

Pharmaceuticals as Environmental Contaminants: an Overview of the Science

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Over the last decade, a new dimension to environmental pollution has become evident — one involving the actions, behaviors, and activities of the individual consumer as a source of chemical pollutants. A major focus on consumer-use chemicals has been directed at the numerous types of chemicals formulated into thousands of different pharmaceutical products. The ubiquitous worldwide use of pharmaceuticals has led for the first time to the realization that the seemingly insignificant contributions from multitudes of individuals can combine to result in measurable levels of newly recognized pollutants in the environment. These countless, individual point sources result in measurable environmental loadings of a wide spectrum of chemicals (active pharmaceutical ingredients: APIs), most of which are designed to have biochemical activity at relatively low concentrations; in general, however, the potential for adverse impacts on non-target organisms by trace levels of APIs is not known. This new dimension to understanding chemical pollution is unique in that many of the substances involved are widely viewed as being desirable or beneficial — and sometimes essential — to the health, well-being, and at times survival of humans and domestic animals.

The prescribing and usage of medications have ramifications extending far beyond conventional medical care. A footprint extends from pharmaceuticals to the environment in the form of unique combinations of trace contaminants. Multitudes of diverse APIs enter the environment passively and actively by a variety of routes — primarily from excretion but also via several secondary routes. Sewers and trash serve as the primary conduits. Depending on the pharmacokinetics of the individual API, excreted residues of ecologic significance can include the unchanged parent API, bioactive metabolites, or products of reversible metabolism such as conjugates; the latter can serve as hidden reservoirs of the parent API, which can be released upon hydrolysis in the environment.

While excretion is the primary focus of environmental scientists, disposal of unwanted, leftover medications by flushing into sewers has gained the majority of attention from the public and healthcare communities. Disposal, however, has been viewed by scientists as a minor route — one that purportedly does not contribute substantially to overall environmental loadings of APIs. This, however, is an assumption, with little supporting evidence. A closely related route is disposal of unused and partially used high-content medical devices (used patches being a prime example). Other routes that have been little investigated include bathing, washing, and laundering, which are all influenced by sweat (a secondary and poorly understood route of excretion for many APIs).

Each of these routes can lead to ecologic exposures (primarily for the aquatic environment). They can also lead to unintentional human exposure (such as by the recycling of APIs in potable water derived from the environment) as well as intentional exposure (e.g., diversion of improperly disposed or stored drugs). Other risks include unintended poisonings of humans (especially children), pets, and scavengers (especially raptors such as eagles and vultures) feeding on carcasses of animals that had undergone therapeutic treatments.

Understanding the magnitude of all routes to the environment is important from the perspective of source reduction and pollution prevention, as well as for reducing the incidence of diversion and unintentional (and purposeful) poisonings of humans and pets. One critical aspect of the overall problem has only been recently delineated. Measures designed to reduce the release of APIs to the environment can have major collateral consequences with regard to improving the quality, cost-effectiveness, and efficacy of healthcare. Unused, leftover medications essentially represent wasted healthcare resources and missed opportunities to achieve optimal care. In a perfect system, medications would never go unused. Understanding the numerous causes for unused medications is the key to solving the disposal issue.

NOTICE: Although this work was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy.

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