



Heavy metal effect on aquatic environment and soil

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Abstract

Heavy metals are toxic to people, plants, and water when present in excess. They may also damage soil and aquatic life. Heavy metals damage soil biota by hindering vital microbial processes and decreasing the number and activity of soil microbes. Even at low concentrations, heavy metals may hinder the physiological metabolism of plants. Plants may absorb heavy metals, which can then accumulate in the food chain and endanger animals and humans. Contaminants in aquatic systems, such as heavy metals, may enhance the production of reactive oxygen species. Fish and other aquatic creatures might be harmed by this. So, for agricultural purposes, the compost can't include any heavy metals. This research aimed to evaluate the effects of heavy metal-containing compost on soil, plants, human health, and aquatic life.

Keywords: Heavy metals, aquatic environment, food chain

Introduction

Heavy metals are regarded as a major contributor of water, soil contamination. Various metals, particularly Cu, Ni, Cd, Zn, Cr, and Pb, induce heavy metal contamination of the soil [1]. Several heavy metals, including iron (Fe), zinc (Zn), calcium (Ca), and magnesium (Mg), have been identified as biologically essential for humans. It has been proposed that these metals should be included in daily medical and dietary recommendations. On the contrary, substances like As, Cd, Pb, and methylated forms of Hg have no acknowledged significance in human biochemistry and physiology. Their consumption, even in very small amounts, may be detrimental [2]. These substances are often found in soil and aquatic environments. A completed product with a high level of heavy metals might pose a risk to the soil, plants, and human health. Concerns about both human health and the environment arise from the absorption of heavy metals by plants, their subsequent accumulation in human tissues, and their biomagnification along the food chain [3].

Heavy metals have detrimental effects on soil microorganisms, leading to alterations in the diversity, abundance, and general functionality of soil microbial communities [4]. High levels of lead (Pb) in soils can decrease soil productivity, while extremely low levels of Pb can hinder important plant processes like photosynthesis, mitosis, and water absorption. This can lead to toxic symptoms such as dark green leaves, wilting of older leaves, stunted foliage, and brown short roots [5]. The absorption of metals by plants from soils at high concentrations may pose a considerable health risk owing to the potential repercussions on the food chain [6]. The absorption of heavy metals by plants and their subsequent accumulation in the food chain constitutes a potential hazard to human health. Ingestion of food contaminated with heavy metals.

Heavy metals present in agricultural runoff pose a potential threat to aquatic plants and animals when they reach the aquatic environment. The presence of heavy metal pollutants in biodegradable waste, such as sewage sludge, municipal solid waste, and pig manure, may disrupt the composting process by inhibiting the growth of

microorganisms. Heavy metals disrupt the life cycle of earthworms during the process of vermicomposting. Hence, the primary aim of this research was to evaluate the consequences of compost, which contains high levels of heavy metals, on soil quality, plant growth, human well-being, aquatic ecosystems, and the composting process itself [7].

Methods -Results& Discussion

Impacts on the Aquatic Ecosystem

Aquatic organisms may experience considerable oxidative stress and toxicity at low concentrations due to the presence of heavy metals. Consequently, these contaminants have a significant influence on ecotoxicology. Furthermore, due to the resistance of metals to microbial degradation, they persist indefinitely in the marine environment [8]. Heavy metal pollution in a river may have a significant negative influence on the ecological equilibrium of the aquatic environment, leading to a reduction in the diversity of aquatic organisms as contamination levels increase [9].

Typically, when large amounts of heavy metals are released into water systems, they bind to the solid waste particles that ultimately sink and form part of the sediment. Surface sediment is the primary repository or sink for metals and other pollutants in aquatic environments. Aquatic macrophytes with extensive root systems, along with other aquatic organisms, have the ability to absorb pollutants that are linked to sediment [10]. Metals may cause environmental deterioration in areas where water quality limits are not surpassed, but species in or near the sediments are adversely affected [11]. This occurs because a significant proportion of the trace metals that are introduced into the aquatic environment ultimately get linked with the sediment at the bottom. The presence of elevated levels of micropollutants, namely metals, in rivers may significantly influence the composition of diatom populations [12, 13].

Heavy metals may be transferred by biomagnification to higher trophic levels in the food chain after being absorbed by an aquatic organism. Most of the heavy metal load that humans and other apex predators bear is derived from fish.

This implies that there is a possibility of substantial biomagnification in the aquatic environment due to their consumption^[14]. Contaminants present in aquatic systems, such as heavy metals, induce the production of reactive oxygen species (ROS), which may cause injury to fish and other aquatic organisms^[15]. Due to the potential presence of diverse environmentally persistent contaminants, such as heavy metals, fish may be a food source that poses a public health concern. Consuming fish with high levels of heavy metals is worrisome due to the potential health problems associated with long-term exposure^[16]. Mercury (Hg) is considered one of the most serious pollutants due to its adverse effects on marine life and potential harm to humans. Methylmercury is a hazardous chemical compound of mercury that is generated in aquatic sediments via the process of bacterial methylation of organic mercury. Essentially, the majority of the mercury present in fish muscles is in this specific state^[17]. Metals in fish are conveyed via the bloodstream, often binding to proteins via ions. The metals interact with the organs and tissues of the fish, accumulating to different extents in specific organs or tissues of the fish.

One of five pathways exists for contaminants to reach fish. Skin, food, non-food particles, gills, oral water intake, and non-food particles are all examples of such routes. When pollutants enter the bloodstream, they are either transported to a storage site (the bone) or processed and stored in the liver. There are a few possible destinations for the pollutants that the liver breaks down: the blood, the bile, the kidneys, the gills, or even fat, another kind of hepatic tissue^[18].

Benthic macroinvertebrate assemblages, which include species with varying degrees of susceptibility to contaminants, have been used to thoroughly evaluate the biological impacts of metal contamination in streams. Their key roles in lotic systems include managing organic matter decomposition and nutrient cycling and serving as a major link between primary producers and higher trophic levels in lotic food webs. Many species of moving-water fish rely mostly on invertebrates for their diet, but researchers have yet to determine the nutritional value of heavy metals' impacts on macroinvertebrates. Most commercially or recreationally important salmonid species rely on drift-prone macroinvertebrates, therefore understanding how heavy metal pollution affects these creatures is of the utmost importance^[19].

Effect on Soil

In the industrialised world, heavy metal poisoning of the soil is a major concern^[20]. In addition to having a negative impact on a number of factors that affect the quality and yield of plants, heavy metal pollution also alters the microbial community's size, composition, and activity^[21]. As a result, heavy metals are one of the main causes of soil contamination. Numerous metals, in particular Cu, Ni, Cd, Zn, Cr, and Pb, are responsible for heavy metal contamination of the soil^[22]. It is generally known that heavy metals have negative impacts on the biological and chemical characteristics of soil. The magnitude of the impacts of metals on biological and biochemical qualities is significantly influenced by the soil's features, such as its organic matter, clay content, and pH^[23].

By changing the microbial population that produces enzymes, heavy metals have an indirect effect on the enzymatic activity of soil^[24]. By interfering with important

microbial activities and reducing the quantity and activity of soil microorganisms, heavy metals have harmful effects on the soil biota. On the other hand, long-term impacts of heavy metals can boost bacterial community tolerance as well as fungi like arbuscular mycorrhizal (AM) fungus's tolerance, which might be crucial for the regeneration of polluted ecosystems^[25]. According to Chen *et al.*^[26], heavy metal contamination of soils led to reductions in both the biomass and diversity of bacterial communities, as well as a relative rise in soil actinomycetes.

Due to the diverse chemical affinities of the enzymes in the soil system, Karaca *et al.*^[27] observed that various metals had varying effects on the enzyme activity. Because of its increased mobility and lesser affinity for soil colloids, Cd is more hazardous to enzymes than Pb. More so than cellulose activity, copper inhibits b-glucosidase. Urease, catalase, invertase, and acid phosphatase activity are all dramatically reduced by Pb. As (V) inhibits phosphatase and sulfatase, but that urease was unaffected. Protease, urease, alkaline phosphatase, and arylsulfatase are negatively impacted by Cd contamination, however invertase is not significantly affected^[28].

Indicators of soil quality include the diversity and activity of soil microorganisms, which are crucial in the recycling of plant nutrients, preservation of soil structure, detoxification of toxic substances, control of plant pests, and maintenance of plant growth communities. The operation of soil microorganisms in environments subject to persistent heavy metal pollution must be studied^[29]. As Cr (III) and Cr (VI), which have different chemical characteristics and toxicities, chromium is frequently found in soils. While Cr (VI) is a potent oxidizer and a very dangerous species, Cr (III) is a micronutrient and a species that is non-hazardous and 10 to 100 times less toxic than Cr (VI)^[22].

Cr (VI) has been shown to alter the makeup of soil microbial communities and, at high concentrations, to have negative impacts on microbial cell metabolism^[30]. Heavy metal pollution (Cr, Zn, and Cd) affected the metabolism of soil microbes in all cases and that this was due to the toxic effects that heavy metals have on soil microorganisms, which changes their diversity, population size, and overall activity. Generally speaking, a rise in metal content has a negative impact on the microbiological characteristics of the soil, such as respiration rate and enzyme activity, which appear to be highly helpful indicators of soil pollutions. A small alteration in the soil was seen in lead-contaminated soil (Pb)^[31].

Conclusion

Compost containing heavy metals may alter the biological, chemical, and physical characteristics of soil. Because these metals impair physiological metabolism, they cause crops to produce less when they are absorbed by plants from the soil. Concerns about both human health and the environment arise from the absorption of heavy metals by plants, their subsequent accumulation in human tissues, and their biomagnification along the food chain. Aquifers become contaminated with heavy metals from agricultural runoff, harming aquatic life. So, if the compost is going to be used in agriculture, it needs to be pathogen- and heavy metal-free.

Compliance with ethical standards

Acknowledgments

We are grateful to Prof. Vidyavati, former Vice Chancellor of Kakatiya University, Warangal for her valuable suggestions and constant encouragement.

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