

# HEAVY METALS, SOURCES AND POLLUTION

## 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. Examples of heavy metals include mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), thallium (Tl), and lead (Pb).
- Heavy metals are natural components of the Earth's crust. They cannot be degraded or destroyed.

- As trace elements, some heavy metals (e.g. copper, selenium, zinc) are essential to maintain the metabolism of the human body. However, at higher concentrations they can lead to poisoning.
- Heavy metals can enter a water supply by industrial and consumer waste, or even from acidic rain breaking down soils and releasing heavy metals into streams, lakes, rivers, and groundwater.
- Heavy metals are dangerous because they tend to bioaccumulate. **Bioaccumulation** means an increase in the concentration of a chemical in a biological organism over time, compared to the chemical's concentration in the environment. Compounds accumulate in living things any time they are taken up and stored faster than they are broken down (metabolized) or excreted.

## Sources of Heavy Metals

- Reported sources of heavy metals in the environment include:
  - ✓ geogenic
  - ✓ industrial
  - ✓ agricultural
  - ✓ pharmaceutical
  - ✓ domestic effluents
  - ✓ atmospheric
  
- Although heavy metals are naturally occurring elements that are found throughout the earth's crust, most environmental contamination and human exposure result from anthropogenic activities.

# DETRIMENTAL EFFECTS OF HEAVY METALS



# Arsenic

## Environmental Occurrence, Industrial Production and Use

- Arsenic is a ubiquitous element that is detected at low concentrations in virtually all environmental matrices.
- Several arsenic-containing compounds are produced industrially, and have been used to manufacture products with agricultural applications such as insecticides, herbicides, fungicides, algicides, sheep dips, wood preservatives, and dye-stuffs.

# Potential For Human Exposure

- It is estimated that several million people are exposed to arsenic chronically throughout the world, especially in countries where the ground water is contaminated with high concentrations of arsenic.
- Exposure to arsenic occurs via the oral route (ingestion), inhalation, dermal contact, and the parenteral route to some extent.
- Contamination with high levels of arsenic is of concern because arsenic can cause a number of human health effects.
- Several epidemiological studies have reported a strong association between arsenic exposure and increased risks of both carcinogenic and systemic health effects.

# Cadmium

## Environmental Occurrence, Industrial Production and Use

- Cadmium is a heavy metal of considerable environmental and occupational concern. It is widely distributed in the earth's crust at an average concentration of about 0.1 mg/kg.
- Cadmium is frequently used in various industrial activities. The major industrial applications of cadmium include the production of alloys, pigments, and batteries.

## Potential For Human Exposure

- The main routes of exposure to cadmium are via inhalation or cigarette smoke, and ingestion of food. Skin absorption is rare.
- Other sources of cadmium include emissions from industrial activities, including mining, smelting, and manufacturing of batteries, pigments, stabilizers, and alloys.
- Exposure to cadmium is commonly determined by measuring cadmium levels in blood or urine. Blood cadmium reflects recent cadmium exposure.

# Chromium

## Environmental Occurrence, Industrial Production and Use

- Chromium (Cr) is a naturally occurring element present in the earth's crust, with oxidation states (or valence states) ranging from chromium (II) to chromium (VI).
- Chromium compounds are stable in the trivalent [Cr(III)] form and occur in nature in this state in ores, such as ferrochromite.
- Elemental chromium [Cr(0)] does not occur naturally.
- Chromium enters into various environmental matrices (air, water, and soil) from a wide variety of natural and anthropogenic sources with the largest release coming from industrial establishments.

- Chromium released into the environment from anthropogenic activity occurs mainly in the hexavalent form [Cr(VI)].
- Hexavalent chromium [Cr(VI)] is a toxic industrial pollutant that is classified as human carcinogen by several regulatory and non-regulatory agencies.
- The health hazard associated with exposure to chromium depends on its oxidation state, ranging from the low toxicity of the metal form to the high toxicity of the hexavalent form.

## Potential For Human Exposure

- In humans and animals, [Cr(III)] is an essential nutrient that plays a role in glucose, fat and protein metabolism by potentiating the action of insulin.
- However, occupational exposure has been a major concern because of the high risk of Cr-induced diseases in industrial workers occupationally exposed to Cr(VI).
- Breathing high levels of chromium (VI) can cause irritation to the lining of the nose, and nose ulcers.
- The main health problems seen in animals following ingestion of chromium (VI) compounds are irritation and ulcers in the stomach and small intestine, anemia, sperm damage and male reproductive system damage.
- Chromium (III) compounds are much less toxic and do not appear to cause these problems.

# Lead

## Environmental Occurrence, Industrial Production and Use

- Lead is a naturally occurring bluish-gray metal present in small amounts in the earth's crust.
- Although lead occurs naturally in the environment, anthropogenic activities such as fossil fuels burning, mining, and manufacturing contribute to the release of high concentrations.
- Lead has many different industrial, agricultural and domestic applications.

# Potential For Human Exposure

- Exposure to lead occurs mainly via inhalation of lead-contaminated dust particles or aerosols, and ingestion of lead-contaminated food, water, and paints.
- Lead absorption is influenced by factors such as age and physiological status.
- In the human body, the greatest percentage of lead is taken into the kidney, followed by the liver and the other soft tissues such as heart and brain, however, the lead in the skeleton represents the major body fraction.
- Since the late 1970's, lead exposure has decreased significantly as a result of multiple efforts including the elimination of lead in gasoline, and the reduction of lead levels in residential paints, food and drink cans, and plumbing systems.

# Mercury

## Environmental Occurrence, Industrial Production and Use

- Mercury is a heavy metal belonging to the transition element series of the periodic table. It is unique in that it exists or is found in nature in three forms (elemental, inorganic, and organic), with each having its own profile of toxicity.
- At room temperature elemental mercury exists as a liquid which has a high vapor pressure and is released into the environment as mercury vapor. Mercury also exists as a cation with oxidation states of +1 (mercurous) or +2 (mercuric).

## Potential For Human Exposure

- Humans are exposed to all forms of mercury through accidents, environmental pollution, food contamination, dental care, preventive medical practices, industrial and agricultural operations, and occupational operations.
- The two most highly absorbed species are elemental mercury (Hg<sup>0</sup>) and methyl mercury (MeHg).
- After Hg<sup>0</sup> enters the blood, it rapidly passes through cell membranes, which include both the blood-brain barrier and the placental barrier.
- Once it gains entry into the cell, Hg<sup>0</sup> is oxidized and becomes highly reactive Hg<sup>2+</sup>.