J. Biol. Chem. Research. Vol. 26, No. 2: 46-50 (2009)
(An International Journal of Life Sciences and Chemistry)

ISSN 0970-4973 (Print)
Published by Society for Advancement of Science®

jbiolchemres@gmail.com
info@jbcr.in

REVIEW ARTICLE

An Overview on Lead (Pb) Toxicity: A Real Environmental Hazard

S.A. Musanna and Aziz B. Abidi
Department of Botany, Shia P.G. College, Lucknow, U.P., India

ABSTRACT

In the recent years, search for better quality of life in urban areas has been provoking an increase in urban agriculture. However, this new way of agriculture can bring risks to human health since this land is highly contaminated, due to anthropogenic activities. This way, lead (Pb) phytotoxicity approach must be taken into consideration since it can be prejudicial to human health through food chain. Lead is a silvery-white highly malleable metal. Archeological research indicates that Pb has been used by humans for a variety of purposes for more than 5,000 years. Lead is one of the most widely distributed trace metal. It is ranked second of all hazardous substances by the Agency for Toxic Substances and Disease Registry (ATSDR, 2007). Lead is considered as important potent environmental contaminant. Various ecological, environmental and evolutionary processes in the microsphere are disrupted because of lead toxicity to the microbial community. It is commonly used in fertilizers, batteries, chemicals and ceramics, in different products like pottery, gasoline, lead glass, pesticides, paints, hair dyes, rubber toys and newsprint. Lead is not an essential element for plant and it induced toxicity in plants in terms of their growth, development, and biochemical attributes. Primary effects of Pb toxicity in plants include stunted root growth, probably due to inhibition of cell division in root tips. Even in high concentrations it completely kills the plants.
Keywords: Human health, Urban agriculture, Anthropogenic activities, Phytotoxicity, Hazardous substances.

INTRODUCTION

Heavy metal pollution has become one of the most important environmental problems worldwide. Metal pollutants are particularly difficult to remediate from the soil, water and air because, unlike organic pollutants that can be degraded to harmless small molecules, toxic elements, such as lead, mercury, cadmium, copper and zinc, are immutable by biochemical reactions.

In the recent years, search for better quality of life in urban areas has been provoking an increase in urban agriculture, however, this way of agriculture, can bring risks to human health since this land is highly contaminated, due to anthropogenic activities. This way, lead (Pb) phytotoxicity approach must be taken into consideration since it can be prejudicial to human health through food chain.

Lead is a silvery-white highly malleable metal. The chemical symbol for lead, Pb, is an abbreviation of the Latin word *plumbum,* meaning soft metal. Archeological research indicates that Pb has been used by humans for a variety of purposes for more than 5,000 years. Infact, archeological discoveries found glazes on prehistoric ceramics. The Egyptians used grounded Pb ore as eyeliner with therapeutic properties and cosmetics kohl, Pb-based pigments were used as part yellow, red and white paint. In ancient Rome-lead was used to build pipes for water transportation (Johanson, 1998, Rehren, 2008 and Retief and Cilliers, 2005). Apart from the natural weathering processes, Pb contamination of the environment has resulted from mining and smelting activities, Pb containing paints, gasoline and explosives as well as from the disposal of municipal sewage sludge enriched in Pb (Chaney and Ryan, 1994). Despite regulatory measures adopted in many countries to limit Pb input in the environment, it continues to be one of the most serious global environmental and human hazards. As many of the Pb-pollutants are indispensable for modern human life, soil contamination with Pb is not likely to decrease in the near future (Yang et al, 2000).

Pb is considered a general protoplasmic poison, which is cumulative, slow acting and subtle. Soils contaminated with Pb cause sharp decreases in crop productivity thereby posing a serious problem for agriculture (Johanson and Eaton, 1980).

Sources of Lead

Lead is one of the most widely distributed trace metals. It is ranked second of all the hazardous substances by the Agency for Toxic Substances and Disease Registry (ATSDR, 2007). Lead is considered as important potent environmental contaminants. Various ecological, environmental and evolutionary processes in the microsphere are disrupted because of lead toxicity to the microbial community. It is commonly used in fertilizers, batteries, chemicals and ceramics, in different products like pottery, gasoline, lead glass, pesticides, paints, hair-dyes, rubber toys and newsprint. Major lead content in the soil comes from the weathering of geological rock formations, lead mine's discharge, automobile exhausts, industrial applications, smelting operations, fertilizer impurities, use of lead arsenate in metal plating and finishing operations, tetra methyl lead applications as anti-knocking agent in petrol (ref) and plants obtain lead from such agencies (ref). Increase in lead concentration in cultivated soils is detected in close proximity to industrial sites.

Tetraethyl and tetramethyl Pb are added to gasoline to increase the octane rating. In urban areas automobile exhaust contributes substantially to the atmospheric pollution. Pb compounds are major pollutants emitted by automobiles. Plants growing near highways are usually exposed to more Pb than other localities. Sewage sludge containing large quantities of lead and other metals is regularly discharged on to field and garden soils due to increased trends in urbanization (Paivoke, 2002).

Compounds of lead used as agricultural chemicals such as Pb-arsenate, which is used as a pesticide, contaminate agricultural soils. Mine water also transports a large amount of fine-grained sediments contaminated with Pb (Laxen and Harrison, 1977).

Pb uptake by plants

Plants are important component of the ecosystems as they transfer the metals from abiotic into biotic environments (Chojnacki et al, 2005, Richardson et al, 1993, Krupa, 1993, Maksymiec and Baszynski, 1996). The metals may enter the food chain either through water supplies and aquatic organisms or through arable produce and grazing animals (Thornton, 1991). Excessive concentrations of Pb exhibit noxious effects to plants. Pb is considered to have low solubility and availability for plant uptake because it precipitates as phosphates and sulphates, chemicals commonly found in the rhizosphere of plants (Blaylock and Huang, 2000). Several studies have shown that most of the absorbed Pb remains accumulated in the roots, making the root the first barrier for the Pb translocation to the above ground plant parts, acting like a natural barrier. Moreover, the increase in accumulation level is directly proportional to the amount of exogenous Pb.

Pb is taken up by plants mainly through the root system and partly, in minor amounts through the leaves. Inside the plants Pb accumulates primarily in the root but a part of it is translocated to the aerial portions. Soil pH, soil particle size, cation exchange capacity as well as plant factors such as root surface area, root exudation and mycorrhizal transpiration rate affect the availability and uptake of lead. Limited translocation of Pb occurs from root to other organs due to the barrier function of the root endodermis. At lethal concentrations this barrier is broken and the flux of Pb enters the vascular tissues. Pb deposits of various sizes are present mainly in the intercellular spaces, cell walls and vacuoles. Small deposits of this metal are also seen in the endoplasmic reticulum, dictyosome and dictyosome derived vesicles. After entering the cell, Pb inhibits activities of many enzymes, upsets mineral nutrition and water balance, changes the hormonal status and affects membrane structure and its permeability.

Adverse effect of Pb

The visual general symptoms of Pb toxicity are fast inhibition of root growth, underdeveloped growth of the plant, blackening of root system and chlorosis. Pb inhibits photosynthesis, let downs mineral nutrition and water balance, enzyme activities, (Sharma and Dubey, 2005). These disorders upset normal physiological activities of the plant. At high concentrations Pb finally may lead to cell death (Ernst, 1998; Seregin and Ivanov, 2001). Similarly, Pb inhibits germination of seeds and retards growth of seedlings, decreases germination percent, germination index, root/shoot length, tolerance index and dry mass of roots and shoots (Mishra and Choudhari, 1998). The growth development, fresh biomass and growth tolerance index of root, shoot and leaves were negatively affected by increasing levels of Pb concentrations in tomato seedlings. Similar results were obtained by some other studies at the calculated Pb concentrations: root, shoot and leaf growth; fresh and dry biomass is greatly reduced in Pisum Sativum (Kevresan et al., 2001), in Zea mays (Malkowski et al., 2002; Cimrin et al., 2007).

Effects of Pb in ecosystem

Lead can concentrate in various kinds of plants, including single-celled algae in aquatic ecosystems, vegetables, grains and fruit eaten by humans and domesticated animals. Fortunately, however, lead does not appear to bio magnify up through the food chain. Other contaminants, such as PCBs or methyl mercury, do build up in increasing concentrations in organisms that eat plants or animals below them in the food chain. The opposite seems to be true for lead; top predators usually tend to have substantially lower lead levels than their prey. Raptors typically have lower take-up levels. This may result from regurgitating indigestible material such as bones of their prey where lead often accumulates. An exception may be the poisoning that occurs in carrion eaters, raptors, and other birds of prey when they eat something that contains lead shot.

Effects of Pb in plants

The effects of lead on plants, especially at high concentrations, are harmful. They include inhibition of growth, interference with cell division and with water absorption and balance, and reduction of photosynthesis, the vital process whereby plants use the energy from sunlight to convert carbon dioxide and water into sugars, protein, fats and other products. The by-products of photosynthesis are useful in promoting growth and provide sustenance for the animal kingdom including humans. Thus a reduction in the process of photosynthesis can cause harmful effects at multiple levels in the food chain.

Effects of Pb in microorganisms

Evidence exists to show that lead at the concentrations occasionally found near roadsides (i.e., 10,000 - 40,000 ppm dry weight), can wipe out populations of bacteria and fungi on leaf surfaces and in soil. This can have a significant impact, given that many of these micro-organisms are an essential part of the decomposing food chain. The micro-organism populations affected are likely to be replaced by others of the same or different species, although these may be less efficient at decomposing organic matter. Evidence also suggests that micro-organisms can make lead more soluble and hence more easily absorbed by plants. That is, bacteria exude organic acids that lower the pH in the immediate vicinity of the plant root.

CONCLUSION

In summary, lead is not an essential element for plant although, it accumulates in different parts of plant and negatively affects various physiological processes. Lead induced toxicity in plants in terms of their growth, development and biochemical attributes. Primary effects of Pb toxicity in plants include stunted root growth, probably due to inhibition of cell division in root tips. Secondarily, it results in cellular damage. Even in high concentrations it completely kills the plant.

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Corresponding author: S.A. Musanna, Department of Botany, Shia P.G. College, Lucknow, U.P., India