

Hazardous Effects of Lead (Pb) in the Environment

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1. Introduction

Global industrialization and urbanization in the past decades have resulted in the generation of huge quantities of toxic wastes. These wastes include a variety of organic and inorganic compounds which pose serious threats to the environment. Organic contaminants include various compounds such as heavy metals, petroleum hydrocarbons, polychlorinated benzenes (PCBs) and other pollutants like radionuclides (Oncel *et al*, 2000). There are 35 metals that concern because of occupational or residential exposure; 23 of these are the heavy elements or "heavy metals". The term heavy metal refers to any metallic chemical element that has a relatively high density and is toxic or poisonous at low concentrations.

Lead (Pb) is one of the most widespread heavy metal contaminant in the environment. It is highly toxic to living organisms and one of the main sources of environmental pollution (Mahaffay, 1990). Lead forms a variety of compounds and exists in the environment in various forms. Organic lead compounds, which cross the skin and respiratory tract easily, affect the central nervous system predominantly.

2. Distribution & occurrence of Lead

Lead is ubiquitous and widely distributed as metallic lead, inorganic compounds & organometallic compounds. Metallic lead usually found in ore with zinc, silver and copper (most abundantly) and is extracted together with these metals. The main lead mineral is galena (PbS), which contains 86.6 % lead by weight. Other common varieties are cerussite (PbCO₃) and anglesite (PbSO₄).

Lead has been known since ancient times and is relatively abundant in the earth's crust (13 g/ton, ranking 36th), where it is found in galena (PbS). Lead having 82 atomic number in the periodic table and its atomic weight 207.19. The lead crystal has a cubic

structure with centered faces. Lead. This metal is highly resistant to corrosion because of this property; it is used to contain corrosive liquids (for example, sulfuric acid) because lead is very malleable and resistant to corrosion. It is extensively used in building construction- for example in the external coverings of roofing joints.

3. Sources of lead

Lead can be found in many products and locations. Some you might never have thought of, including some imported candies, toys and traditional medicines. Lead was used in household paint until 1978 and was also found in leaded gasoline, some types of batteries, water pipes, and pottery glazes. Lead paint and pipes are still found in many older homes and lead is sometimes also found in water, food, household dust and soil. There are various sources of lead in the environment-

3.1 Paint Industry

Now a day's various paint industries are using lead in the manufacturing of paints. Lead was used in paint to add color, improve the ability of the paint to hide the surface it covers and to make it last longer. However, when such paint is peeling, flaking, chipping or otherwise deteriorating it can create lead contaminated dust and paint chips that pose a potential health risk, especially to children. Lead based paint is also a potential hazard if it is disturbed during remodeling or repainting activities that create lead contaminated dust.

3.2 Dust and soil

Lead dust is the most common way that people are exposed to lead. Inside the home, most lead dust comes from chipping and flaking paint or when paint is scraped, sanded or disturbed during home remodeling. Young children usually get exposed to lead when they put something with lead dust on it into their mouths. Lead dust may not be visible to the

Sources of water-borne lead pollution

The source of lead was found to be lead pipe used in interior and exterior plumbing. The hard waters contain carbonate and sulphate ions which react with lead to form a water-insoluble protective coating of $PbCO_3$ and $PbSO_4$. Many industries utilizing lead releases lead contaminated water in the near by water-bodies leading to water pollution.

Lead-containing ceramic glazes have been a serious source of lead poisoning when used on containers of foodstuffs. It has been found that highly acidic liquids such as apple juice may dissolve the glaze and release lead into the liquid.

3.5 Children's jewelry and toys

Lead has been found in inexpensive children's jewelry sold in vending machines and large volume discount stores across the country. It also has been found in inexpensive metal amulets worn for good luck or protection. Some costume jewelry designed for adults has also been found to contain lead. It is important to make sure that children don't handle or mouth any jewelry.

3.6 The workplace and hobbies

People exposed to lead at work may bring lead home on their clothes, shoes, hair or skin. Some jobs that expose people to lead include: home improvement; painting and refinishing; car or radiator repair; plumbing; construction; welding and cutting; electronics; municipal waste incineration; lead compound manufacturing; manufacturing of rubber products, batteries, and plastics; lead smelting and refining; working in brass or bronze foundries; demolition; and working with scrap metal.

3.7 Lead-glazed ceramics, china, leaded crystal

Lead is used in industries for glazing ceramic pots. It may get into foods or liquids that have been stored in ceramics, pottery, china, or crystal with lead in it. Lead-glazed dishes usually come from other countries.

3.8 Imported food in cans that are sealed with lead solder

In 1995 the United States banned the use of lead solder on cans. But lead solder can still be found on cans made in other countries. These cans usually have wide seams and the silver-gray solder along the seams contains the lead. Cans containing lead may be brought to the United States and sold. Over time the lead gets into the food. Foods that are acidic cause lead to get into the food faster. Food and liquids

naked eye. Homes near busy streets may contain higher levels of lead in the soil because lead used to be used in gasoline. Today, lead still comes from metal smelting, battery manufacturing and other factories that use lead. This lead gets into the air and then mixes with the soil. Lead-based paint mixing with soil is a problem during home remodeling if

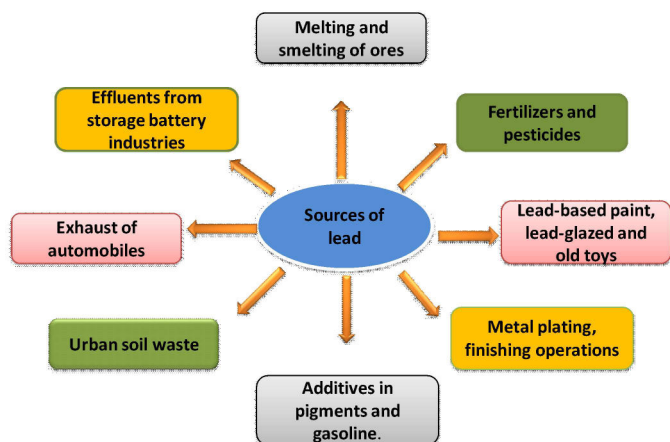


Figure 1: Sources of lead in the environment.

3.3 Drinking Water

Lead seldom occurs naturally in water supplies like rivers and lakes. Lead enters into drinking water primarily as a result of the corrosion or wearing away, of materials containing lead in the water distribution system and household or building plumbing. These materials include lead-based solder used to join copper pipe, brass and chrome plated brass faucets and in some cases, pipes made of lead that connect houses and buildings to water mains. In 1986, Government banned the use of lead solder containing greater than 0.2% lead, and restricted the lead content of faucets, pipes and other plumbing materials to 8.0%. Older construction may still have plumbing that has the potential to contribute lead to drinking water.

3.4 Sources of Airborne Lead

Amount of lead in the air has increased markedly due to anthropogenic activities. Atmospheric lead concentration in urban areas are 50 times higher than rural areas. Lead in air comes mainly comes from automobile emissions & industrial sources (e.g., smelters, waste incinerators, and lead-acid battery manufacturers). Atmospheric Lead can be in the form of gaseous compounds or particulate matters. Gaseous emissions are by combustion of tetraethyl lead and tetramethyl lead in automobile engines.

stored in lead crystal or lead-glazed pottery or porcelain. Food can become contaminated because lead can leach in from these containers.

4. Uses of lead

Lead has a number of uses but many of these are currently being phased out because of growing awareness of its toxicity and of the damage that uncontrolled dispersion in the environment has already caused. Lead is used in applications where its low melting point, ductility and high density and resistance from corrosion is an advantage.

- Lead is used as electrodes in the process of electrolysis. Lead is used in solder for electronics, although this usage is being phased out by some countries to reduce the amount of environmentally hazardous waste. Lead is used in high voltage power cables as sheathing material to prevent water diffusion into insulation.
- Lead is used as shielding from radiation (e.g., in X-ray rooms). Molten lead is used as a coolant (e.g., for lead cooled fast reactors).
- Lead is added to brass to reduce machine tool wear. Lead, in the form of strips, or tape, is used for the customization of tennis rackets. Tennis rackets of the past sometimes had lead added to them by the manufacturer to increase weight.
- It is used to form glazing bars for stained glass or other multi-lit windows. Lead, or *sheet-lead*, is used as a sound deadening layer in some areas in wall, floor and ceiling design in sound studios where levels of airborne and mechanically produced sound are targeted for reduction or virtual elimination.
- Lead has many uses in the construction industry (e.g., lead sheets are used as architectural metals in roofing material, cladding, flashing, gutters and gutter joints, and on roof parapets). Detailed lead moldings are used as decorative motifs used to fix lead sheet. Lead is often used to balance the wheels of a car; this use is being phased out in favor of other materials for environmental reasons.
- Lead compounds are used as a coloring element in ceramic glazes, notably in the colors red and yellow. Lead is frequently used in polyvinyl chloride (PVC) plastic, which coats electrical cords.

- Lead is used in some candles to treat the wick to ensure a longer, more even burn. Because of the dangers, European and North American manufacturers use more expensive alternatives such as zinc.
- Some artists using oil-based paints continue to use lead carbonate white, citing its properties in comparison with the alternatives. Tetra-ethyl lead is used as an anti-knock additive for aviation fuel in piston-driven aircraft.

5. Environmental hazards of lead

5.1 Effects on plants :

Plants can take up high levels of lead from soils. Higher concentrations of lead can cause the negatively influence on the plant growth (Sharma et al., 2005). Through plant uptake, lead enters food chains. There are various effects which is caused by lead in the plants-

- The visual non-specific symptoms of Pb toxicity are rapid inhibition of root growth, stunted growth of the plant and chlorosis.
- Pb toxicity inhibits germination of seeds and retards growth of seedlings. Pb decreases germination percent, germination index, root/shoot length, tolerance index and dry mass of roots and shoots.
- Pb phytotoxicity leads to inhibition of enzyme activities, disturbed mineral nutrition, water imbalance and change in hormonal status and alteration in membrane permeability.

A generalized view of the effects of Pb toxicity on key physiological processes in plants is presented in figure 2.

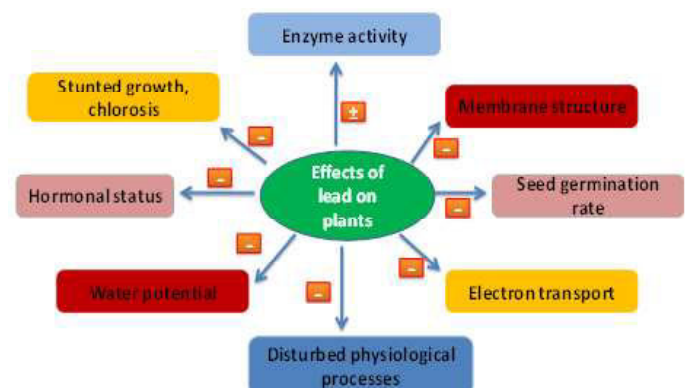


Figure 2. A generalized view of lead toxicity in plants. '+' and '-' signs indicate positive and negative effects respectively.

5.2 Effects on humans of lead

Lead interferes with a variety of body processes and is toxic to many organs and tissues including the heart, bones, intestines, kidneys, and reproductive and nervous systems. It interferes with the development of the nervous system and is therefore particularly toxic to children, causing potentially permanent learning and behavior disorders. Symptoms include abdominal pain, confusion, headache, anemia, irritability, and in severe cases seizures, coma, and death.



Table1: Effects of lead toxicity on plants, humans and animals. (a) chlorosis on plant leaf, (b) head pressing behavior in cattle, (c) lead infected vultures and (d) characteristic finding of lead poisoning in humans- dense metaphyseal lines.

- **Plumbism-** Lead poisoning or plumbism is defined as a toxic condition caused by the ingestion or inhalation of the metallic element lead, which is found in many places, including the air, soil, water, houses, ceramic cookware, and solder used in metal cans and pipes. Lead poisoning occurs when blood lead levels are equal to or greater than 10 $\mu\text{g}/\text{dl}$ (micrograms per deciliter). These enter the body by respiration (of dust, fumes, or sprays) or by

ingestion of food or other substances that contain lead.

- **Neurotoxicity:** Lead uptake through the blood-brain barrier and into the brain proceeds at an appreciable rate, consistent with its action as a potent central neurotoxin. The effects of lead on the brain, including mental retardation and cognitive deficit, are mediated by its interference with three major neurotransmission systems: the dopaminergic, cholinergic and glutamatergic systems (Dart et al., 2004; Needleman, 2004).
- Children with high levels of lead in their bodies can suffer from damage to the brain and

nervous system, behavior and learning problems, such as hyperactivity, slowed growth hearing problems and headaches (Chisolm and Harrison, 1956).

- Adults with higher level of lead can suffer from reproductive problems (in both men and women), high blood pressure and hypertension, nerve disorders, memory and concentration problems, muscle and joint pain, anemia, constipation and abdominal spasm.

5.3 Effect of lead on animals

Humans are not alone in suffering from lead's effects; plants and animals are also affected by lead toxicity to varying degrees depending on species. Animals experience many of the same effects of lead exposure as humans do, such as abdominal pain, peripheral neuropathy, and behavioral changes such as increased aggression.

5.3.1 Wildlife

Lead, one of the elements that causes toxicity in waterfowl which has been known to cause death of wild bird populations. When hunters use lead shot, waterfowl such as ducks can ingest the spent pellets later and be poisoned; predators that eat these birds are also at risk. Cattles show head pressing behavior. Turkey vultures "*Cathartes aura*" and California condors can be poisoned when they eat carcasses of animals shot with lead pellets. Other threats to wildlife include lead paint, sediment from lead mines and smelters, and lead weights from fishing lines. Lead in some fishing gear has been banned in several countries (Buekers et al., 2009)

5.3.2 Aquatic Birds:

Lead poisoning in aquatic birds may occur when spent lead shot is mistaken for gravel (which is normally consumed to aid in digestion) and ingested. Birds may also be exposed to lead when feeding on fish attached to lead fishing gear such as sinkers or jig heads. In addition to loons, frequent victims of lead poisoning include swans, pelicans, geese, ducks, cormorants, cranes, and herons.

6. Mechanism for environmental cleanup

6.1 Phytoremediation using hyperaccumulator plants

Phytoremediation is an eco-friendly technology of using plants, grown in polluted soil and water to remove metals. The use of plants provides a number of advantages compared to common remedial technologies such as excavation and offsite disposal, thermal desorption, incineration, and physical and

chemical degradation. There are many plant species reported which can absorb the heavy metals from soil and water. These plants are known as hyperaccumulator plants like *Brassica juncea*, *Zea mays*, *Tagetes erecta* L., *Thlaspi caerulescens*, *Amaranthus*, *Helianthus annuus*, *Brassica chinensis*, maize, willow, poplar, water hyacinth plant, *Moringa* sps. have been identified as phytoremediator plants. Phytoremediation represents a set of innovative technologies (phytotechnologies) that takes advantages of the specific extractive and metabolic capabilities of plants.

6.2 Bioremediation using microbes

A diversity of bacteria, fungi, and algae has been characterized as to their capacity to degrade lead. Researchers have endeavored to utilize microbes to facilitate the removal of both organic and inorganic contaminants from the environment, especially from soil. There are some of lead resistance bacteria such as *Escherichia* sp., *Sphingomonads*, *Pseudomonas* sp., *Bacillus subtilis*, *Arthrobacter* and *Ochrobactrum* which can remove the metals.

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