Lipid peroxidation in the tissues of hydrobionts under the influence of toxicants of different chemical nature

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Aquatic ecosystems are continuously exposed to a wide range of anthropogenic pollutants, including heavy metals, herbicides, and mycotoxins, which affect the physiological state of hydrobionts. These toxicants can initiate oxidative stress and disrupt cellular homeostasis, leading to lipid peroxidation in biological membranes. The intensity of lipid peroxidation is considered an important biomarker of toxic impact in fish and other aquatic organisms. Previous research has shown that xenobiotics significantly influence antioxidant enzyme activity in fish tissues (Yakovenko et al., 2017). In particular, carp and crucian carp are widely used as model organisms for studying biochemical responses to environmental pollution. Therefore, investigation of lipid peroxidation processes under exposure to toxicants of different chemical nature is of high ecological relevance.

The study is based on the analysis of scientific literature and biochemical investigations of fish tissues under exposure to toxic substances. Objects of study include hydrobionts such as common carp and crucian carp, which are sensitive indicators of aquatic pollution. The research considers data on lipid peroxidation intensity in liver and muscle tissues under the influence of various xenobiotics. Comparative analysis of toxic effects was performed for different chemical groups of pollutants, including heavy metals, herbicides, and mycotoxins. Special attention was given to aflatoxin B1 as a potent biological contaminant affecting oxidative processes (Simonova & Mekhed, 2025b). Statistical and multivariate approaches such as MANOVA were previously applied to ensure reliability and integrity of ecological and biomedical data (Lukash et al., 2026). Biochemical indicators of oxidative stress were evaluated based on established experimental models of lipid peroxidation in fish tissues.

The analysis demonstrated that exposure of hydrobionts to toxicants of different chemical nature leads to a significant increase in lipid peroxidation intensity in tissues. Heavy metals were shown to induce oxidative stress by generating reactive oxygen species and disrupting membrane stability. Herbicides also contributed to oxidative damage, affecting metabolic processes and antioxidant defense systems in fish organisms. Mycotoxins, particularly aflatoxin B1, demonstrated a strong pro-oxidant effect, significantly increasing lipid peroxidation levels in crucian carp tissues (Simonova & Mekhed, 2025b).

Liver tissues showed the highest sensitivity to toxic exposure, as this organ is responsible for detoxification processes and metabolic regulation. In carp, increased levels of diene conjugates and other lipid peroxidation products were observed under pollutant influence (Bloha et al., 2019). Similar patterns of oxidative stress activation were reported in studies analyzing the effects of xenobiotics on antioxidant systems in fish (Yakovenko et al., 2017). The intensity of lipid peroxidation depended on the chemical structure and concentration of toxicants, as well as duration of exposure.

It was also found that different toxicants activate oxidative processes through various mechanisms. Heavy metals primarily induce oxidative stress via Fenton-type reactions, while organic pollutants such as herbicides and mycotoxins interfere with enzymatic antioxidant systems. Aflatoxin B1 exhibited a particularly strong effect on lipid peroxidation in fish tissues, confirming its high biological toxicity (Simonova & Mekhed, 2025b). The imbalance between pro-oxidant and antioxidant systems leads to cellular damage, lipid membrane degradation, and functional disorders in hydrobionts.

Statistical approaches such as MANOVA have been recommended for improving the reliability of toxicological and ecological studies, ensuring correct interpretation of biochemical data (Lukash et al., 2026). Overall, the obtained data confirm that lipid peroxidation is a universal response of hydrobionts to toxic stress and can be used as a reliable biomarker of aquatic pollution.

Lipid peroxidation is a key indicator of oxidative stress in hydrobionts exposed to toxicants. Toxic substances of different chemical nature significantly increase lipid peroxidation intensity in fish tissues. Heavy metals, herbicides, and mycotoxins act through different mechanisms but lead to similar oxidative outcomes. Liver tissue is the most sensitive organ to toxic exposure in fish organisms. Aflatoxin B1 demonstrates a particularly strong pro-oxidant effect on crucian carp tissues. The antioxidant defense system is disrupted under continuous exposure to xenobiotics. Carp and crucian carp can be effectively used as bioindicators of aquatic pollution. The intensity of lipid peroxidation depends on the chemical structure and dose of toxicants. Biochemical markers of oxidative stress are valuable tools for environmental monitoring. Further research is needed to clarify long-term effects of combined toxicant exposure on aquatic ecosystems.

References

Symonova, N. A., Mekhed, O. B., Kupchyk, O. Y., & Tretyak, O. P. (2018). Toxicants in the degradation of lipids in the organism scaly carp. *Ukrainian Journal of Ecology*, *8*(4), 6–10.

Блоха, А. К., Симонова, Н. А., & Мехед, О. Б. (2019). Вміст дієнових кон’югатів в печінці коропа за дії полютантів. *Біологічні дослідження – 2019: Збірник наукових праць*, 141–144.

Лукаш, О., Сікура, А., Мехед, О., & Стрілець, С. (2026). MANOVA як інструмент забезпечення доброчесності медико-біологічних та екологічних досліджень. *Biota. Human. Technology*, *(1)*, 226–234. https://doi.org/10.58407/bht.1.26.19

Симонова, Н. А., & Мехед, О. Б. (2025). Вплив афлатоксину В1 на інтенсивність перекисного окиснення ліпідів у тканинах карася звичайного. *Слобожанський науковий вісник. Серія: Природничі науки*, *(2)*, 65–69. https://doi.org/10.32782/naturalspu/2025.2.8

Симонова, Н. А., & Мехед, О. Б. (2025). Вплив токсикантів різної хімічної природи на інтенсивність перекисного окиснення ліпідів в печінці коропа лускатого. *Природнича освіта і наука*, *(4)*, 171–180.

Симонова, Н. А., Іскевич, О. В., & Мехед, О. Б. (2016). Вивчення впливу токсикантів різної хімічної природи на активність системи антиоксидантного захисту у печінці цьогорічки коропа лускатого. *Фундаментальні та прикладні дослідження у сучасній науці: Збірка наукових праць*, 5.

Тюпова, Т., Ткаченко, Г., Мехед, О., & Курхалюк, Н. (2023). Відповіді на оксидаційний стрес у наземних молюсків як біомаркери для оцінки впливу токсикантів. *Biota, Human, Technology*, *(1)*, 41–51.

Яковенко, Б. В., Третяк, А. П., Мехед, О. Б., Хайтова, А. Д., & Симонова, Н. А. (2017). Вплив ксенобіотиків на активність антиоксидантної системи в тканинах коропа. *Наукові записки Тернопільського національного педагогічного університету. Серія: Біологія*, *2*(69), 76–80.

Assessment of the phytotoxicity of testosterone in the context of wastewater reuse in agriculture

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Wastewater used in agricultural practices may contain various toxicants (Al-Hazmi et al., 2023). In particular, residues of various drugs and chemicals are often found in wastewater, in particular anabolic steroids (Shimko et al., 2022), which can be used in bodybuilding. Nandrolone and other anabolic steroids are found in wastewater (Causanilles et al., 2018; Xie et al., 2025), in particular testosterone and its derivatives (González et al., 2020; Yazdan et al., 2022; Almazrouei et al., 2023). Researchers have shown that the average total hormone concentration in wastewater was 3562–5400 ng/L, among which androgens accounted for 96% of the total hormone concentration (Chang et al., 2011). It was noted that the content of estrogens (estrone, 17β-estradiol, 17α-ethinylestradiol, and hexestrol), two progestogens (testosterone, dihydrotestosterone), and one progestogen (progesterone) in various types of water samples (mineral, tap, well, pond, swimming pool, river, and waste) ranging from 3.0 to 110 ng/L (Chafi & Ballesteros, 2022). Trace amounts of steroid hormones have a variety of effects on the plant (Almazrouei et al., 2023). *Lepidium sativum* L. is known to be responsive to various stressors, including toxicants. Its growth parameters serve as indicators of substrate and compound toxicity (Tkachuk & Zelena, 2023; (Tkachuk et al., 2024). The aim of this study was to investigate the growth indicators of *L. sativum* L. as a sensitive model plant under the influence of testosterone solutions.