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Ecological risk assessment of pharmaceuticals in the receiving environment of pharmaceutical wastewater in Pakistan

Muhammad Ashfaq[a,b,*], Khujasta Nawaz Khan[a], Muhammad Saif Ur Rehman[c], Ghulam Mustafa[a], Muhammad Faizan Nazar[a], Qian Sun[b], Javed Iqbal[c], Sikandar.I. Mulla[b], Chang-Ping Yu[b]

[a] *Department of Chemistry, University of Gujrat, H. H. Campus, Gujrat 50700, Pakistan*
[b] *Institute of Urban Environment, Chinese Academy of Sciences, Xiamen 361021, China*
[c] *Department of Chemical Engineering, COMSATS Institute of Information Technology, Lahore 54000, Pakistan*

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ABSTRACT

The pharmaceutical industry of Pakistan is growing with an annual growth rate of 10%. Besides this growth, this industry is not complying with environmental standards, and discharging its effluent into domestic wastewater network. Only limited information is available about the occurrence of pharmaceutical compounds (PCs) in the environmental matrices of Pakistan that has motivated us to aim at the occurrence and ecological risk assessment of 11 PCs of different therapeutic classes in the wastewater of pharmaceutical industry and in its receiving environmental matrices such as sludge, solid waste and soil samples near the pharmaceutical formulation units along Shiekhupura road, Lahore, Pakistan. Target PCs (paracetamol, naproxen, diclofenac, ibuprofen, amlodipine, rosuvastatin, ofloxacin, ciprofloxacin, moxifloxacin, sparfloxacin and gemifloxacin) were quantified using in-house developed HPLC-UV. Ibuprofen (1673 µg/L, 6046 µg/kg, 1229 µg/kg and 610 µg/kg), diclofenac (836 µg/L, 4968 µg/kg, 6632 µg/kg and 257 µg/kg) and naproxen (464 µg/L, 7273 µg/kg, 4819 µg/kg and 199 µg/kg) showed the highest concentrations among 11 target PCs in wastewater, sludge, solid waste and soil samples, respectively. Ecological risk assessment, in terms of risk quotient (RQ), was also carried out based on the maximum measured concentration of PCs in wastewater. The maximum RQ values obtained were with paracetamol (64 against daphnia), naproxen (177 against fish), diclofenac (12,600 against *Oncorhynchus mykiss*), ibuprofen (167,300 against *Oryzias latipes*), ofloxacin (81,000 against *Pseudomonas putida*) and ciprofloxacin (440 against *Microcystis aeruginosa*). These results show a high level of ecological risk due to the discharge of untreated wastewater from pharmaceutical units. This risk may further lead to food web contamination and drug resistance in pathogens. Thus, further studies are needed to detect the PCs in crops as well as the government should strictly enforce environmental legislation on these pharmaceutical units.

1. Introduction

Rapid growth in human population, urbanization and industrialization has caused a proportional increase in the environmental contamination with several inorganic and organic pollutants (Belhaj et al., 2015). Among these pollutants, pharmaceuticals are considered as emerging contaminants due to their frequent use, detection in different environmental matrices in high concentrations and the potential risk to the ecosystem (Verlicchi et al., 2012a, 2012b; Lombardo-Agui et al., 2014). Pharmaceuticals are complex molecules, mostly organic in nature with different physicochemical and therapeutic properties (Kummerer, 2009). These pharmaceutical compounds (PCs) ultimately become the part of the environment via various point sources such as manufacturing facilities, hospitals, agricultural and land runoff, household use and improper disposal. It is generally assumed that the release of PCs from pharmaceutical production plants is negligible (Kummerer, 2009). Usually, these production facilities employ good manufacturing practices (GMPs), comply with environmental legislations, and they try to recover active pharmaceutical ingredients (Kummerer, 2009). However, this hypothesis does not exist valid as researchers have detected high concentrations of PCs in industrial wastewater (Cardoso et al., 2014). It is therefore necessary to expand the investigation regarding the occurrence, distribution and risk assessment of PCs (Birch et al., 2015; Hughes et al., 2013) particularly in highly populated developing countries.

In our previous study, we have discussed the occurrence and

* Corresponding author at: Department of Chemistry, University of Gujrat, H. H. Campus, Gujrat 50700, Pakistan.
E-mail addresses: ashfaqchemist@hotmail.com, ashfaq@iue.ac.cn (M. Ashfaq).

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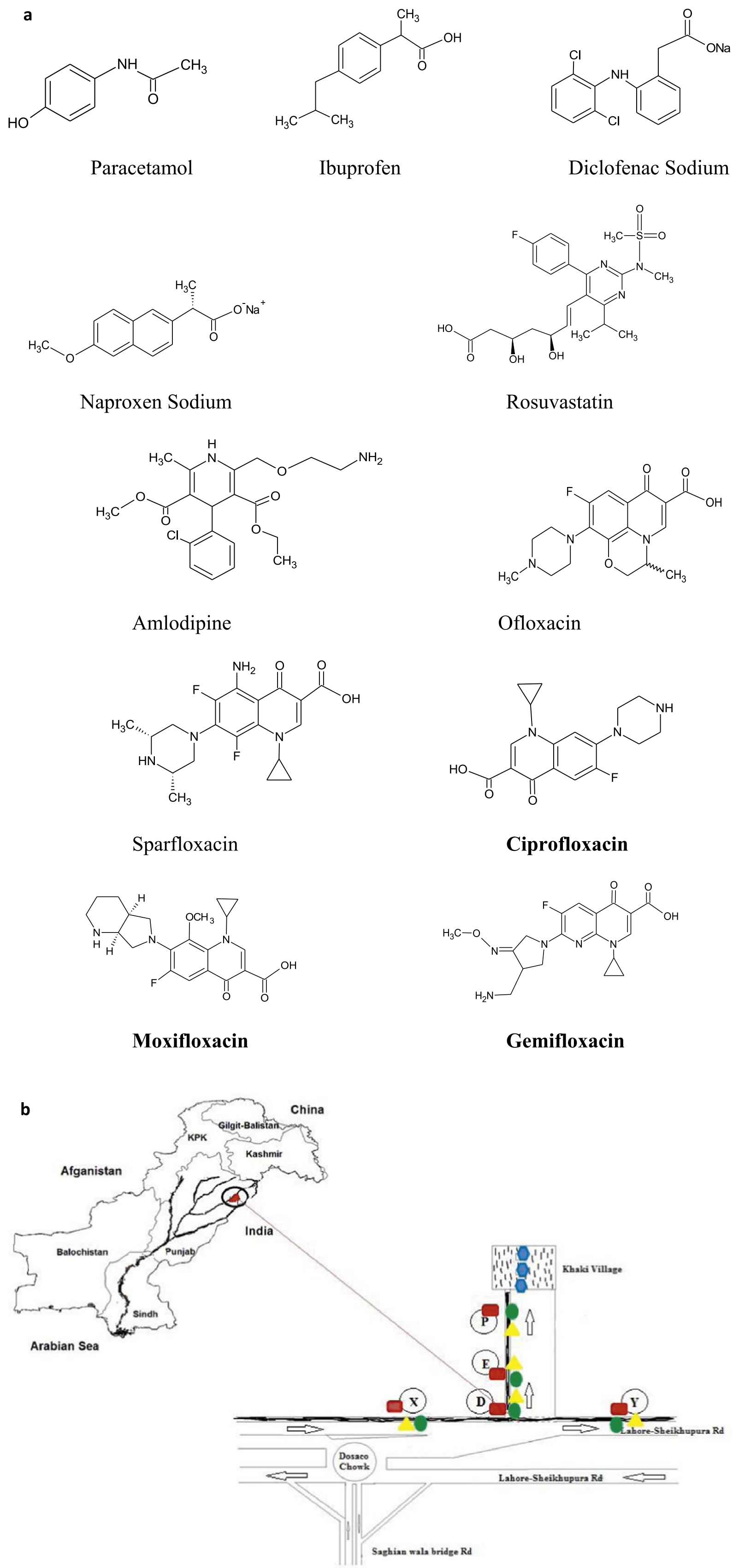

Fig. 1. a) Chemical structures of selected pharmaceuticals b) Location of sampling point of different types of samples. X, D, E, P and Y represent different sampling sites whereas the symbols in yellow represents wastewater samples, green for sludge samples, red for solid waste samples and blue for soil samples.