

Bioaccumulation and Biomagnification: How they work and why they're so dangerous



Have you ever wondered where things like chemicals from pesticides or smoke from factory smokestacks end up? Or wonder how it affects the food you eat? Most people only think about the benefits of a well-balanced meal. However, knowing what potential hazards are lurking in your food is just as important as getting the right nutrients.

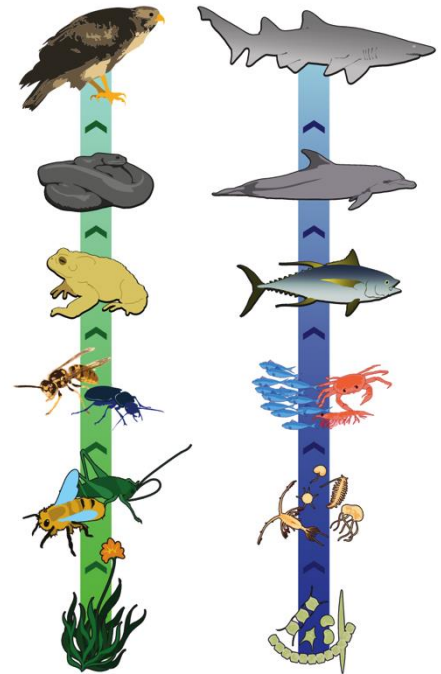
All animals, including humans, accumulate many essential vitamins and nutrients to nourish their body on a daily basis. However, some harmful chemicals that are released into the environment work their way up the food chain and accumulate in our bodies. How this happens is a complex series of events but grasping how it occurs is simply a matter of understanding how pollution can incorporate itself into our food chains and become very hazardous.

Pollution

Pollution is the release of toxic chemicals into the environment. Some pollutants are from natural sources such as volcanic eruptions and wildfires, but most are from human activities. Common human-produced pollutants originate in pesticides as well as industrial and automobile emissions. The stuff that comes out of your car's tailpipe will eventually make its way into creeks, rivers, and lakes. Once these chemicals are in the air, soil, and water, they can easily enter into the food



chain. Once in the water, tiny organisms called phytoplankton ingest these pollutants. These organisms either cannot get rid of the pollutants as fast as they take them in or not at all and therefore; they remain inside their bodies until they die. Continuing up the food chain, zooplankton is an organism that eats the phytoplankton. The pollutants that were inside the phytoplankton are then transferred to the zooplankton, which also can't break down the pollutants. The only thing they can do is store them. The more phytoplankton the zooplankton eats, the more pollutants they store. This process is called bioaccumulation. Bioaccumulation is defined as the accumulation of substances inside an organism. The pollutants are passed up the food chain as zooplankton are eaten by small fish, which are then eaten by bigger fish and so on. This process continues up the food chain as the pollutants are becoming more and more concentrated and harmful. Lastly, birds, large predators, and humans eat the large fish and take on the highly concentrated pollutants, which at this point can be harmful if not deadly.



Bioaccumulation

Bioaccumulation (bioamplification) is the gradual buildup of chemicals that cannot be broken down (metabolized) or excreted from an organism. Because some chemicals are persistent chemicals,



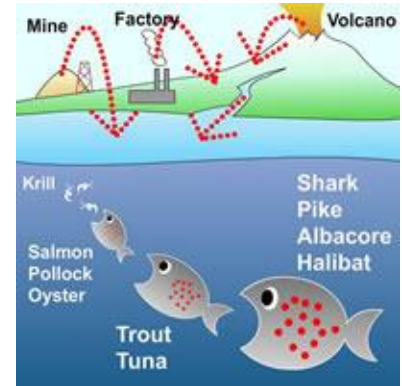
A farmer spraying his crops with a pesticide

they don't break down over time. Instead, the persistent chemicals are stored in fatty tissue or are bound to proteins inside the body causing them to accumulate. Examples of bioaccumulated heavy metals include mercury (in the form methylmercury), copper, cadmium, and lead. Bioaccumulation may not pose a threat to organisms at the bottom of the food chain because their concentrations are so low, but through the process of bioaccumulation and biomagnification, the further

up the chain you go, the more harmful they become. In fact, the levels of concentration increase by a factor of 10 at each food chain level.

How biomagnification works

Bioaccumulation is the buildup (accumulation) of chemicals inside an organism. Since these chemicals can't be removed from the body efficiently, they are passed up the food chain. As previously mentioned, when a chemical moves higher up the food chain, it becomes more concentrated. Biomagnification is the increasing concentration of a substance at higher and higher levels of a food chain. In other words, as the chemicals accumulate, their concentrations become magnified. Organisms at the top of the food chain like humans are always affected the most by biomagnification because that's when the accumulation is greatest.



Picture showing how chemical concentrations can increase up the food chain

The health effects of bioaccumulation and biomagnification

The effects of bioaccumulation and biomagnification depend greatly on the chemical that is being accumulated as well as the organism that is ingesting it. When an oil spill occurs, polycyclic aromatic



Oil Spill - Photo credit: Louisiana GOHSEP

hydrocarbons (PAHs) are released. These have been linked to cancers in humans as well as an inability to fight disease in other organisms. Heavy metals including cobalt, nickel, tin, and cadmium, which are released from mining operations and industrial plants can also have drastic effects. They can interfere with the body's ability to form blood cells, and can negatively affect the kidneys, liver, nervous and circulatory systems ability to function. Other studies have also found a link between heavy metals and cancer.

Putting it all together

Chemicals released into the environment through various forms of pollution find their way into



organisms at the bottom of the food chain. The chemicals cannot be metabolized, (broken down) or excreted fast enough and therefore, must be stored in the fatty tissues of the organism. Larger organisms eat smaller ones and as you higher up the food chain, the chemicals become more and more concentrated. Animals at the upper end of the food chain like large predators and

humans receive very high doses of the chemical due to biomagnification. These larger doses can have very negative health effects such as poor organ function and/or cancer.

Case Study: DDT



A classic example of bioaccumulation occurred due to the release of an insecticide called dichlorodiphenyltrichloroethane (DDT). Prior to 1972, DDT was used all over the United States mostly to kill mosquitoes and other insects. After the spray was used, it would be washed away by the rain and end up in lakes and larger bodies of water. DDT accumulated and was magnified in large predatory birds that ate the fish that ate the smaller fish, etc. all the way down to the very small organisms that ingested it in the first place. The DDT chemical then becomes incorporated into the bird's shells, which caused them to become very weak and thin. The shells broke easily causing the baby birds inside to die. With a decrease in baby birds, there was a significant decline in overall population. This population decrease not only affected the birds but also the entire ecosystem. This trend was only broken when the use of DDT's was disallowed in 1972. Since then, the bird populations have come back and the ecosystems are once again in balance.



Reading Comprehension Questions

1. What is pollution?
2. When pollutants enter the water, which organism first ingests them?
3. Why do pollutant chemicals accumulate inside the organisms?
4. What is bioaccumulation?
5. Where are these chemicals stored inside the organism?
6. Why does bioaccumulation not negatively affect organisms lower on the food chain?
7. If the concentration of a chemical were 10-units/g at level one of the food chain, what would the concentration be at level three?
8. What are some of the noted effects of PAHs?
9. Why was DDT so harmful to the large predatory bird population?

Extension Questions

10. Create a clear and detailed diagram that shows how bioaccumulation and biomagnification work within an ecosystem.
11. Why did the presence of DDT affect the entire ecosystem and not just the predatory birds? Your answer must be at least three good sentences long.

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