

Aqua-toxicity of Pharmaceuticals and Illicit Drugs: Planetary Boundaries Interactions, Sustainability Relations, and Future Readiness - Are We Prepared to Combat the Threat?

Farzana Ferdoush^a, Mohammed Ali Nause Russel^b, Md. Rakib Rarvez^c, Mosammat Mustari Khanaum^d

^a Ahsanullah University of Science and Technology, Dhaka, Bangladesh; ^b University of Glasgow, Glasgow, UK
^c Inha University, South Korea; ^d North Dakota State University, ND, USA

INTRODUCTION & AIM

Pharmaceutical and illicit drug contamination of water systems has emerged as a critical environmental challenge, exacerbated during the recent pandemic by shifts in healthcare use and human behavior. While previous studies have examined the effects of individual compounds on surface and groundwater, their broader implications for planetary boundaries and sustainability frameworks remain insufficiently explored. This study systematically reviews the literature to assess how pandemic-induced changes have influenced pharmaceutical and illicit drug pollution in surface water system and to evaluate their linkages to the Sustainable Development Goals (SDGs) and planetary boundaries. Using a four-step PRISMA framework, 19 relevant studies were selected from an initial pool of 556 articles. The analysis identified 63 pharmaceutical compounds, classified into eight (8) drug categories, with documented impacts across seven (7) SDGs (Goals 3, 5, 6, 11, 12, 14, and 15), of which SDG 3 (Good Health and Well-Being) and SDG 6 (Clean Water and Sanitation) were most affected. At the planetary scale, pharmaceutical contamination was associated with pressures on the Novel Entities and Biosphere Integrity boundaries. These findings highlight pharmaceutical pollution as a cross-scale sustainability challenge and underscore the need for integrated monitoring, policy intervention, and sustainable water management strategies to mitigate long-term environmental and human health risks.

METHOD

- Four-step Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA, Moher et al., 2009).
- Literature review to identify key interconnections between pharmaceutical and illicit drug pollution, human health risks, and global environmental risks.
- Categorize pharmaceutical compounds and identify their linkages to the Sustainable Development Goals (SDGs) and corresponding SDG targets, with a focus on water system pollution.
- Evaluated the implications of pharmaceutical contamination for planetary boundary transgression.

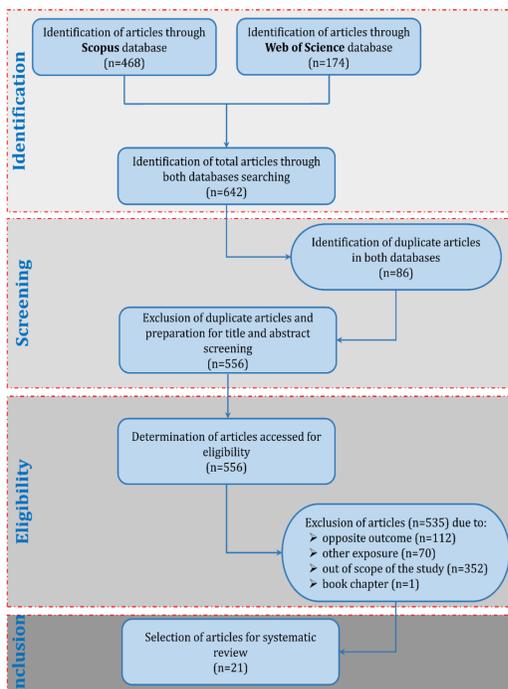


Fig. Flow chart of PRISMA method employed in the systematic review.

RESULTS & DISCUSSION

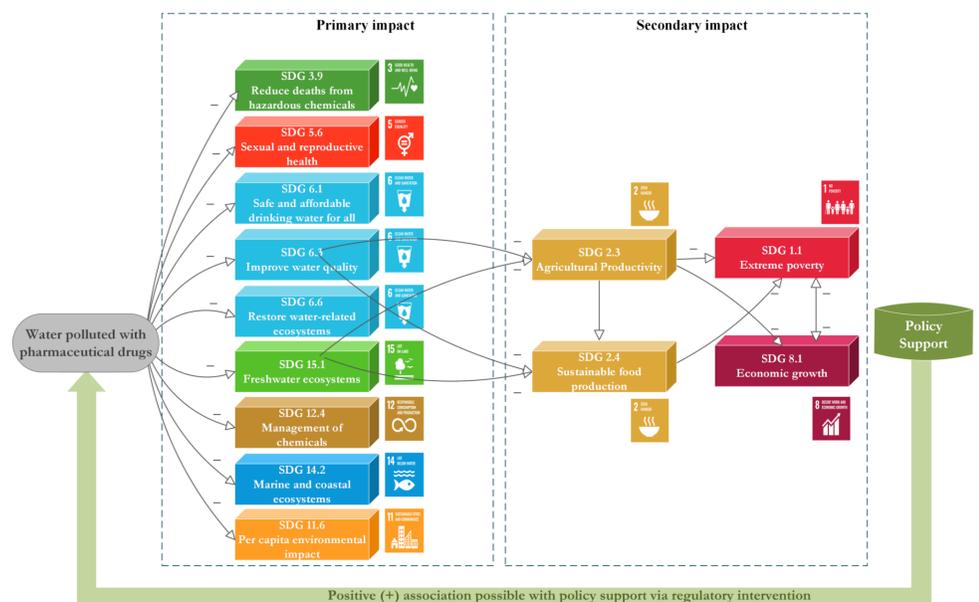


Fig. Conceptual ecological impact on Sustainable Development Goals (SDG) targets.

- A total 63 different drugs samples were observed in surface water sample including remdesivir, hydroxychloroquine, azithromycin, acetaminophen, diphenhydramine, citalopram, amitriptyline, doxepin, tinidazole, linezolid, ritonavir etc.
- Those 63 pharmaceutical compounds were classified into 8 drug categories.
- These pharmaceuticals directly impacted 7 SDG targets and indirectly affected 4 additional targets.
- Clear linkages were identified between the 8 drug categories and 7 SDGs.
- Among the 9 critical processes defined in the planetary boundaries framework, 2 were negatively affected by water pollution caused by these pharmaceutical compounds.

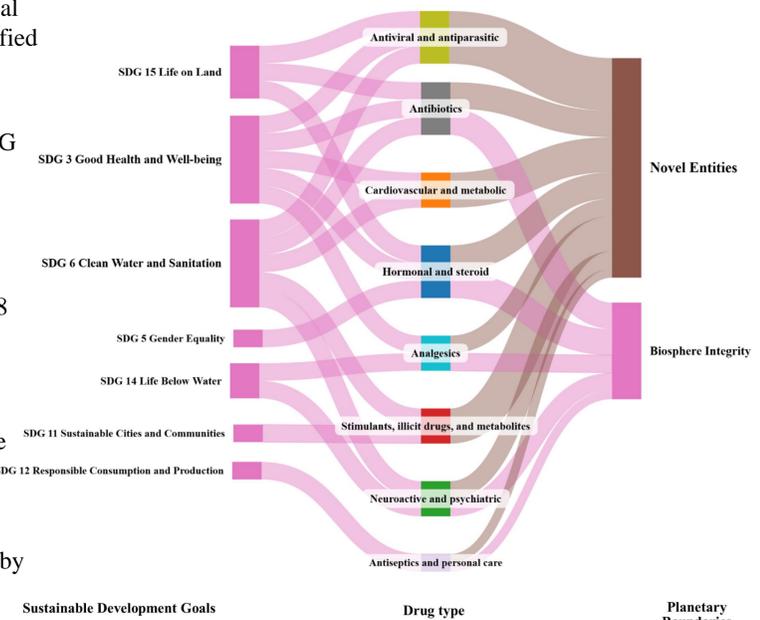


Fig. Illustration showing how pharmaceutical contaminants impacting SDGs and Planetary Boundaries.

CONCLUSION

- A total 63 pharmaceutical compounds were classified into 8 drug categories.
- Pharmaceutical contamination was linked to 7 SDGs: SDG 3, 5, 6, 11, 12, 14, and 15.
- SDG 3 (Good Health and Well-Being) and SDG 6 (Clean Water and Sanitation) were the most impacted.
- Impacts were associated with 2 planetary boundaries: Novel Entities and Biosphere Integrity.
- Results highlight pharmaceutical pollution in water system as a cross-scale sustainability challenge affecting human health, water systems, and ecosystem integrity.

FUTURE WORK / REFERENCES

- Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & PRISMA Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Annals of internal medicine*, 151(4), 264-269
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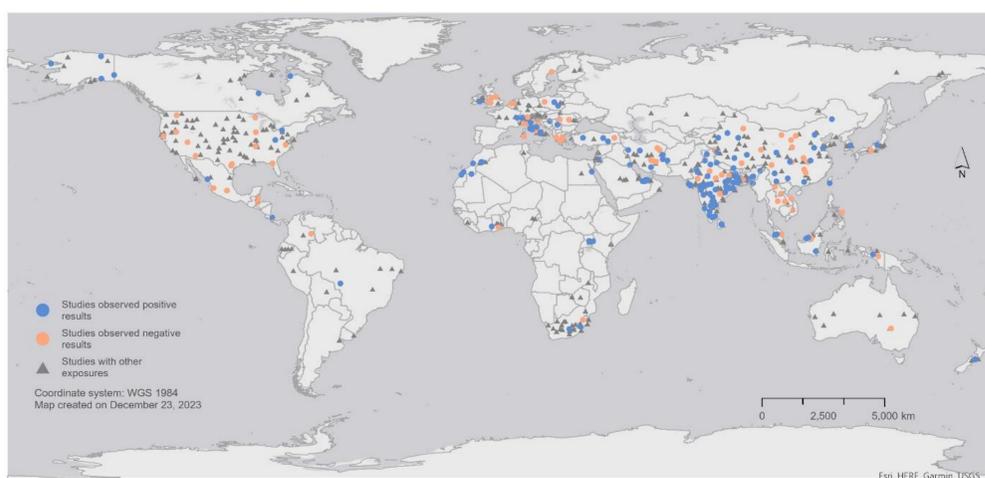


Fig. Global research on the relationship between recent pandemic and environmental quality.