Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 02, Issue: 04 (JULY-AUGUST, 2022)
Available online at http://www.agriarticles.com
©Agri Articles, ISSN: 2582-9882

Cadmium: An Environmental Pollutant

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Cadmium (Cd) contamination of soil and food crops is a ubiquitous environmental problem that has resulted from uncontrolled industrialization, unsustainable urbanization and intensive agricultural practices. Being a toxic element, Cd poses high threats to soil quality, food safety, and human health. Land is the ultimate source of waste disposal and utilization therefore, Cd released from different sources (natural and anthropogenic), eventually reaches soil, and then subsequently bio-accumulates in food crops. The stabilization of Cd in contaminated soil using organic amendments is an environmentally friendly and cost effective technique used for remediation of moderate to high contaminated soil.

Globally, substantial amounts of organic waste are generated every day that can be used as a source of nutrients, and also as conditioners to improve soil quality. Several soil remediation techniques have been investigated in both field and controlled environment experiments, such as soil washing, phytoremediation, solidification, stabilization, excavation, and electro-remediation techniques. Among these techniques, in-situ stabilization of contaminants using organic amendments exhibits great potential for cost-effective performance. Large volumes of organic wastes are routinely produced from livestock and poultry industries to meet human consumption demand. These wastes must be treated to meet environmental regulations, including safe disposal to land. These materials, along with other agricultural and urban wastes, can be used as organic amendments for the remediation of metal contaminated soil. They may provide the large quantities needed to treat large expanses of agricultural lands, because these wastes are available in large volume and are typically inexpensive. The remediation of Cd contaminated soil using organic amendments depends on the availability and costs of organic amendments, as well as their effectiveness. Many research showed that, incorporation of organic amendments into Cd contaminated soil is a fruitful option for improving soil quality. More studies are necessary to evaluate the long term impact of organic amendments incorporation in cadmium metal contaminated soils to aid food security on a large field scale.

Sources of Cadmium

Atmospheric emissions of cadmium: The main forms of Cd in aerosol-size suspended particles are the oxide, sulphide, sulphate and chloride. The aerosol particles in air can be deposited onto soil and vegetation by both wet and dry deposition. In the atmosphere the Cd-containing particles tend to be relatively stable chemically and have residence times in the troposphere of between 1 and 4 weeks depending on their size and the prevailing climatic conditions.

Metalliferous mining: Mines are sources of both particulate and soluble ionic forms of metals but the latter tend to drain into watercourses and/or the groundwater and are less likely

to affect soils directly, except when a flood occurs. It is mainly the particles which contaminate soils in the vicinity of sites where metallifereous ores have been handled, such as mines, roads, rail terminals, docks and smelters.

General urban/industrial atmospheric emissions of cadmium: The major industrial uses of Cd are in: corrosion protection of iron, steel and other metals; pigments for glass, enamel, paints and plastics; stabilizers for plastics, insecticide production; and Ni-Cd batteries. Cadmium is a contaminant of some Zn compounds used in various products, including rubber. Motor-vehicle tyres contain considerable amounts of Zn and hence will contain some Cd.

Emissions from municipal solid waste incinerators and coal burning: Municipal solid waste (MSW) incinerators gave rise to much higher concentrations of Cd in particulates than a coal-fired electricity generating stations.

Soil contamination by long-range atmospheric transport of cadmium: Cadmium-containing aerosols from most of the types of sources discussed above can be transported very long distances in the atmosphere before they reach the ground. Therefore, emission sources in one country may contaminate surface soils in other distant countries. Atmospherically-supplied Cd is likely to be strongly concentrated in the upper few cm of a humus-rich natural soil, but in a cultivated mineral soil it will be mixed throughout the entire plough layer (15-20 cm). Mineral soils have a greater bulk density and higher natural Cd content than the humus layer. In the cultivated mineral soils, the atmospheric contribution to the total Cd content is proportionally smaller and less discernible than in the humus layer of a natural soil. It may still be significant with respect to plant uptake, however, because it is likely to be present in chemical forms that are generally more plant-available than the naturally occurring Cd associated with the soil-mineral material.

Sources of cadmium applied directly to soils: Unlike the insidious pollution of soils via deposition of Cd-containing particles from the atmosphere, direct application of materials to land can include Cd which is a contaminant of widely used materials, such as fertilizers, and also substances recognized as containing a mixture of heavy-metal contaminants, such as sewage sludge and municipal-waste derived composts.

Effect of Cadmium Polluted Soil o Plant Growth

→ Inhibition of cytoplasmic enzymes.
→ Damage to cell structures due to oxidative stress.
→ Replacement of essential nutrients at cation exchange sites of plants.
→ Reduction in the number of beneficial soil microorganisms.
→ Enzyme activities useful for plant metabolism may also be hampered.

Cd accumulation in the plant lead to causes:

- Physiological, Biochemical and structural changes in the plant
- Cd inhibits the photosynthesis, celvin cycle, carbohydrate metabolism
- disturb the uptake and translocation of nutrients a interfering the metabolism result in inhibition of growth and development
- Cadmium inhibits transpiration and photophosphorylation
- Enzyme inhibition eg. RUBP carboxylase
- NADPH increases, lead to cause extracellular superoxide formation, peroxide accumulation, lipid peroxidation.
- Oxidative stress

Remediation Technologies

- To develop the suitable techniques for waste disposal and management and treatment.
- Control use of fertilizer having a high cadmium content.

- Use the alternative raw material (organic amendments; biochar, natural zeolite etc.) so to reduce the chances of contamination of soil, air and water bodies.
- Consideration of site selection, crop, fertilizer management, soil pH, liming and irrigation water quality should be there.
- To identify the way out to make the environment safe phytoremediation is the best approach and the tolerant and sensitive plant genotype.

Conclusion

Cadmium contamination is a global problem whereas metals immobile nature makes them feasible to remediate with in-situ remediation techniques. Several immobilization agents can be employed for effective remediation of contaminated sites. Organic amendments with high specific surface area and CEC enable metals sorption on their surfaces and reduce mobility by adsorption or complexation processes. Stabilization by clay minerals involves surface adsorption, ion exchange and co precipitation reducing metals availability and uptake. Several studies found that time management, moisture regime and amendments availability are key factors which affect remediation process. Remediation cost of Cd contaminated sites can be decreased by finding suitable amendments which in addition to the remediation can also provide nutrients as fertilizer. All around the world different association and organization provide the regulatory guideline but still Indian system lack the information about the limiting value of Cd in different media, so need to focus on research.

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