

**OCCURRENCES AND ENVIRONMENTAL FATE OF  
EMERGING CONTAMINANTS (PESTICIDES AND  
PHARMACEUTICALS) IN INDIAN WATER  
MATRICES**

by

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Submitted

in fulfilment of the requirements of the degree of Doctor of Philosophy

to the



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## Certificate

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This is to certify that the thesis entitled “**Occurrences and Environmental Fate of Emerging Contaminants (Pesticides And Pharmaceuticals) in Indian Water Matrices**”, being submitted by Pravin Kumar to the Indian Institute of Technology Delhi, is worthy of consideration for the award of the degree of ‘**Doctor of Philosophy**’ and is a record of the original bona-fide research work carried out by him under our guidance and supervision. The results contained in the thesis have not been submitted in part or full, to any other University or Institute for the award of any degree or diploma.

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## Abstract

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Presence of emerging contaminants (EC's) in wastewater, surface water, groundwater and even in potable water has been established by a number of studies. Some of these EC's are absolute threat to environmental or public health. A number of EC's are not classified as a threat to environment due to lack supporting scientific evidences. The adequate sound scientific information/data about the occurrences, fate and their environmental interaction is not available throughout the world. Their occurrences, especially in developing nation, have been poorly determined and people believed that the problem of EC's is development related problem and confined to the developed nation only. No major EC's have been reported so far from their water matrices. Thus a class of EC's, pesticides and pharmaceutical residues, were investigated from selected Indian water matrices, where they been inadequately addressed, and a hazard quotient based risk probability was determined. In safe guarding water resources against EC's, we first need to know their distribution and fate. Since, there are no existing reports for the investigated water matrices for the monitored EC's; it is the one of the first attempt to define their presences. Sample preparation and extraction was achieved by liquid liquid extraction and solid phase extraction technique while GC-ECD, GC-MS and HPLC-PDA were used in analytical determination. The extraction and determination methods were optimized for simultaneous determination of multiple compounds.

Some of the most persistent pesticides i.e. organochlorine pesticides (OCPs) contamination was evaluated in potable water resources, groundwater (Palla wellfield in Delhi) and surface water (rivers) of the Ganga basin. Samples collected from Palla wellfield in Delhi and various sites across Ganga river, from its origin in Gangotri glaciers to Farakka Barrage

downstream (at India-Bangladesh international border) in different sampling campaigns. Samples were also collected from the major tributaries of the Ganga river. The investigation showed that the wellfield have relative higher OCPs contamination then rivers of Ganga basin. The quality of water produced by Ranney wells was inferior to water produced by bore-wells from the same wellfield, thus it is wiser to develop a wellfield with bore-wells than Ranney wells, if the wellfield is prone to pesticide contaminations. The total pesticide contamination in all the investigated potable water resources was well within limit of Indian standards (IS :10500) for drinking water. In the Ganga river, the OCPs contamination was relatively low ( $\text{ng L}^{-1}$ ) and different types of pesticides residues were dominated (in occurrences) in different regions/stretches. The comparison of present OCPs contamination level to the previous literature reports showed a decreased trend in pesticides contamination in Ganga basin rivers, which is considered a good sign from environmental point of view. The restriction on use of OCPs for agriculture purposes in country may have helped in bringing this positive change.

Pharmaceutical residues contamination was determined from the domestic wastewater in Delhi, river Yamuna in Delhi region and Ganga river. It was observed that most of targeted pharmaceuticals were detected in the samples of the domestic wastewater and Yamuna river water (Delhi), however the Ganga river showed pharmaceutical residues at few sites only. The efficiency of the present sewage treatment processes for the removal of pharmaceuticals was also investigated. The STPs investigated were Okhla Sewage Treatment Plant and Vasantkunj Sewage Treatment Plant, both located in Delhi. The removal efficiency for pharmaceutical residues of both the process (activated sludge process and extended aeration based plant) was quite similar. The results also showed that investigated wastewater treatment plants lacks complete removal of the pharmaceutical residues from the wastewater during treatment and thus

significant high levels of pharmaceutical residues were being detected in the treated effluents and effluent receiving water body, river Yamuna in Delhi. It was found that the municipal wastewater treatment plants are employed up-to secondary level of wastewater treatment, thus an up-gradation of the existing plants may help in bringing down the environmental levels of pharmaceutical contaminants. The relative lower levels of pharmaceutical traces in big rivers (Ganga and its other tributaries) showed the importance of having high dilution potential in the river to maintain its health as the rivers with high flow were found to contain very less pharmaceutical residues.

The hazard assessment for the reported pharmaceutical residues was done by developing the hazard quotients (HQs). The HQs were determined by using the determined measured environmental concentrations (MEC) and predicted no effect concentration (PNEC) from literature. The HQs were also determined for pharmaceutical contamination reported in other water matrices (industrial effluents, hospital effluents, groundwater, lake water and river water) from Krishna, Kaveri and Godavari river basins in southern part of the India. The findings showed that industrial effluents have the highest HQ posing the maximum risk potential. The reported HQs for industrial wastewater were some of the world's highest HQs ever reported. The other water matrices were also ranked higher on potential to cause hazard from pharmaceutical residues. Among individual pharmaceutical residues, ciprofloxacin showed maximum hazard potential for all the water matrices. The high concentration of ciprofloxacin in aquatic matrices showed that immediate action are needed to regulate the environmental release of antibiotics and to study the environmental impacts of these compounds in broader aspects. The presently developed HQ could be used as an indicator to severity of the pharmaceutical contamination and

may act as screening study for the future investigations. The present study is the first attempt to fill the huge lacuna existing about EC's occurrences and fate from Indian environment.

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