Polluted Landfill adaptation into agricultural soil: heavy metal phytoremediation with Indian Black Mustard (Brassica Nigra) and Dolomitic Lime Fertilizer.

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Abstract. Bio-medical and electronic waste accumulation from industry and anthropogenic sources is deposited at landfill sites over the years, possessing waste degradation into heavy metal deposition in soil such as Cd, Ni , Pb, which is detrimental to the developing embryo development and affects respiratory function. The hyper-accumulator herb, such as Indian mustard (Brassica Nigra), which was able to absorb heavy metals from the soil and water and wipe out soil after a period of time and disposed of it. Dolomitic Lime Fertilizer is an Inorganic compound derived from mixture of calcium carbonate (caco3) and magnesium carbonate (mgco3) are used for the sustained agriculture. The Extraction of heavy metals along with Dolomitic lime helps to increase the nitrogen fixation rate in soil and reduce the acidity nature of the soil also acts as a soil conditioners. They provide eco-friendly, cheap and renewable resource for the subsequent years. Phytoremediation of contaminated sites is requires low cost and more renewable compared to remediation strategies that involve removing polluted soil constituents.

Keywords: Phytoremediation, Heavy metals, Dolomitic lime, Indian mustard.

1. INTRODUCTION

Soil heavy metal pollution is an emerging environmental controversy that affects both agricultural productivity and irrigation systems throughout the world. Such heavy metals and metalloids possess an immense amount of bio-hazardous material such as Cd, Ni , Pb and Cr are known to be non-essential heavy metals that are hazardous due to concentration beyond their acceptable limit. The higher concentration of non-essential minerals causes living organisms to malfunction. Via natural calamities and human anthropogenic activities these metals join the Soil environment in their everyday lives. In order to innovate the research and experimental study on Indian Black Mustard (Brassica nigra), we carried out a detailed study to enrich the contaminated soil using inorganic wastes and Starch water as a bio fertilizer to reduce the level of PH in the soil by
producing organic acids, thus reducing the existing microbial organisms in the soil and protecting the soil texture. The presence of heavy metal compounds from the soil enhances the leachate toxicity that penetrates the soil surface and dissolves in the residential areas surrounding the dumping yard at the underground water table. Thus it offers an environmentally friendly conversion of heavy metal contaminated landfill for plant purposes to enrich agricultural soil.

2. REVIEW OF LITERATURE

Chhotu D. Jadia and M.H.Fulekar (2008), the main aim of the study is to promote the Phytoremediation process to clean up the heavy metal contamination from the environment. It is also related to the In situ, solar driven technology to make use of vascular plants to absorb and transport the metals from soil to shoot system. They applied their technology in shallow soil, ground water and surface water bodies to provide a eco-friendly remedial measures.

M.Ghosh and S.P Singh (2005), this project is about study of phytoremediation and its applications. They study the no-edible species of plants which not included in food chain to remediate soil. They propose the in-situ and ex-situ method of cultivations of hyper accumulator plants to uptake heavy metals from soil. They study natural ability of the plants and its function on this process.

H.G.Aliyu and H.M.Adamu (2014), this study shows that, Maize can cleanup contamination in very short period of time without any cost implications and no time consumption. They suggested that temperature and light not only influencing the growth, but also affects the metal absorption. The temperature, water control, competing ions are parameters affects the absorption rate of heavy metals by the plant species. Hazrat Ali, Ezzat Khan and Muhammad Anwar Sajad (2013), They proposed various techniques involved in phytoremediation such as phytoextraction, phytovolatisation, Rhizofiltration, Phytomining etc. They also study the mechanism and role of phytochelatins and metallothioneins in phytoextraction.

Amin Mojiri (2011), A study was carried out to investigate the ability of Corn (Zea mays) plant for phytoremediation. At the end of 60 days, they analysis the soil texture, cation exchange, Ph, electrical conductivity and extractable cadmium and lead are measured after the test. It shows that Corn is a effective accumulator plant for phytoremediation of cadmium and lead from the contaminated soil.

Scott Angle and Alan JM Baker (1997), they conclude that hypertolerance is the basic to hyper accumulation and high rates of uptake in plants. They increase the annual rate of phytoextraction by improved hyper accumulator plants and agronomic technology. It uses "Metallophores" to aid phytoextraction of soil metals.

Wendy Ann Peer and Angus S.Murphy (2015), they employed technique such as EDTA chelators to boost up the rate of uptake of metals in Indian mustard and sunflower. They analysis
all non-essential heavy metals such as Cd, Ni, Pb, Cr, Hg, Br etc. Some plants selected to uptake high concentration of metals such as gold and Ni.

I.D. Pulford and C. Waston (2002), they introduced the concept of phytoremediation of metals using specific trees. It controls the movement of heavy metals at Rhizosphere of the trees. It accumulates the high amount of heavy metals for more number of years. Field trials shows that cleanup of such soils could be achieved within a few years.

3. METHODOLOGY

- Site characterization
- Sample Construction
- Laboratory Determination
- Sample Testing
- Farming of sampling at 3 various conditions
- Monitoring the plant
- Test the absorption of metals from plant and soil
- Comparison of tested results at the end of experiment
- Treatment of soil using Dolomitic Lime fertilizer
- Results of lime treated soil
- Conclusion

Heavy metals Analysis (Atomic Mass Spectroscopy)

Growth and water absorption rate
4. MATERIAL AND METHODS

4.1. Site characterization

The population of the city of Chennai is 43.43 lakhs, according to census 2016, and the average per capita of solid waste generated from City was estimated at 585 grams. Chennai’s cooperation claims that every day, it produces 5000MT of garbage. They are collected the waste through different methods of collection and transported to Kodungaiyur dump yard. This started in 1987. Currently over 26 acres of plot in this area is used for garbage dumpsite, while only 100 acres of land was used to dump hazardous waste. Kodungaiyur's latitude and longitude will be 13 ° 08'02 "N, and 80 ° 16'09" E. Elevation of the site lies above the mean sea level of 7 metres.

4.2. Sample Construction

The experiment is performed under room temperature and optimum pressure at open sunlight. Soil samplings from site depth were taken from 0-30 cm. Soil samples in experimental atmosphere are allowed to dry for 24 hours at a temperature range of 25-30o C. To extract hard materials from the soil, the samples are sewn by 12mm sieve, then the soil samples are subjected to 4.25 mm sieve. The mustard plantlets are planted in a glass container filled with a mixture of sieved samples and e-waste (including other inorganic compounds) collected in Two Layers from the site. The experiment consists of three samples each weighing 4.81 kg, the soil sample density is approximately 2082kg / m3, and the heavy metal contamination in the samples is cadmium (0.10 mg / kg), nickel (42.40 mg / kg), and lead (97.80 mg / kg). Upon seed planting the water is irrigated as per requirement. Samples were taken, after 50 days, for processing.

4.3. Laboratory determination

Until titration, the conical flask is washed clean with acid and distilled water. 1 g of each of the soil samples is put in this tank. The concentrated acids such as 25 cm3 HNO3, 6 cm3 H2SO4, 5 cm3 per chloric acid are mixed together and subjected to furnace. Where the solution is gently mixed at medium temperature, and where standby. Thus the procedure continues until the expulsions of the white dense flumes.45cm3 of deionized water is added for a minute to the solution within the furnace condition. It is then cooled at low temperature and filter for 5 minutes. The filtered solution is subjected to heavy metal analysis using Atomic mass spectroscopy.

5. SAMPLE TESTING

From atomic absorption spectrometry results, the soil is polluted with a high toxicity content relative to the allowable limits of metals concentration in soil as given by TCLP 's provisional code-Toxicity Characteristic Leaching Procedure is a test to assess the mobility of pollutants in solid waste or soil. And WHO (1996); Housing Ministry, the Netherlands, 1994.
Table 1. Concentration of Heavy Metals from the Sample from the Site

| S.NO | PARAMETERS | METHODS          | UNITS | RESULTS |
|------|------------|------------------|-------|---------|
| 1.   | Lead       | TNTH/SOIL/SOP/022 | mg/kg | 99.6    |
| 2.   | Cadmium    | TNTH/SOIL/SOP/022 | mg/kg | AQL(LOQ:0.8) |
| 3.   | Nickel     | TNTH/SOIL/SOP/022 | mg/kg | 43.23   |

AQL-Above Quantification Limit and LOQ- Limit of Quantification

6. MONITORING OF SAMPLES

Table 2. Increase in Length of the Plant in Centimeters (cm)

| Day | Length in cms | Average length in cms |
|-----|---------------|-----------------------|
|     | sample A | sample B | sample C | |
| 0   | 0 | 0 | 0 | 0 |
| 8   | 3.36 | 3.25 | 3.06 | 3.12 |
| 16  | 9.6  | 9.2  | 8.7  | 9.26 |
| 24  | 17.56 | 17.2 | 16.9 | 18.22 |
| 32  | 32.87 | 30.5 | 31.7 | 29.6 |
| 40  | 56.87 | 52.8 | 55.4 | 50.02 |
| 44  | 60.44 | 60.12 | 59.67 | 58.07 |

The growth of the samples after 40 days.

7. TEST THE ABSORPTION OF METALS FROM PLANT AND SOIL

The plants from the samples are plucked out together with the roots being washed and dried for 48 hours under sunlight. It is then converted to fine-powered form. It undergoes a Spectrometry of Atomic Absorption.

Table 3 Concentration of Heavy Metals after End of Experiment

| S.NO | PARAMETERS | METHODS          | UNITS | RESULTS |
|------|------------|------------------|-------|---------|
| 1.   | Lead       | TNTH/SOIL/SOP/022 | mg/kg | 17.80   |
| 2.   | Cadmium    | TNTH/SOIL/SOP/022 | mg/kg | AQL(LOQ:0.75) |
| 3.   | Nickel     | TNTH/SOIL/SOP/022 | mg/kg | 10.43   |

BQL-Below Quantification Limit and LOQ- Limit of Quantification

8. TREATMENT OF SOIL USING DOLOMITIC LIME

8.1. Dolomitic Lime
Dolomitic lime is the additional nutrient compound which acts as the Agricultural lime; it supplies magnesium and Calcium at the ratio of 6:1. It suppresses the acidity of the treated soil and maintains the PH balance over the period. It also acts as the disinfectant in farming to resist the growth of bacteria and other microorganisms without causing any damages to the livestock. Dolomitic Lime Fertilizer is an Inorganic compound derived from a mixture of calcium carbonate (caco$_{3}$) and magnesium carbonates (Mgco$_{3}$) are used for the sustained agriculture. The Extraction of heavy metals along with Dolomitic lime helps to increase the nitrogen fixation rate in soil and reduce the acidity nature of the soil also acts as a soil conditioners. The optimum range of PH in agricultural soil varies from 5.5 to 6.5. If the soil exist high range of acid content such as 4.5 to 5.0, it may cause deficiency of nutrient to the crops and damage the vegetation. The Dolomitic lime acts as the conditioner and reduces the soil acidity up to 80% and helps in Nitrogen Fixation in plants.

**8.2. Experimental Procedure**

1. For applying lime to the sample requires 60ml of lime powder for 1 square feet area of the soil.
2. Sprinkle the lime over the dry area of the sample at the moderate temperature.
3. Dig the sample up to 10cm and pour the lime, mixed with water of ratio 1:3.
4. After a week, tilt and spread the soil samples and exposed to open atmosphere before the sampling of seeds.
5. Then the soil may undergo for Vermi-Composting.

**9. RESULTS AND ANALYSIS**

**9.1 Comparison of end results with the samples.**

| S.NO | HEAVY METALS | CONTROL (mg/kg) | CONTAMINATED SOIL (mg/kg) |
|------|--------------|-----------------|--------------------------|
| 1.   | Pb           | 17.80           | 96.80                    |
| 2.   | Cd           | 0.75            | 0.8                      |
| 3.   | Ni           | 12.43           | 43.23                    |

The concentration units of above metals are in mg/kg.

From the above findings, after cultivation of mustard plantlets at the end of 40 days, there is a progressive decrease in the concentration of heavy metal content in soil. Thus, it demonstrates that Indian Black mustard has a remarkable capacity to absorb and store high soil metal concentrations. The ability of different plant species to absorb and store heavy metals in their tissue is commonly known as hyper accumulators. It has the ability to withstand the conditions and hardness of hard soil. The harvested soil after 40 days shows that only in ideal temperature conditions and sufficient amount of water supplied to the samplings the plants expand and pick up the heavy metals. Many non-essential metals like mercury, arsenic, chromium, etc. ... are absorbed Compared to Ni, Cd and Pb, at a minor level.
9.2. Results of Dolomitic lime Fertilizer

- High yield obtained by correcting the PH and neutralizing the soil condition.
- Increases the Water soluble rate of soil and provide efficient phosphate content to soil.
- It resists the degradation of Molybdenum amount in field.
- Enhances the growth of earthworms and fix the organic material in soil such as nitrogen, sulphur and phosphorus.
- Preventing the accumulation of heavy metals.
- Maintain the Structure of soil and its Texture.

10. CONCLUSION

The Indian black mustard plant has the ability to remove heavy metal constituents from landfill soil using Phyto-extraction method as a result of the experiment. The findings show that at the end of the experiment there is a drop in concentration of Cadmium, Nickel and lead from the samples. The treatment of Starch water prepared from the Rice in fermented condition acquired with Lactobacillus microbe is used to purify the unwanted microbes from organic matter and also increases the plant's root's Nitrogen Fixing Capability (NFC). It also removes the foul odor of organic matter present inside the soil during decomposition. It retains the soil’s original Habitat and increases crop yield.

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