Heavy Metals And Bioaccumulation:-

Why Heavy Metals Accumulate in Your Food and Your Body?

Picture the food web–an interconnected tangle of species, all relying on each other for energy and nutrients. Though most of what gets passed along from the tiniest microbes to humans enables us to live, a small fraction of it can be toxic. Heavy metals are natural elements that–in high doses–are poisonous to humans. They enter our bodies mainly from lower down on the food chain through a process called **bioaccumulation**.

What are heavy metals, and what does it mean for them to bioaccumulate? Why is heavy metals bioaccumulation dangerous for your health? We've got the answers–and some tips on what to do–below.

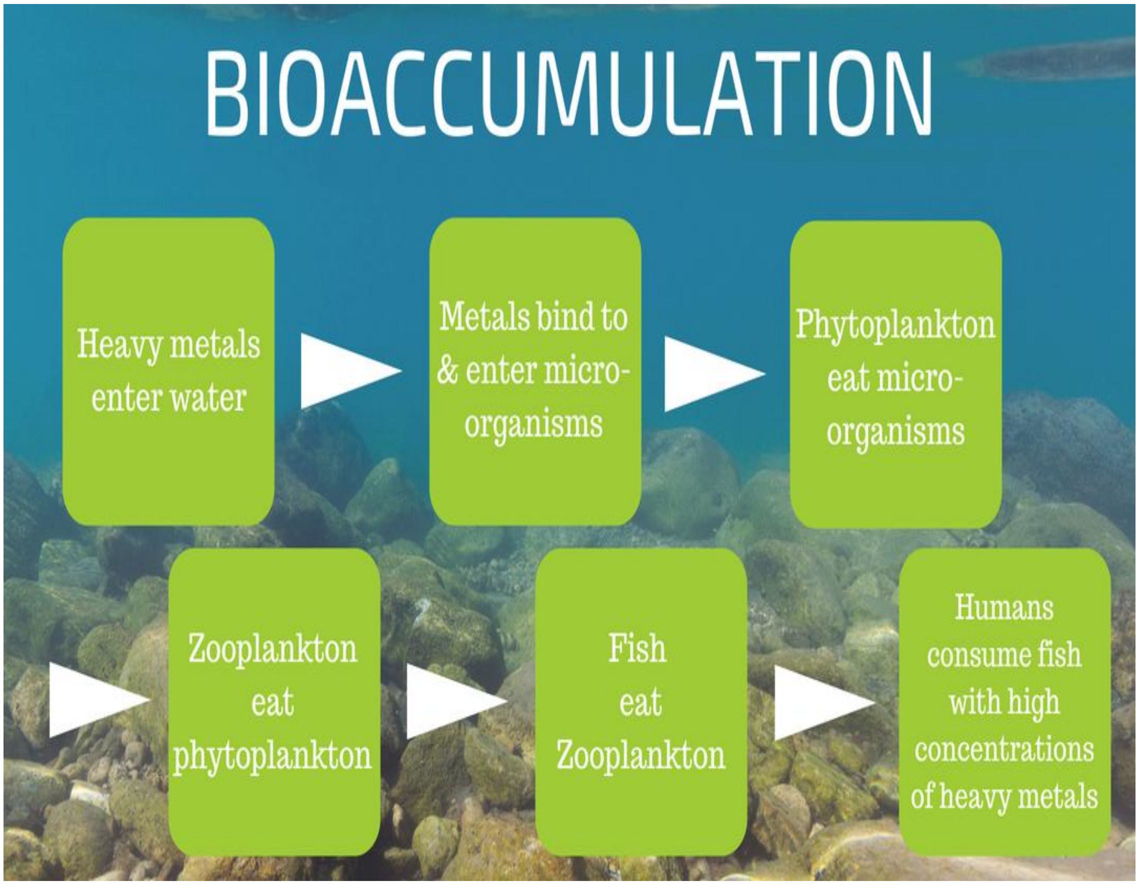
What are Heavy Metals?

Heavy metals are present in earth's crust alongside other metals, minerals, and organic matter. Some examples include: mercury, lead, arsenic, cadmium, chromium, copper, & thallium. Heavy metals are defined as "heavy" in comparison to water, meaning that they have a higher molecular weight than 18 g/mol. Heavy metals also find their way into watersheds from concentrated wastewater, sewage, industrial activities, and mining operations. These metals can contaminate soil systems and water sources.

People are exposed to heavy metals in a few different ways, primarily through drinking water or food (crops can uptake metals from contaminated soil or meat and fish products may contain bioaccumulated metals). Many heavy metals are poisonous to humans, even in small concentrations.

What is Bioaccumulation?

Bioaccumulation is essentially the buildup of contaminants such as heavy metals or pesticides in living organisms. Aquatic organisms are often subject to bioaccumulation because they absorb contaminants from the water around them faster than their bodies are able to excrete them. Humans are *also* subject to bioaccumulation, either from consuming contaminated aquatic organisms or from exposure to contaminants in our food, air, or water. Heavy metals *do not* biodegrade, which means they can last for a long time in our bodies.



Bioaccumulation in the food chain begins with the smallest microorganisms and ends with humans. Heavy metals are able to bind to the surface of microorganisms (like phytoplankton in oceans) and sometimes enter the cells themselves.

Once they enter the cell, heavy metals can react with chemicals released by the microorganism to digest food, and undergo chemical transformations. (An example is mercury becoming methylmercury, which is especially dangerous because methylmercury is more easily absorbed by living organisms.) Insects and zooplankton eat microorganisms, fish eat zooplankton, and eventually humans order a tuna to eat at a restaurant!

At every point in this process, heavy metals bioaccumulate in the bodies of each living organism—by the time they get to us, we consume the heavy metals in high concentrations. The increase of heavy metals concentration up the food chain is called biomagnification.

Health Effects of Heavy Metals

Unfortunately, heavy metals can have serious health effects for humans. Many play a role in cancer development or cause internal organ damage, even at low concentrations. Cadmium, cobalt, lead, nickel, and mercury are also known to affect the formation of blood cells–the metals can react with the surface of the cells, making them less elastic and therefore less able to circulate throughout the body. Here we’ve summarized five critical heavy metals and their known health effects:

Mercury

Mercury is known to cause brain damage in developing children, and if you’re pregnant, it can cause birth defects or possibly a miscarriage. Methylmercury compounds are also known to cause cancer. There is a deep concern about mercury exposure through predatory fish such as tuna, which is the second most popular fish in the US. An example to demonstrate the magnitude of the issue is if a 45 lb child eats one 6 oz can of white tuna per week, the child is already exceeding the US Environmental Protection Agency (EPA) mercury limit.

Lead

Lead is particularly harmful for children. It is structurally similar to calcium and can therefore replace calcium in the growing bones of children. Once the child is grown, the lead can release into the body and cause brain and nerve damage. Lead can also cause anaemia, reproductive issues, and renal impairment. People are usually exposed to lead through contaminated food or water, or in the case of children, from ingesting objects with lead paint. Lead can be expelled at very low levels, but at high or continuous doses, lead bioaccumulates in the body.

Cadmium

Cadmium remains in human bodies for decades, and long-term exposure is linked to renal dysfunction. A high concentration exposure can also lead to bone defects and lung disease, which may eventually become lung cancer. People can be exposed to cadmium not only through food and water, but also from tobacco in cigarettes.

Chromium

At low levels, chromium only causes skin irritation and ulcers. Longer-term exposure, however, can lead to liver issues, renal tubular damage, and cancer. Similar to mercury, chromium easily accumulates in aquatic life.

Arsenic

Arsenic is technically considered a metalloid, but acts like a heavy metal in its toxicology. Arsenic exposure can cause breathing problems, lung and skin cancer, decreased IQ, nervous system issues, and even death at high levels. Arsenic easily enters groundwater and soils from natural sources and industrial operations. Some crops can uptake arsenic after irrigation or from the soil, an example being rice, leading to exposure through food.

Industrial wastewaters

Industrial effluent control is of vital importance, particularly in developing countries where control is often very poor or non-existent. There is an old axiom which states that 'good sewage treatment starts with good control of industrial effluents'. Non-existent control could mean an inability to treat domestic sewage effectively.

The prime reasons for the control of industrial wastewaters are:

- to protect workers working within the sewerage system
- to protect the fabric of the sewer and the fabric of any downstream treatment works
- to prevent fires and explosions due to inflammable or explosive chemicals
- to prevent surcharging or blockages within the sewerage system
- to protect the physical operation of downstream treatment works
- to ensure that industrial discharges do not affect the performance of downstream biological treatment processes
- to protect the environment where sewers eventually discharge to a watercourse or to the sea
- to ensure that industrial discharges do not affect disposal of sludges from treatment works.

The organization responsible for the sewerage system and sewage treatment works must set standards for individual sewer discharges, based upon the following factors:

- the type and nature of the industrial wastewater
- the capacity of the sewerage system to accommodate the wastewater
- the potential of the wastewater to cause surcharging or blockages of the sewerage system
- the potential effect on the capacity of the treatment plant
- the potential effect on biological treatment processes.

For any given sewerage system, the total daily flow, suspended solids, BOD or COD, and ammonical nitrogen determine the size and capacity of the required sewage treatment works. Pretreatment of industrial wastewaters may be required to maintain flows and loads within treatment capacities, or extension of the treatment works may be necessary. Substances that affect biological processes must be limited to concentrations below those that would cause problems and the limits need to be set taking account of quantities arising from other sources.

If the standard for the sewage treatment discharge has limits on certain substances, the only recourse may be to control them at the industrial source. Standards for substances such as sulphides, cyanides and heavy metals should be set at very low limits, whereas some, such as the ‘red list substances’, should be banned altogether. Others including many volatile organic compounds could also be considered for prohibition. Toxic metals arising from industry need to be controlled as they become incorporated into the biosolids (sludge) and can seriously affect disposal to agricultural land. In some countries (e.g. USA) pretreatment standards apply to specific industrial categories, so that all are treated with some degree of equity, but this is not the case in other countries.

Uptake and Bioaccumulation

Bioaccumulation and biomagnification are two terms commonly used for metal toxicity. Bioaccumulation refers to how pollutants (metals) enter a food chain and relates to the accumulation of contaminants, in biological tissues by aquatic organisms, from sources such as water, food, and particles of suspended sediment. Bioaccumulation involves, relative to the ambient value, an increased concentration of a metal in a biological organism over time. Accumulation in living things can occur whenever metals are taken up and stored faster than they are metabolized or excreted. Understanding the dynamic processes of bioaccumulation can have important ramifications in protecting human beings and other organisms from the adverse effects of metal exposure, and hence, bioaccumulation is an important consideration in the regulation and treatment of metals associated with acid mine drainage. First some terminology: in conjunction with bioaccumulation, we define uptake, bioconcentration, and biomagnification. Uptake describes the entrance of a chemical into an organism such as by breathing, swallowing, or absorbing it through the skin without regard to subsequent storage, metabolism, and excretion. Bioconcentration is the specific bioaccumulation process by which the concentration of a chemical in an organism becomes higher than its concentration in the air or water around the organism. Although the process is the same for natural and anthropogenic chemicals, the term bioconcentration usually refers to chemicals foreign to the organism. For fish and other aquatic animals, bioconcentration after uptake through the gills or, in some circumstances, through the skin, is usually the most important bioaccumulation process. Biomagnification refers to the tendency of pollutants to concentrate as they move from one trophic level to the next. The process occurs when a chemical or metal becomes increasingly concentrated as it moves up through a food chain, i.e., the dietary linkages between single-celled plants and increasingly larger animal species. The natural bioaccumulation process is essential for the growth and nurturing of organisms. Bioaccumulation of substances to harmful levels, however, may also occur.

Acid and alkaline mine waters commonly contain high concentrations of dissolved metals and metal-oxide particulates.

The acidification of wetlands can elevate the concentrations of metals and increase the potential bioavailability in aquatic plants and freshwater biota, and can influence the uptake of metals in both submerged and rooted plants. Arsenic concentrations in freshwater macrophytes affected by effluents from a gold mine were examined by Dushenko *et al.* (1995). Macrophytes concentrated arsenic relative to sediment concentrations, with submerged species containing much higher levels of arsenic than those in air-exposed plants. The differences observed were attributed to growth form and the ability of plants to exclude arsenic with increasing sediment concentrations. Plants in the vicinity of high arsenic values showed clear indications of necrosis of leaf tips and reduced micronutrient levels of copper, manganese, and zinc in root tissues. A study of arsenic contamination in wood mice proximal to abandoned mine sites has shown that the extent of accumulation depends on the level of habitat contamination (Erry *et al.*, 2000). Rai *et al.* (2002) observed that metals correlated positively with metal concentrations in adjacent water and sediments, which had been impacted by domestic and industrial discharges.