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EFFECTS AND ECOLOGICAL CHARACTERISTICS OF XENOBIOTICS ON LIVING ORGANISMS

Teshayev Mukhriddin Isomiddin og'li
Lecturer, Department of "General Sciences", Asia International University

Abstract: This article provides information on the major groups of xenobiotics, their ecological characteristics, and various naturally occurring toxic substances such as phytotoxins, alkaloids, and simple toxic compounds synthesized by bacteria.

Keywords: Xenobiotics, bacterial toxins, mycotoxins, aflatoxins, phytotoxins, alkaloids.

Introduction

Xenobiotics are generally divided into three categories:

1. **Naturally occurring compounds.**
2. **Substances formed inside the human body under specific conditions.**
3. **Compounds that enter the body through consumption, processing, or storage of food products**, including:

- Fresh food raw materials or products obtained through chemical or microbiological synthesis;
- Residues introduced during raw material harvesting (metals, pesticides, biostimulators, antibiotics, etc.);
- Food additives such as colorants, preservatives, and antioxidants;
- Substances migrating from polymer containers and packaging materials;
- Biologically derived compounds (mold, fungi, bacterial toxins);
- Chemicals formed during cooking or heat treatment (e.g., benzo(a)pyrene from smoking, nitrosamines, or lysylalanine formed when meat is cooked in alkaline water).

Ecological Features of Naturally Occurring Xenobiotics

Naturally derived xenobiotics fall into three groups: **biological**, **inorganic**, and **non-biological organic compounds**. Biological xenobiotics include substances synthesized by bacteria, fungi, plants, and animals.

Bacterial toxins typically possess high molecular mass and consist of **proteins, polypeptides, or lipopolysaccharides** with strong antigenic properties. More than 150 bacterial toxins are known today, and many of them rank among the most potent poisons. The most dangerous include **botulinum toxin, cholera toxin, tetanotoxin, staphylococcal toxins, and diphtheria toxin**. Botulinum and staphylococcal toxins have even been considered as potential chemical warfare agents. These toxins harm various systems of mammals, especially the nervous and cardiovascular systems, and sometimes mucous membranes.

Bacteria can also produce relatively simple toxic molecules such as **formaldehyde, acetaldehyde, and butanol**.

Mycotoxins exhibit wide chemical diversity and biological activity. Of particular concern are toxins produced by microscopic fungi contaminating food and feed. Examples include **ergot alkaloids** produced by *Claviceps* species, as well as **aflatoxins** synthesized by *Aspergillus* fungi. Ergot alkaloids affect the central nervous system and cause severe vasoconstriction and uterine muscle contraction. Historically, consumption of ergot-contaminated grain caused large-scale poisoning outbreaks. While such incidents are now rare among humans, livestock remain vulnerable.

Aflatoxins, especially those produced by *Aspergillus flavus*, frequently contaminate crops like wheat and maize and exhibit strong acute toxicity and carcinogenic potential.

Properties of Carcinogenic Substances

Many higher fungi synthesize toxic molecules with varied structures and biological effects. Among the most dangerous are **amanitins, amanins, and phalloidins**, present in the death cap mushroom, which can cause fatal liver and kidney damage. Other toxins such as muscarine, gyromitrin, and ibotenic acid also pose significant health risks. Some fungal metabolites, including those from hallucinogenic mushrooms, affect the nervous system and alter perception.

Plants produce a vast number of toxic compounds known as **phytotoxins**. These serve as metabolic by-products and sometimes provide protective functions against herbivores. Phytotoxins encompass a wide range of chemical groups including **alkaloids, organic acids, terpenoids, lipids, glycosides, saponins, flavonoids, coumarins, and anthraquinones**.

Alkaloids are nitrogen-containing heterocyclic compounds, and several thousand have been identified. Many are highly toxic to humans and other mammals.

Cardiac glycosides strongly affect heart muscle, while saponins irritate mucous membranes and can cause hemolysis. Coumarins act as anticoagulants and photosensitizing agents.

Some plant toxins—such as atropine, galantamine, physostigmine, strophanthin, and digitoxin—are widely used in medicine. Others, like cocaine, nicotine, morphine, harmine, and cannabinoids, can induce dependence.

Certain plant metabolites also show allergenic or carcinogenic effects. Safrole (found in black pepper), solanine (in sprouted potatoes), quinones, and phenolic compounds are notable examples.

Conclusion

Environmental exposure to toxic substances and damaging factors has caused significant harm to humans, animals, and plants. Xenobiotics can provoke antigenic reactions and may exhibit **carcinogenic, mutagenic, and embryotoxic** properties, posing serious risks to biological systems.

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