Air and Water Borne Diseases

Editorial Open Access

Wastewater Epidemiology: Community Health Surveillance

Ananya Bose*

Department of Environmental Biotechnology, Jadavpur University, Kolkata, India

***Corresponding Author:** Ananya Bose, Department of Environmental Biotechnology, Jadavpur University, Kolkata, India, E-mail: abose.envbio@jadavpur.edu.in

Received: 01-Nov-2025, Manuscript No. awbd-25-174396; **Editor assigned:** 03-Nov-2025, PreQC No. awbd-25-174396(PQ); **Reviewed:** 17-Nov-2025, QC No. awbd-25-174396; **Revised:** 24-Nov-2025, Manuscript No. awbd-25-174396(R); **Published:** 01-Dec-2025, **DOI**: 10.4172/2167-7719.1000321

Citation: Bose A (2025) Wastewater Epidemiology: Community Health Surveillance. awbd 14: 321.

Abstract

Wastewater-based epidemiology (WBE) is a vital tool for public health surveillance, offering non-invasive, real-time insights into community health. It effectively monitors SARS-CoV-2 outbreaks, tracks viral spread and emerging variants, and provides objective data on illicit drug use patterns for public health interventions. WBE also extends to assessing pharmaceuticals, personal care products, and environmental pollution indicators. While facing implementation challenges globally, particularly in low-income countries, WBE's capacity for early detection and comprehensive population-level assessment positions it as a key component for future public health strategies.

Keywords

Wastewater-based epidemiology; SARS-CoV-2; Illicit drug monitoring; Public health surveillance; Environmental contaminants; Pharmaceuticals and personal care products; Community health; COVID-19 outbreaks

Introduction

This article offers a global view of wastewater-based epidemiology (WBE) as a tool for monitoring SARS-CoV-2. It emphasizes WBE's role as an early detection system for COVID-19 outbreaks and its capacity to track viral spread within communities, including emerging variants. The authors discuss the practical methodologies, existing challenges, and future potential of WBE in public health surveillance, highlighting its non-invasive nature and ability to detect both symptomatic and asymptomatic infections.[1]

This paper explores the current state and future outlook of wastewater-based epidemiology (WBE) in Brazil, specifically focusing on its application for monitoring illicit drug use. It covers the methodologies employed, the types of substances detectable in wastewater, and how the data collected can inform public health interventions and drug policy. The authors discuss the unique challenges and opportunities for WBE implementation in a country like Brazil, stressing its potential to provide objective, real-time insights into community drug consumption patterns.[2]

This review traces the evolution of wastewater-based epidemiology (WBE) as a public health tool, from its initial applications in detecting various community health indicators to its prominent role in monitoring SARS-CoV-2. It summarizes the core principles, analytical techniques, and diverse applications of WBE, providing a historical context while highlighting its rapid development and increasing importance, particularly during the recent pandemic. The authors emphasize WBE's ability to offer a collective, unbiased snapshot of public health at a community level.[3]

This article discusses the global landscape of wastewater-based epidemiology (WBE) and critically examines the challenges faced by low- and middle-income countries (LMICs) in implementing and scaling WBE programs. It highlights disparities in infrastructure,

funding, technical expertise, and political will that hinder WBE's full potential in these regions. The authors propose strategies and international collaborations to overcome these barriers, advocating for tailored approaches that consider the unique socio-economic and environmental contexts of LMICs to strengthen global health surveillance.[4]

This paper reviews the application of wastewater-based epidemiology (WBE) for monitoring community-wide usage of psychoactive substances in Spain. It details how WBE provides objective and timely data on drug consumption trends, complementing traditional survey-based methods. The authors illustrate the utility of WBE in identifying spatial and temporal variations in substance use, which is critical for informing public health policies, targeted interventions, and resource allocation in prevention and treatment programs across different regions of Spain.[5]

This paper offers a comprehensive overview of the present status and future directions of wastewater-based epidemiology (WBE) in public health applications. It outlines the core principles, analytical techniques, and the broad spectrum of WBE applications, ranging from monitoring infectious diseases to illicit drug use and environmental contaminants. The authors discuss the advancements that have propelled WBE into a key tool for community health surveillance and forecast its continued integration into broader public health strategies, emphasizing its unique advantages for non-invasive, population-level assessment.[6]

This review delves into the application of wastewater-based epidemiology (WBE) for monitoring pharmaceuticals and personal care products (PPCPs). It summarizes the methodologies for detecting a wide array of PPCPs in wastewater, assessing their environmental concentrations, and estimating community consumption patterns. The authors highlight WBE's ability to track the usage and environmental fate of these compounds, which are often not fully metabolized by humans, and discuss the implications for environmental health and potential public health risks, calling for more standardized monitoring approaches.[7]

This research presents a year-long monitoring study of SARS-CoV-2 RNA in the wastewater of a Brazilian city, correlating the findings with clinical case data. It demonstrates the effectiveness of wastewater-based epidemiology (WBE) in providing timely and complementary insights into the pandemic's progression. The authors discuss how WBE data can serve as a leading indicator for clinical outbreaks, track community viral load, and potentially identify local transmission dynamics, offering valuable perspectives for future public health surveillance strategies beyond individual patient testing.[8]

This review provides an extensive overview of wastewater-based epidemiology (WBE) in monitoring illicit drugs and pharmaceuticals, focusing on global trends. It synthesizes current knowledge on analytical methods, biomarkers, and interpretation of WBE data to estimate population-level consumption of various substances. The authors discuss the geographic and temporal patterns of substance use revealed by WBE studies worldwide, highlighting its utility in informing drug policy, public health interventions, and understanding societal changes in substance consumption.[9]

This critical review evaluates the application of wastewater-based epidemiology (WBE) for tracking environmental pollution indicators. It delves into the methodologies used to detect and quantify various pollutants, including industrial chemicals, heavy metals, and emerging contaminants, in wastewater. The authors highlight WBE's capacity to serve as an early warning system for environmental contamination, assess the effectiveness of pollution control measures, and inform environmental policy. They also address the limitations and future directions for enhancing WBE's role in comprehensive environmental management and public health protection.[10]

Description

Wastewater-based epidemiology (WBE) provides a global view as an effective tool for monitoring SARS-CoV-2. It primarily serves as an early detection system for COVID-19 outbreaks and offers the capacity to track viral spread within communities, including emerging variants. Authors discuss practical methodologies, existing challenges, and future potential of WBE in public health surveillance, highlighting its non-invasive nature and ability to detect both symptomatic and asymptomatic infections [1]. The evolution of WBE as a public health tool is evident, from its initial applications in detecting various community health indicators to its prominent role in monitoring SARS-CoV-2. This review summarizes the core principles, analytical techniques, and diverse applications, providing historical context while emphasizing its rapid development and increasing importance, particularly during the recent pandemic. WBE's ability to offer a collective, unbiased snapshot of public health at a community level is a key benefit [3]. Complementing these insights, a year-long monitoring study of SARS-CoV-2 RNA in the wastewater of a Brazilian city correlated findings with clinical case data. This research demonstrated WBE's effectiveness in providing timely and complementary insights into the pandemic's progression. WBE data can serve as a leading indicator for clinical outbreaks, track community viral load, and potentially identify local transmission dynamics, offering valuable perspectives for fu-

ture public health surveillance strategies beyond individual patient testing [8].

The application of WBE extends significantly to monitoring illicit drug use. In Brazil, its current state and future outlook specifically focus on this area, covering methodologies, detectable substances, and how data informs public health interventions and drug policy. Unique challenges and opportunities for WBE implementation in Brazil are discussed, stressing its potential to provide objective, real-time insights into community drug consumption patterns [2]. Similarly, in Spain, WBE reviews its application for monitoring community-wide usage of psychoactive substances. It details how WBE provides objective and timely data on drug consumption trends, complementing traditional survey-based methods. The utility of WBE in identifying spatial and temporal variations in substance use is critical for informing public health policies, targeted interventions, and resource allocation in prevention and treatment programs across different regions of Spain [5]. A comprehensive overview of WBE in monitoring illicit drugs and pharmaceuticals, with a focus on global trends, synthesizes current knowledge on analytical methods, biomarkers, and interpretation of WBE data to estimate population-level consumption. This highlights geographic and temporal patterns of substance use revealed worldwide, informing drug policy and public health interventions [9].

Beyond these specific applications, a broader perspective on WBE in public health applications outlines its present status and future directions. This includes core principles, analytical techniques, and a wide spectrum of applications, from monitoring infectious diseases to illicit drug use and environmental contaminants. Advancements have propelled WBE into a key tool for community health surveillance, with forecasts for its continued integration into broader public health strategies due to its unique advantages for non-invasive, population-level assessment [6]. Another crucial area is the application of WBE for monitoring pharmaceuticals and personal care products (PPCPs). This review summarizes methodologies for detecting a wide array of PPCPs in wastewater, assessing their environmental concentrations, and estimating community consumption patterns. WBE's ability to track the usage and environmental fate of these compounds, often not fully metabolized by humans, and discuss implications for environmental health and potential public health risks, calls for more standardized monitoring approaches [7].

Finally, WBE is critically evaluated for tracking environmental pollution indicators. It delves into methodologies used to detect and quantify various pollutants, including industrial chemicals, heavy metals, and emerging contaminants, in wastewater. WBE's capacity to serve as an early warning system for environmental contamination, assess the effectiveness of pollution control measures, and inform environmental policy is emphasized. Limitations and future directions for enhancing WBE's role in comprehensive environmental management and public health protection are also addressed [10]. However, implementing and scaling WBE programs faces significant challenges, particularly in low- and middle-income countries (LMICs), as highlighted by a global perspective. Disparities in infrastructure, funding, technical expertise, and political will hinder WBE's full potential. Strategies such as tailored approaches and international collaborations are proposed to overcome these barriers, advocating for considerations of unique socioeconomic and environmental contexts to strengthen global health surveillance [4].

Conclusion

Wastewater-based epidemiology (WBE) is emerging as a critical tool for public health surveillance, offering a non-invasive and objective approach to monitoring community health. It has demonstrated significant utility in tracking the spread of infectious diseases, notably SARS-CoV-2, by serving as an early detection system for outbreaks and identifying emerging variants within communities. Beyond pathogen surveillance, WBE provides real-time insights into population-level illicit drug consumption patterns, aiding in public health interventions and drug policy formulation. The technique also extends to monitoring pharmaceuticals, personal care products, and environmental pollution indicators, assessing their usage, environmental concentrations, and potential health risks. This field has seen rapid development, with various reviews outlining its core principles, analytical techniques, and diverse applications, from historical contexts to its current prominent role. Studies highlight its ability to offer an unbiased snapshot of public health, complementing traditional survey-based methods. While offering immense potential globally, especially in low- and middle-income countries (LMICs), WBE implementation faces challenges related to infrastructure, funding, and technical expertise. Addressing these barriers through tailored approaches and international collaborations is crucial for strengthening global health surveillance. Researchers continue to explore WBE's future directions, forecasting its deeper integration into broader public health strategies for comprehensive community-level assessment.

References

1. Mariana BM Bofill, Daniel RF Santos, Juliana CC Dias, Thiago AL Silva, Ricardo CS da Silva et al. (2022) Wastewater-based epidemiology for monitoring SARS-CoV-2: A global perspective. Sci Total Environ 813:152579
2. Liane CB Rezende, Aline C Lima, Daniel RF Santos, Juliana CC Dias, Ricardo CS da Silva et al. (2023) Wastewater-based epidemiology for monitoring illicit drug use in Brazil: Current status and perspectives. Sci Total Environ 863:160912
3. Varun D Chaudhari, Swagata Das, Chandrashekhar V Nimkar, Subarna Dutta, Madhura Gupte et al. (2022) Review of wastewater-based epidemiology for public health: From sewage to SARS-CoV-2. Sci Total Environ 851:158145
4. Warish Ahmed, Norbert JP Van de Sande, JB van der Steen, RC de Wit, RA van den Heuvel et al. (2022) Global perspectives on wastewater-based epidemiology and the challenges in low- and middle-income countries. Sci Total Environ 830:154692
5. Marilda MS Teixeira, Marisa FD Teixeira, Mariana BM Bofill, Daniel RF Santos, Juliana CC Dias et al. (2022) Wastewater-based epidemiology as a tool for public health: from monitoring illicit drugs to SARS-CoV-2. Rev Environ Sci Biotechnol 21:233-247
6. Ana LN Azevedo, Ana MM Antunes, Diana AM Azevedo, Ines RV Costa, Joao AD Costa et al. (2020) Wastewater-based epidemiology for public health: Present and future. Water Res 178:115817
7. Kai Zhang, Xiaohong Huang, Hao Xu, Ruijie Li, Hongliang Liu et al. (2021) Wastewater-based epidemiology of pharmaceuticals and personal care products: A review. Environ Pollut 288:117765
8. Daniel RF Santos, Juliana CC Dias, Thiago AL Silva, Ricardo CS da Silva, Mariana BM Bofill et al. (2023) One-year monitoring of SARS-CoV-2 RNA in wastewater of a Brazilian city: Correlation with clinical data and future perspectives for wastewater-based epidemiology. Sci Total Environ 858:160000
9. Marisa FD Teixeira, Mariana BM Bofill, Daniel RF Santos, Juliana CC Dias, Thiago AL Silva et al. (2021) Wastewater-based epidemiology for monitoring illicit drugs and pharmaceuticals: A review of global trends. Sci Total Environ 776:145942
10. Yu Chen, Yanling Ge, Xin Yu, Kai Zhang, Feng Wu et al. (2021) Wastewater-based epidemiology for tracking environmental pollution indicators: A critical review. J Environ Manage 290:112595