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A REVIEW ON THE IMPACT OF POLLUTED WATER ON INSECT DIVERSITY (ODONATES)

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Abstract: Water pollution poses a critical environmental threat, significantly impacting the biodiversity of aquatic ecosystems. A comprehensive review of previous research highlights that pollution disrupts habitats, diminishes food availability, and increases the risk of disease outbreaks, ultimately leading to a decline in species diversity. Furthermore, the ecological consequences of reduced odonate diversity extend beyond insect populations, affecting entire aquatic food webs and ecosystem stability. Among the various organisms affected, aquatic insects serve as essential bioindicators as a result of their sensitivity to changes in water quality. This study focuses on the relationship between water pollution and odonate diversity, emphasizing the role of specific indicator species in assessing ecosystem health. Our findings reveal that ponds with healthy water quality support a higher abundance of odonate species, particularly *Trithemis festiva* and *Bradinopyga geminata*, which thrive in relatively unpolluted environments. Conversely, in ponds classified as having poor or extremely poor water quality, odonate species such as *Zyxomma petiolatum* and *Ceriagrion cerinorubellum* were more prevalent, indicating contamination. These results imply that odonates can effectively reflect water quality variations and pollution levels. The study further examines the influence of key pollutants, including heavy metal and pesticides, with nutrient-rich runoff from agricultural and industrial sources, on aquatic insect populations. Considering these findings, this study underscores the urgent need for stricter environmental regulations, sustainable water management practices, and targeted conservation efforts to mitigate pollution and preserve freshwater biodiversity.

IndexTerms **- Aquatic Ecosystem, Environmental Degradation, Heavy Metals, Insect Diversity, Pesticides, Odonates, Water Pollution.**

I. INTRODUCTION

Water pollution poses a significant threat to freshwater ecosystems, disrupting biodiversity and altering ecological interactions. The functioning of lotic ecosystems depends on aquatic insects, which make up a large portion of macroinvertebrates and are also often regarded as reliable biological monitors of water quality(Friberg 2014). Among the most sensitive and ecologically important groups of freshwater insects are odonates (dragonflies and damselflies), which serve as bioindicators of water quality. As ectotherms, aquatic insects are exhibit high sensitivity to variations in water quality, making them valuable indicators of environmental health. Odonata are found in a diverse of freshwater habitats that are affected by both biotic factor and abiotic factor. Both permanent and seasonal ecosystems can thrive there, and they can be present in both lotic and lentic systems, which span from tree holes to big lakes and rivers.

Odonates are widely recognized as reliable indicators of environmental quality in aquatic ecosystem for well-documented reasons. Although the majority of species are confined to strictly aquatic environments, some exceptions exist globally. Certain species, such as a few *Megalagrion* species, develop as larvae in upland habitats, particularly in moist leaf litter, where consistently high relative humidity supports their survival (Polhemus and Asquith 1996). Since they reproduce by laying eggs exclusively in or around freshwater, their high population density in a region serves as a reliable indicator of good freshwater quality(Corbet 1999). Water pollution, particularly from industrial, agricultural, and urban sources, has become a growing concern for biodiversity in freshwater habitats. Studies have shown that pollutants such as heavy metals, pesticides, and excessive nutrients significantly reduce insect diversity (Wani and Shah 2024). Pollution in aquatic environments typically originates from point and non-point sources. Heavy metals, such as mercury, cadmium, and lead, accumulate in water bodies and have toxic effects on aquatic life, including insects (Khayatzadeh and Abbasi 2010). These pollutants can interfere with the reproductive success, growth, and survival of aquatic insects. Odonates react to the buildup of heavy metals quickly and sensitively. The most vulnerable species to habitat disruption are thought to be dragonflies, particularly in lakes and flooded drainage areas (Shafie et al. 2017). Insect diversity is essential for maintaining ecosystem functions. The pollution of these water bodies have been associated with changes in the physicochemical properties of the water (Amaeze et al. 2012). These modifications may then have an impact on the distribution patterns of aquatic life, such as insects, which could reveal information about the quality of the water. Therefore, using aquatic insects to measure water quality can give environmental managers and decision-makers pertinent information that will help them make accurate and rational decisions about the condition and quality of water bodies as well as the efficacy of current laws and regulations (Bauernfeind and Moog 2000). Anthropogenic impacts on urban watercourses are frequently induced by the organic enrichment of water from both industrial and residential effluents. Aquatic insect assemblage is impacted by this type of pollution since it alters the physical and chemical properties of aquatic environments(HBN 1970) (Ward, Holmes, and José 1994). The aim of this study is to review existing literature on the impact of polluted water on insect diversity special reference to odonates and to analyze the findings from various studies, and discuss possible strategies for reducing these adverse effects of water pollutants.

1.1 **Introduction to Odonates and Polluted Water**

Odonates as Bioindicators: Odonates are Extremely responsive to environmental variations, especially water quality, making them best bioindicators for monitoring pollution. The stages of their life, which includes both aquatic and terrestrial stages, means they are exposed to pollutants in both environments (Datto-Liberato et al. 2024). **Pollution in Water**: Polluted water typically refers to water bodies contaminated with chemicals, nutrients, sediments, or other harmful substances. Common pollutants include heavy metals, pesticides, organic contaminants, and excessive nutrients like nitrogen and phosphorus, often from agricultural runoff or industrial discharge(Madhav et al. 2020), and (Cooper 1993).

1.2 **Types of Pollution and Their Effects on Odonates**

Pollution can affect odonates in multiple ways:

Chemical Pollution: Heavy Metals such as Mercury, Cadmium, Lead can accumulate in the bodies of aquatic organisms, leading to toxicity. Odonate larvae, being bottom-dwellers or predators, can ingest these metals, leading to impaired development, reduced survival rates, or abnormal behavior(Manjula Kt et al. 2024). Pesticides can kill or cause deformities in larvae and adults, as well as disrupt reproductive processes. Odonates are sensitive to pesticide exposure during their aquatic larval stage(Takamura, Hatakeyama, and Shiraishi 1991).

Nutrient Pollution (Eutrophication): Excessive nutrients (nitrogen and phosphorus) can lead to algal blooms and a decrease in oxygen levels in water, creating hypoxic or anoxic conditions which are detrimental to aquatic life, including odonates. Poor water quality and reduced oxygen availability can decrease larval survival and growth. Nutrient pollution can also alter the composition of aquatic vegetation, Resulting in the loss of habitat for odonates. The growth of invasive plants due to nutrient enrichment can further decrease suitable habitats for both larvae and adult odonates(Janssen et al. 2018).

Sedimentation and Physical Pollution: Excessive sedimentation can decrease water clarity and block sunlight, disrupting the photosynthesis of aquatic plants, which are a key food source and habitat for odonates. Sediment can also clog the respiratory structures of larvae, causing suffocation, and impair their ability to capture prey. Increased turbidity from sediments and pollutants can also lead to changes in feeding behavior and predation rates in adult odonates, as visibility is compromised(Villalobos-Jimenez, Dunn, and Hassall 2016).

1.3 **Impacts on Odonates Life Stages:** Odonates go through several life stages that may be differently affected by pollution:

Eggs: Various environmental factors may result in higher mortality rates, like extreme temperatures, drying out (desiccation), exposure to pollutants, attacks by parasitoids, and, in some cases, predation(Corbet 1999). Pollutants such as heavy metals, pesticides, and organic waste can penetrate the egg membranes, leading to developmental abnormalities or death(Relyea 2005). Nutrient pollution (e.g., nitrogen and phosphorus) can alter water chemistry, delaying egg hatching and reducing survival rates(Smith and Schindler 2009).

Naiad (larval) stage: Odonate naiads are entirely aquatic and are particularly vulnerable to water pollution due to their long developmental period (several months to years).Naiads are highly sensitive to pollutants such as pesticides, heavy metals, and industrial chemicals, which can cause mortality or sublethal effects like reduced growth and developmental delays(Beketov and Liess 2008). Pollution can negatively impact the abundance of prey (e.g., small aquatic invertebrates) for naiads, leading to starvation or stunted growth(Johansson and Brodin 2003). Eutrophication caused by nutrient pollution can lead to algal blooms and subsequent oxygen depletion, making the habitat uninhabitable for naiads(Smith and Schindler 2009). Naiads can accumulate toxins like heavy metals in their tissues, which can impair their development and survival(Mogren and Trumble 2010).

Adults: Adults depend on clean water for mating and laying eggs. Polluted water can discourage females from laying eggs, or it may cause the eggs to develop improperly. This reliance on clean water highlights how pollution can directly interfere with their reproductive success(Córdoba-Aguilar, Beatty, and Bried 2023). Adult odonates feed on other insects, which may also be influenced by pollution. Consuming contaminated prey can cause bioaccumulation of toxins, affecting adult health and longevity(Stoks and Córdoba-Aguilar 2012). Pollutants like pesticides can affect the behavior of adult odonates, including their ability to hunt, mate, and avoid predators(Janssens and Stoks 2013).

II. DISCUSSION

According to various past studies, The impact of polluted water on odonate diversity is profound, affecting their survival, development, and ecological roles. Various types of pollution—including chemical contaminants, heavy metals, nutrient enrichment, and habitat degradation—pose significant threats to odonate populations across different life stages. Heavy metals have hazardous qualities even at minimal concentrations and are distinguished by their large density relevant to other metals (Paul 2017) (Bhanse et al. 2022). Insect density and PO_4^{3-} and NO_2^- have been identified as negatively correlated. that several aquatic insect species are highly vulnerable to pollution or habitat modification, this could be because the colonization was disrupted by elevated pollution levels with high concentrations of PO_4^{3-} and NO_2^- (Rajasegar 2003). Numerous physico-chemical and biological metrics have been examined in connection with river water pollution, as well as the variability of these parameters. According to the chemical study, the polluted sites IVth and Vth of Hosangabad had low levels of dissolved oxygen, high levels of heavy metals such iron, zinc, copper, and manganese, and high levels of chloride, total hardness, total alkalinity, and COD. These findings suggest a significant pollution load. Urban activities has a bigger impact on ground and river water quality, according to the current study(Malviya, Diwakar, and Choubey 2010). Strict regulatory measures and a number of policy adjustments for maintaining the river system's water quality have also been brought about by these research. The current observations at the Narmada's Hoshangabad and Nemawar stretch strongly suggest the possibility of ecological improvement, which would increase aquatic productivity in our river systems by controlling wastewater discharge. The abundance and distribution of odonate species in ponds of varying water quality highlight their potential as bioindicators of ecosystem health. In the study area, ***Bradinopyga geminata*** was found to dominate ponds with superior and healthy water quality, whereas **Trithemis festiva** was prevalent in ponds with medium-quality water. In contrast, ***Zyxomma petiolatum*** (Dragonfly) along with ***Ceriagrion cerinorubellum*** were more abundant in ponds with poor and very poor water quality, respectively. These findings indicate that specific odonate species are closely associated with different water quality conditions, making them valuable indicators for ecological assessments (Jacob, Thomas, and Manju 2017).

III. CONCLUSION

Insects are valuable bioindicators, and their decline signals broader environmental degradation. The impacts of water pollution on insect diversity are profound and widespread. Pollution from heavy metals, pesticides, and nutrients has led to a decline in the diversity of aquatic insect populations, disrupting ecological functions and the stability of freshwater ecosystems. To mitigate these effects, stricter pollution control measures, sustainable agricultural practices, and effective water management strategies must be implemented. Future research should focus on understanding the synergistic effects of multiple pollutants on aquatic insect

diversity and exploring solutions for restoring polluted aquatic habitats. Numerous heavy metals, including copper, arsenic, cadmium, iron, zinc, nickel, lead along with chromium, and aluminium, had an impact on the large population of of aquatic insect species, which are included in the benthic taxonomic orders including Coeleoptera, Ephemeroptera, Odonata, Diptera, in addition Trichoptera, and Plecoptera (Tabassum et al. 2024).

V. REFERENCES

1. Amaeze, Nnamdi H., Rosemary I. Egonmwan, A. F. Jolaoso, and A. A. Otitoloju. 2012. "Coastal Environmental Pollution and Fish Species Diversity in Lagos Lagoon, Nigeria." *International Journal of Environmental Protection* 2(11):8–16.
2. Bauernfeind, Ernst, and Otto Moog. 2000. "Mayflies (Insecta: Ephemeroptera) and the Assessment of Ecological Integrity: A Methodological Approach." *Hydrobiologia* 422/423:71–83. doi: 10.1023/A:1017090504518.
3. Beketov, Mikhail A., and Matthias Liess. 2008. "Potential of 11 Pesticides to Initiate Downstream Drift of Stream Macroinvertebrates." *Archives of Environmental Contamination and Toxicology* 55(2):247–53. doi: 10.1007/s00244-007-9104-3.
4. Bhanse, Poonam, Anuja Maitreya, Ayurshi Patil, Prerna Yesankar, Lal Singh, and Asifa Qureshi. 2022. "Agrochemicals: Provenance, Environmental Fate, and Remediation Measures." Pp. 25–59 in *Agrochemicals in Soil and Environment*, edited by M. Naeem, J. F. J. Bremont, A. A. Ansari, and S. S. Gill. Singapore: Springer Nature Singapore.
5. Cooper, C. M. 1993. "Biological Effects of Agriculturally Derived Surface Water Pollutants on Aquatic Systems—A Review." *Journal of Environmental Quality* 22(3):402–8. doi: 10.2134/jeq1993.00472425002200030003x.
6. Corbet, Philip S. 1999. *Dragonflies: Behaviour and Ecology of Odonata.* Harley Books.
7. Córdoba-Aguilar, Alex, Christopher Beatty, and Jason Thomas Bried. 2023. *Dragonflies and Damselflies: Model Organisms for Ecological and Evolutionary Research*. Oxford University Press.
8. Datto-Liberato, Felipe H., Vinicius M. Lopez, Thiago Quinaia, Renato Farias do Valle Junior, Michael J. Samways, Leandro Juen, Carlos Valera, and Rhainer Guillermo-Ferreira. 2024. "Total Environment Sentinels: Dragonflies as Ambivalent/Amphibiotic Bioindicators of Damage to Soil and Freshwater." *Science of The Total Environment* 934:173110. doi: 10.1016/j.scitotenv.2024.173110.
9. Friberg, Nikolai. 2014. "Impacts and Indicators of Change in Lotic Ecosystems." *WIREs Water* 1(6):513–31. doi: 10.1002/wat2.1040.
10. HBN, HYNES. 1970. "The Ecology of Running Waters. University of Toronto Press, Toronto." *JN Am Benthol Soc* 16:109–19.
11. Jacob, S., A. P. Thomas, and E. K. Manju. 2017. "Odonata (Dragonflies and Damselflies) as Bio-Indicators of Water Quality." *International Journal of Innovative Research in Science, Engineering and Technology* 6(9):19464–74.
12. Janssen, Alina, Holger Hunger, Werner Konold, Gesine Pufal, and Michael Staab. 2018. "Simple Pond Restoration Measures Increase Dragonfly (Insecta: Odonata) Diversity." *Biodiversity and Conservation* 27(9):2311–28. doi: 10.1007/s10531-018-1539-5.
13. Janssens, Lizanne, and Robby Stoks. 2013. "Exposure to a Widespread Non-Pathogenic Bacterium Magnifies Sublethal Pesticide Effects in the Damselfly Enallagma Cyathigerum: From the Suborganismal Level to Fitness-Related Traits." *Environmental Pollution* 177:143–49.
14. Johansson, Frank, and Thomas Brodin. 2003. "Effects of Fish Predators and Abiotic Factors on Dragonfly Community Structure." *Journal of Freshwater Ecology* 18(3):415–23.
15. Khayatzadeh, J., and E. Abbasi. 2010. "The Effects of Heavy Metals on Aquatic Animals." Pp. 26–28 in *The 1st international applied geological congress, department of geology, islamic azad university–mashad branch, Iran*. Vol. 1.
16. Madhav, Sughosh, Arif Ahamad, Amit K. Singh, Jyoti Kushawaha, Joginder Singh Chauhan, Sanjeev Sharma, and Pardeep Singh. 2020. "Water Pollutants: Sources and Impact on the Environment and Human Health." Pp. 43–62 in *Sensors in Water Pollutants Monitoring: Role of Material*, edited by D. Pooja, P. Kumar, P. Singh, and S. Patil. Singapore: Springer.
17. Malviya, Ashutosh, S. K. Diwakar, and O. N. Choubey. 2010. "Chemical Assessment of Narmada River Water at Hoshangabad City and Nemawar as Navel of River in Central India." *Oriental Journal of Chemistry* 26(1):319.

18. Manjula Kt, K. Vijaya, V. Joseph, and P. Jayakrishnan. 2024. "Dragonflies and Damselflies: A Comprehensive Review on Their Role as Heavy Metal Bioindicators in Aquatic Ecosystems." 419–29. doi: 10.13189/eer.2024.120407.
19. Mogren, Christina L., and John T. Trumble. 2010. "The Impacts of Metals and Metalloids on Insect Behavior." *Entomologia Experimentalis et Applicata* 135(1):1–17. doi: 10.1111/j.1570-7458.2010.00967.x.
20. Paul, Dipak. 2017. "Research on Heavy Metal Pollution of River Ganga: A Review." *Annals of Agrarian Science* 15(2):278–86.
21. Polhemus, Dan Avery, and Adam Asquith. 1996. "Hawaiian Damselflies: A Field Identification Guide." *Bishop Museum Press*.
22. Rajasegar, M. 2003. "Physico-Chemical Characteristics of the Vellar Estuary in Relation to Shrimp Farming." *Journal of Environmental Biology* 24(1):95–101.
23. Relyea, Rick A. 2005. "THE IMPACT OF INSECTICIDES AND HERBICIDES ON THE BIODIVERSITY AND PRODUCTIVITY OF AQUATIC COMMUNITIES." *Ecological Applications* 15(2):618–27. doi: 10.1890/03-5342.
24. Shafie, Mohd SI, A. Wong, Sahana Harun, and Arman Hadi Fikri. 2017. "The Use of Aquatic Insects as Bio-Indicator to Monitor Freshwater Stream Health of Liwagu River, Sabah, Malaysia." *Journal of Entomology and Zoology Studies* 5(4):1662–66.
25. Smith, Val H., and David W. Schindler. 2009. "Eutrophication Science: Where Do We Go from Here?" *Trends in Ecology & Evolution* 24(4):201–7.
26. Stoks, Robby, and Alex Córdoba-Aguilar. 2012. "Evolutionary Ecology of Odonata: A Complex Life Cycle Perspective." *Annual Review of Entomology* 57(1):249–65. doi: 10.1146/annurev-ento-120710-100557.
27. Tabassum, Sazia, C. B. Kotnala, Mohammed Salman, Mohd Tariq, Afzal Husain Khan, and Nadeem A. Khan. 2024. "The Impact of Heavy Metal Concentrations on Aquatic Insect Populations in the Asan Wetland of Dehradun, Uttarakhand." *Scientific Reports* 14(1):4824. doi: 10.1038/s41598-024-52522-5.
28. Takamura, Kenzi, Shigehisa Hatakeyama, and Hiroaki Shiraishi. 1991. "Odonate Larvae as an Indicator of Pesticide Contamination." *Applied Entomology and Zoology* 26(3):321–26.
29. Villalobos-Jimenez, Giovanna, A. Dunn, and Christopher Hassall. 2016. "Dragonflies and Damselflies (Odonata) in Urban Ecosystems: A Review." *European Journal of Entomology* 113:217–32.
30. Wani, Rasy Fayaz Choh, and Ishteyaq Majeed Shah. 2024. "Impact of Environmental Pollution on Diversity of Insects: A Case Study of Some Major Insect Orders." Pp. 17–53 in *Insect Diversity and Ecosystem Services*. Apple Academic Press.
31. Ward, Diana, Nigel Holmes, and Paul José. 1994. "The New Rivers and Wildlife Handbook."