisture and sufficient time to reach moderate pH level, a relatively dense and diverse plant community will develop naturally at such sites.
The present list of native plants (Tab. 1) adapted to the climatic condition of the region can provide guide lines for revegetation of Fly ash soil ecosystem and give an indication of the natural succession progress on abandoned industrial wastes of thermal power station at Talcher , Odisha. Such natural vegetation cover will protect the thermal power station and surrounding environment from wind erosion of hazardous Fly ash.

CONCLUSION

Plants were assessed for their tolerance index to have an idea about the air pollution level in that locality. This work has indicated the suitability of *Mangifera indica, Acacia Arabica, Embilia officinalis, Azadirachta indica, Ailanthus excels, Syzygium cumini* as intermediate tolerant species to pollution. It can be utilized for urban plantation and greenbelt development in industrial area to reduce the level of air pollution. Different plants respond I different ways to air pollution, therefore plants growing in actually polluted environment had higher APTI than those from less polluted environment.

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