Impact of heavy metals of soil on public health

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ABSTRACT

Some heavy metals have bio-importance as trace elements but the bio-toxic effects of many of them in human biochemistry are of great concern. Hence, there is a need for proper understanding of mechanism involved, such as the concentrations and oxidation states, which make them harmful. It is also important to know their sources, leaching processes, chemical conversions and their modes of deposition in polluting the environment, which essentially supports life. Literature sources point to the fact that these metals are released into the environment by both natural and anthropogenic means, especially mining and industrial activities, and automobile exhausts. They leach into the underground waters, moving along water pathways and eventually depositing in the aquifer, or are washed away by run-off into surface waters thereby resulting in water and subsequently soil pollution. Poisoning and toxicity in ecosystem occur frequently through exchange and co-ordination mechanisms. When ingested, they form stable bio-toxic compounds, thereby mutilating their structures and hindering bioreactions of their functions.

I INTRODUCTION

Composting can be defined as the process in which organic waste treatment by aerobic microorganisms, as such, it comprises three major phases: mesophilic and thermophilic stages and cooling (the compost stabilization stage). It can reduce the solid waste volume by 40-50%, pathogens are destroy by the metabolic heat generated by the thermophilic phase, degrade a big number of hazardous organic pollutants and make available a final product that can be used as a soil improvement or fertilizer. If the final product contains high heavy metals concentration it may be noxious to soil, plants and human health. Heavy metals uptake by plants and successive accumulation in man tissues and bio magnifications through the food chain causes both human health and environment concerns.

Heavy metals are considered one of the major sources of soil pollution. Heavy metal pollution of the soil is caused by various metals, especially Cu, Ni, Cd, Zn, Cr and Pb. Some heavy metals (like Fe, Zn, Ca and Mg) have been reported to be of bio-importance to man and their daily medicinal and dietary allowancesh had been recommended. However, some others (like As, Cd, Pb, and methylated forms of Hg) have been reported to have no known bio-importance in human biochemistry and physiology and consumption even at very low concentrations can be toxic.
Sources and Emissions

Toxic metals, to a large extent, are dispersed in the environment through industrial effluents, organic wastes, refuse burning, and transport and power generation. They can be carried to places many miles away from the sources by wind, depending upon whether they are in gaseous form or as particulates. Metallic pollutants are ultimately washed out of the air into land or the surface of waterways. Thus air is also a route for the pollution of environment. Metal containing industrial effluents constitute a major source of metallic pollution of hydrosphere. Another means of dispersal is the movement of drainage water from catchment areas which have been contaminated by waste from mining and smelting units. The chief toxic metals in industrial effluents are shown in table-1.

Table 1: Toxic Metal in Industrial Effluents

<table>
<thead>
<tr>
<th>Metal</th>
<th>Manufacturing Industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>Phosphate and Fertilizer, Metal Hardening, Paints And Textile</td>
</tr>
<tr>
<td>cadmium</td>
<td>Phosphate Fertilizer, Electronics, Pigments And Paints</td>
</tr>
<tr>
<td>chromium</td>
<td>Metal Plating, Tanning, Rubber And Photography</td>
</tr>
<tr>
<td>copper</td>
<td>Plating, Rayon And Electrical</td>
</tr>
<tr>
<td>Lead</td>
<td>Paints, Battery</td>
</tr>
<tr>
<td>Nickel</td>
<td>Electroplating, Iron Steel</td>
</tr>
<tr>
<td>Zinc</td>
<td>Galvanizing, Plating Iron And Steel</td>
</tr>
<tr>
<td>Mercury</td>
<td>Chlor-Alkali, Scientific Instruments, Chemicals</td>
</tr>
</tbody>
</table>

Effects on Soil

Soil contamination by heavy metals is of most important apprehension throughout the industrialized world. Heavy metal pollution not only result in adverse effects on various parameters relating to plant quality and yield but also cause changes in the size, composition and activity of the microbial community. Therefore, heavy metals are considered as one of the major sources of soil pollution. Heavy metal pollution of the soil is caused by various metals especially Cu, Ni, Cd, Zn, Cr, and Pb. The adverse effects of heavy metals on soil biological and biochemical properties are well documented. The soil properties i.e. organic matter, clay contents and pH have major influences on the extent of the effects of metals on biological and biochemical properties. Heavy metals indirectly affect soil enzymatic activities by shifting the microbial community which synthesizes enzymes. Heavy metals exhibit toxic effects towards soil biota by affecting key microbial processes and decrease the number and activity of soil microorganisms. Conversely, long-term heavy metal effects can increase bacterial community tolerance as well as the tolerance of fungi such as arbuscular mycorrhizal (AM) fungi, which can play an important role in the restoration of contaminated ecosystems. Chen et al. suggested that heavy metals caused a decrease in bacterial species richness.
and a relative increase in soil action mycetes or even decreases in both the biomass and diversity of the bacterial communities in contaminated soils. Karaca et al reported that the enzyme activities are influenced in different ways by different metals due to the different chemical affinities of the enzymes in the soil system. Cd is the more toxic to enzymes than Pb because of its greater mobility and lower affinity for soil colloids. Cu inhibits β-glucosidase activity more than cellulose activity. Pb decreases the activities of urease, catalase, invertase and acid phosphatase significantly. Phosphatase and sulfatase are inhibited by As (V) but that urease was unaffected. Cd contamination has a negative effect on the activities of protease, urease, alkaline phosphatase and arylsulfatase but no significant effect on that of invertase. Each soil enzyme exhibits a different sensitivity to heavy metals. Diversity and activity of soil microbes play significant roles in recycling of plant nutrients, maintenance of soil structure, detoxification of noxious chemicals and the control of plant pests and plant growth communities are important indices of soil quality. It is important to investigate the functioning of soil microorganisms in ecosystems exposed to long-term contamination by heavy metals. Chromium is commonly present in soils as Cr (III) and Cr (VI), which are characterized by distinct chemical properties and toxicities. Cr (VI) is a strong oxidizing agent and is highly toxic, whereas Cr (III) is a micronutrient and a non-hazardous species 10 to 100 times less toxic than Cr (VI). Cr (VI) has been reported to cause shifts in the composition of soil microbial populations, and known to cause detrimental effects on microbial cell metabolism at high concentrations. Ashraf and Ali also reported that the heavy metals exert toxic effects on soil microorganism hence results in the change of the diversity, population size and overall activity of the soil microbial communities and observed that the heavy metal (Cr, Zn and Cd) pollution influenced the metabolism of soil microbes in all cases. In general, an increase of metal concentration adversely affects soil microbial properties e.g. respiration rate, enzyme activity, which appears to be very useful indicators of soil pollutions. In case of soil contaminated with lead (Pb) slight change was observed in the soil microbial profile.

**Effects on Aquatic Environment**

Heavy metals are highly persistent, toxic in trace amounts, and can potentially induce severe oxidative stress in aquatic organisms. Thus, these contaminants are highly significant in terms of ecotoxicology. Moreover, metals are not subject to bacterial degradation and hence remain permanently in the marine environment. Contamination of a river with heavy metals may cause devastating effects on the ecological balance of the aquatic environment, and the diversity of aquatic organisms becomes limited with the extent of contamination. Heavy metals released into aquatic systems are generally bound to particulate matter, which eventually settle down and become incorporated into sediments. Surface sediment therefore is the most important reservoir or sink of metals and other pollutants in aquatic environments. Sediment-bound pollutants can be taken up by rooted aquatic macrophytes and other aquatic organisms. Because a major fraction of the trace metals introduced into the aquatic environment eventually become associated with the bottom sediments, environmental degradation by metals can occur in areas where water quality criteria are not exceeded, yet organisms in or near the sediments are adversely affected.
Effects on Human Health

The plant uptake of heavy metals from soils at high concentrations may result in a great health risk taking into consideration food-chain implications. Utilization of food crops contaminated with heavy metals is a major food chain route for human exposure. The food plants whose examination system is based on exhaustive and continuous cultivation have great capacity of extracting elements from soils. The cultivation of such plants in contaminated soil represents a potential risk since the vegetal tissues can accumulate heavy metals. Heavy metals become toxic when they are not metabolized by the body and accumulate in the soft tissues. Chronic level ingestion of toxic metals has undesirable impacts on humans and the associated harmful impacts become perceptible only after several years of exposure.

Cadmium (Cd) is a well-known heavy metal toxicant with a specific gravity 8.65 times greater than water. The target organs for Cd toxicity have been identified as liver, placenta, kidneys, lungs, brain and bones. Depending on the severity of exposure, the symptoms of effects include nausea, vomiting, abdominal cramps, dyspnea and muscular weakness. Severe exposure may result in pulmonary edema and death. Pulmonary effects (emphysema, bronchiolitis and alveolitis) and renal effects may occur following subchronic inhalation exposure to cadmium and its compounds. The Itai-itaidisease in Japan brought the dangers of environmental Cd to world attention. Cd has been associated to a lesser or greater extent with many clinical conditions including anosmia, cardiac failure, cancers, cerebrovascular infarction, emphysema, osteoporosis, proteinuria, cataract formation in the eyes. Yet, it has been difficult to tie down obvious links of environmental exposures with morbidity and mortality.

Zinc is considered to be relatively non-toxic, especially if taken orally. However, excess amount can cause system dysfunctions that result in impairment of growth and reproduction. The clinical signs of zinc toxicosis have been reported as vomiting, diarrhea, bloody urine, icterus (yellow mucus membrane), liver failure, kidney failure and anemia.

Copper (Cu) is an essential element in mammalian nutrition as a component of metalloenzymes in which it acts as an electron donor or acceptor. Conversely, exposure to high levels of Cu can result in a number of adverse health effects. Exposure of humans to Cu occurs primarily from the consumption of food and drinking water. Acute Cu toxicity is generally associated with accidental ingestion; however, some members of the population may be more susceptible to the adverse effects of high Cu intake due to genetic predisposition or disease. Excessive human intake of Cu may lead to severe mucosal irritation and corrosion, widespread capillary damage, hepatic and renal damage and central nervous system irritation followed by depression. Severe gastrointestinal irritation and possible necrotic changes in the liver and kidney can also occur. The effects of Ni exposure vary from skin irritation to damage to the lungs, nervous system, and mucous membranes.
Effects on Composting Process

Heavy metals effects are not limiting up to soil, plants, and human health but also affect composting process by changing microbial diversity. Microorganisms are helpful in degradation of organic matter; detoxify some organic and inorganic pollutants, change mobility and bioavailability of heavy metals to plants. Since heavy metals can affect the microbial reproduction and cause morphological and physiological changes. So the biodegradation processes might be influenced by toxic heavy metals in environment. Microbial enzymes might be affected by heavy metals due to the potential inhibition to both enzymatic reactions and complex metabolic processes. Heavy metals decrease the phosphatase synthesis during the composting process. Microorganisms have to cope with toxic Pb during their growth in the Pb-contaminated substrates and the exposure of microorganism to metals always inhibits microbial growth and activity.

Heavy metals in general are potent inhibitors of enzymatic reactions. Cu and Cd in addition to binding with aromatic amino acid residues in enzyme molecules can also cause oxidative damage of proteins by the induction of oxidative stress associated with the production of reactive oxygen species like hydroxyl or superoxide radicals. The significant impacts of high Cu and Zn on a vermicomposting system including accumulation in worm tissue and reductions in the number of juveniles produced. While *Eisenia fetida* earthworm has the potential to be used in the vermicomposting of organic waste, the level of Cu and Zn needs to be monitored to ensure the earthworm population in the system.

II CONCLUSION

Heavy metals containing compost may change the physical, chemical and biological properties of soil. These metals uptake by plants from the soil, it reduces the crop productivity by inhibiting physiological metabolism. Heavy metals uptake by plants and successive accumulation in human tissues and biomagnifications through the food chain causes both human health and environment concerns. Heavy metals containing agricultural runoff enter in aquatic environment, and harm to aquatic plants and animals. Therefore, if the compost has to be applied in agriculture it should be free from pathogens and heavy metals.

REFERENCES


