



## PROJECT

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### 1) Project title

**Wastewater-Based Epidemiology as an Integrated Tool for Pharmacological and Epidemiological Surveillance in Public Health**

### 2) Abstract (max 500 words)

Wastewater-Based Epidemiology (WBE) represents an emerging and highly promising approach for public health surveillance, based on the analysis of chemical and biological biomarkers in urban wastewater. Recent studies demonstrated that the systematic analysis of wastewater is a highly sensitive tool for monitoring the use of pharmaceuticals and psychoactive substances within the population. Through the quantification of specific biomarkers, WBE makes it possible not only to detect variations in the consumption of medications — including analgesics, anti-inflammatories, antidepressants, and other widely used pharmacological classes — but also to identify changes in the use patterns of lifestyle-related substances such as caffeine, nicotine, and recreational drugs. This approach enables the timely observation of increases or decreases in the intake of such compounds, providing a dynamic picture of collective behaviors and population responses to health, social, or environmental events.

In recent years, WBE has also emerged as a highly effective tool for the identification of specific microbiological targets, establishing itself as a surveillance and early-warning methodology capable of detecting the circulation of pathogens within the population. This approach has shown a significant contribution both in the timely identification of epidemiological hotspots and in supporting the management of healthcare resources. The SARS-CoV-2 pandemic further confirmed the strategic value of WBE, highlighting its ability to provide timely, non-invasive, and representative information on infection trends, to anticipate epidemic curves, and to guide operational decisions in Public Health emergencies.

Despite methodological advances, the integrated potential of WBE as a bridge between Public Health and Pharmacology remains underexplored. On one hand, WBE allows the quantification of the population's real exposure to pharmaceuticals and metabolites, providing valuable data for assessing therapeutic adherence, inappropriate medication use, and the impact of prescribing policies. On the other hand, correlating pharmacological biomarkers with epidemiological indicators can enhance the understanding of collective health dynamics, supporting clinical and regulatory decision-making. Moreover, WBE offers a unique opportunity to monitor the emergence of antimicrobial resistance, exposure to environmental contaminants, and the effectiveness of preventive interventions.

In this context, the proposed PhD project aims to develop an integrated framework combining WBE methodologies with advanced pharmacological analyses, with the objective of creating a predictive system capable of correlating specific wastewater biomarkers with Public Health indicators. The integration of WBE and pharmacology enables the investigation of crucial issues such as appropriate medication use, population responses to critical health events, early identification of emerging risks, and the assessment of the environmental impact of pharmaceutical residues.

The project includes: (1) the development of advanced analytical methods for the detection and quantification of pharmaceuticals and metabolites in wastewater; (2) the integration of WBE data with territorial epidemiological indicators to identify emerging patterns, risk behaviors, and early signals of health crises; (3) the evaluation of the environmental impact of pharmaceutical residues and antimicrobial resistance.

In a context of increasing health system complexity, this interdisciplinary approach may contribute to the development of more resilient, sustainable, and prevention-oriented surveillance systems. The project aims to strengthen the role of WBE as a strategic tool for Public Health.