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Adaptation of Polluted Landfill into Agricultural Soil: Phytoremediation of Heavy Metals with Indian Black Mustard (Brassica Nigra) and Starch Water Bio-fertilizer

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ABSTRACT: The accumulation of Bio-medical and Electronic wastages from the industries and anthropogenic origin, are dumped at the landfill sites over the years possess degradation of waste into heavy metal deposition in soil such as Cd, Ni, Pb which are harm ful to the emerging Embryo formation and affects respiratory functions. The hyper accumulator plant such as Indian mustard (Brassica Nigra) which having capable to uproot heavy metals from the soil and water and cleanup the soil and disposed away after the period of time. Starch water from Boiled rice is a upcoming technology to provide cheap, eco-friendly, and modern tool for renewable agriculture. Phytoremediation along with Bio-fertilizershelpstheplanttospeedupdegradationoforganicparticleswiththeassociationoffermented rice starches which improves soil soundness by decomposing any foreign particles and reduce emerging unwanted microbes along with the disintegrated compounds and removes risky heavy metals from soil or water. Phytoremediation of contaminated sites are cost efficient and renewable to thepubliccomparedtoremediationstrategiesinvolvingremovalofpollutedsoilconstituents.

KEYWORDS: Phytoremediation, Indian mustard, Heavy metals, Lactic acid bacteria, Starch water.

I. INTRODUCTION

Soil heavy metal pollution is an emerging worldwide environmental controvency that affects the agricultural productivity and also Irrigation systems. Those heavy metals and metalloids are occupy enumerous bio - toxic content such as Cd, Ni, Pb and Cr are considered as a non - essential heavy metalswhichbecomestoxicduetoconcentrationbeyonditsadequatelimit. TheHigherconcentration of the non-essential minerals leads to malfunctioning of living systems. These metals enter into Soil ecosystem through natural calamities and anthropogenic activities of Humans in their daily life. Hence to innovate the research and experimental investigation on Indian Black mustard (Brassica nigra), wemadeadetailedstudytoenrichthecontaminatedsoilusinginorganicwastagesandStarch water as a bio fertilizer to reduce PH level in the soil by producing organic acids, thus acids reduces the existing soil microbial organisms and protects the soil texture. The presence of Heavy metal compounds from the soil, enhance the toxicity of leachate which penetrates through the soil surfaceanddissolvedattheundergroundwatertableoftheresidentialareaswhichsurroundedbythe dumping yard. Thus it provides an Eco friendly conversion of heavy metal polluted landfill to enrich agricultural soil for vegetationpurpose.

II. 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 themetalsfromsoiltoshootsystem.Theyappliedtheirtechnologyinshallowsoil, ground water and surfacewaterbodiestoprovideaeco-friendly remedial measures.M.GhoshandS.PSingh (2005),this project is about study of phytoremediation and its applications. They study the no-edible species of

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plantswhichnotincludedinfoodchaintoremediatesoil.Theyproposethein-situandex-situmethod of cultivations of hyper accumulator plants to uptake heavy metals from soil. They study natural ability of the plants and its function on thisprocess.

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 influcing the growth, but also affects the metal absorption. The temperature,watercontrol, competingionsareparametersaffectstheabsorptionrateofheavymetals 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 .sort listing of Hyper accumulator plants on the basis of metal accumulation fromsoil.Amin Mojiri (2011),A study was carried out to investigate the ability of Corn (Zea mays) plant for phytoremediation. Attheendof60days,theyanalysisthesoiltexture,cationexchange,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 hypertolerence is the basic to hyper accumulationandhighratesofuptakeinplants. Theyincreasetheannualrateofphytoextraction by improved hyper accumulator plants and agronomic technology. It uses "Metallophores" to aid phytoextration of soilmetals.Wendy Ann Peer and Angus S.Murphy (2015), they employed technique such as EDTA chelators to boostuptherateofuptakeofmetalsinIndianmustardandsunflower.Theyanalysisallnon-essential heavymetalssuchasCd,Ni,Pb,Cr,Hg,Bretc.. Someplantsselectedtouptakehighconcentrationof 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. Fieldtrialsshowsthatcleanupofsuchsoilscouldbeachievedwithinafewyears.

III. Methodology

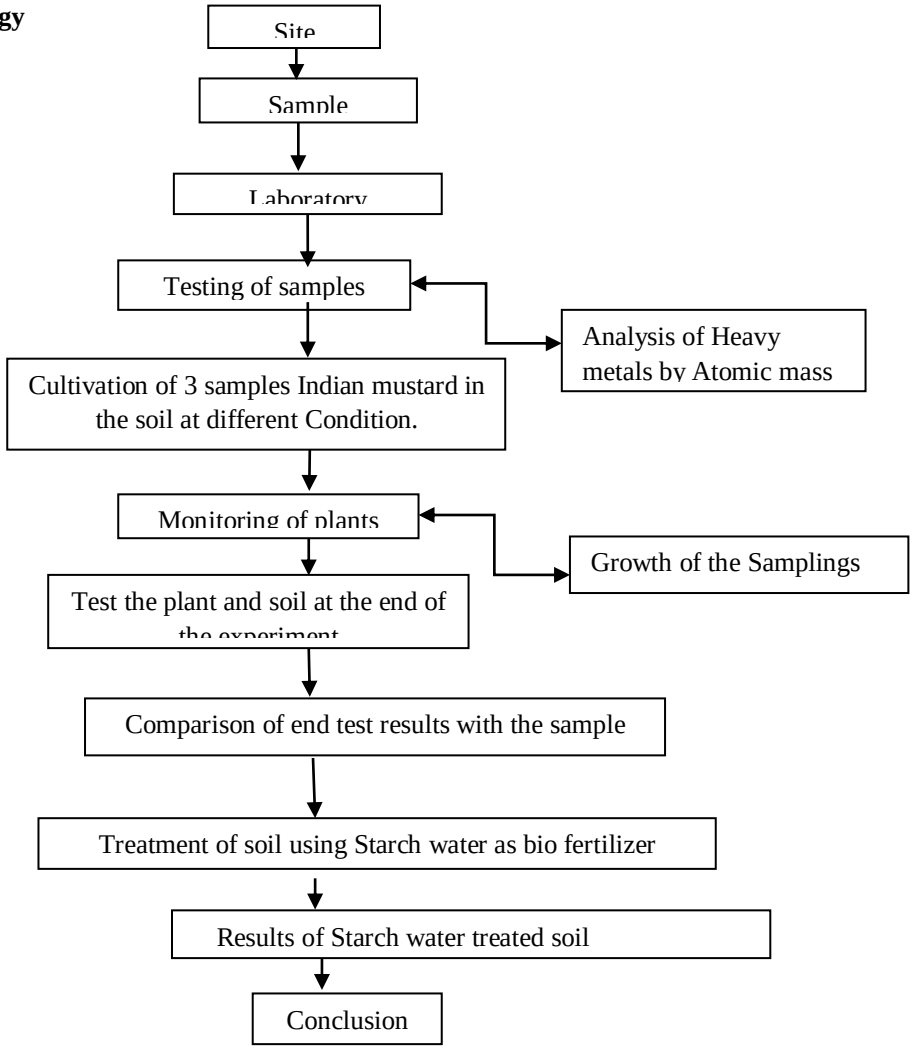

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Figure 1.Accumulation of Various Industrial Wastages to Dumpsite.

IV. Material and methods

4.1. Site description

According to census 2016, the population of the Chennai city is 43.43 lakhs and the average per capita of solid waste generated from City was estimated as 585 grams. Cooperation of Chennai says that,itgenerates5000MTofgarbageevery day.Thesearecollectedondailybasisincludingvariouscollection methods and transported to dump yard at Kodungaiyur. It was started in the year of1987.Approximately more than 26 acre plot in this area is used for garbage dumpsite, whereas only 100 acres of land are used to dump the hazardous wastes. Latitude and longitude of kodungaiyur will be 13° 08' 02" N and 80° 16' 09" E. Elevation of 7 meter above mean sea level.

4.2. Sample preparation

The experiment is carried out at open sunlight under the room temperature and optimum pressure.Soil samplings of 0 - 30 cms from depth of site were taken. Soil samples are allowed to dry in experimental atmosphere at the temperature range of 25 – 30º C for 24 hours. The samples are seived by 12mm seive to remove hard materials from the soil then it is subjected to 4.25 mm seive to obtain the soil samples. The mustard planlets are planted in the glass container filled with mixture of seived samples and e-waste (including other inorganic compounds) collected from the site in Two layers. the experiment consist of 3 samples each weighting of 4.81kg , the density of the soil sample is about 2082kg/m3 and the heavy metal contamination in samples are cadmium (0.10 mg/kg), Nickel (42.40 mg/kg) , Lead (97.80 mg/kg). The water is irrigated as per requirement after the planting of seeds. Samples were taken for testing, after 50 days.

Figure 3. Sieving of Raw Materials and Separate Solid Particles from Soil.

4.3.

Figure 4.Preparation of Samples to Cultivate Plantlets in the Hard Soil including Inorganic Wastes

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The conical flask is washed with acid and distilled water before titration. The soil sample of 1g of each is placed in this flask. The concentrated acids such as HNO^3 of 25 cm^3, H_2so_4 of 6cm^3, perchloricacidof5cm^3aremixedandsubjectedtofurnace.Wherethesolutionismixedgentlyand standby at medium temperature. Thus procedure is continues until the white dense flumes expelsion.45cm^3 of deionized water is added to solution inside the furnace condition for a minute. Thenitisallowedtocoolingfor5minutesandfiltered.ThefilteredsolutionissubjectedtoAtomic mass spectroscopy for heavy metalanalysis.

V. Testing of samples

From the results of atomic absorption spectrometry, thesoiliscontaminatedwithhighrangeoftoxicitycontentascomparedtothepermissiblelimitsof heavy metals in soil as per provisional code given by TCLP - Toxicity Characteristic Leaching Procedure is a test to determine the mobility of contaminants in solid wastes or soils. and WHO (1996); Ministry of Housing, Netherlands1994.

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	97.80
2.	Cadmium	TNTH/SOIL/SOP/022	mg/kg	AQL(LOQ:0.10)
3.	Nickel	TNTH/SOIL/SOP/022	mg/kg	42.43

AQL-Above Quantification Limit and LOQ- Limit of Quantification

VI. 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	3.22
16	9.6	9.2	8.7	9.16
24	17.56	17.2	16.9	17.22
32	32.87	30.5	31.7	31.6
40	56.87	52.8	55.4	55.02
44	60.44	60.12	59.67	60.07

The growth of the samples after 45 days.

VII. Harvesting and testing of sample at end of experiment.

The plants from the samples are plucked out along with the roots are cleaned and dried under the sunlightfor48hours.Thenitisconvertedintofinepoweredform.ItisundergoesAtomicAbsorption Spectrometry.

Table 3 Concentration of Heavy Metals after End of Experiment

S.NO	PARAMETERS	METHODS	UNITS	RESULTS
1.	Lead	TNTH/SOIL/SOP/022	mg/kg	97.80
2.	Cadmium	TNTH/SOIL/SOP/022	mg/kg	AQL(LOQ:0.10)
3.	Nickel	TNTH/SOIL/SOP/022	mg/kg	42.43

BQL-Below Quantification Limit and LOQ- Limit of Quantification

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VIII. Treatment of soil using Starch water bio fertilizer

8.1. Bio-fertilizer

A Bio fertilizer is the anatomical substance which contains microbes and biological elements in state of mobility. It is applied to root system and surface of ground to enhance the growth of the sampling byprovidingvarioussupplementssuchasNitrogenfixation,growthdevelopingmineralsandsoluble calcium phosphorus content to the soil. Bio fertilizers decrease the usage of artificial fertilizers and non- a bio degradable component which causes damage to fertility of the soil. The microorganisms present in the bio fertilizers have ability to restore the Nutrient content and reconstruct the organic values of the soil. Use of Bio fertilizers enhance the tenability of the soil and its properties and retain itshealth.

8.2Introduction of starch water

A Starch water fertilizer is the simple phenomenon that, fermented water obtained from rice soaked withwateralongwithmilkfortwodays.ThefermentationprocessproducestheLacticBacteriaasthe end product. The bacteria naturally having the ability to improve and maintain the soil health. The processoflacticbacteriainvolvesdecompositionoforganicmatterintocarbondioxidewithexpulsion ofLacticacidformation.Itremovesthefoulodourfromthecompostanddecayingsoil.Instarch;the bacteria will grow faster and attain maximum efficiency of number of microbes. The unwanted pathogenisdestroyedduringthefermentationandfertilizerisobtainedattheend.Itachievesthesoil fertility and nutrient by providing nutritional components by the Lactic acid bacteria and its by- products.

8.3 Apparatus required

- Glassjars
- Unbakedrice
- Isopropyl alcohol orvinegar
- Milk andwater
- plain cotton clothes withthreads

8.4.Experimental procedure

Clean and sterilize the glass jar completely using Isopropylalcohol.
Soaktheunbakedriceinwaterfor10minutes.Fillmorethanhalfoftheglassjarbystarchand cover the opening using cloth allow for airexchange.

Placethejaroutsidewithoutcontactofsunlight,thusresisttheUVraystokillbacteriainsidethe jar. Allow it for twodays.
Atanotherjar,quarterportionofjarisfilledwithfermentedricewaterandremainingportionis filled with milk. And close the lid allows it for 5 -7days.

Separatetheliquidphasefromthemixturebyfiltration.Theliquidportioniscalled Lactobacillus.Transfertheliquidintoanotherjarandcloseit,keepitforlongdays.
1glassofLABismixedwith3glassesforwaterandappliestosoilandplantsliberally.

Pour 3 glasses of mixture to each sample of soil after plant isremoved.
MakeupthesoilusingMixerequipmentafter3daysofLABtreatmenttomaintainconsistencyof the soil and also removes the foul odour fromsoil.

IX. RESULTS AND ANALYSIS

9.1 Comparison of end results with the samples.

Table 4. Results of Experiments

S.NO	HEAVY METALS	CONTROL	CONTAMINATED SOIL
1.	Pb	17.80	97.80
2.	Cd	0.5	0.10
3.	Ni	12.43	42.40

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

Fromtheaboveresults,thereisaprogressivedecreaseinconcentrationofheavymetalcontentinsoil afterthecultivationofmustardplantletsattheend48days.ThusshowsthatIndianBlackmustardhas a unique ability to absorb and store high concentration of metals from soil. The ability of the specific plant species to extract and accumulate the heavy metals in their tissue are widely known as Hyper accumulators.Ithasanabilitytotoleratethehardsoilconditionsandtexture.Theharvestedsoilafter48 days shows that, the plants grow and uptake the heavy metals only in optimal temperature conditions and adequate amount of water supplied to the samplings. It is absorb other non-essential metals such as mercury, Arsenic, Chromium, etc... At minor level compared to Ni, Cd and Pb.

9.2 Results of Starch water treated soil

- It fixes the nutrient opportunity to thesoil.
- Since they are living organisms, it can molecularly attract to rhizosphere. It converts the complexorganicmaterialintosimplecompounds.Henceitcanuprootbytheplantseasily.It maintainsthenaturaltextureofthesoil.Itincreasesthecropyieldby30-40%andstimulates the plantgrowth.

X. Conclusion

As the result of the experiment, The Indian black mustard plant having the capability to absorb the heavy metals constituents from the landfill soil using Phytoextraction method. The results show that thereisdecreaseinrangeofCadmium,Nickelandleadfromthesamplesattheendoftheexperiment. The treatment of Starch water prepared from the Rice under fermented condition accumulated with Lactobacillus microbe is used to clean up the unwanted microbes from the organic matter and also increases the Nitrogen fixation capability (NFC) of root of the plant. It also removes the foul odour during the decomposing of organic matter present inside the soil. It retains the original Habitat of the soil and increases the cropyield.

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