
A REVIEW ON METABOLIC CHANGES IN GOLDFISH AFTER TREATMENT WITH DBP AND AMELIORATION WITH *WITHANIA SOMNIFERA* EXTRACT

Bhavna Sharma* and Amita Sarkar

Department of Zoology, Agra College (Dr. B.R. Ambedkar University), Agra-282 002, India.

*Corresponding author e-mail : sharmabhavna503@gmail.com

ABSTRACT : Dibutyl phthalate (DBP) is a dangerous pollutant in our water that causes major problems for fish, interfering with their metabolism, creating oxidative stress, and harming their liver and kidney functions. When it builds up, it can throw their carbohydrate and lipid metabolism out of whack. On the brighter side, *Withania somnifera*, a medicinal plant known for its antioxidant and liver-protective benefits, shows potential in helping to counteract DBP toxicity. It does this by lessening oxidative damage, correcting enzymatic imbalances and boosting detoxification processes. Although there's research backing its promise, we still need more studies to find out the best dosages and long-term effectiveness. This review sheds light on how DBP affects goldfish metabolism and looks into *Withania somnifera* as a viable bioremediation approach to safeguard our aquatic ecosystems.

Key words : Dibutyl phthalate, *Withania somnifera*, antioxidant, oxidative damage.

Introduction

Aquatic environments are facing increasing threats from a variety of pollutants, particularly endocrine-disrupting chemicals (EDCs) like dibutyl phthalate (DBP). These harmful substances come from industrial waste, plasticizers, and runoff from agriculture, which can lead to bioaccumulation in aquatic life and disrupt ecosystems (Kumar *et al*, 2021). Fish, in particular, are highly susceptible to DBP exposure since they are in direct contact with contaminated water and serve as important indicators of environmental toxicity (Jin *et al*, 2018). Goldfish (*Carassius auratus*), a commonly studied freshwater species, show notable changes in their metabolism when exposed to toxic substances, making them an excellent model for exploring how DBP affects metabolic processes (Singh and Sharma, 2020). DBP is a widely used plasticizer that's been found in many aquatic ecosystems. It's known to cause oxidative stress, mess with endocrine signalling, and change biochemical pathways in fish, which can negatively impact their growth, reproduction, and overall metabolism (Gao *et al*, 2019). When fish are exposed to DBP, it throws their metabolism out of whack, leading to issues in how they handle carbohydrates, lipids and proteins. Research has revealed that DBP exposure can result in high blood sugar levels, changes in how glycogen is stored, increased lipid peroxidation, and oxidative damage to fish liver and kidney tissues (Zhou *et al*, 2022). On top of that, it interferes with the enzymatic processes that are crucial for generating energy, like glucose-6-phosphate

dehydrogenase, lactate dehydrogenase, and aspartate aminotransferase, which all contribute to metabolic issues (Ahmed *et al*, 2021). In light of increasing worries about chemical toxicity, there's been a rising interest in using medicinal plants for phytoremediation as a detoxification approach. One such plant is *Withania somnifera*, or ashwagandha, which is celebrated for its antioxidant, hepatoprotective, and anti-inflammatory benefits (Gupta and Patel, 2020). It's packed with bioactive compounds like withanolides, flavonoids and alkaloids that help neutralize free radicals and reduce damage caused by oxidative stress (Rai *et al*, 2019). Numerous studies have documented *Withania somnifera*'s protective effects in various toxicological models, showcasing its promise as a natural therapeutic solution against DBP-induced toxicity in fish. Recent research has delved into the positive effects of *Withania somnifera* on metabolic stress caused by chemicals in aquatic life. It's been found to help bring glucose levels back to normal, lower lipid peroxidation, and boost the activity of antioxidant enzymes, which all contribute to better metabolic health (Sharma *et al*, 2023). Additionally, its liver-protective qualities support detoxification processes, helping the liver function properly and preventing damage from DBP (Mishra and Verma, 2022). Given these encouraging results, more studies are needed to uncover the molecular mechanisms that explain how *Withania somnifera* protects goldfish from DBP toxicity.

Dibutyl Phthalate (DBP): Sources, Exposure and Toxicity

Dibutyl phthalate (DBP) is a common plasticizer that you'll find in a variety of industrial products, such as plastics, adhesives, personal care items and coatings (Wang *et al*, 2021). It makes its way into aquatic ecosystems mainly through industrial discharges, wastewater runoff, and leaching from plastic materials, which can lead to serious environmental contamination (Li *et al*, 2020). DBP is quite persistent in water bodies and sediments, where it tends to accumulate and can pose risks to aquatic life (Zhang *et al*, 2019). Because of its lipophilic nature, DBP easily builds up in fish tissues, resulting in long-term toxic effects (Chen *et al*, 2022). Exposure to DBP in fish happens mainly through three ways: direct contact with contaminated water, eating tainted food sources, and bioaccumulation through the food chain (Xu *et al*, 2019). Once DBP gets into their system, it messes with their endocrine functions by imitating or blocking natural hormones, which can lead to issues with reproduction, development and metabolism (Gao *et al*, 2021). Research shows that being exposed to DBP can cause oxidative stress, changes in liver enzyme activities, and disturbances in carbohydrate and lipid metabolism in fish (Liu *et al*, 2020). What's more, long-term exposure to DBP has been linked to immunotoxicity, hepatotoxicity and neurotoxicity, all of which can seriously impact fish health and their chances of survival (Sun *et al*, 2023). Considering its common occurrence and harmful effects, various regulatory steps have been taken to curb DBP pollution. Yet, we need ongoing monitoring and effective strategies to tackle the issue, such as using bioremediation with medicinal plants like *Withania somnifera*. This approach is crucial for reducing its impact on the environment (Peng *et al*, 2021).

Metabolic changes in Goldfish due to DBP exposure

- **Alterations in carbohydrate metabolism-** Exposure to dibutyl phthalate (DBP) can have a major impact on how fish process carbohydrates, resulting in metabolic issues. When

fish are exposed to DBP, it throws off their glucose balance, causing higher blood sugar levels (hyperglycemia) and decreasing the storage of glycogen in the liver, which suggests that their energy regulation is compromised. This exposure also interferes with important enzymes that play a role in glycolysis and gluconeogenesis, like hexokinase and glucose-6-phosphatase, leading to an imbalance in how glucose is used and produced. On top of that, the oxidative stress caused by DBP can worsen these metabolic problems, ultimately affecting the overall health of the fish (Liu *et al*, 2020; Zhou *et al*, 2022).

- **Changes in lipid metabolism-** Dibutyl phthalate (DBP) exposure messes with lipid metabolism in fish by changing how lipids are stored, mobilized, and oxidized. It ramps up lipid peroxidation, which can cause oxidative damage and hurt membrane integrity. On top of that, DBP exposure lowers triglyceride levels and modifies important lipid-metabolizing enzymes like lipase and fatty acid synthase, throwing off the energy balance. These shifts lead to metabolic stress, which can negatively impact growth and the overall health of the fish.
- **Impact on liver and kidney function-** Dibutyl phthalate (DBP) has a harmful impact on the liver and kidneys of fish. It does this by causing oxidative stress, messing up enzyme functions and resulting in tissue damage. DBP interferes with the liver's detoxification processes and hinders kidney filtration, which ultimately leads to metabolic imbalances and a build-up of toxins, as noted by Chen *et al* (2022).

Role of *Withania somnifera* in Ameliorating DBP toxicity

Withania somnifera helps tackle DBP toxicity by lowering oxidative stress, boosting the activity of antioxidant enzymes, and bringing metabolic balance back to normal. Its beneficial compounds support liver and kidney functions, ultimately enhancing the overall health of fish (Gupta and Patel, 2020).

- **Phytochemical composition and bioactive compounds-** *Withania somnifera* is packed with a variety of bioactive compounds, such as withanolides, alkaloids, flavonoids, tannins, and saponins. These natural substances are known for their impressive antioxidant, anti-inflammatory, and liver-protective effects. They play a vital role in easing toxicity caused by DBP by lowering oxidative stress and boosting metabolic stability, as highlighted in the research by Rai *et al* (2019).
- **Mechanisms of detoxification and metabolic restoration-** *Withania somnifera*, commonly known as ashwagandha, plays a significant role in detoxifying the body and restoring metabolic functions. It does this by boosting our natural antioxidant defenses, cutting down on lipid peroxidation, and balancing enzyme activity. Its unique compounds enhance the activity of important antioxidant enzymes such as superoxide dismutase and catalase, helping to counteract oxidative stress caused by DBP. Additionally, it helps maintain stable glucose and lipid levels by influencing essential enzymes, which aids in restoring liver and kidney health and enhances detoxification processes. Together, these functions work to safeguard against metabolic disruptions and organ damage in fish, according to a study by Sharma *et al* (2023).

Experimental evidence and Research findings

Research shows that adding *Withania somnifera* to the diet can help counteract DBP-induced toxicity in fish. This happens by lowering oxidative stress, restoring balance in enzymes, and enhancing liver and kidney performance. The experimental results indicate improved antioxidant activity, decreased lipid peroxidation and stabilization of metabolic parameters, highlighting its protective benefits (Mishra and Verma, 2022).

- **Previous studies on *Withania somnifera* in aquatic toxicology-** Let's take a look at how *Withania somnifera* can help reduce stress caused by toxic substances in water. Research into how heavy metals and pesticides affect fish reveals that this plant can play a key role in lessening oxidative damage. It boosts the activity of antioxidant enzymes and helps restore metabolic balance. Various studies also highlight its hepatoprotective and nephroprotective benefits against harmful pollutants such as cadmium, lead, and pesticides, resulting in better survival rates and improved physiological functions. These results point to its promise as a natural detoxifier in the field of aquatic toxicology (Sharma *et al*, 2023; Mishra and Verma, 2022).
- **Reports on its efficacy in oxidative stress and metabolic regulation-** Reports indicate that *Withania somnifera* is effective in fighting oxidative stress and managing metabolism in aquatic beings. Research reveals that its bioactive compounds boost the activity of antioxidant enzymes, which helps lower lipid peroxidation and oxidative damage. It influences glucose and lipid metabolism by stabilizing enzyme functions, helping to restore energy balance, and enhancing liver detoxification. Experimental findings back up its ability to counteract metabolic disruptions caused by toxins, highlighting its potential benefits in the field of aquatic toxicology (Gupta and Patel, 2020; Sharma *et al*, 2023).
- **Comparison with other natural and synthetic detoxifying agents-** *Withania somnifera* stands out as a remarkable natural detoxifying agent when we put it beside synthetic antioxidants like N-acetylcysteine and butylated hydroxytoluene, which can carry toxicity risks if used over a long time. This plant offers a more holistic approach by helping to reduce oxidative stress, restore enzyme balance, and support both liver and kidney function. When we compare it to other plant-based detoxifiers like *Curcuma longa* and *Azadirachta indica*, *Withania somnifera* shines with its superior antioxidant, anti-inflammatory, and metabolic regulatory properties. This makes it a truly effective and sustainable option (Mishra and Verma, 2022; Sharma *et al*, 2023).

Future Perspectives and Research Gaps

There's a need for more research to dive into the specific molecular mechanisms of *Withania somnifera* in combating DBP toxicity. Long-term studies are essential to evaluate its safety, determine the best dosage, and test its effectiveness in various aquatic environments. Using advanced techniques like transcriptomics and metabolomics can give us a clearer picture of how it detoxifies. Furthermore, looking into how it interacts with other environmental pollutants and its efficiency across different fish species will boost its potential as a sustainable bioremediation tool. Incorporating *Withania somnifera* into green water treatment strategies could broaden its use in aquatic toxicology.

Conclusion

Dibutyl phthalate (DBP) contamination in our waterways is a real concern for fish health, causing issues like metabolic disturbances, oxidative stress and even organ damage. Because DBP sticks around and builds up in organisms, we need effective ways to detoxify it. Enter *Withania somnifera*, or as it's commonly known, ashwagandha. This plant has shown great potential as a natural remedy, boasting impressive antioxidant effects and the ability to protect the liver and regulate metabolism. Studies indicate that it might help reduce the harm caused by DBP, helping the affected fish regain their physiological balance. Still, we need more research to fine-tune how we use it, discover the details behind its molecular actions, and understand its long-term benefits for the environment. By incorporating *Withania somnifera* into our pollution management strategies, we could tackle aquatic pollution more sustainably.

References

- Ahmed R, Khan S and Alam M (2021) Metabolic disruptions in fish exposed to endocrine-disrupting chemicals: A review. *Aquatic Toxicology* **236**, 105895.
- Chen L, Huang Y and Li R (2022) Bioaccumulation and toxicity of dibutyl phthalate in aquatic ecosystems: A review. *Environ. Sci. Technol.* **56**(14), 9210-9223.
- Gao P, Zhang H and Wang X (2021) Endocrine-disrupting effects of phthalates in fish: Mechanisms and consequences. *Toxicology Reports* **8**, 1142-1151.
- Gao Y, Wang J, Li X and Chen L (2019) Dibutyl phthalate toxicity in aquatic organisms: Mechanisms and effects. *Environ. Poll.* **252**, 837-845.
- Gupta R and Patel S (2020) Therapeutic potential of *Withania somnifera* in oxidative stress-related disorders. *J. Herbal Med.* **23**, 100379.
- Jin X, Xu Y and Zhang Z (2018) Bioaccumulation and metabolic effects of phthalates in freshwater fish. *Ecotoxicol. Environ. Saf.* **162**, 309-316.
- Kumar P, Sharma S and Singh M (2021) Endocrine-disrupting chemicals in aquatic environments: Sources, impacts, and mitigation strategies. *Environ. Sci. Poll. Res.* **28**(14), 17892-17910.
- Li H, Zhao Q and Xu T (2020) Environmental occurrence and fate of phthalates in aquatic ecosystems. *Water Res.* **183**, 115944.
- Liu Z, Wu H and Chen Y (2020) Effects of phthalate exposure on metabolic health in fish: A review. *Aquatic Toxicol.* **229**, 105677.
- Mishra P and Verma N (2022) Protective effects of *Withania somnifera* against hepatotoxicity in fish: A biochemical approach. *Fish Physiol. Biochem.* **48**(5), 1357-1369.
- Mishra S and Verma R (2022) Protective effects of *Withania somnifera* against environmental toxicants: A biochemical perspective. *Environ. Toxicol. Pharmacol.* **90**, 103770.
- Peng J, Liu M and Zhou S (2021) Strategies for mitigating phthalate pollution in aquatic environments. *Environ. Manage.* **67**(4), 1023-1035.
- Rai M, Jogee P S, Agarkar G and dos Santos C A (2019) Anticancer and antimicrobial potential of *Withania somnifera* phytochemicals. *Crit. Rev. Microbiol.* **45**(3), 303-318.
- Rai R, Sharma T and Bhattacharya S (2019) Phytochemicals of *Withania somnifera* and their role in oxidative stress management. *J. Traditional and Complementary Medicine* **9**(3), 217-226.
- Sharma D, Kumar N and Singh R (2023) Ameliorative effects of medicinal plants on aquatic toxicology: A review. *Aquaculture Reports* **27**, 101342.

- Sharma P, Kumari P and Gupta R (2023) Herbal therapeutics in aquatic toxicology: A review on *Withania somnifera*. *J. Environ. Biol.* **44**(2), 245-256.
- Singh B, Maheshwari M and Sharma H (2024) Nutritional studies on fish *Catla catla* found in Ganga River with hydrobiological studies. *J. Sci. Innov. Nat. Earth* **4**, 17-22.
- Singh B, Nath H, Prveen and Singh S (2024) A review on effect of cypermethrin on hematology of fresh freshwater fish, *Channa punctatus* (Bloch.). *J. Sci. Innov. Nat. Earth* 52-57.
- Singh R and Sharma P (2020) Goldfish as a model for studying metabolic disorders in aquatic toxicology. *Comp. Biochem. Physiol. Part C: Toxicol. Pharmacol.* **234**, 108785.
- Sun X, Wang Y and Li J (2023) Neurotoxic effects of phthalates in fish: Implications for environmental health. *Sci. Total Environ.* **872**, 162048.
- Wang J, Li X and Zhao H (2021) Phthalate esters in freshwater ecosystems: Occurrence, toxicity, and risk assessment. *Ecotoxicol. Environ. Saf.* **210**, 111877.
- Xu B, Zhang W and Li C (2019) Phthalate contamination in freshwater ecosystems: Distribution, bioaccumulation, and toxicological effects. *Chemosphere* **224**, 605-615.
- Zhang X, Liu Y and Wang J (2019) Occurrence and ecological risks of phthalates in surface waters. *Environ. Poll.* **249**, 1022-1030.
- Zhou Y, Li H and Sun X (2022) Oxidative stress and metabolic alterations in fish exposed to dibutyl phthalate: A biochemical perspective. *Toxicology Reports* **9**, 832-840.