Ecopharmacovigilance: A Review of Environmental Impacts of Pharmaceuticals

Dr. Lekhika Singh
Tutor, Krishna Institute of Medical Sciences,Krishna Vishwa Vidyapeeth
"Deemed To Be University",Karad –415110,Maharashtra

Dr. A.V.Chavda
Tutor, Krishna Institute of Medical Sciences,Krishna Vishwa Vidyapeeth
"Deemed To Be University",Karad –415110,Maharashtra

Dr.A.S.Shah
Tutor, Krishna Institute of Medical Sciences,Krishna Vishwa Vidyapeeth
"Deemed To Be University",Karad –415110,Maharashtra

Abstract

Ecopharmacovigilance monitors medications' environmental effects. Pharmaceuticals are used worldwide, raising worries about their environmental impact and health risks. This review paper summarizes ecopharmacovigilance knowledge.

Pharmaceuticals enter the environment through human and animal urine, incorrect disposal, and industrial wastewater discharge. Pharmaceuticals can pollute air, water, and soil. These substances can interact with non-target species and cause ecological problems at different trophic levels.

Environmental pharmaceuticals affect aquatic, terrestrial, and microbiological life. Behaviour, growth, reproduction, development, and physiological and biochemical systems are affected. Pharmaceutical exposure disrupts aquatic food webs, endocrine systems, and antibiotic resistance. Pharmaceutical bioaccumulation and biomagnification can affect higher trophic levels.

Pharmaceuticals' various chemical characteristics, low concentrations, and complicated matrices make environmental detection and monitoring difficult. HPLC, MS, and immunoassays have been used, but standardization, matrix interferences, and the wide range of medicines in the environment provide challenges. Analytical methodologies for certain pharmacological classes and their transformation products need further development.

Pharmaceutical makers, regulators, healthcare providers, and the public must work together to reduce pharmaceutical environmental consequences. Eco-friendly medications, wastewater treatment improvements, and correct disposal are strategies. Mitigation measures include

green pharmacy, which reduces pharmaceutical use and waste and avoids hazardous substances.

In conclusion, ecopharmacovigilance is essential for recognizing and managing pharmaceutical environmental consequences. We can protect the environment and encourage responsible pharmaceutical use for ecosystems and human health by taking a holistic approach and promoting sustainable behaviours.

Keywords: ecopharmacovigilance, pharmaceuticals, environmental impacts, contamination, monitoring, mitigation

Introduction

Human health and wellbeing have considerably improved as a result of the widespread use of medications. Concerns have been raised concerning these chemicals' possible ecological effects, though, as a result of increased consumption and consequent environmental release of these compounds. An emerging field called ecopharmacovigilance focuses on monitoring and evaluating the environmental dangers connected to medications. In order to address the environmental issues that pharmaceuticals bring, this review paper intends to provide a thorough introduction to the topic of ecopharmacovigilance [1,2].

Pharmaceutical use has increased significantly over the past few decades as a result of variables like population growth, aging populations, and medical advancements. Because of the active substances that are excreted in human and animal waste, medicines are now pervasive in the environment. The contamination of natural ecosystems is also a result of improper disposal methods and the release of wastewater from pharmaceutical manufacture. Due to their possible negative impacts on ecosystems and human exposure, medicines in the environment are a cause for concern. These substances can affect non-target species, such as aquatic critters, terrestrial fauna, and even microbial communities, even if they are intended to have specific impacts on the organisms they are intended to affect. Understanding how pharmaceutical pollution affects the environment is essential for efficient environmental management and the preservation of biodiversity [3-5].

Additionally, the environmental discharge of pharmaceuticals can result in long-term persistence and bioaccumulation in species, raising questions regarding possible dangers to the environment and human health. Additionally, the pharmaceutical transformation products that result from metabolic processes or environmental degradation can have various chemical characteristics and may present additional difficulties for detection and evaluation [6,7].

Ecopharmacovigilance is essential in systematically monitoring, assessing, and reducing the environmental effects of pharmaceuticals due to the intricacy and complexity of pharmaceutical contamination. This review study intends to investigate the ecological consequences of medicines, emphasize obstacles in detection and monitoring, and propose viable mitigation techniques. It also discusses the origins and pathways of pharmaceutical contamination. This study seeks to contribute to the establishment of effective policies and

practices for environmental preservation and sustainable pharmaceutical use by putting light on these concerns [8-10].

Sources and Pathways of Pharmaceutical Contamination

Point and diffuse sources of pharmaceutical contamination can cause environmental contamination [1]. Pharmaceuticals can enter the environment by direct discharge at point sources such pharmaceutical production facilities, hospitals, and wastewater treatment plants [2]. These facilities frequently discharge wastewater with pharmaceutical residues that has not been adequately or not at all treated [3]. Domestic wastewater, agricultural runoff, and animal husbandry operations are examples of diffuse sources [4]. Pharmaceuticals are introduced through these routes into soil, water, and even the atmosphere [5].

Pharmaceutical contamination originates mostly from pharmaceutical production sites. Studies have shown that these factories' effluents include a variety of medicines [6]. Additionally, poor disposal techniques, such as throwing away or flushing unneeded prescriptions down the toilet, cause pharmaceuticals to leak into the environment [7]. Hospitals are also significant point sources since patients excrete drugs and old or unused medications are disposed of there [8].

Pharmaceutical contamination can also be caused by diffuse sources like home wastewater. Pharmaceutical residues excreted by people following drug use can be found in domestic wastewater [9]. Additionally, through runoff and leaching, agricultural practices, such as the use of medications in livestock production, contribute to the contamination of water bodies [10]. Pharmaceuticals may be released into the environment through the application of manure as a result of animal husbandry methods such the giving of antibiotics to encourage growth [11].

Through the volatilization of water and soil surfaces and the discharge of aerosols during pharmaceutical manufacture, medications can enter the atmosphere [12]. Pharmaceuticals may change after entering the environment by a variety of processes, including as degradation, sorption to sediment, or uptake by plants [13]. Their persistence and mobility in the environment may also be impacted by these changes.

For successful ecopharmacovigilance and the creation of suitable mitigation solutions, it is essential to understand the origins and pathways of pharmaceutical contamination. By locating these sources, it is possible to put in place focused actions to lessen the amount of drugs that enter the environment and lessen their ecological effects.

Ecological Effects of Pharmaceuticals

It has been discovered that pharmaceuticals in the environment have a variety of negative consequences on many ecosystems and creatures [1]. The ecological effects of pharmacological exposure are particularly dangerous for aquatic animals like fish, amphibians, and invertebrates [2]. Pharmaceuticals have been proven to affect aquatic organisms' behaviour, growth, reproduction, and development [3]. For instance,

antidepressant exposure has been linked to alterations in fish behaviour, including changed eating and mating habits [4].

Pharmaceuticals can also interfere with aquatic creatures' endocrine systems, which can cause problems in reproduction [5]. In fish exposed to hormonal contraceptives such ethinylestradiol, endocrine disruption has been noted [6]. In addition, bacteria, including those found in aquatic systems, can become resistant to antibiotics as a result of the presence of antibiotics in the environment [7].

Aquatic food webs may experience cascading impacts from pharmaceutical pollution. For instance, the primary producers that form the basis of aquatic ecosystems, such as algae and phytoplankton, can be harmed by the presence of medicines [8]. This may then have an effect on the diversity and quantity of organisms at higher trophic levels, such as fish, birds, and zooplankton, which depend on these organisms for food [9].

Pharmaceuticals may have an impact on a range of animals in terrestrial environments, including mammals, birds, and insects [10]. Pharmacological exposure can affect a wildlife species' behaviour and physiology as well as its ability to reproduce [11]. Additionally, the fall in vulture populations brought on by the consumption of tainted carcasses has been linked to the growing use of veterinary medications in cattle production [12].

Pharmaceuticals' ecological effects must be understood in order to evaluate any threats to ecosystems and the need for mitigation measures. The ecological effects of pharmaceutical contamination can be reduced by taking the necessary precautions after determining the precise effects on various organisms and trophic levels.

Detection and Monitoring Challenges

Pharmaceuticals have a variety of chemical properties, are present at low quantities, and can be found in complex matrices, which makes it difficult to detect and monitor them in the environment [1]. Numerous analytical methods, such as high-performance liquid chromatography (HPLC), mass spectrometry (MS), and immunoassays, have been used for their detection [2]. Due to the large variety of pharmaceutical chemicals and their transformation products that are prevalent in the environment, standardizing analytical procedures is still difficult [3].

Because of their low quantities in environmental samples, pharmaceuticals present one of the biggest detection hurdles. Pharmaceutical residues are frequently discovered in the parts per billion (ppb) or parts per trillion (ppt) range [4], usually at trace quantities. Because of this, sensitive analytical techniques must be created that can identify and measure these chemicals at such low concentrations [5].

Another difficulty for pharmacological detection and monitoring is the complexity of environmental matrices such water, sediment, and soil [6]. The accuracy and dependability of analytical data can be impacted by the presence of a variety of coexisting molecules, interfering substances, and matrix effects in these matrices [7]. Additionally, the many

chemical characteristics of medications, such as variations in polarity and stability, make it more difficult to analyze them in intricate environmental matrices [8].

Comprehensive monitoring initiatives are also hampered by the absence of defined methodologies for assessing certain pharmacological classes and the materials that are used in their transformation [9]. Numerous pharmaceutical classes have distinctive chemical characteristics that call for particular analytical techniques for their detection [10]. Effective monitoring requires the development of thorough analytical techniques that cover a wide variety of medicinal substances and their transformation products.

Despite these difficulties, improvements in analytical techniques have enhanced the identification and quantification of pharmaceuticals in environmental samples [11], including the use of high-resolution mass spectrometry and the development of sample preparation techniques. The accuracy and comparability of analytical results are further ensured by standardization initiatives, such as the creation of reference materials and proficiency testing programs [12].

Ecopharmacovigilance must advance if these issues are to be resolved and reliable analytical techniques for pharmaceutical detection and monitoring are to be developed. More precise evaluations of pharmaceutical contamination can be made, which will help with improved understanding and management of their environmental effects. This is made possible by enhancing the sensitivity, selectivity, and dependability of analytical procedures.

Strategies for Mitigation

Pharmaceutical producers, regulatory agencies, healthcare providers, and the general public are just a few of the various stakeholders that must be involved in a thorough strategy to mitigate the environmental effects of pharmaceuticals [1]. To reduce pharmaceutical contamination and encourage sustainable practices, a number of tactics can be used.

The creation and application of medications that are ecologically friendly is a crucial strategy. Green pharmacy programs promote the development and manufacture of chemicals that are less persistent, less bioactive, and more easily degradable in order to lessen the environmental impact of pharmaceuticals [2]. This includes investigating more environmentally friendly synthesis techniques and taking the environment into account when developing new drugs [3].

Technology improvements for wastewater treatment are also essential for reducing pharmaceutical contamination. Pharmaceutical residues in effluents may not be efficiently removed by conventional wastewater treatment facilities [4]. In order to remove pharmaceuticals from wastewater before it is released into the environment, advanced treatment methods such ozonation, activated carbon adsorption, and membrane filtration must be developed and put into use [5].

Preventing pharmaceutical contamination is mostly made possible by following proper disposal procedures for discarded or expired drugs. Public education efforts and collection

initiatives may persuade people to discard or return unneeded prescriptions to designated drop-off places as opposed to flushing them down the toilet [6]. The release of drugs into the environment can also be avoided with the use of pharmaceutical take-back initiatives at healthcare facilities [7].

For the purpose of encouraging safe pharmaceutical use, education and awareness efforts geared toward patients and healthcare professionals are crucial. The overall environmental impact of pharmaceuticals can be decreased by highlighting the significance of effective prescribing practices, dose optimization, and the avoidance of unneeded medication use [8].

To create standards and best practices for sustainable pharmaceutical usage, stakeholders including academic institutions, regulatory agencies, and industry must work together. These initiatives ought to concentrate on reducing pharmaceutical usage, encouraging the adoption of eco-friendly substitutes, and guaranteeing proper disposal procedures [9].

In conclusion, reducing the environmental effects of pharmaceuticals necessitates a multifaceted strategy that includes a range of participants. We can lessen the ecological effects of pharmaceutical contamination and promote sustainable practices for the benefit of ecosystems and human health by promoting the development of environmentally friendly pharmaceuticals, enhancing wastewater treatment technologies, putting into place proper disposal practices, and raising awareness about responsible pharmaceutical use.

Conclusion

Addressing the environmental issues brought on by medications requires ecopharmacovigilance. These substances are now present in the environment due to their extensive use and disposal, raising questions regarding their effects on the environment. The sources and pathways of pharmaceutical contamination, the ecological effects of pharmaceuticals on aquatic and terrestrial organisms, the difficulties in detecting and monitoring pharmaceuticals, and the mitigation strategies have all been highlighted in this review paper.

Collaboration is necessary to properly protect the environment and advance sustainable practices. To create and implement environmentally friendly pharmaceuticals, enhance wastewater treatment technologies, encourage proper disposal procedures, and spread awareness about responsible pharmaceutical use, regulatory authorities, pharmaceutical manufacturers, healthcare providers, and the general public must collaborate.

We can reduce the environmental risks associated with medications and maintain the long-term sustainability of both ecosystems and human health by taking a comprehensive approach and implementing the principles of ecopharmacovigilance into pharmaceutical operations. To advance the subject of ecopharmacovigilance and handle the changing difficulties at the interface between pharmaceuticals and the environment, ongoing research, monitoring, and innovation are crucial.

References:

1. Boxall, A. B. A. (2004). The environmental side effects of medication. EMBO reports, 5(S1), S111-S115. doi: 10.1038/sj.embor.7400220
2. Kümmerer, K. (2009). The presence of pharmaceuticals in the environment due to human use - present knowledge and future challenges. Journal of Environmental Management, 90(8), 2354-2366. doi: 10.1016/j.jenvman.2009.01.023
3. Ternes, T. A. (1998). Occurrence of drugs in German sewage treatment plants and rivers. Water Research, 32(11), 3245-3260. doi: 10.1016/S0043-1354(98)00099-2
4. Kasprzyk-Hordern, B., Dinsdale, R. M., & Guwy, A. J. (2009). The removal of pharmaceuticals, personal care products, endocrine disruptors and illicit drugs during wastewater treatment and its impact on the quality of receiving waters. Water Research, 43(2), 363-380. doi: 10.1016/j.watres.2008.10.047
5. Peng, X., Ou, W., Wang, C., Wang, Z., Huang, Q., Jin, J., & Tan, J. (2014). Occurrence and ecological potential of pharmaceuticals and personal care products in groundwater and reservoirs in the vicinity of municipal landfills in China. The Science of the total environment, 490, 889–898. https://doi.org/10.1016/j.scitotenv.2014.05.068
6. Bound, J. P., & Voulvoulis, N. (2005). Pharmaceuticals in the aquatic environment – A comparison of risk assessment strategies. Chemosphere, 58(7), 797-809. doi: 10.1016/j.chemosphere.2004.09.067
7. Tousova, Z., Oswald, P., Slobodnik, J., Blaha, L., Muz, M., Hu, M., Brack, W., Krauss, M., Di Paolo, C., Tarcai, Z., Seiler, T. B., Hollert, H., Koprivica, S., Ahel, M., Schollée, J. E., Hollender, J., Suter, M. J., Hidasi, A. O., Schirmer, K., Sonavane, M., … Schulze, T. (2017). European demonstration program on the effect-based and chemical identification and monitoring of organic pollutants in European surface waters. The Science of the total environment, 601-602, 1849–1868. https://doi.org/10.1016/j.scitotenv.2017.06.032
8. Goyal, Rajat; Sharma, Archana; Thakur, Vijay Kumar; Ola, Monika; Sharma, Prabodh Chander (2021). Green chemistry approaches towards the design and synthesis of anti-infective fluoroquinolone derivatives. Current Research in Green and Sustainable Chemistry, 4(), 100044–. doi:10.1016/j.crgsc.2020.100044
9. M. Ågerstrand; M. Wester; C. Rudén (2009). The Swedish Environmental Classification and Information System for Pharmaceuticals — An empirical investigation of the motivations, intentions and expectations underlying its development and implementation. , 35(5), 0–786. doi:10.1016/j.envint.2008.12.001
10. Daughton, C. G., & Ternes, T. A. (1999). Pharmaceuticals and personal care products in the environment: agents of subtle change?. Environmental health perspectives, 107 Suppl 6(Suppl 6), 907–938. https://doi.org/10.1289/ehp.99107s6907
11. Kasprzyk-Hordern, B., Dinsdale, R. M., & Guwy, A. J. (2008). Multiresidue methods for the analysis of pharmaceuticals, personal care products and illicit drugs in surface water and wastewater by solid-phase extraction and ultra performance liquid chromatography-electrospray tandem mass

spectrometry. Analytical and bioanalytical chemistry, 391(4), 1293–1308. https://doi.org/10.1007/s00216-008-1854-x

12. World Health Organization. (2017). Wastewater treatment. Retrieved from https://www.who.int/news-room/fact-sheets/detail/wastewater-treatment
13. Zuccato, E., Castiglioni, S., Fanelli, R., Reitano, G., Bagnati, R., Chiabrando, C., Pomati, F., Rossetti, C., & Calamari, D. (2006). Pharmaceuticals in the environment in Italy: causes, occurrence, effects and control. Environmental science and pollution research international, 13(1), 15–21. https://doi.org/10.1065/espr2006.01.004
14. Liu, J., & Wong, M. H. (2013). Pharmaceuticals and personal care products (PPCPs): A review on environmental contamination in China. Environment International, 59, 208-224. doi: 10.1016/j.envint.2013.06.014
15. Paíga, P., Santos, L. H. M. L. M., Ramos, S., Jorge, S., Silva, J. G., & Delerue-Matos, C. (2016). Presence of pharmaceuticals in the Lis river (Portugal): Sources, fate and seasonal variation. The Science of the total environment, 573, 164–177. https://doi.org/10.1016/j.scitotenv.2016.08.089
16. Snyder, S. A., Adham, S., Redding, A. M., Cannon, F. S., DeCarolis, J., Oppenheimer, J., & Wert, E. C. (2007). Role of membranes and activated carbon in the removal of endocrine disruptors and pharmaceuticals. Desalination, 202(1-3), 156-181. doi: 10.1016/j.desal.2006.12.020
17. Verlicchi, P., Al Aukidy, M., & Zambello, E. (2012). Occurrence of pharmaceutical compounds in urban wastewater: Removal, mass load and environmental risk after a secondary treatment—A review. Science of the Total Environment, 429, 123-155. doi: 10.1016/j.scitotenv.2012.04.028
18. Larsen, T. A., Lienert, J., Joss, A., & Siegrist, H. (2004). How to avoid pharmaceuticals in the aquatic environment. Journal of Biotechnology, 113(1-3), 295-304.
19. Díaz-Cruz, M. S., López de Alda, M. J., & Barceló, D. (2003). Environmental behavior and analysis of veterinary and human drugs in soils, sediments and sludge. TrAC Trends in Analytical Chemistry, 22(6), 340-351. doi: 10.1016/S0165-9936(03)00603-7
20. Brooks, B. W., Foran, C. M., Richards, S. M., Weston, J., Turner, P. K., Stanley, J. K., ... & Barreda, D. (2003). Aquatic ecotoxicology of fluoxetine. Toxicology Letters, 142(3), 169-183. doi: 10.1016/S0378-4274(03)00034-4