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REMEDIATION OF CONTAMINATED SOIL USING INDIAN MUSTARD THROUGH PHYTOREMEDIATION TECHNIQUE

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Abstract–

Rapidly increasing urban population is influencing the land use patterncausing enormous degradation to the surrounding environment. Phytoremediation is the name given to a set of technologies that use different plants as a containment, destruction, or an extraction technique.Phytoremediation as a remediation technology that has been receiving attention lately as the results from field trials indicate a cost savingscompared to conventional treatments.This project elaborates the various types of remediation technique used for contaminated soil. As this technique is so high cost effective and they are very difficult to carried out in a field, to overcome this phytoremediation technique is used.This presented work consist of two main part. The first part consists of all remediation technique used for contaminated soil, and the second part consist of experimental analysis of phytoremediation technique.

Keywords:- phyto-plant, Lead (Pb), Zinc(Zn),Copper(Cu),Cadmium (Cd), heavy metals , soil pollution , phytoremediation.

Introduction

Contamination of the environment by heavy metals has increased sharply at the beginning of the 20th century, as a result of industrial revolution and excessive population growth, posing major environmental and human health problems worldwide. Heavy metals are among the contaminants in the environment. Beside the natural activities, almost all human activities also have potential contribution to produce heavy metals as side effects. Migration of these contaminants into non-contaminated areas as dust or leachates through the soil and spreading of heavy metals containing sewage sludge area few examples of events contributing towards contamination of the ecosystems. Environmental pollution by heavy metals, even if it is at low concentrations and the long- term cumulative health effects that go with it, is of major health concerns all over the world.The term phytoremediation (phyto = plant and remediation = correct evil) is relatively new, coined in 1991. Basic information for what is now called phytoremediation comes from a variety of research areas including constructed wetlands, oil spills, and agricultural plant accumulation of heavy metals. The term has been used widely since its inception, with a variety of specific meanings. Phytoremediation is an emerging technology that uses various plants to degrade, extract, contain, or immobilize contaminants from soil and water.This technology has been receiving attention lately as an innovative, cost-effective alternative to the more established treatment methods used at hazardous waste sites. Phytoremediation is an energy efficient, aesthetically pleasing method of remediating sites with low to moderate levels of contamination that it can be implemented in conjunction with other effective traditional methods as finishing step to the remedialprocess. Specially selected or engineered plants are used in the process

Soil Pollution

Soil Pollution is defined as the presence of toxic chemicals (pollutants or contaminants) in soil, in high enough concentrations to pose a risk to human health and/or the ecosystem. In the case of contaminants which occur naturally in soil, even when their levels are not high enough to pose a risk, soil pollution is still said to occur if the levels of the contaminants in soil exceed the levels that should naturally be present.

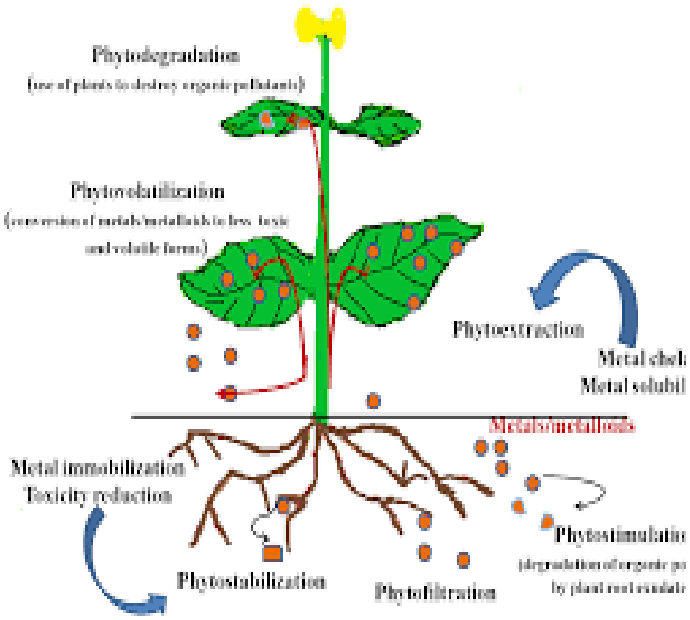
All soils, whether polluted or unpolluted, contain a variety of compounds (contaminants) which are naturally present. Such contaminants include metals,

inorganic ions and salts (e.g. phosphates, carbonates, sulphates, nitrates), and many organic compounds (such as lipids, proteins, DNA, fatty acids, hydrocarbons, PAHs, alcohols, etc.). These compounds are mainly formed through soil microbial activity and decomposition of organisms (e.g., plants and animals).

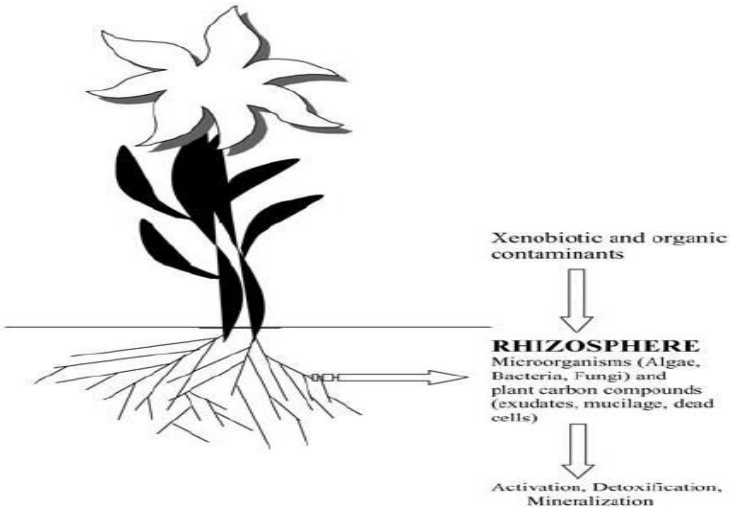
Additionally, various compounds get into the soil from the atmosphere, for instance with precipitation water, as well as by wind activity or other types of soil disturbances, and from surface water bodies and shallow groundwater flowing through the soil.

When the amounts of soil contaminants exceed natural levels (what is naturally present in various soils), pollution is generated. There are two main causes through which soil pollution is generatedanthropogenic (man-made) causes and natural causes.

Various Process Used In Phytoremediation

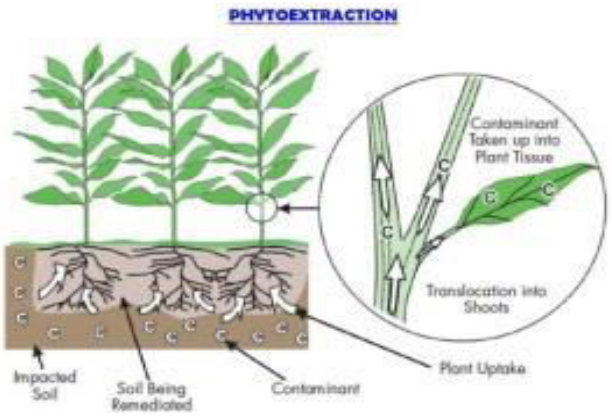


1. Rhizofiltration



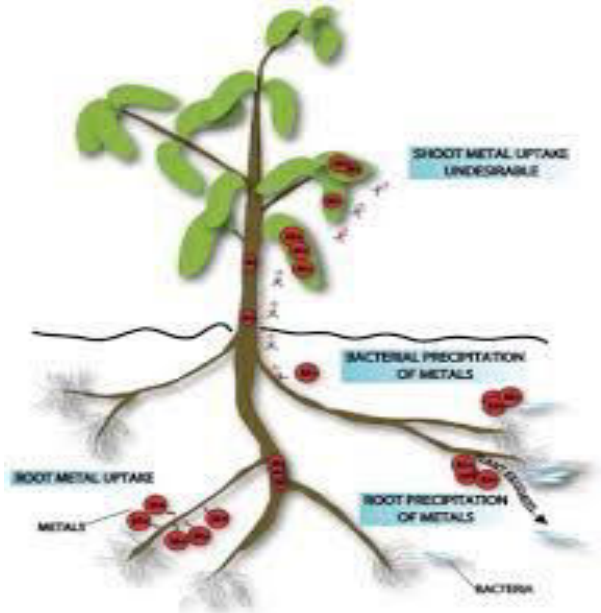
Rhizofiltration is the adsorption or precipitation onto plant roots, or absorption into the roots ofcontaminants that are in solution surrounding the root zone, due to biotic or abiotic processes.Plant uptake, concentration, and translocation might occur, depending on the contaminant. Exudates from the plant roots might cause precipitation of some metals. Rhizofiltration first results in contaminant containment, in which the contaminants are immobilized or accumulated on or within the plant. Contaminants are then removed by physically removing the plant.

2. Phytoextraction



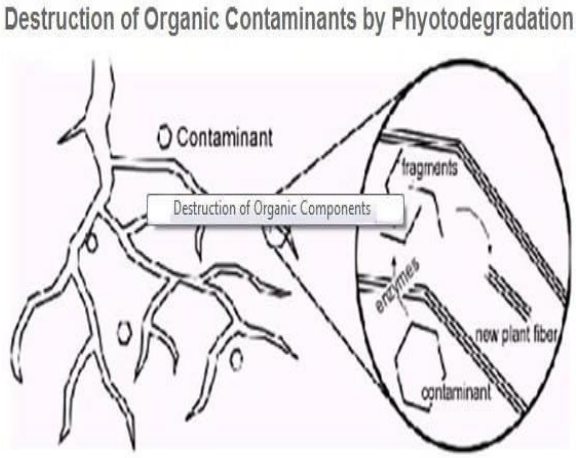
Phytoextraction is the uptake of contaminants by plant roots and translocation within the plants. Contaminants are generally removed by harvesting the plants. This concentration technology leaves a much smaller mass to be disposed of than does excavation of the soil or other media. This technology is most often applied to metal-contaminated soil.

3. Phytostabilization



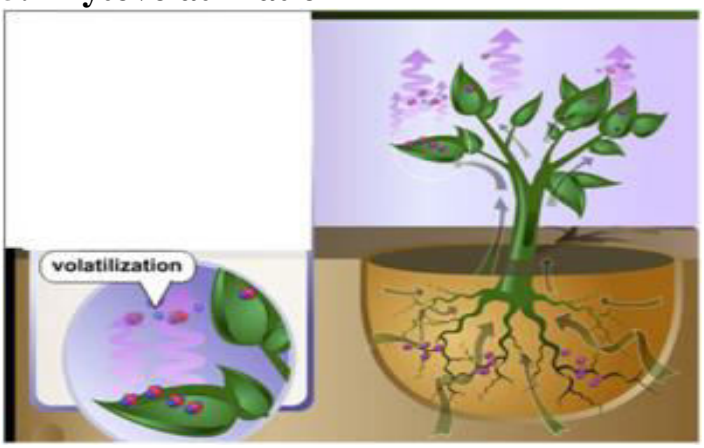
Phytostabilization is defined as immobilization of a contaminant in soil through absorption and accumulation by roots, adsorption onto roots, or precipitation within the root zone of plants, and the use of plants and plant roots to prevent contaminant migration via wind and water erosion, leaching, and soil dispersion.

4. Phytodegradation



Phytodegradation is the breakdown of an organic contaminant in soil through microbial activity that is enhanced by the presence of the root zone Phytodegradation is also known as plant-assisted degradation, plant-assisted bioremediation, plant-aided in situ biodegradation, and enhanced rhizosphere biodegradation.

5. Phytovolatilization



Phytovolatilization is the uptake and transpiration of a contaminant by a plant, with release of the contaminant or a modified form of the contaminant to the atmosphere from the plant throughcontaminant uptake, plantmetabolism, and plant transpiration. Phytodegradation is a related phytoremediation process that can occur along with phytovolatilization.

Working Of Phytoremediation There are several ways in which plants are used to clean up, or remediate, contaminated sites. To remove pollutants from soil, sediment and/or water, plants can break down, or degrade, organic pollutants or contain and stabilise metal contaminants by acting as filters or traps.

The uptake of contaminants in plants occurs primarily through the root system, in which the principal mechanisms for preventing contaminant toxicity are found. The root system provides an enormous surface area that absorbs and accumulates the water and nutrients essential for growth, as well as other non-essential contaminants. Researchers are finding that the use of trees (rather than smaller plants) is effective in treating deeper contamination because tree roots penetrate more deeply into the ground.

In addition, deep-lying contaminated ground water can be treated by pumping the water out of the ground and using plants to treat the contamination. Plant roots also cause changes at the soil-root interface as they release inorganic and organic compounds (root exudates) in the rhizosphere.

These root exudates affect the number and activity of the microorganisms, the aggregation and stability of the soil particles around the root, and the availability of the contaminants. Root exudates, by themselves

can increase (mobilise) or decrease (immobilise) directly or indirectly the availability of the contaminants in the root zone (rhizosphere) of the plant through changes in soil characteristics, release of organic substances, changes in chemical composition, and/or increase in plant-assisted microbial activity.

Phytoremediation is an alternative or complimentary technology that can be used along with or, in some cases in place of mechanical conventional clean-up technologies that often require high capital inputs and are labour and energy intensive. Phytoremediation is an in situ remediation technology that utilises the inherent abilities of living plants.

It is also an ecologically friendly, solar-energy driven clean-up technology, based on the concept of using nature to cleanse nature

Methodology

Introduction: In this study an assessment of remediation of contaminated soil has been done using Indian Mustard. In this chapter, collection of soil sample in nag river Nagpur, plant types, andexperimental methods have been described. This experiment is undergoing in two different parts i.e. Part A which consists of soil already contaminated and Part B which consists of artificial soil.

PART A
History of nag river Nagpur

The Nag River is a river flowing through the city of Nagpur in Maharashtra, India. It is
known for providing the etymology for the name Nagpur. Forming a part of the Kanhan-Pench river system, the Nag River originates in Lava hills near wadi. In 2014 a water analysis was carries out on nag river to find out the presence of heavy metal concentration in river water (1R. G. Gupta, 2S. N. Nandeshwar, 3A. S. Mahakalkar 2014). There are many industries in the vicinity of the nag river which causes this contamination. There are few villages on the bank of river which use to use this water for farming purpose. By the analysis it was found that the water contained lead, nickel, cadmium, zinc, copper, manganese etc.

Testing of soil sample collected from nag river Nagpur

After collecting the soil sample, we wanted to identify the amount of heavy metals present in
soil. For this purpose, we took the soil sample and give it to “ANOCON LABORATORY
PVT. LTD.”on 13th January 2020 for detection of amount of heavy metals in soil.

Soil sampling from Nag river Nagpur

Soil sample from nag river were collected on the basis of its history. The sample were
collected from Shankar nagar indicate in given Fig. The soil sample was taken at a depth of
30 cm to receive the heavy contaminated metals in soil. 4 kg of soil sample were collected from Nag River. During sampling everyone was wearing hand gloves and face mask for personal protection. We referred the guidelines of Agronomy: soil sampling guideline for sampling of soil.

Soil Sampling

Result and discussion (Part A)

TEST PARAMETER	*MEASUREMENT UNIT*	*TEST METHOD*	*TEST RESULT*
Lead(Pb)	mg/kg	ANqr/Lab SOP/lnorg/General/01	_
Copper (Cu)	mg/kg	ANqr/Lab SOP/lnorg/General/01	*8.85*
Arsenic (As)	mg/kg	ANqr/Lab SOP/lnorg/General/01	_
Tin (Sn)	mg/kg	ANqr/Lab SOP/lnorg/General/01	_
Zinc (Zn)	mg/kg	ANqr/Lab SOP/lnorg/General/01	*14.98*
Cadmium(Cd)	mg/kg	ANqr/Lab SOP/lnorg/General/01	_
Mercury (Hg)	mg/kg	ANqr/Lab SOP/lnorg/General/01	_
Methyl Mercury	mg/kg	ANqr/Lab SOP/lnorg/General/01	_

On 17 th January we got the test results and we found out that there were only two metals present in that soil sample i.e. copper and zinc which are by default present in the soil and
plants need these metals for their growth. So, to carry out phytoremediation we need heavy
metals in soil which we didn't found in the sample we collected. Due to many restrictions imposed by government on industries there are very less metals present in the soil now a days
and many factories are also closed as they were polluting the environment. To carry
phytoremediation process, we need to fabricate the soil by manually adding heavy metals in
it.

PART B

Experimental analysis on artificial soil.

As we saw in the first experiment that there were no metals present in soil, so to counter this problem in second experiment we fabricated the soil by adding lead in it. We used AR grade 99.5% lead powder for this experiment. As lead is harmful for human health if consumed, we used hand gloves and face mask for protection. For this experiment we made two pots. In Pot A we took 2kg of soil sample (soil sample was collected from the same location as in first experiment) and in this pot we added lead according to permissible limit. In Pot B we took 2kg of soil sample and in this pot, we added lead more than permissible limit. we used Indian mustard for this experiment as it can effectively extract lead from soil and is easily available at home also. We added 10-10 grams of Indian mustard in each pot. Then the pots were kept for acclimatization.

Nag river soil sample kept in tray

Observation

Under the daily observation following record was noted down.
On day 1 after harvesting of seeds the pots were kept for acclimatization.
2. On day 2 there were no changes seen in pots.
3. On day 3 Pot A showed some progress where plant started to grow whereas in
pot b there was no change.
4. On day 4 plants in pot A grew more than day 3 and plant in pot B started to
grow.
5. On day 5-6-7 there were no changes except the growth of plant.
6. On day 8 it was observed that plants in pot A were in more quantity as
compared to pot B where there were less amount of plants.
7. On day 9-10 the growth was observed in both the plants.
8. On day 10 it was observed that plants in pot A were greenish in color whereas
in pot B the plants were a bit grayish in color.
9. On day 11-12-13 there was growth in plants in both the pots and the change in
color was same except of pot B where color got a bit darker.
10. On day 15 the pot A was in proper healthy condition with green color whereas
plant in pot B some steams started to get dryandleaf's turned yellow.

Pot A & Pot B

left side is Pot A and right side of photo is Pot B

RESULT AND DISCUSSION

In first experiment before sampling we did some research and found that there is presence of heavy metals in nag river soil. Then we took the soil sample from the nag river and gave it to the lab for assessment of heavy metals. After few days we got the results and we found that there were no metals present in the soil except copper and zinc which are essential for the growth of a plant. This was because the authorities have put up some restrictions on
industries which were polluting the river. That's why there were no metals present in the soil we collected. So this experiment was a fail.

plants and we saw that in pot A the plants were growing fast and in pot B the growth was
slow. this was because the lead content in pot A was low and in pot B the lead content was
more than required, so some of the seeds were not able to extract the lead in pot B because of
high concentration. After 15 days of plantation we were going to give the soil sample for
assessment of heavy metals but due to covid-19 pandemic the lab was closed and we were not
able to give the samples for testing. So to counter this problem we did some research on this
topic, used research papers to study the behavior of plant and we found out that then Indian
mustard was effective in extracting lead from soil (Phytoremediation of lead using Indian
mustard Jae-Min Lim, Arthur L. Salido , David J. Butcher*) .So based on our research we took outthe results for this experiment which are as follows: -

Pots	POT A	POT B
Before Plantation (mg/kg)	85	95
After Plantation (mg/kg)	79	93

CONCLUSION

To conclude, we believe phytoremediation can be an attractive alternative to conventional techniques. Phytoremediation might be best suited for remote areas where human contact is limited or where soil contamination does not require an immediate response. This process may take time but is effective. Using Indian mustard for extraction of lead is effective.
Looking at results Indian mustard is effective in condition where the concentration of lead is low and where the concentration is high the efficiency of Indian mustard gets low. This process may be time consuming but is cost effective and requires no skilled labor. If good species is available then phytoremediation is an excellent method.

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