EOH 3101
Principles of Environmental Health

Environmental Health Issues:
Heavy Metal Pollution
Introduction

- Can also be called trace elements / toxic metals
- Heavy metals exhibit metallic properties
- They are members of the transition metals, metalloids, lanthanoids and actinoids
- May include elements lighter than carbon and can exclude some of the heaviest metals
Types of heavy metals

Transition metals

1. They represent the transition between group 2 elements and group 13 elements
2. They are paramagnetic
3. Most of them are very colourful, such as CuSO₄ (blue) and KMnO₄ (purple)
The metalloids

1. Also known as semi metals
2. They often form amphoteric oxides, and often behave as semiconductors
3. Other examples are Boron (B), Silicon (Si) and Polonium (Po)
The Lanthanoids and Actinoids

Lanthanoids
1. Comprises 15 elements with atomic numbers 57 to 71
2. They are similar chemically to each other
3. Examples are Boron (B), Silicon (Si) and Polonium (Po)

Actinoids
1. These are 15 elements which lie from actinium (Ac) and lawrencium (Lr)
2. They exhibit less similarities compared to the Lanthanoid series, and exhibit a wider range of oxidation states
3. All actinoids are radioactive
How does heavy metals pollute the environment?

- Example: Mercury (Hg)
- Natural - volcanoes are responsible for approximately half of atmospheric mercury emissions
- Anthropogenic: 65% from stationary combustion (coal-fired power plants); 11% from gold production; 6.4% cement production

Mercury is used in gold production.
Importance of heavy metals on health

- As trace elements, they are required in small amounts to maintain the health and metabolism of the human body.

- Selenium (Se) – a study showed a reduced occurrence of total cancers; can help prevent the recurrence of TB (Se supplements + other nutrients).

- Zinc (Zn) – important trace elements in enzymes; interacts with a wide range of organ ligands; roles in the metabolism of RNA and DNA.

- Iron (Fe) – deficiency may cause iron deficiency anaemia.

- Molybdenum (Mo) – important in enzymes; may help prevent tooth decay.

- Manganese (Mn) – important as co-factors in enzymes.
Other uses of heavy metals

- Arsenic – used as a herbicide, insecticide, pesticide and in various alloys
- Mercury - Gaseous mercury is used in mercury-vapor lamps and “neon-signs” type advertising signs and fluorescent lamps.
- Copper – sinks, plumbing fittings, frying pans, roofing, cupronickel alloy (coins)
- Cadmium – rechargeable batteries, jewellery
- Iron – most widely used of all metals, 95% of worldwide metal production (construction of machinery and machinery tools)
Health effects – Transition metals

Example – mercury (Hg)

- Low concentrations of 0.7 – 42 μg/m3 of mercury vapour – effects such as tremors, impaired cognitive skills, sleep disturbances in workers with chronic exposure

- Acute exposure (4 – 8 hours) to levels of 1.1 to 44 mg/m3 – psychotic reactions (delirium, hallucinations and suicidal tendencies)

- Continuing exposure – fine tremor develops and may escalate into violent muscular spasms

- Long term, low level exposure – fatigue, irritability, loss of memory, vivid dreams and depression
Health effects – the Metalloids

- Example – Germanium (Ge)
- Not essential for human health
- 1922 – inorganic germanium is used as a treatment for anaemia
- Its role in cancer treatment is debatable
- Some compounds (germanium chloride and germane, GeH4) are a liquid and gas – may be very irritating to the eyes, skin, lungs and throat
Health effects - Lanthanoids

- Trivalent lanthanoid ions (such as La³⁺ and Gd³⁺) can interfere with calcium channels in human and animal cells.
- Lanthanoids can alter or even inhibit the actions of various enzymes.
- Lanthanoid ions found in neurons can regulate synaptic transmission, and may block some receptors.
- In animals, lanthanum may produce glycaemia, low blood pressure, degeneration of the spleen and hepatic alterations.
# Health effects - Actinoids

**Example: Uranium**

<table>
<thead>
<tr>
<th>Body system</th>
<th>Human studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renal</td>
<td>Elevated levels of protein excretion, urinary catalase and diuresis</td>
</tr>
<tr>
<td>Brain/CNS</td>
<td>Decreased performance on neurocognitive tests</td>
</tr>
<tr>
<td>DNA</td>
<td>Increased reports of cancers</td>
</tr>
<tr>
<td>Reproductive</td>
<td>Uranium miners have more first born female children</td>
</tr>
<tr>
<td>Lungs/respiratory</td>
<td>No adverse health effects reported</td>
</tr>
<tr>
<td>Gastrointestinal</td>
<td>Vomiting, diarrhea, albuminuria</td>
</tr>
<tr>
<td>Immune system</td>
<td>Chronic fatigue, rash, ear and eye infections, hair and weight loss, cough. May be due to combined chemical exposure rather than DU alone</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>Myocarditis resulting from the uranium ingestion, which ended 6 months after ingestion</td>
</tr>
<tr>
<td>Tissues surrounding embedded DU fragments</td>
<td>Elevated uranium urine concentrations</td>
</tr>
</tbody>
</table>
Other detrimental health effects

Chromium - low level exposure: skin irritation and cause ulceration; Long term exposure – kidney and liver damage, damage to circulatory and nerve tissue

Selenium – damage to circulatory system, severe damage to nervous system

Copper – high doses can cause anaemia, liver and kidney damage, stomach and intestinal irritation; Cirrhosis of the liver in children is linked with preparing milk in copper cookware

Molybdenum – high levels can interfere with body’s uptake of copper, producing copper deficiency
Arsenic (As) poisoning in Bangladesh

- Caused by wells dug for water development programme
- Wells dug to eradicate illnesses caused by drinking contaminated surface water, where 2.5 million wells were dug
- The problem: groundwater from the wells is contaminated with high levels of arsenic
- Health problems: chronic arsenic poisoning – initially causes skin lesions especially on hands and feet
- When cumulative dose is high enough – may lead to death from cancer
Figure 1. Arsenic Levels in Bangladesh
A Columbia University graduate student collects water samples at a field site near Lashkardi village, Bangladesh
Thank you for your attention !!!