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EFFECT OF HEAVY METALS ON PLANTED SPECIES ROOT GROWTH AND BIOMASS OVER COAL OVERBURDEN DUMP

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ABSTRACT

The coal overburden dumps are devoid of essential nutrients and excess in heavy metals due to the weathering of exposed parent rock, which cause leaching of heavy metals. Due to the presence of excess heavy metals root growth is also affected and further affects the biomass. Pot experiments were conducted to see the effect of the heavy metals on the root growth and biomass after one year of planted species of tree and grasses on coal overburden dump top material. Results shows that the root growth and biomass of planted tree and grasses species strict to the availability of heavy metals found in pure dump top material and found more where soil is mixed with dump top material and maximum in pure soil. This proves that the soil mixed with the dump top material neutralizes the heavy metals effects up to certain extent. Further in the pure soil the root growth and biomass were found highest due to availability of heavy metals within the desirable limit.

INTRODUCTION

Opencast coal mining contributes 78.92% over total coal production of 313.547 MTS in 2000-01(Ghosh, 2001). In the opencast coal recovery, destroy vegetation (Mohanty, 2001) and causes exposure of strata which finally by decomposition and exchange reaction with other spoil minerals, can give rise to high concentration of heavy metals like Al, Mn, Fe, Zn, Pb, Cu, Cr, Cd and

Ni (Singh, *et.al*., 2002).

Reclamation by means of re-vegetation is the best option by which many shortfall can be minimized (Nikhil, 2002). Root growth and plant establishments have directly proportionate to each other. This gives the support and strengthens to the plant. Failure or weakening of root system due to any adverse reason may withdraw the support and finally plants will die (Nikhil, 2000). Therefore, especially on the dump, the root system must be strong enough to bind the silt, moisture and support the plant to establish on it (Nikhil, 1998)

However, it is important to see that the root growth may not be much affected by the heavy metals present in the dump (Nikhil, *et.al*., 2003). Therefore a suitable soil amendment is required to minimize the effect of heavy metals. Soil amendment is one of the best one to support plant growth and establishment on the dumps (Nikhil, 2002).

A pot experiment was conducted to study how the species are affected in terms of its root growth and biomass due to some heavy metals present beyond the desirable limit. Moreover addition of soil as amendment has given encouraging results but it has been found that its performance is not as good as the pure soil having the environment of equilibrium (Nikhil, 1998).

MATERIAL AND METHODS

The coal overburden dump materials were collected from an Opencast Coal Mining Project of B.C.C.L at West Mudidih, in Dhanbad district of Jharkhand state and brought to CMRI laboratory for the experimentation with the CMRI garden soil. Six tree and three grass species were dibbled at 1.5-cm depth in each pot containing about 8 kg of material. Each treatment was replicated five times to maintain homogeneity among treatments. Pots were thoroughly washed and lined with polythene and then dump material and soil were filled. Root length and biomass are considered parameters for the study through these experiments. The pot experiments were conducted for seeing the effect of heavy metals on the root length and biomass of different species of tree and grasses in dump, soil and dump with soil mixture at ratio of 3:1.

Standard methods were also adopted for the analysis of heavy metals in soil and overburden top material.

A total of nine planted species with six trees and three grass species were considered for the study. Among the tree species *Dalbergia sissoo* (Ds), *Albizia lebbeck* (Al), *Acacia nilotica* (An), *Azadirachta indica* (Ai), *Leucacena leucocephala* (Ll) and *Samanea saman* (Ss) along with three grass species *Cymbopogan citratus* (Cc), *Vetiveria zizanioides* (Vz) and *Saccrum spontanium* (Ss) were taken for the experiments.

After a year from the date of plantation in all pots, the fills were wetted with water for two days and when it seemed to be loosen then the fills were taken out from the pot without damaging the pot. Then the plastic cover around the pot material is slowly separated from the material. After the whole material taken out from the pot with plant were again washed with pressure water gently so that all the material around the root would had been washed away completely. Before such a process, the stem part is cut down with the help of sharp knife and separated from the root. Then the root is spreaded and kept carefully on the clean and dried newspaper under shade for taking the root length (cm/plant). These roots were kept for continuous drying till the whole root gains the same weight. Then the root is weighed and root biomass (gm/plant) were estimated.

RESULTS

Heavy metals content in Dump and Soil

Eight heavy metals were analyzed for dump material and CMRI garden soil to see the effect on root growth and biomass. The heavy metals analyzed were Iron (Fe), Zinc (Zn), Nickel (Ni), Cadmium (Cd), Chromium (Cr), Lead (Pb), Manganese (Mn) and Copper (Cu).

The data given in the **Table.1** shows that the heavy metal concentrations of iron, zinc, nickel, cadmium, chromium, lead, manganese and copper were found $12.84X10^3$µg/g,53.70µg/g, 9.2µg/g, 0.0µg/g, 6.10µg/g, 13.20µg/g and 307.3 µg/g (dry weight basis) respectively in the soil.

Whereas in the dump material iron 999µg/g, zinc 79.2µg/g, nickel 80.60µg/g, cadmium 1.56µg/g, chromium 50.70µg/g, lead 40.80µg/g, manganese 501.20µg/g and copper 38.80µg/g have been found.

Root length after one year

The root length was noted after one year of growth on the dump, dump with soil mix and soil in all the six tree and three grass species. It is clear from the **Table 2a** that the root growth of the six tree species root is more in the soil than in dump with soil mix and least on the dump material.

Among the six tree species *Dalbergia sissoo* has achieved 74cm, 67cm and

TABLE - 1
Heavy metal content of O.B.dump & CMRI garden soil in µg/g (dry wt. basis)

S.No.	Heavy Metals	Heavy Metals Content in µg/g (dry wt. Basis)		Excess in Dump (in %)
		O.B.Dump	CMRI Soil	
1.	Iron (Fe)	999.0	$12.84X10^3$	(-) 92.22
2.	Zinc (Zn)	79.20	53.70	32.20
3.	Nickel (Ni)	80.60	9.20	88.21
4.	Cadmium (Cd)	1.56	0.00	100.00
5.	Chromium (Cr)	50.70	6.10	87.97
6.	Lead (Pb)	40.80	13.20	67.65
7.	Manganese (Mn)	501.20	307.30	38.69
8.	Copper (Cu)	38.80	66.20	(-) 41.39

TABLE - 2A

Effect of Heavy metals on the tree species average root length(in cm) and biomass(gm/plant) grown in the different treatments and their comparative analysis (in %)

Sr. No.	Name of the Species	Treat-ment	Average RL (cm)	Less from the soil (%)	Average Root Biomass (gm/plant)	Less from the soil (%)
1.	Dalbergia sissoo	A	42	43.24	9	51.35
		B	67	9.46	11.25	39.19
		C	74	0.0	18.50	0.0
2.	Albizia lebbeck	A	48	50.52	25.5	47.42
		B	63	35.05	42.75	11.86
		C	97	0.0	48.5	0.0
3.	Acacia nilotica	A	27.50	57.03	16.50	40.11
		B	48	25	26.25	4.72
		C	64	0.0	27.55	0.0
4.	Azadirachta indica	A	33	45	10.80	60.80
		B	47	21.67	15.70	43.01
		C	60	0.0	27.55	0.0
5.	Leucacena leucocephale	A	57	43.56	15.5	39.69
		B	76	24.75	20.8	19.07
		C	101	0.0	25.70	0.0
6.	Samania saman	A	35	36.36	16.25	36.27
		B	48	12.73	20.75	18.63
		C	55	0.0	25.50	0.0

TABLE - 2B

Effect of Heavy metals on the grass species average root length(in cm) and biomass(gm/plant) grown in the different treatments and their comparative analysis (in %)

Sr. No.	Name of the Species	Treat-ment	Average RL (cm)	Less from the soil (%)	Average Root Biomass (gm/plant)	Less from the soil (%)
1.	Cymbopogan citratus	A	60	33.33	10	16.67
		B	82	8.9	11	8.33
		C	90	0.0	12	0.0
2.	Vetiveria zizanioides	A	103	23.3	13	18.75
		B	120	10.45	15	6.25
		C	134	0.0	16	0.0
3.	Saccrum spontanium	A	52	25.71	11	8.33
		B	60	14.29	12	0.0
		C	70	0.0	12	0.0

42cm on soil, dump with soil mix and dump respectively. In case of *Albizia lebbeck* the root length was achieved as 97cm, 63cm and 48cm in soil, dump with soil mix and dump respectively.

Whereas, the *Acacia nilotica* root length attained 64cm, 48cm 27.50cm on soil, dump with soil and dump respectively. Moreover, the *Azardiracta indica* had gained the root length by 60cm, 47cm and 33cm over the soil, dump with soil mix and dump respectively.

In comparison to this *Leucacena leucocephale* achieved the root length by 101cm, 76 cm and 57cm respectively. Wherein, the *Samania saman* achieved 55cm, 48cm and 36cm on soil, dump with soil mix and dump respectively.

Among the three grass species the root length attained after one year of the growth has been shown in the **Table 2b**.

In the *Cymbopogan citratus* the root length attained by 90cm, 82cm and 60cm over the soil, dump with soil mix and dump respectively. Comparison to this, *Vetiveria zizanioides* has attained the root length by 134cm, 120cm and 103cm on soil, dump with soil mix and dump respectively. The third grass *Saccrum spontanium* is native grass, which attained the root length after one year by 70cm, 60cm and 52cm over soil, dump with soil mix and dump respectively.

Root biomass after one year

The root biomass was weighted after one year of growth on the dump, dump with soil mix and soil in the entire six tree species. It is clear from the **Table 2a** that the six tree species root biomass is found more in the soil followed by the less biomass on dump with soil mix and least on the dump.

Among the six tree species *Dalbergia sissoo* has achieved root biomass 18.5gms, 11.25gm and 9.0gm in soil, dump with soil mix and dump respectively. In case of *Albizia lebbeck* the root biomass was achieved as 48.5gm, 42.75gm and25.5gm on soil, dump with soil mix and dump respectively.

Whereas, the *Acacia nilotica* attained root biomass by 27.55gm, 26.25gm and 16.50gm on soil, dump with soil mix and dump respectively. Moreover, in *Azardiracta indica* attained the root biomass by 27.55gm, 15.7gm and 10.80gm over the soil, dump with soil mix and dump respectively.

In comparison to this *Leucacena leucocephale* achieved the root biomass by 25.7gm, 20.8gm and 15.5gm respectively. Wherein, the *Samania saman* achieved root biomass by 25.5gm, 20.75gm and 16.25gm over soil, dump with soil mix and dump respectively.

Among the three grass species the root biomass attained after one year of the growth has been shown in the **Table 2b**. In the *Cymbopogan citratus* the root biomass attained by 12gm, 11gm and 10gm over the soil, dump with soil mix and dump respectively. Comparison to this, *Vetiveria zizanioides* has attained the root biomas by 16gm, 15gm and 13gm on soil, dump with soil mix and dump respectively. The third grass *Saccrum spontanium* is native grass, which attained the root biomass after one year by 12gm, 12gm and 11gm over soil, dump with soil mix and dump respectively.

DISCUSSION

Heavy metals content

Whereas in the dump, all the heavy metals were found in more concentration except two-heavy metals iron and copper which is relatively high in the garden soil. The data reveals that the iron and copper both are excessively present by 92.22% and 41.39% respectively in the garden soil compared with the dump material. Whereas, other heavy metals like zinc, nickel, cadmium, chromium, lead and manganese were present more by 53.70%, 9.20%, 100%, 6.10%, 13.20% and 307.3% respectively in the dump material compared with garden soil.

The dump is in excess of heavy metals from the garden soil except iron and copper which is in excess in garden soil. This may be due to the leaching of the heavy metals and exposure of the parent rock (Nikhil, 2002)[3].

Effect of heavy metals on root length

This has been noted from the **Fig. 1** that the root length is highly affected from the heavy metals present on the dump. The root growth in terms of root length in *Dalbergia sissoo* is found less by 43.24% on dump and only 9.46% on dump with soil mix. In *Albizia lebbeck* the root length is found less by 50.52% and 35.05% on dump and dump with soil mix respectively.

Whereas the same trend has been noted and found that root length is behind in the two treatments i.e. in dump and dump with soil mix. It has been noted that the root length is less by 57.03% and 25% in *Accacia nilotica*, 45% and 21.67% in *Azadirachta indica*, 43.56% and 24.75% in *Leucacena leucocephale* and 36.36% and 12.73% in *samania saman* respectively.

Where in the grass species the root length is not much affected as in the tree species because the grass roots were fibrous in nature and secondary root development is more prominent than the primary root growth (as seen in the tree species). In *Cymbopogan citratus* it was noted 33.33% and 8.9% followed by 23.3% and 10.45% in *Vetiveria zizanioides* and 25.71% and 14.29% *Saccrum spontanium* on dump and dump with soil mix treatment respectively.

Avenhaus *et.al.*, (1989) reported that the development of root tips is even reduced by the heavy metals present in the combination of Cd 2μg/l, Pb 25μg/l, Cu 10μg/l and Zn 200μg/l.

This shows that the heavy metals has adverse effect on the root growth and soil and other suitable amendment neutralizes the adverse effect up to certain extent and help the plant to establish (Nikhil, 2003).

Effect of heavy metals on the Root Biomass

This has been noted from the **Fig. 2** that the root biomass is highly affected from the heavy metals present on the dump. The root growth in terms of root

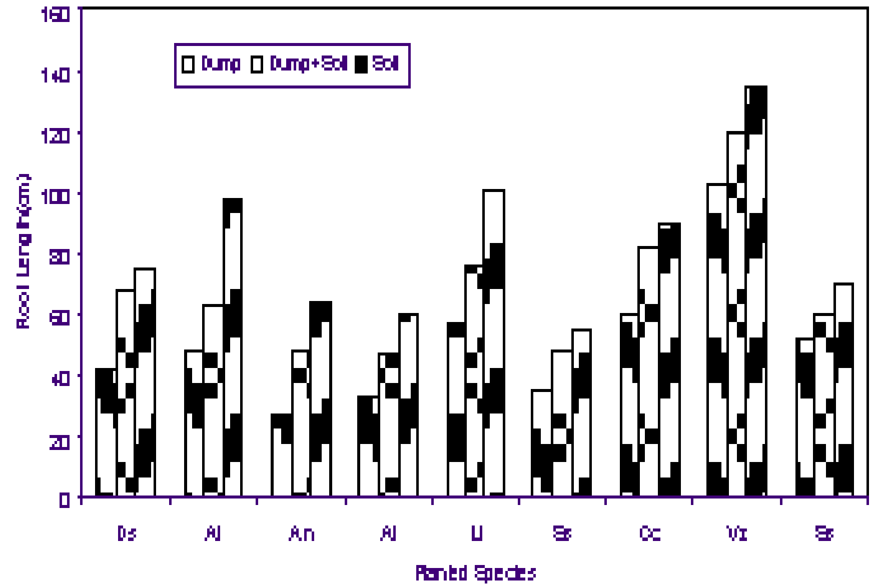

Fig.1- Effect of heavy metals on the root length of planted species in different treatment

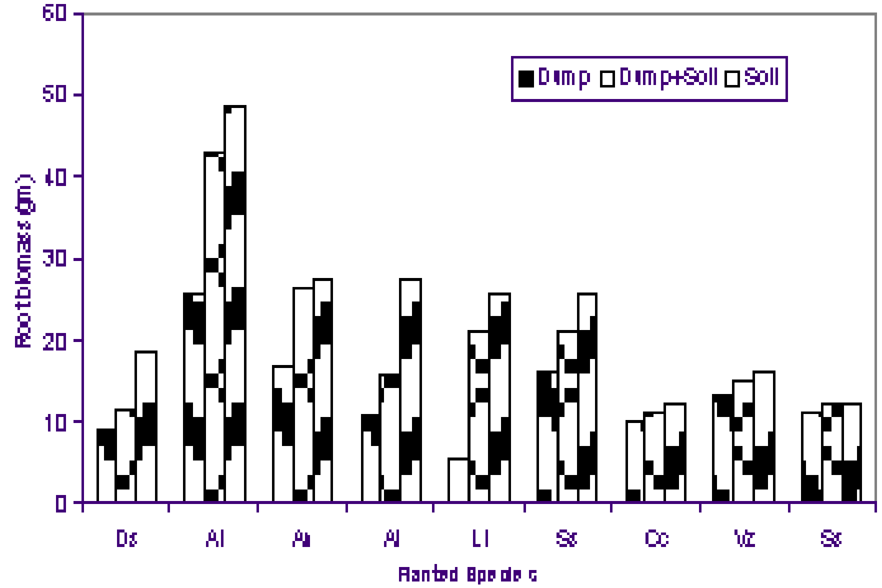

Fig.2- Effect of heavy metals on the root biomass of planted species in different treatment

biomass in *Dalbergia sissoo* is found less by 51.35% on dump and only 39.19% on dump with soil mix from the garden soil in which the heavy metals concentration found minimum except iron and copper.

In *Albizia lebbeck* the root biomass is found less by 47.42% and 11.86% on dump and dump with soil mix respectively over garden soil.

Whereas the same trend has been noted and found that root biomass is behind in the two treatments i.e. in dump and dump with soil mix over the garden soil. It has been noted that the root biomass is less by 40.11% and 4.72% in *Accacia nilotica*, 60.80% and 43.01% in *Azadirachta indica*, 39.69% and 19.07% in *Leucacena leucocephale* and 36.27% and 18.63% in *samania saman* respectively.

Where in the grass species the root biomass is not much affected as in the tree species because the grass roots were fibrous in nature and secondary root development is more prominent than the primary root growth as seen in the tree species. As the heavy metals are present at the depth of the dump due to leaching and grass root does not goes in the depth the effect of heavy metals is found less.

In *Cymbopogan citratus* it was noted 16.67% and 8.33% followed by 18.75% and 6.25% in *Vetiveria zizanioides* and 8.33% and 0.0% in *Saccrum spontanium* on dump and dump with soil mix treatment respectively over the garden soil.

Further, Dadhwal,et.al., (1995) reported that the addition of normal soil in the dump material improves biological atmosphere and increase in biomass of tree species.

Figge, et.al., (1995) reported that suitable amendments may promote re-vegetation of mine spoil containing high level of heavy metals by providing a temporary window of opportunity for plant establishment in a less toxic environment.

Presumably, once plants are established on disturbed sites they may begin a process of reconditioning the site by increasing litter and organic matter accumulate, thereby increasing the potential for natural re-vegetation and reducing future pollution of surrounding areas (Wilson,et.al., 1991).

CONCLUSION

Establishment of vegetation on the disturbed or contaminated land is difficult due to heavy metals contamination, low pH, less nutrients, less organic carbon and compaction etc. But this can be promoted by suitable amendment, which will support the plant establishment and survival up to maximum. Amendment through soil helps in creating biological environment, which minimizes the adverse effect for plant survival and establishment. Further, this experiment can be elaborated and conducted to verify and to see the exact mechanism of adverse effect of heavy metals on the plants planted on the coal overburden dumps.

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