

A Channel of Food Basket Contamination: Negative Aspect of Development



Botany

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ABSTRACT

The metal contamination of food crops is a global environmental issue. As metals are non-biodegradable having long biological half-lives, they get ultimately biomagnified in various trophic levels. They are omnipresent in the environment through natural and anthropogenic activities. Accumulation of metals in human body above their requirements can pose a significant health risk. So, the metals must be controlled in food sources to assure public health safety.

Introduction

In order to fulfil the desires, man exploits the environmental factors to a greater extent, by which the environment loses its natural capacity for self-stabilization. Unknowingly, different environmental activities such as construction of roads dams, airports, buildings, irrigation projects, power plants and industries have some negative repercussions on the environment in which man lives. Thus, the developmental activities are unsustainable for global ecosystem and playing negative role for natural ecosystem. Particularly, pollution of the biosphere by toxic metals has accelerated severely since the beginning of the industrial revolution. The primary sources of this pollution include the burning of fossils fuels, mining and smelting of metalliferous ores, municipal wastes, fertilizers, pesticides, and sewage (Singh and Prasad, 2011). The metals can also influence the quality of the atmosphere and surface water, and also threaten the health of animals and humans upon entering in to the food-chain and lead to food basket contamination. Due to such toxic effects, it is very necessary to find out some management strategies to remediate or restore the metal contaminated area.

Level of food basket contamination

Heavy metal contamination of food crops cannot be underestimate as these foodstuffs are important components of human diet. Elevated levels of heavy metals may cause oxidative stress, displacement of other essential metals in pigments or enzymes leading to disruption of function of these molecules and of many metabolic processes, and finally may reduce growth and yield (Wang et al., 2003). Toxicity symptoms may be chlorosis in young leaves, browning of coralloid roots and serious inhibition of plant growth. Xiong and Wang (2005) showed that seed germination was significantly reduced due to the treatment of Cu in *Brassica pekinensis*. The toxic heavy metals not only pose their damaging effects on the plants, but become a health hazard to man and animals through their food chain contamination.

Nada et al. (2007) have studied the effects of different concentrations of Cd (0, 25, 50, 150 μ M) on growth of almond seedling (*Prunus dulcis*). With increase in the concentration of Cd in growth medium, there was reduction in the dry weight of leaf of almond seedling. Root growth was significantly reduced by 26 % at 150 μ M concentration of Cd (Nada et al., 2007). Athar and Ahmad (2002) showed that heavy metal toxicity (Cd, Cu, Ni, Zn, Pb and Cr) resulted into significant reductions in plant growth and grain yield of wheat (*Triticum aestivum*). The higher the concentrations of metals in the soil, the greater were the toxic effects on the plant. Phytotoxic effects of heavy metals showed a trend Cd > Cu > Ni > Zn > Pb > Cr (Athar and Ahmad, 2002).

Divya et al., (2015) have reported that the accumulation of Zn and Cd was found to be higher than the food adulteration act in tubers such as colocasia, elephant yam, potato, sweet potato, tapioca and yam, collected from three different markets of Ernakulam district (Cochin, Thripunithura, Ernakulam), of Kerala state, India.

Dietary exposure to several heavy metals including Ni, Cd, Cr, Co, Pb, As, Hg, Zn and Cu, has been recognized as a risk to human health through the consumption of vegetable crops by Tasrina et al., (2015). The source and magnitude of heavy metal contamination in soil and various kinds of vegetables including potato, red amarantha, spinach, amarantha, carrot, cabbage, tomato and brinjal at Pakshi, Bangladesh, India were analysed. Along all the metals, the level of lead (Pb) in vegetables at all tested areas was higher than that of the permissible limits of International standards. However, long term exposure of these vegetables may lead to excess accumulation of other kind of metals also that may pose significant risk to human health.

Impact of metal contamination on human health

Through metal contaminated food chain, human beings are constantly exposed to heavy metals. There are various symptoms of metal contamination in human health such as headache, short-term memory loss, mental confusion, gastro-intestinal upsets, food intolerances, allergies, vision problems, chronic fatigue, fungal infections etc. In addition, several heavy metals have been classified as carcinogenic and mutagenic (Mudgal et al., 2010). So the heavy metal is one of the major contaminate in the environment. Biotoxic effects of heavy metals depend upon concentrations and oxidation states, kind of sources and mode of deposition (Duruibe et al., 2007). The exposure of human beings to heavy metals increases with an increasing consumption of the products that has been contaminated by the toxic heavy metals. Non-biodegradable and persistent nature of heavy metals is responsible for the accumulation of heavy metals in the tissues of human beings such as kidney, bone and liver. Heavy metals after ingestion by human being combine with protein and enzymes to form stable biotoxic compounds thereby disturbing their structures.

Severe exposure of Cd may result in pulmonary effects (emphysema, bronchialitis and alveolitis) and renal effects may also result due to subchronic inhalation (European Union, 2002; Young, 2005). Toxicity of Pb causes inhibition of haemoglobin synthesis, dysfunctions in kidney and reproductive systems, cardiovascular system and chronic damage to the central nervous system and peripheral nervous system (Ogwuegbu and Muhanga, 2005). Inorganic arsenic and trivalent arsenite are found to be very toxic. Lower concentration of As results in hyper-pigmentation, peripheral nerve damage, weakness in the hands and feet, blood vessel damage resulting into gangrenous condition affecting the extremities (Col et al., 1999). Heavy metals are most toxic in their particular ionic forms such as Cd⁺², Pb⁺², Hg⁺², Cr⁺² and As⁺³. In the form of most stable oxidation state, heavy metals can form complex with the biomolecules of human body and due to their biostabilities, they cannot be extracted from the body by detoxification therapies (Duruibe et al., 2007). Intawongse and Dean (2006) assessed the bioavailability of metals (Cd, Cu, Zn, Mn) in the human gastrointestinal tract by extracting the edible parts of plants using an *in vitro* gastrointestinal extraction technique. This technique measures the fraction of

solubilized metal from a contaminated sample under simulated gastrointestinal conditions available for absorption. Results showed that bioavailability of heavy metals depended upon their solubility rate. For the gastric (acidic) extraction phase, the greatest extent of metal-releasing capacity has been observed in lettuce (for Mn, 64 % and Zn, 45 %), and radish (for Cd, 54 % for

Mn, 46 % and for Cu 63 %). Pb and Cd levels were evaluated in vegetables near Niger Delta Oil area of Nigeria, and it was slightly higher than the limits of heavy metals in the United Kingdom and resulted in a health risk to people who were dependent on these contaminated vegetables for their daily meals (Eriyamremu et al., 2005). Figure 1 shows an overview of food chain contamination and its impact on human health.

Figure 1: Food chain contamination from different sources and their impact on human health

Management strategies to reduce food basket contamination and future perspective

There should be some integrated approaches rather than isolated solutions to control the incidence of toxic metals in crops and reduce contamination throughout the feed and food chains. There are different techniques for metal remediation. Some methods such as excavation, solidification and burial are used traditionally but they are very costly and they simply involve the isolation of the metals from system. In recent years, attention has focused on the development of in situ immobilization methods that are generally less expensive and less disruptive to the natural ecosystems. Some studies showed that organic amendments of compost, farmyard manure and biosolid compost reduced the availability of heavy metal in soil (Brown et al. 2003). The logical and rational remediation process includes amendments of soil with synthetic and organic products, which merits systematic investigation. Due to variation in physico-chemical properties of soil and by introducing additional binding sites they help in reducing the metal availability. Stabilized metals then become less available for plants, and their uptake through the food chain is reduced (Guo et al. 2006). Along with this there are new technologies for metal remediation i.e. phytoremediation. It is the use of plants to remove metal contaminants and it is inexpensive, effective and an eco-friendly technique (Barman et al. 2000; Singh et al. 2004). Main route of food chain contamination is uptake of heavy metal by the plants from soil. There are some biotechnological approach is also that increases the remediation potential of plants.

Conclusion and future perspectives

The accumulation of toxic metals in various crops is of major

concern as it has major implications for feed safety and food security. At metal contaminated areas effective legislation, guidelines and detection are necessary. Failure to control the metal contamination will result in severe complications in the future because of its adverse effects. With the help of several engineering solutions it can be controlled. Regular monitoring of heavy metal contamination is one of the momentous steps to prevent additional exposure of heavy metals in the environment and in humans. National as well as international co-operation is vital for framing appropriate solutions to prevent heavy metal toxicity. Along with this counseling programmes related with environmental education and awareness should also be implemented to understand people for making the environment pollutant free.

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REFERENCE

- [1] Athar, R., & Ahmad, M. (2002). Heavy metal toxicity: effect on plant growth and metal uptake by wheat and in free living Azotobacter. *Water, Air and Soil Pollution*, 138, 165 – 180. [2] Barman, S.C., Sahu, R.K., Bhargava, S.K., & Chatterjee, C. (2000). Distribution of heavy metals in wheat, mustard and weed grown in field irrigated with industrial effluents. *Bulletin of Environmental Contamination and Toxicology*, 64, 489-496. [3] Brown, S. L., Henry, C.L., Chaney, R.L., Compton, H., & DeVolder, P.S. (2003). Using municipal biosolids in combination with other residuals to restore metal-contaminated mining areas. *Plant and Soil*, 249, 203-215. [4] Col, M., Col, C., Soran, A., Sayli, B.S., & Ozturk, S. (1999). Arsenic-related Bowen's disease, palmar keratosis, and skin cancer. *Environmental Health Perspectives*, 107: 687-689. [5] Divya, L., George, J., & Midhun, G. (2015). Heavy Metal Contamination of Some Common Tubers Sold in Local Markets of Ernakulam District, Kerala, India. *International Research Journal of Biological Sciences*, 4(3), 49-52. [6] Duruibe, J. O., Ogwuegbu, M. O. C., & Egwurugwu, J. N. (2007). Heavy metal pollution and human biotoxic effects. *International Journal of Physical Sciences*, 2 (5), 112-118 [7] Eriyamremu, G.E., Asagba, S.O., Akpoborie, A., & Ojeaburu, S.I. (2005). Evaluation of lead and cadmium levels in some commonly consumed vegetables in the Niger-Delta Oil Area of Nigeria. *Bulletin of Environmental Contamination and Toxicology*, 75, 278-28. [8] European Union (2002). Heavy Metals in Wastes, European Commission on Environment http://ec.europa.eu/environment/waste/studies/pdf/heavy_metals_report.pdf. [9] Guo, G., Zhou, Q., & Ma, L.Q. (2006). Availability and assessment of fixing additives for the in situ remediation of heavy metal contaminated soils: a review. *Environmental Monitoring Assessment*, 116,513-528. [10] Intawongse, M., & Dean, J. R. (2006). Uptake of heavy metals by vegetable plants grown on contaminated soil and their bioavailability in the human gastrointestinal tract. *Food Additives and Contaminants*, 23 (1), 36 – 48. [11] Mudgal, V., Madaan, N., Mudgal, A., Singh, R.B., & Mishra, S. (2010). Effect of toxic metals on human health. *Open Nutraceuticals Journal*, 3, 94-99. [12] Nada, E., Ben A. E., Rhouma, A., Ben R.B., Mezghani, L., & Boukhris, M. (2007). Cadmium-induced growth inhibition and alteration of biochemical parameters in almond seedlings grown in solution culture. *Acta Physiologie Plantarum*, 29, 57-62. [13] Ogwuegbu, M.O.C., & Mhanga, W. (2005). Investigation of lead concentration in the blood of people in the copper belt province of Zambia. *Journal of Environment*, 1 (1), 66 – 75. [14] Singh, A., & Prasad, S. M. (2011). Reduction of heavy metal load in food chain: technology assessment. *Review of Environmental Science and Biotechnology*, 10,199-214 [15] Singh, K.P., Mohan, D., Sinha, S., & Dalwani, R. (2004). Impact assessment of treated/untreated waste water toxicants discharge by sewage treatment plant on health agricultural and environmental quality in waste water disposal area. *Chemosphere*, 55, 227-255. [16] Tasrina, R.C., Rowshon, A., Mustafizur, A.M.R., & Ali M.P. (2015). Heavy Metals Contamination in Vegetables and its Growing Soil. *Journal of Environment and Analytical Chemistry*, 2,3, 2-6. [17] Wang, C.X., Mo, Z., Wang, H., Wang, Z.J., & Cao, Z.H. (2003). The transportation, time-dependent distribution of heavy metals in paddy crops. *Chemosphere*, 50 (6), 717-723. [18] Xiong, Z.T., & Wang, H. (2005). Copper toxicity and bioaccumulation in chinese cabbage (*Brassica pekinensis* Rupr.). *Environmental Toxicology*, 20 (2), 188 – 194. [19] Young, R.A. (2005). Toxicity Profiles: Toxicity Summary for Cadmium, Risk Assessment Information System, University of Tennessee (rais.ornl.gov/tox/profiles/cadmium.html).