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Review of the source and extent of heavy metal pollution of soil: Impacts and mitigation approaches

[1]Elizabeth Thingom and [2]Dr. Ravindra Kumar

[1]Research Scholar, Arni School of Science, Arni University, Indora, Kathgarh, Kangra, Himachal Pradesh, India
[2]Assistant Professor, Arni School of Science, Arni University, Indora, Kathgarh, Kangra, Himachal Pradesh, India

Corresponding Author: Elizabeth Thingom

Abstract

In last few decades, due to the rapid increase in the population, industrialization and newer agricultural practices, the aquatic resources of India have been deteriorating. The pollution of aquatic ecosystems by heavy metals is of a great concern due to their persistence, toxicity and accumulative behaviour. The heavy metals can change the trophic status of aquatic ecosystems and make them unsuitable for various purposes. They also pose a serious threat to human health. In the last few decades of the 20th century, environmental pollution emerged as a major concern for the survival and welfare of mankind throughout the world. In fact, most of the developed countries have already realized the fact that the very existence of life on earth may be endangered, if suitable steps are not taken for the control and abatement of environmental pollution. This is why the industrialized and developed nations have already been spending vast amount of money to control the environmental pollution and the developing countries are beginning to follow their action within the constraints imposed by the limited financial resources, infrastructural facilities and the scarcity of trained man power. Different standards for sediment pollution which are in use have also been discussed. It showed that environmental degradation has become a major societal issue in India due to uncontrolled anthropogenic activities, besides natural factors. There is an urgent need of creating awareness amongst the public of these problems and find preventive and remedial solutions for management. Expensive high-tech remedial measures are not suitable for the country, and hence emphasis has to be given on prevention. Indigenous research towards mitigation and remediation has to be encouraged, keeping in mind India's unique problems of poverty, crowding and malnutrition.

Keywords: Environmental pollution, management

Introduction

Developing countries of the world are facing pollution problems due to toxic elements in the environment. Among these elements heavy metals are stable and persistent environmental contaminants. Some metals like Zn, Cu, Fe and Mn, are required for biological functioning while others like Cd, Cr, Pb and Hg have no known significant contribution, but may exhibit extreme toxicity even in trace amounts. These toxic elements enter into the environment both as a result of natural processes and as pollutants from human activities. India is one of the wettest countries in the world having 1,170 mm average annual rainfall. It has annual precipitation of water (including snowfall) to the extent of 4000 km3, of which 1869 km3 water on an average is annually available. Ganga Brahmaputra-Meghna system is the major contributor (60%) of total water resource potential of the country

Rapid industrialization has resulted in the generation of liquid, solid and gaseous wastes in such a huge quantity that a serious threat is likely to be posed to the quality of water in the years to come. The crux of the present-day environmental problem concerning the water is further accentuated due to everyday pouring in of the filth from the communities, untreated wastes from industries and even increasing run-off excess and unutilized fertilizers and pesticides from agricultural fields, orchards and forests. This problem is getting from bad to worse with advancement of technology pertaining to meet the increasing demands of swarming human population. Industrialization is the mainstay of modern society for economic prosperity of our

nation. When in 1947, the country threw off the yoke of foreign domination and emerged as a sovereign independent nation. The national Government realized that industrialization was necessary to stabilize the economy of democratic India. Although, rapid industrialization is the utmost need of developing country like India, there should be awareness about the way in which factory effluents should be discharged without much damage to the flora and fauna.

Pollution of the biosphere by heavy metals due to industrial, agricultural and domestic activities has created a serious problem for the safe and rational utilization of soils and water. Heavy metal pollution is a serious threat to the environment due to the fact that they cannot be degraded, rather they persist and are accumulated, hence pose severe affects on all life forms. They can cause adverse toxic effects on the plants growing in the affected area leading to a decrease in agricultural productivity. Other side of picture is that due to high cost and scarcity of chemical fertilizers, the land disposal of agricultural, municipal and industrial waste is widely practiced as a major and economic source of nutrients and organic matter for growing cereal crops by poor farmers in Pakistan. The use of such waste water in irrigation system definitely provides some nutrients to enhance the fertility of soil but also deposit toxicants that change soil properties in the long run. This necessitates a detailed scientific study before any specific waste can be used for irrigation for a particular crop and environmental conditions. Environmental pollution has become a serious problem, at present. Emitted effluents and solid wastes from various industries have increased the number of contaminants in air, water and soil to hazardous level in many areas. Moreover, indiscriminate use of insecticides, herbicides, pesticides and some other chemicals used for plant protection and allied purposes have also led to their accumulation to damaging concentration in the organisms of the higher trophic level. In the local area, effluents of certain industries are being discharged into city sewage drain. This water is being used for irrigation purposes of crops in several adjoining farms. It was therefore, of interest to see, whether and to what extent such irrigation with polluted water could harm the plants. The heavy metals in the distillery effluent show biomagnification through food chains and their concentration becomes toxic in edible parts of crop plants.

Sources of pollution

Heavy metal pollution arises from natural as well as anthropogenic sources. Natural sources include seepage from rocks into water, volcanic activity, forest fires, etc. Anthropogenic sources mainly include domestic and industrial wastes. Natural sources contribute less pollution while a good number of toxic elements enter through sewage and industrial wastes. Domestic sources: Discharge of untreated sewage in water is the most important water pollution source in India. Indian Planning Commission in its Tenth Plan Document reported sewage as a highly polluting source contributing to about 80% of the total water pollution. Out of about 38000 million litres per day of sewage generated, treatment capacity exists for only about 12000 million litres per day. Thus, there is a large gap between generation and treatment of wastewater in India. Even the treatment capacity existing is also not effectively utilized due to operation and maintenance problems. Operation and maintenance of existing plants and sewage pumping stations is not satisfactory, as nearly 39% plants are not conforming to the general standards prescribed under the Environmental (Protection) Rules for discharge into streams. In Class I cities of India, about 2277 lakh population lives in 498 cities. They generate about 35558 MLD wastewater out of which a very little amount (11553 MLD about 32%) is treated (CPCB 2009-10). In Class II towns of India, about 300 lakh population lives in 410 towns. They generate 2696 MLD wastewater but only 234 MLD (8.6%) is treated (CPCB 2009-10). The rest of the wastes are discharged into aquatic systems.

Industrial source: About 57,000 polluting industries of India generate about 13,468 MLD of wastewater, out of which nearly 60% is treated, which comes from large and medium industries (Sengupta 2006). Pollution through major and small industries is also a great concern nowadays. The CPCB has listed the major polluting industries in India as cement mills, sugar, thermal power plants, distilleries, fertilizers, oil refineries, caustic soda production, petrochemicals, zinc smelting, copper smelting, aluminium smelting, sulphuric acid, integrated iron and steel, pulp and paper, tanneries, pharmaceuticals, dye and dye intermediates and pesticides industries. In these, distilleries, textile, engineering and pulp and paper industries are added impetus effects on aquatic water bodies than others.

Effect of heavy metal uptake on plants

Studied the accumulation of Cd residue from phosphate fertilizers and their effects on plants. At least 80% of Cd impurities in phosphate fertilizers, applied during normal cropping practices, could be accounted for in the cultivated layers of soil examined. Cadmium along with Fe, Cu, Al, Co and Mo usually accumulates more in the roots than in the shoots. However, often moderate and sometimes large conc. of these elements can be found in the shoots. Studied Cd uptake and distribution between roots and shoots of a tolerant and non-tolerant population of *Holcus lonatus* with reference to both concentration and total contents. They observed that the uptake of Cd into the roots of both normal and tolerant plants from nutrient solutions containing 1.00 ppm Cd in extensive and in normal plants as much as 90% of the whole plant Cd remains in the root but translocation allows shoot concentrations to reach 145 ppm. In tolerant plants translocation of Cd to shoots is further reduced with a concomitant increase in waste of Cd concentration in roots.

Summarized the critical level of copper in certain crop plants like wheat, barley, lettuce and rye grass. Extracted fertilizers and animal feed from molasses fermentation residues for their utilization in the crops. Studied the fertilizers aeration interaction in maize under temporary flooding condition. Described the use of sewage sludge on agricultural land and the effects of various metals on the growing crops. Conducted one and two years pot trials with oat, maize, mustard and sunflower to investigate how phosphatic fertilizers with varying Cd concentration affect the Cd enrichment of the plants (in each case only the shoots were analysed for Cd). Cadmium in plant materials as well as in soil fertilizers were determined by flameless atomic absorption spectroscopy using a graphite vessel. They found

that the soil content of water-soluble Cd and not the total Cd content of the soil is the decisive factor for the Cd enrichment of plants. The Cd content of the plant material is very strongly influenced by soil pH. Cd uptake increases as the soil pH decreases. Even slight changes in the pH value resulting from any kind of fertilizer application can lead to considerable changes in the Cd content of the plants.

Review of Literature

Investigating the effect of heavy metals on alfa alfa (*Medicago sativa* L.) reported stimulated seed germination, root and shoot elongation at 5 ppm but at higher concentration of 40 ppm there was reduction in the seed germination and root and shoot growth. worked on distribution of heavy metals in spring wheat (*Triticum aestivum* L.) and reported that concentration of Cd and Pb in different parts of plants was very much lower than the concentration applied in the irrigation water. that higher accumulation of heavy metals was found in the plant parts in naturally growing weeds and cultivated crop plants irrigated with treated industrial effluent. the effect of heavy metal accumulation in maize (*Zea mays* L.). They reported that root growth with fresh and dry weight decrease progressively with increasing concentration of Cu^{+2} in solution. Shoot growth with fresh and dry weight decrease progressively when leaves were treated with increasing concentration of Cu^{+2} in solution.

Soil is the most important component of the environment, but it is the most undervalued, misused and abused one of the earth's resources. Soil contamination has become a serious problem in all industrialized areas of the country. Soil is equally regarded as the ultimate sink for the pollutants discharged into the environment. Most plants and animals depend on soil as a growth substrate for their sustained growth and development. In many instances the sustenance of life in the soil matrix is adversely affected by the presence of deleterious substances or contaminants. The entry of the organic and inorganic form of contaminants results from disposal of industrial effluents. The source of the organic and inorganic elements of the soil of contaminated area was mainly from unmindful release of untreated effluent on the ground. The contamination of soils with heavy metals or micronutrients in phytotoxic concentrations generates adverse effects not only on plants but also poses risks to human health.

Effect of pollution on environment

Extracted potash fertilizer from distillery wastes. Studied the use of chemicals *viz*. nitrogen, phosphorus and potassium present in effluents in agricultural fields. Estimated trace elements in corn, grown on long term sludge disposal site. worked out the utilization of industrial wastes in agricultural field. studied the nature and extent of heavy metal pollution from industries situated in the vicinity of Ludhiana. The effluent samples from the industrial units were analysed periodically and revealed Zn, Fe and Ni in particular while Pb, Cu, Cd, Ca and Mn in general near by metal industries. They observed that the concentrations of these heavy metals are more in the evening than in the morning hours. The heavy metals in the industrial effluents were found variable depending upon the source and of much higher conc. than the contents observed in soil.

Experimental plant

The test plant, *Brassica juncea* L. belongs to the family Brassicaceae and includes about 375 genera and 3200 species. Different oil-rich species of Brassicaceae are grown in different parts of the country. *Brassica juncea* is most widely grown in U.P, Punjab, Bihar and Bengal. The characteristic plant of *Brassica* is a tall, annual herb with 120-150cm height, with simple or branched stem, large leaves (the lower being lyrately pinnatipartite), bicarpellary, syncarpous superior ovary bearing large number of ovules on parietal placenta and siliqua with replum. The plant has tap root with secondary roots coming- out as laterals, branched stem, hairy and lyrate leaves. The infloresence is corymbose receme and bears small ebracteate bright yellow flowers. The biological yield as measured in terms of total dry matter of the plant at final harvest is closely related with economic (seed) yield.

The crop is largely grown during the cold season, especially in Doaba districts and usually sown in parallel lines mixed with wheat and barley. The oil yield of the seeds is an important ingredient of Indian cookery and is also used for lighting purpose.

The fruit is a siliqua developed from a bicarpellary, syncarpous and superior orary and is about 3.5cm in length with an extended beak and is divided longitudinally into two halves by the replum, a thin and membranous structure. The two halves are cleaved away from base upwards leaving the replum with the seeds pressed against it.

Conclusion

The problem of waste disposal in its acute forms in which it exists today began in Nineteenth century with advent of industrial revolution and phenomenal growth of population. The waste disposal problem, however, evokes little interests from the mill owners because of additional costs involved in treatment of waste.

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