Microensayo

How does Bioaccumulation of Toxic Substances Occur? How do They Affect Biodiversity, the Health of Organisms and What are the Ecological Implications of these Effects on the Ecosystems on which We Depend?

¿Cómo la bioacumulación de sustancias tóxicas ocurre? ¿Cómo éstas afectan la biodiversidad, y la salud de los organismos y cuáles son las implicaciones biológicas de estos efectos en los ecosistemas de los cuales dependemos?

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Abstract

Plants, animals, and people are suffering the consequences of using chemicals in industries such as agri-food, specifically the use of pesticides, which most of the time end up having lethal and sub-lethal effects on the organisms that form the food chains. Likewise, chemical accumulations have been observed to be exponentiated at higher trophic levels, producing detrimental effects from the base to the top, and being greater each time.

Keywords: Bioaccumulation, biomagnification, sub-lethal, detrimental effects, pesticides.

Resumen

Plantas, animales y personas están sufriendo las consecuencias del uso de productos químicos en industrias como la agroalimentaria, especialmente el uso de pesticidas, cuyos productos, en la mayoría de los casos, acaban teniendo efectos letales y subletales sobre los organismos que forman las cadenas tróficas. Asimismo, se ha observado que las acumulaciones químicas se exponencian en los niveles tróficos superiores, produciendo efectos perjudiciales desde la base hasta la cima, y siendo cada vez mayores.

Palabras clave: Bioacumulación, biomagnificación, subletal, efectos perjudiciales, plaguicidas.

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Nowadays, chemical products such as fertilizers, insecticides, and pesticides are used widely in the agro-food industry, especially systemic ones, due to their great capacity to reduce production losses. The total number of active ingredients worldwide reached 3.5 million tons in 2021, causing an increase in what is called bioaccumulation. (Tison et al., 2024).

In the first instance, chemicals are accumulated in the plant's systems affecting it in multiple ways. The pesticides generate DNA disintegration and damage to the pBR322 plasmid, most of the times because pesticides cause lipid peroxidation by raising the level of reactive oxygen species (ROS) due to oxidative stress, damaging proteins, lipids, and DNA, which produces the formation of thiobarbituric acid reactants (TBARS) (products of the degradation and oxidation of cell membrane lipids), indicators of cell tissue damage (genotoxicity, phytotoxicity, and cytotoxicity). Likewise, there is an increase in proline, which is an amino acid with antioxidant properties, and in enzymatic

antioxidants. Furthermore, the plant suffers alterations in mitochondrial membrane potential, apoptosis, defoliation, reduction in the vigor and mitotic indexes, chromosomal abnormalities in meristematic cells, decreased photosynthetic rates, affections in the hormone system, and a significant reduction in chlorophyll and protein contents. (Hamaad et al., 2020).

Then, in a second instance, the primary consumers, that is, herbivores and pollinators, acquired the accumulation initially in the plants, frequently in sublethal doses, having low degrees of contaminants' concentration, passing the chemicals to the whole trophic chain, by acting as transference vectors (particularly the arthropods). Afterward, in the third instance, the primary consumers are preyed on by the secondary consumers (insectivores) and omnivorous species, who are themselves prey to other species, until the chemicals reach the top of the food chain, where the apex predators are. All the above mentioned with what is called biomagnification, describing the phenomenon that generates higher concentrations of bioaccumulation in upper levels of the trophic chain, leaving internal concentrations in the apex predators that are 1,000 times over than those in treated plants. (Tison et al., 2024).

Once the upper levels of the trophic chain are reached, different effects could be seen, including among the most common the followings: death, emergence failure of the parasitoid, reduced reproduction, seizures, decreased activity accompanied by a reduced motor function, secondary outbreaks, hyperactivity, survival deterioration, paralysis, reduction of predation (impaired predatory behavior, such as reduced herbivory), reduced fertility, change in the community structure, among others, thus determined by the organisms sensibility, age, body size, life expectancy, nutrition, lipidic content (fat percentage), immunity, health, co-exposure to other hazards and detoxification mechanisms. (Tison et al., 2024).

Now, connecting the previous with an experiment carried out, in which a tray with five plants was watered with water plus a systematic insecticide (experimental tray), while a second one was watered with just water (control tray), it could be said that the plants with insecticide suffered the phytotoxic, genotoxic, and cytotoxic effects that characterize the use of that kind of hostile products, at the same time exposing other living beings to sublethal amounts, such as the bee that was flying every day near it due to the plants' zone and the dying insect

found in the substrate of the experimental tray (it remains immobile even when the tray was moved, but still alive because when was tried to remove it scaped flying a short distance). The plants of the control tray grew green, strong and healthy, while the experimental tray plants showed a discolored, grayish and completely weak growth.

In conclusion, many ecological and physiological alterations happened after the continued use of chemicals, such as insecticides and pesticides, which are persistent due to the nature of those chemicals by themselves, but also due to their transformation products (isomers and impurities), for this reason measures have to be taken in order to avoid an increase in the bioaccumulation and biomagnification in plants, arthropods, animals and humans. (Gobierno de México, n.d.; Tison et al., 2024).

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