International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

Bioremedition of Contaminated Agricultural Soil by Use of Microbes

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Abstract: ***Soil is a crucial component of rural and urban environments and in both places, land management is the key to soil quality. This series of technical notes examines the urban activities that cause soil degradation. Accumulation of toxic metals (cadmium, copper, lead, nickel, zinc, manganese, chromium, arsenic, potassium, sodium etc.,)in the agricultural soils is an issue of health concern because toxic metals may be transferred to plant and food which affects the crop yield that causes infertility of agricultural land. The reclamation of metal polluted soils, e.g by using chemical extracts is usually difficult and incomplete. An alternative option is to decrease the transfer of heavy metals from soil to food and by inoculating the soil with microorganisms and they are selected for their ability to absorb heavy metals. The selected microbes were found to grow in the presence of high level heavy metals in laboratory conditions. The aim of the present work is to give an overview of the heavy metal contaminant in agricultural soil and also the mechanism of removal of these toxic metals from the contaminated sources by the application of potential microbes.***

Keywords: Heavy metals, Cationic metals, Anionic metals, Soil texture, Sodium, Bioremediation

1. Introduction

The contamination of soils by deposition of heavy metals from various sources has engrossed a great attention worldwide in recent years. Heavy metals in soil are of special concern because they do not degrade naturally unlike new organic contaminants and retained in soil for longer period. Heavy metals either leach into ground or surface water and enter into the growing food crops. From here, they migrate into the food chain by direct or indirect usage of respective crops[(1)].Agricultural soils normally contain low background levels of heavy metals. Contamination from industrial activities or byproducts can increase the natural levels of heavy metals in soil, creating a health hazard to people, livestock and plants. Fertilizers and other soil amendments also add small amounts of heavy metals to the soil. The actual toxicity of heavy metal will be affected by soil texture, organic matter, and pH. Mining, manufacturing, and the use of synthetic products (e.g. pesticides, paints, batteries, industrial waste, and land application of industrial or domestic sludge) can result in heavy metal contamination of urban and agricultural soils [(2)]. Heavy metals also occur naturally, but rarely at toxic levels. Excess heavy metal accumulation in soils is toxic to humans and other animals. The health effects to heavymetals depends on the amount and duration of exposure. Exposure to heavy metals is normally chronic (exposure over a longer period of time), due to food chain transfer. Acute (immediate) poisoning from heavy metals is rare through ingestion or dermal contact. Chronic problems associated with long-term heavy metal exposures are

- Lead – mental lapse.
- Cadmium – affects kidney, liver, and Gastrointestinal tract.
- Arsenic – skin poisoning, affects kidneys and central nervous system.

The most common problem causing cationic metals (metallic elements whose forms in soil are positively charged cations e.g., Pb2+) are mercury, cadmium, lead, nickel, copper, zinc, chromium, and manganese. The most common anionic compounds are arsenic, molybdenum, selenium, and boron [(3)]. Inhalation and ingestion of heavy metals may cause various diseases such as anemia, neuropsychological effects, liver diseases, gastrointestinal pathologies, teratogenic implications. Moreover, the DNA-damaging effects of certain metals in humans can lead to induction of cancer and a decrease in fertility. In addition, heavy metals in soils may adversely affect soil ecology, agricultural production or products and water quality [(4)].Heavy metals in soil may be found in one or more of the following forms:

Dissolved form in soil solution
Exchangeable form in organic and inorganic components
As structural components of the lattices of soil minerals,
As insoluble precipitates with other soil components [(5)].

The main objective of present study is to identify the level of heavy metals present in agricultural soil, then that can be decreased using a technique known as bioremediation. Bioremediation is the process of introducing organisms into a contaminated environment in order to remove the pollutants.

2. Methodology

2.1 Sample Collection

Soil sample was collected from Vaiyakattuputhur, Tiruppur District, Tamilnadu, India. Agricultural soil sample was collected to a depth of approximately 10-15 cm. The samples were allowed to dry for about 48 hrs at room temperature and sieved. Sieved samples were subjected for physico-chemical parameters viz. pH, soil texture, water holding capacity, nitrate, phosphate, potassium, sodium, and heavy metals viz. As, Mn, Zn,Cd, Ni, Cu, Cr and Pb.

2.2 Sample treatment

About 20 g soil was dissolved in 100 ml distilled water (1 : 5: w/v) and kept on mechanical shaker for 12hrs. Solution was filtered through Whatman no. 1 filter paper and filtrate was used as soil extract.

2.3 Sample analysis

The pH was measured and the soil texture, water holding capacity, were measured using standard protocols. Nitrates and phosphates were estimated using Spectrophotometer. Potassium and sodium were estimated by flame photometer. Heavy metals were analyzed using Atomic Absorption spectrophotometer.

3. Result and Discussion

3.1 Physico-chemical parameters

Soil pH is the measure of soil alkalinity, acidity, neutrality. It is simple but very important estimation for soils, since soil pH influences to a great extent to the availability of nutrients to crops. It also affects microbial population in soils. The pH value of contaminated soil sample is 6.0, and non contaminated soil sample is 7.0**.**

Water holding capacity is used to identifiy the land that is suitable for crop production. The value of water holding capacity in contaminated soil is 60%, and the non contaminated soil sample is 80%**.**

Soil texture or particle size distribution is a stable soil characteristic which influences physical and chemical properties of the soil. The sizes of the soil particles have a direct relationship with the surface area of the particles. Soil particles remain aggregated due to various types of binding forces and factors which include the content of organic matter, other colloidal substances present in the soil, oxides of iron and aluminium and the hydration of clay particles etc. The soil texture Clay loam) in both contaminated and non contaminated soil samples were same**.**

Phosphate is one of the trace element in soil, that play a role in crop cultivation in agricultural land. The value of phosphate in contaminated soil sample is 2.029 and non contaminated soil sample is 2.046**.**

Potassium plays a vital role in the formation or synthesis of amino acids and proteins from ammonium ions which is absorbed from the soil. The value of potassium in contaminated soil is 28.4 and non contaminated soil sample is 27.7**.**

Sodium has been known since at least the beginning of recorded history of crop cultivation that salts have an affect on agriculture. It gets accumulated in the soil, due to inadequate leaching and drainage of irrigation waters. Which affects the agricultural land and crop cultivation. The value of sodium in contaminated soil is 1145 and in non contaminated soil sample is 385.

Nitrate is a well-known contaminant of natural environment. It is an important environmental and human health analyte, and thus its detection and quantification are considered to be essential. The value of nitrate in contaminated soil is 0.002, and in non contaminated soil sample is 0.003.

Manganese is an essential element and appears to have a role in the formation or synthesis of chlorophyll. Due to deficiency of manganese, the carbohydrate synthesis is disturbed, and result which in retarded growth, decrease in the content of ash and failure to reproduce. The value of manganese in contaminated soil sample is 0.03 and in non contaminated soil sample is 0.06 **(Table-1).**

3.2 Metal concentration

Arsenic is a naturally occurring element that is frequently characterized as a metal, despite having properties of both a metal and a nonmetal. Arsenic is often found in rocks that contain other valuable metals, such as copper and lead. Arsenic has long been recognized as a poison, and large oral doses can cause death. Lower doses of arsenic can cause decreased production of red and white blood cells, and arsenic poisoning is often characterized by visible changes in the skin. The concentration of Arsenic (0.02ppm) in both contaminated and non contaminated soil samples were same**.**

Zinc is one of the important trace elements that play a vital role in the physiological and metabolic process of many soil microorganisms. Nevertheless, higher concentrations of zinc can be toxic to the soil organism. It plays an important role in protein synthesis. The concentration of Zinc (0.2ppm) in both contaminated and non contaminated soil samples were same.

Cadmium may damage the metabolism of calcium, which will cause calcium deficiency and result in cartilage disease and bone fractures, etc. Agency for Toxic Substances Management Committee has listed Cadmium as the sixth most toxic substance that damages human health. The concentration of Cadmium (0.1ppm) in both contaminated and non contaminated soil samples were same.

Nickel concentration has been considered to be an essential trace element for all living things. At high level concentration of Ni is known as carcinogens. There is evidence that the geno toxic effects of nickel compounds may be indirect through the inhibition of DNA repair systems. As a result of this inhibition it has been suggested that accumulation of nickel in breast tissue may be closely related to malignant growth process. The concentration of Nickel (0.2ppm) in both contaminated and non contaminated soil samples were same.

Copper comes under toxic heavy metals, if present in high concentration, it may lead to serious diseases e.g. Wilson's disease. It is accumulates in liver and brain thereby causes digestion and neural disorders. The concentration of Copper (0.2ppm) in both contaminated and non contaminated soil samples were same**.**

Chromium is a naturally occurring heavy metal that is commonly used in industrial processes. The primary health impacts from chromium are damage to the gastrointestinal, respiratory, and immunological systems, as well as reproductive and developmental problems. Chromium is a known human carcinogen. The concentration of Chromium (0.2ppm) in both contaminated and non contaminated soil samples were same.

Lead is a naturally occurring heavy metal and a powerful neurotoxin. The health effects of lead exposure can include neurological damage, reduced IQ, anemia, nerve disorders, and a number of other health problems. The effects of lead are most severe in children, and at high concentrations, lead poisoning can cause death. The concentration of lead (0.2ppm) in both contaminated and non contaminated soil samples were same (**Table 2).**

4. Conclusion

The present study reveals the level of heavy metals, micro, and macro nutrients level in agricultural soil of Vaiyakattuputhur,Tiruppur District, Tamilnadu, India. Based on the study, metal concentration is present in trace level, and the nutrients level present in low concentration, and the sodium level present in high concentration.

5. Future Scope

Degradation of sodium in contaminated agricultural soil is a complex process. Incorporation of microorganisms will be a good remedy for the prevention of contaminated agricultural soil.

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Table 1: Physico-chemical parameters of Contaminated and Non Contaminated Soil extract

Physical-chemical parameters	*Contaminated Soil extract*	*Non contaminated Soil extract*
pH	6	7
Water holding capacity	60%	80%
Soil texture	Clay loam	Clay loam
Phosphate	2.029	2.046
Potassium	28.4	27.7
Sodium	1145	385
Nitrate	0.002	0.003
Manganese	0.03	0.06

Table 2: Heavy metals concentration of Contaminated and Non Contaminated Soil extract

Heavy Metals	Contaminated soil extract	Non contaminated soil extract
Arsenic	0.02ppm	0.02pm
Zinc	0.2ppm	0.2ppm
Cadmium	0.1ppm	0.1ppm
Nickel	0.2ppm	0.2ppm
Copper	0.2ppm	0.2ppm
Chromium	0.2ppm	0.2ppm
Lead	0.2ppm	0.2ppm