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DRUG RESIDUES IN WATER: THE EMERGING TARGETS IN BIOSENSING

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While bringing many benefits to society, the trace presence of pharmaceuticals (drugs, personal care products) in fresh water and water-bodies has become a worldwide issue of increasing concern. About 2.000 active pharmaceutical ingredients are being administered worldwide in prescription medicines, over-the-counter therapeutic drugs and veterinary drugs, as well as human health. Their presence is witnessed in all types of water bodies such as fresh water, surface water, ground and drinking water, sewage, wastewater treatment plants (WWTPs) and agricultural effluents with a low concentration ranging up to $ng.L^{-1}$ (ppt). These are water-soluble agents but not biodegradable, thus they can accumulate and pose a harmful effect to human health and ecosystem. These factors result in the presence of pharmaceutical traces in the raw influent of the WWTPs. Even if the Water Framework Directive requires European countries to monitor certain substances classified as "priority pollutants", measurement campaigns have highlighted diffuse and persistent pollution of surface water by drugs and PCP called emerging pollutants, refractory to conventional wastewater treatment.

Small doses of these chemical entities continue to remain in the effluent after the treatment process and are discharged into the environment. Variety of methods including UV-degradation, photolysis, oxidation, reverse osmosis, nanofiltration, and adsorption has been used for their remediation from water and water bodies. Some of these methods have been commercially limited by toxic sludge generation, incomplete removal, high capital and operating costs, and the need for skilled operating and maintenance personnel. The adsorption technologies are a low-cost alternative, easy to use, especially, where there is a dearth of advanced technologies, skilled personnel, and available capital, and adsorption appears to be the most broadly feasible pharmaceutical removal method. These remediation methods are easily integrated with (WWTPs).

The presence of these drug residues in water and water bodies for a long time, however, the interest in this field arises from the fact that they are not considered under the legislation, which regulates water quality. However, they may be introduced in future legislation, because many organizations, e.g. the World Health Organization (WHO), European Union (EU) and Food Safety Standard of India (FSSAI) have elaborated the need for more systematic studies on the transport, occurrence and fate of pharmaceuticals in water bodies. An important limitation of such studies is the availability of sufficiently sensitive and reliable analytical methods for these investigations. Moreover, standardization of the protocols for the sampling and the analysis of pharmaceuticals is required, in order to better facilitate the comparison of data.

The earlier reported new analytical techniques including liquid chromatography with tandem mass spectrometry (LC-MS2) and gas chromatography with mass spectrometry (GC-MS), enables the determination of these compounds as much as down to $ng.L^{-1}$. However, the requirement of cost, no account of bioavailability, no identification of unknown's samples, requirement of skilled operator, prior knowledge of substance limits their utility. There are several integrated monitoring programmes of these contaminants made by Organisation for Economic Co-operation and Development (OECD) countries, for example passive sampling, spot sampling and target chemical analysis, ecological indicators, bioassays. No single method or combination of available methods is able to meet all the divergent monitoring purposes. Likewise, the passive sampling coupled with effect-based approaches can be considered as potential tool for monitoring these contaminants in European water bodies. While both approached could be employed separately, but the implementation of method depends upon various factors as pollution burden and ecological health status.

Recently, biosensors and bio-assays have also been emerged out as potential tool which possess high selectivity, low detection limit, ability to identify the mixture effect, microbial burden and identifying the health of aquatic life by determining the biomarkers, real-time monitoring, ease of modification as per method requirement. The lack of systematic monitoring programmes for pharmaceuticals, the modelling of assessment data has potential to serve as a valuable and cost-effective basis for prioritisation, risk assessments, and could address the knowledge gaps. Modelling the source-to-effect means existence of contaminants and accumulation to living entities could be an effective tool to identify and target sources of pollution for monitoring. The computational method such as QSAR-based models provide the platform to screen large sets of chemicals in a very short time with the aim of ranking and prioritising the most hazardous contaminant focusing further experimental studies. This model could also be used to model the toxicity, both regarding mixtures and in the assessment of unknown substances such as transformation products. For example, the OECD has recognised the potential for QSARs to reduce the costs of testing, reduce the need for animal testing and to strengthen chemical regulation in water bodies. In Sweden, modelling helped to determine the exposure potential of some of the nation's top-used pharmaceuticals to the Baltic Sea.

Herein, we can conclude that the existing methods have potential to determine and quantify the pharmaceutical contaminants in water matrices, however, the development of analytical method with higher selectivity, less inputs, on-line monitoring, improved detection limit as much as down to pg.ml-1 and effective treatments strategies could be a potential tool to check the quality of water and quantify the contaminants present in water bodies.