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Mini Review

Pharmaceuticals in Environment: A review on its effect

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Abstract

Pharmaceuticals consumed in enormous quantities worldwide are a great concern. Administered pharmaceuticals are excreted by humans, as a parent compound or metabolite, with urine (mainly) and faeces. The pharmaceutical industrial effluent after incomplete processing also contributes to substantial amount of the pharmaceuticals in the surface and ground water. Pharmaceuticals includes a broad class of chemicals, ranging from over-the-counter and prescription drugs, diagnostic agents, nutraceuticals (e.g., vitamins) etc. Sewage treatment facilities due to their inefficiency and the chemical's structure of the compounds, are not always effective in removing the active chemical from waste-water. As a result, pharmaceuticals find their way into the aquatic environment, where they directly affect organisms and can be incorporated into food chains. Antibiotics are turning up in the environment in substantial quantities due to better detection methods and a growing population.

Introduction

The increasing concern on the presence of pharmaceutical compounds in the environment has increased nowadays mainly due to their potential risk to the aquatic environment [2,6]. Thousands of tons of pharmaceuticals are used yearly with different purposes such as the prevention, diagnosis, cure and mitigation of diseases or just to improve the state of health not only in humans but also in animals. Pharmaceuticals encompass a broad class of chemicals, like over-the-counter and prescription drugs, veterinary drugs, diagnostic agents, nutraceuticals (e.g., vitamins)[12]. Pollution by pharmaceuticals can occur in concentrations of parts per billion (ppb), or parts per trillion (ppt) (where 1 ppt equates to 1 ng/L). Previously these levels have been considered too low to cause any detrimental environmental effects. Many chemicals have been shown to have effects on aquatic life at similar concentrations[6]. The sources of pharmaceuticals unlike other pollutants are much more difficult to control and, due to their importance to human health and the economy. 30 to 90% of an administered dose is excreted in the urine as the active substance[11]. Many pharmaceutical compounds are not treated in STPs[6], and up to 90% of drug residues may remain in effluent after treatment[12]. Following treatment, the sewage effluent containing pharmaceutical parent compounds and degradation products can be discharged from the STP directly into aquatic environments, where pharmaceuticals that may have been transformed during treatment could be converted back into parent forms[12]. Pharmaceutical concentrations measured in surface waters are generally well below concentrations that are known to cause acute toxicity to aquatic organisms. However, chronic exposure to pharmaceuticals has the potential for numerous more subtle effects, such as metabolic or reproductive changes on non-target organisms[2].

Pharmaceuticals in Environment

Most ingested drugs are excreted primarily via the faeces and urine in varying amounts of metabolized and unmetabolized forms. Metabolism may result in chemicals that are either more or less biologically active than the form in which they were consumed. While chemicals excreted as conjugates (combined with other chemicals in the body to make them water soluble) are usually biologically inactive, once in the environment, they can undergo hydrolysis, which can render them active, again[9]. The untreated sewage effluents from the pharmaceutical industries contribute to substantial amount of the pharmaceuticals in the surface and ground water[9].

The other environmental exposure pathways of pharmaceuticals are manufacturing and hospital effluents, land applications (e.g., biosolids and water reuse), concentrated animal feeding operations (CAFOs), and direct disposal/ introduction to environment[2].

Sewage treatment facilities are not always effective in removing the active chemical from waste-water. As a result, pharmaceuticals find their way into the aquatic environment, where they directly affect organisms and can be incorporated into food chains.

Recent Studies

In a 2004-2009 study, US Geological Survey scientists found that effluents from two wastewater treatment plants

(WWTPs) that receive discharge from pharmaceutical manufacturing facilities (PMFs) had 10 to 1000 times higher concentrations of pharmaceuticals than effluents from 24 WWTPs across the nation that do not receive PMF discharge[10].

In a recent study by Swedish research team led by Joakim Larsson from the University of Gothenburg showed extraordinarily high levels (mg/L) of several drugs in the effluent from local wastewater treatment plant near Hyderabad in India[4].

Major Impact

Antibiotic resistance is a major concern surrounding the issue of pharmaceuticals. Exposure of massive numbers of microorganisms to sub lethal concentrations of antibiotics due to its release into environment allows for the development of resistance. There is indirect evidence that exposure to antibiotics has brought about the resistance of bacteria in the environment. The use of antibiotics in livestock feed coincided with the discovery of resistant E. coli where there previously was no resistance in the guts of pigs and in meat products[13]. Fluoroquinolone antibiotics were shown to exert genotoxic effects for the genetically modified bacterial strain *Salmonella typhimurium* at concentrations as low as 5µg/l for norfloxacin and 25µg/l for ciprofloxacin[5]. The development of resistance to antimicrobial agents makes treatment of infections very difficult to cure, therefore this issue is an important consideration for the treatment of wastewater, especially that which is discharged from hospitals, veterinary clinics, or other locations where large amounts of antibiotics are used[4].

Three antibiotics, erythromycin, clarithromycin, and amoxicillin at 1000 µg/L concentrations, significantly decreased denitrification rates by benthic bacteria[1]. Antibiotics present in sewage can also negatively impact bacteria associated with biological processes within sewage treatment plants[4].

Antimicrobial resistant strains of salmonella and campylobacter have been isolated from poultry and meat samples taken from grocery stores in the U.S. Many of the drugs used in animal feed are the same as those prescribed to humans, making treatment ineffective[14].

Presence of estrogenic compounds in the water is associated with feminizing phenomenon in fishes and some cancer in human[3]. Municipal wastewater treatment plants don't completely break down these estrogenic compounds or their metabolites. In locations surrounding fish farms, many sediment bacteria were found with antibiotic resistance. This resistance is attributed to the high number of antibiotics utilized as feed additives in fish farms. Bacterial resistances to erythromycin, tobramycin, chloramphenicol, and tetracycline were discovered in effluent from slaughterhouses[14].

Conclusion

Pharmaceuticals are being released into the environment in extremely large quantities on a regular basis. The exact effects that each drug is having on ecosystems, biota, and humans, however, are still are not completely understood. Although the side effects on human and animal health are usually investigated in thorough safety and toxicology studies, the potential environmental impacts of the manufacture and use of medicines are less well understood and have only recently become a topic of research interest. Therefore more research is critically needed. Inadequate regulations are implemented to monitor or control them, even though water quality standards are enforced in countries throughout the world.

Analyses have proved that pharmaceuticals have potential adverse human and environmental effects from indirect exposure. Likes pesticides are highly regulated by means of rigorous pretesting to demonstrate no adverse environmental effects of the chemicals, new pharmaceutical manufacturing requirements might be required of industry as a possible solution to preventing further environmental pollution by such products.

The government and NGOs must make concerted efforts to educate people on the dangers of dumping pharmaceuticals into the environment and encourage them to report if noticeable any change in water or environment that can be attributed to the presence of pharmaceuticals in the environment. The academia should be stimulated by the government and proper environmental legislation put in place to spur research and garner rigorous efforts towards investigating the short and long term effects of pharmaceuticals excreted into the environment. Enacted legislation should be enforced more strongly to arrest the unwanted and wanton disposal of pharmaceuticals into the streams, rivers and water bodies by individuals and industry.

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