

Introduction: With growing technological advances newer and more effective drugs are being manufactured and are being used on an ever-growing scale for people with various medical conditions. Pharmacovigilance studies are done to monitor any obnoxious reactions of these drugs at therapeutic concentration. With growing research in the field of ecology and environment many of the adverse effects of these drugs on the environment have come to light. The first study that detected drugs in sewage took place at the Big Blue River sewage treatment plant in Kansas City in 1976 (1). In the meantime, a number of findings related to rising levels of some drugs and their adverse effects on the flora and fauna has necessitated some action by regulatory agencies like FDA and European Union. Still, there is a lack of substantial protocol for a prospective monitoring of drug concentration in the environment and the evident adverse effects.

Discussion: We are living in an environment that is polluted not only by heavy metals, pesticides, and emissions from gasoline engines, but also with pharmaceutical chemicals. These pharmaceuticals enter into the environment through various routes causing harmful effects.

Literature on the above subject was searched in almost all major search engines including PubMed with the keywords- Ecopharmacology, Pharmaceuticals and Personal Care Products (PPCPs), Clinical trials and Environment. A number of studies measuring the levels in surface water, groundwater and drinking water of some drugs given therapeutically to humans and animals including antibiotics, hormones, pain killers, tranquilizers, beta blockers and anticancers were found (2, 3, 4, 5, 6). When a human or an animal is given a drug, approximately 50% to 90% of it is excreted unchanged. The remainder is excreted in the form of metabolites. It means that once they are excreted into the environment, they enter food chains and concentrate as they move upward into larger predators (7). Some prominent examples are that of vultures falling prey to Diclofenac sodium, antidepressant drugs like Fluoxetine (Prozac) triggering spawning in shellfish and traces of Cocaine detected in River Thames (8). Few drugs also tend to persist in the environment after their excretion for example Clofibrilic acid in the aquatic environment disturbing the local fauna. Ecopharmacology (Ecosystem + pharmacology) describes entry of chemicals or drugs into the environment through any route and at any concentration disturbing the balance of ecology (ecosystem), as a consequence. If these drugs enter through living organisms via elimination subsequent to pharmacotherapy, it should be a specific domain of pharmacology and not of environmental studies. This domain may be referred as Pharmacoenvironmentology. Apart from that, Ecopharmacology as a major term should be restricted to studies of "PPCPs" irrespective of doses and route of entry into environment. PPCPs comprise a very broad, diverse collection of thousands of chemical substances, including prescription and over-the-counter therapeutic drugs, fragrances, cosmetics, sun-screen agents, diagnostic agents, nutraceuticals, biopharmaceuticals, dyes, pesticides, and many others. This broad collection of substances refers, in general, to any product consumed by individuals for personal health or cosmetic reasons. The term Pharmacoenvironmentology can be used for this specialty dealing specifically with pharmacological agents and their impact on the environment, after elimination from humans and animals, post-therapy.

Though a number of regulatory bodies like FDA and European Union have set some cut-off limit for environmental concentration of drugs, no actual testing is conducted after a drug is marketed to see if the environmental concentration was estimated correctly.

When a new drug is proposed for market, FDA requires the manufacturer to conduct a risk assessment that estimates the concentrations that will be found in the environment. If the risk assessment concludes that the concentration will be less than one part per billion, the drug is assumed to pose acceptable risks. FDA has never turned down a proposed new drug based

on estimated environmental concentrations, and no actual testing is conducted after a drug is marketed to see if the environmental concentration was estimated correctly (9). Apart from that there is little concern and research to find the adverse effects on environment, of particular drugs given at therapeutic doses. Even in clinical trials, where many limitations like that of limited size, narrow population, narrow indications and short duration are observed, we as well found that evaluation of drugs on environment is practiced very minimally.

The European Union has described a two phased approach to evaluate Medicinal Products in environment. The environmental concentration of the medicinal product is calculated in Phase I. Substances with a very high specific mode of action like hormones are directed to Phase II irrespectively of the result of the exposure calculation. In the second phase, information on the physical, chemical and toxicological properties are obtained and assessed in relation to the environmental exposure of the medicinal product (10). As a part of Good Clinical Trial, studies on impact of particular drugs on the environment should too be incorporated. Some concerns that need to be taken up under Pharmacoenvironmentology are that of drugs and their exact concentration in different components of the environment. Another concern is that of development of antibiotic resistance in pathogens in the environment owing to their exposure to antibiotics eliminated after therapy.

Conclusions: Pharmacovigilance pertains to the study of adverse effects of drugs at therapeutic doses on human beings. In this context, Pharmacoenvironmentology may be an extension of Pharmacovigilance dealing specifically with the effects pertaining to the environment and ecology of drugs given in therapeutic concentrations. Pharmacologists having this particular expertise (pharmacoenvironmentologist) may be made a compulsory component of the team assessing different aspects of drug safety. We need to monitor the effects of drugs not only as a good medical practice, but also to safeguard our environment.

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Authors' contributions: All authors have made substantial contributions while writing this paper right from conception and design, acquisition of data and finally in the analysis and interpretation of the data. All authors have also been involved in drafting the manuscript and revising it critically for important intellectual content. We give final approval of the version to be published. Each author has participated sufficiently in the work to take public responsibility for appropriate portions of the content.

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