An Investigational Analysis of Napier Grass (Pennisetum Purpureum) as a Phytoremediation Agent for Heavy Metal Absorption from Soil

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Abstract
Heavy metals are the significant source of contaminant in the environment. Deposition of metals can degrade soil quality. Phytoremediation is environmental friendly and potentially affordable technology for the extraction of metals from the soil and Napier grass is found to be highly effective for the absorption of toxic metals form soil due to its idiosyncratic morphological and physiological characteristics. This paper aims to collate some particulars about heavy metals of Cr, Cu, Pb and Zn present in sediments of Gomti river and their treatment. The concentrations of various metals (Cr, Cu, Pb and Zn) were determined in recently deposited surface sediments of the Gomti river in the Lucknow urban area. Markedly elevated concentrations (milligrams per kilogram) of some of the metals, Cr (16.2 mg/Kg) Cu (23.45 mg/Kg), Pb (46.92 mg/Kg), and Zn (77.12 mg/Kg) were observed. Profiles of these metals across the Lucknow urban stretch show a progressive downstream increase due to additions from drainage networks discharging the urban effluents into the river. This study reveals that the urbanization process is associated with higher concentrations of heavy metals such asCu, Cr, Pb, and Zn in the Gomti river sediments. To keep the river clean for the future, it is strongly recommended that urban effluents should not be overlooked before their discharge into the river.

1.0 Introduction:

Rapid industrialization of the countries results in the production of large amount of discharge heavy metal into the environment. This huge increase in production of heavy metals and their continuous discharge into the environment specially on land and water causes severe environmental pollution and health hazards to the human being. Many research outcomes are allocated for the safe disposal of these discharge but no permanent solution for removal of these toxic metal come.

Heavy metals are typicallymarked as elements with metallic properties as lusture, malleability , ductility etc. The prevalent heavy metal contaminants includes Cd, Cr, Cu, Hg, Pb, and Zn. These metals are naturally present in soil [1]. Some of these metals are micro-nutrients necessary for plant growth, such as Zn, Cu, Mn, Ni, and Co, while others have unknown biological function, such as Cd, Pb, and Hg.

Now a days, interest of many researchers has been focused in developing cost effective and environmentally friendly technologies for the remediation of toxic heavy metals from the soil and waste water with toxic metals. Heavy metals are not easily degradable in nature and entering in the food chain to a very high toxic amount leading to undesirable effects beyond a certain limit.

Napier grass(Pennisetum purpureum) , a perennial plant , well known as elephant grass, having significant potential of carbon sequestration. Napier grass captures the CO_2 from the atmosphere and convert it into carbohydrates. It contributes to Soil organic carbon (SOC) by adding soil through root and also helping to combat global warming. Due to deep root system , rapid growth and high biomass Napier grass have capacity to explores significant volume of soil which enhance its capacity to absorb toxic metals from contaminated areas of soil.

Pennisetum purpureum roots releases the phytochelatins and metallothioneins that alters the chemical composition of metals in the soil, enhance metal solubility and its uptake by roots.The accumulation and concentration of contaminants from a polluted environment by plant roots are known as phytoaccumulation. The contaminants are thereafter relocate and deposited in the aerial parts of the plant (leaves and shoots). Pollutant absorption by plant roots, accompanied by translocation and accumulation in shoots and leaves, is referred to as phytoabsorption, phytosequestration, or phytoaccumulation. Plants' aerial portions (shoots and leaves) can be harvested and burnt for energy, with metals reclaimed from the ash as recycling. This approach has been widely used for phytoremediation and elimination of metals such as lead, zinc, copper, nickel, and cadmium utilizing plants such as sunflower and Thlaspi caerulescens [2].

2.0 Literature Review-

Phytoremediation was well defined by Luowen Lyu[3] as "technique that is based on thecombined effort of plants and its association with microbial communities to improve urban sustainability and to improve indoor air quality ". Indoor air phytoremediation systems rely on biotic and abiotic factors .

In comparison with conventional techniques of remediation, phytoremediation is affordable technique do not prompt the secondary contaminants into the environment [4]

Hybrid Giant Napier [HGN] grass is a fast-growing , salt tolerant plant which can grow in saline soil and play significant role uptake of sodium saline soil so that both soil salinity and pH are reduced [5]. The potential of intercropping Pennissetum purpureum Schum with Melia azedarach L. and Broussonetia paprifera for phytoremediation of heavy metal contaminated soil , a pot experiment was conductucted to examine the effecct effect of intercropping on plant biomass and chenge in heavy metal content in soil, [6].

Several methods are already being used to clean up the environment from these kinds of contaminants, but most of them are costly and far away from their optimum performance. The chemical technologies generate large volumetric sludge and increase the costs [7];
Pennisetum purpureum, also known as Cenchrus purpureus (synonym), Napier grass, Uganda grass orelephant grass, is a native plant to subtropical Africa, from which it is believed to have been distributed to other tropical and subtropical regions around the world [8].Newest feasible synergism between phytoremediation and bioenergy production has been inspected by Kumar et al in 2017 [9]. Phytoremediation can pull out all harmful contaminants and enhance soil quality and synchronic production of renewable bioenergy such as biogas by employing the biomass.[10]
Furthermore the potentiality of recovered P. purpureum contaminated with heavy metals forethanol production have been explored by Ko et al. [11]. This study revealed that the zinc metal contaminated biomass resulted in 10% less efficient enzymatic hydrolysis of substrate as comparedwith the noncontaminated biomass. Similarly cadmium contaminated biomass appeared in 33% lessefficiency as compared to non-contaminated biomass. Chromium showed similar results as cadmium. Which is showing that more sugars are available for fermentation [12].
The obtained data shows thus that ethanol productionfrom biomass which was harvested after phytoremediation process is more feasible and Phytoremediation can remove toxic metals from soil which persists in them.
Pennisetum purpureum, is prominent fastest-growing plants in the world having perennial nature and have high biomass yield [13]. Apart from, it has been noticed that P. purpureum also has an efficient photosynthetic rate [14]. This is accomplished by the unique spatial and physical properties of the bundle sheath cell wall of the plant which allows for minimal CO_2 diffusion or leakage.
A good phytoremediator must have substantial growth and high biomass to accumulate large amounts of the contaminants in their systems. Fast-growing plants would act an exceptional phytoremediator due to their voluminous root system, strong growth and high water uptake [15].
P. purpureum yield up to 78 tons/ha of dry matter yearly which signifying its rapid growth [16]. Besides rapid growth, an ideal phytoremediator must have a high tolerance to the pollutants and the ability to degrade or concentrate high levels of pollutants in their system. its biomass [17]. P. purpureum can tolerated innumerable highly contaminated conditions [18]
P. purpureum has also been able to do Rhizofiltration of chlorobenzenes contaminants[19]. Chlorobenzenes are aromatic organic compounds with high toxicity and low biodegradation power [20]. Soil and wastewater contamination by Chlorobenzenes compounds is of great environmental concern. Chlorobenzene are extensively used in synthesis of lubricants , manufacturing of electric transformers,dyes and insecticides and consequently persist into the environment.[21]. This challenge can be conceivably solved by bed out the P. purpureum plant in the contaminated area. By the

cultivation of P. purpureum plant in sewage sediments for 150 days it was found that the concentrations of 1,4- dichlorobenzene and 1,3,5-trichlorobenzene in sewage sediments decreases and its concentration increases in the roots of plant during the cultivation period[22].

3.0 Material and Methods -

Collection and preparation of samples

Soil sample was collected from Gomti River site, Gomti nagar Vistar Lucknow, India. After collection, the soil was air dried to force out for extramoisture and the sample was prepared for seedling.

Seeds of Napier grass were collected from Amazon (Lagrifarm Super Napier Grass seeds). Theseed of samples were sown in two different pots containing soil samples collected from selected site.

The seeds were grown through proper protection of any other type of contamination and then plant sampleswere mowed after 8th and 12th weeks after germination. Then samples were washed with distilled water then grind and homogenized the samples. The homogenized sample was stored and refrigerated to (-4°c) in sealed container until the next analysis.

4.0 Heavy metal analysis for plant and soil-

4.1 Digestion for sludge analysis-

1 gram of ground sample (dry weight) of sludge was taken to a beaker. 5 ml of nitricacid was addedto the sludge sample and covered with a watch glass. The samples were then heated at 95°C for 10 minutes without boiling and sample was allowed to cool. Then 5ml concentrated HNO_3 was again added and heated for 30 minutes.HNO_3 was added repeatedly until brown fumes were emitted that indicates the complete reaction with HNO_3. Sample wasthen allowed to evaporate untill approximately 5 ml solution remain left. After cooling the sample, 3 ml of water and 2 ml of 30% H_2O_2 were added and warmed to begin the peroxide reaction.

The addition of 30% H_2O_2 was continued with warming until the effervescence was minimal After the completion of peroxide reaction, the sample volume was reduced to approximately 5 ml. Finally, the sample was cooled, diluted with water upto 20 ml and filtered through a 0.45 µm filter paper.Analysis of Cr, Cu, Zn, and Pb was carried out by Atomic Absorption Spectrophotometer (AAS) (Model novAA400P).

4.2 Digestion for plant analysis -

0.5 g of pulverized sample was taken in a 200 ml measuring flask and 5 mL of concentrated Nitric acid (HNO_3) was added. The beaker was covered with watch glass and allowed to stand for overnight. After that, the covered beaker was placed on hot plate and heated at 125ºC for one hour and then cooled. The digestion was continued at same temperature with the presence of 1- 2 mL of 30% H_2O_2 until the digest was clear. When the digested sample was clear, temperatures wasreduced to 80ºC and continue heating until dryness. Then diluted nitric acid and deionized water were added as a ratio of 1:2 to dissolve digest residue and bring sample to final volume of 50 ml. Finally, the sample was filtered through a 0.45 µm filter paper and preserved for the analysis of Cr, Cu, Zn, and Pb by Atomic Absorption Spectrophotometer (AAS) (Shimadzu AA 6800).

5.0 Results and Discussions-

Heavy metal concentrations of sludge sample have shown in Graph-1. The concentrations of various metals Cr,Cu, Pb and Znwere found in soil sample of the Gomti river in the Lucknow metropolis. The elevated concentrations of some of the metals, Cr (16.2), Cu (23.45), Zn (77.12) and Pb (46.92) in mg/kg were observed.

Graph-2 and Graph-3 revealed the aggregation of Cr, Cu, Zn, and Pb per unit dry massof root, shoot, and -leaves of Napier grass. The table -1 and table -2 also indicates the heavy metal uptake data of 8 and 12 weeks of harvesting. It revealed that all metal extraction except lead by different parts of Napier grass increased from 8 weeks to 12 weeks though the accumulation pattern was not same for these metals. After 8 weeks of harvesting, the concentration of chromium in root was 4.35 mg/kg which increased to 12.25 mg/kg after 12 weeks of plantation, i.e., about a 4 fold higher uptake rate accounted during the last 4 weeks of its growth But, the uptake rate of copper in root was almost same after 12 weeks as was in 8^{th}weeks. In case of zinc and lead, accumulation rate in root was very slightly increased as compared to 8^{th} weeks.

Result shows that in case of Cr , where the accumulation was declined in shoot portion while the concentration of Cu, Zn and Pd was considerably increased in shoot portion as in Cu (2.2-4.5 mg/Kg) almost double, in case of Zinc (16.7-19.7 mg/Kg) and in case of Pd (0.59 -1.72 mg/Kg) almost trice .The accumulation rate of Cr, Cu, Zn and Pb in leaf portion of the plant was better in 12^{th}weeks of growth compared to 8 weeks.

Usually, the process of metal uptake and accumulation by plants is based on the availability of metal concentration in soil, solvability sequencesand plant species growing on these soils [23].The transport of metals from roots to shoot, and leaf includes long distance affected by many factors.

Table-1

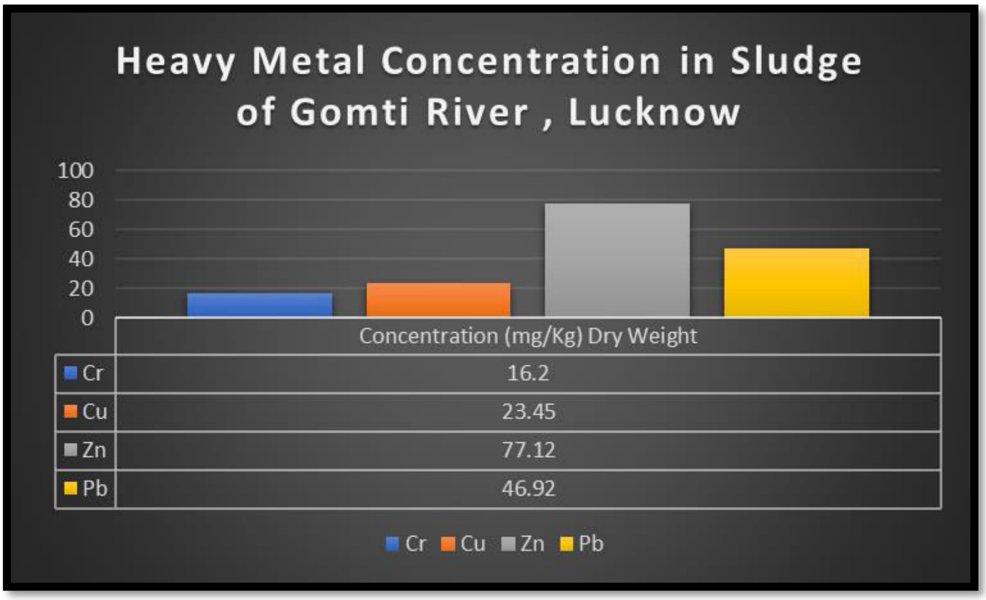
Heavy metals in different part of Napier Grass after 8 weeks of plantation

Parameters	Heavy Metals (mg/Kg)			
	Cr	Cu	Zn	Pb
Root	4.35	21	23	1.54
Shoot	3.21	2.2	16.7	0.59
Leaf	1.25	6.5	10	1.48

Table-2
Heavy metals in different part of Napier Grass after 12 weeks of plantation

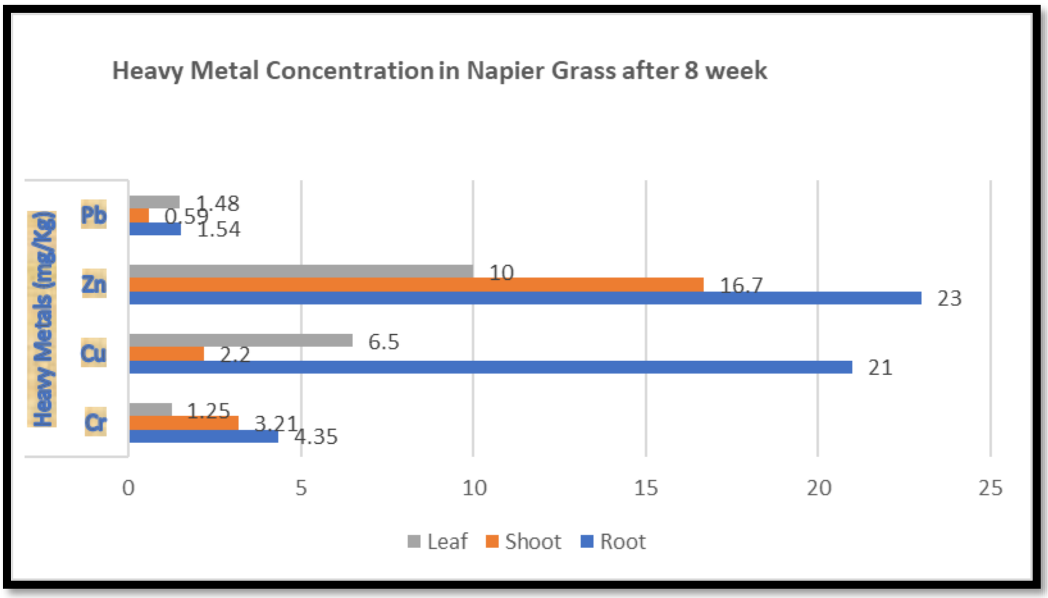
Parameters	Heavy Metals (mg/Kg)			
	Cr	Cu	Zn	Pb
Root	12.25	22.42	24.75	1.75
Shoot	2.15	4.5	19.7	1.72
Leaf	2.81	8.1	11.29	2.89

Graph-1
Heavy metals present in Sludge sample collected from Gomti River Site, Lucknow



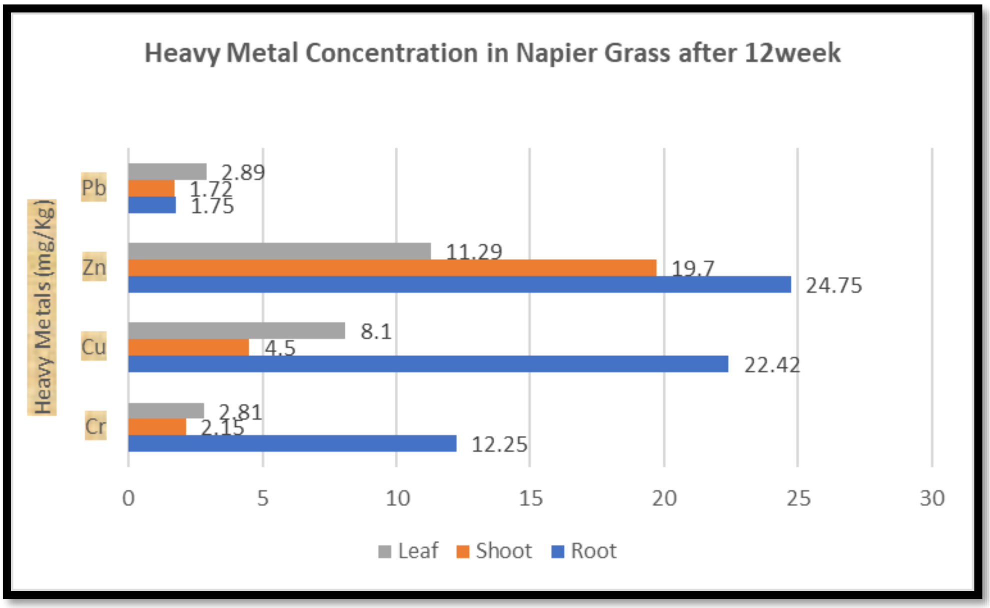
Graph-2

Uptake of heavy metals in different part of Napier Grass after 8 weeks of plantation from sludge



Graph-3

Uptake of heavy metals in different part of Napier Grass after 12 weeks of plantation from sludge



6. **Conclusion-**

The results of research studies showed that Napier grass was fully fledged in sample sludge and accumulatedhigh concentration of heavy metals in different parts of the plant grown .Assessment of heavy metal concentration in sludge sample and multiple plants sample could have given some information about the average lowering of heavy metal concentration in the sludge after application of phytoremediation. Profiles of Cr, Cu, Pd and Zn metals across the Lucknow urban sprawl show a gradual drift in downstream due to additional discharge of the municipal sewage into the Gomti river. This study reveals that the urbanization process is associated with higher concentrations of heavy metals such as Cr, Cu,Zn and Pbin the Gomti river sediments. To maintain the sustainability of Gomti river , it is strongly recommended that municipal wastemust not be ignored before their discharge into the river.

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