ISSN: 2583-6013

MEDICINE: A CURE FOR HUMANS, POISON FOR THE ENVIRONMENT

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Disease emergence has been concomitant to human evolution. The infamous episodes of epidemics and pandemics highlight the significance of medicine in the society. Originating as natural remedies, the cure gradually transformed into artificially designed chemical drugs, an effective tool for reinforcing the healthcare system.

Pharmaceutical industry is a major component of healthcare sector. Aiming at the improvement of public health, it develops drugs and formulations for the treatment of existing and nascent maladies. Medicine is a double-edged sword that conceals its detrimental effects on the environment and global health under the mask of short-term relief.

Effects of medications on the Environment

The upstream, midstream and downstream processes involved in drug production consume a significant amount of energy and water, and release numerous air pollutants (such as particulate matter, methylene chloride, methanol, toluene, hydrogen chloride, and volatile organic compounds) along with greenhouse gases. These operations increase the environmental footprint of the pharmaceutical sector and lead to high scope emissions.

Pharmaceutical waste management is a major challenge. Waste, including chemicals, expired drugs, vials, and packaging materials (plastics), when improperly disposed of in the environment, can contaminate nearby soil and water bodies, permeate the aquifers polluting the groundwater, impact land productivity, water quality, ecosystem health, and associated biodiversity.

Considered as major sources of pharmaceutical waste, residues from drug manufacturing units, healthcare institutions, households, agriculture and animal husbandry comprise of Active Pharmaceutical Ingredients (APIs), hormones, antibiotics, pain relievers, antidepressants, antineoplastic drugs and parasiticides. These Environmentally Persistent Pharmaceutical Pollutants (EPPPs)remain potent even after their consumption and excretion, and persist in the environment for a long time, affecting non-target species of the biosphere.

Animal husbandry employs several veterinary pharmaceuticals, including topical antiseptics, fungicides, antiparasitic drugs and steroids, to improve animal health and productivity. The land application of livestock manure (obtained from drugs-administered animals) in agriculture can lead to soil contamination with bioactive compounds, thus impacting the soil biota, nearby flora and fauna, and crop growth.

Diclofenac, a veterinary non-steroidal anti-inflammatory drug used in livestock farming, was banned from use due to its nephrotoxic effects on the vulture populations, causing a sharp decline in the species numbers.

Aquaculture employs fish feeds containing high levels of toxic compounds, including polychlorinated biphenyls, brominated flame retardants, polycyclic aromatic hydrocarbons, and methylmercury. Release of the uneaten feed pellets and fish wastes from farms into nearby water bodies causes bioaccumulation of these organic water pollutants in the marine food chain. Additionally, the antimicrobials used for disease prevention in fish cages can disrupt the naturally existing microbial community and give rise to new strains.

Impact on aquatic ecosystem - As the pharmaceutical residues are released into the aquatic ecosystem via direct discharge of treated and untreated wastewater, surface runoff (from landfills), and agricultural runoff, deleterious consequences are faced by aquatic life.

Commonly used for alleviating pain and inflammation in humans, non-steroidal anti-inflammatory drugs such as ibuprofen and aspirin can adversely affect the physiological processes of aquatic organisms. The drug metabolites impact the growth, reproduction and behaviour by their cytotoxic and genotoxic properties.

The biologically active components of oral contraceptives and steroid hormones can cause sex reversal in fishes and amphibians (feminization of males), sterilization, disruption of gonadal functions and decline in fecundity, thus endangering the genetic viability and survivability of aquatic species.

Capable of affecting the neuroendocrine system in living beings, psychiatric drugs like phenelzine, venlafaxine, fluoxetine (drugs used to treat depression, obsessive-compulsive disorder and panic attacks in humans) can bioaccumulate in the fishes, alter their behaviour and delay their brain and reproductive development, thus threatening the species survival. These endocrine-disruptors can biomagnify along the food chain, causing ecotoxicological effects in the long run.

Exposure to tetracycline, sulfamethoxazole, and ciprofloxacin antibiotics can stimulate cyanobacterial growth in aquatic ecosystems. Specific antibiotics (such as quinolones) are known to cause toxic chronic effects and cell damage in micro and macro life forms. Additionally, the chloroplast replication and metabolic pathways are affected in antibiotic-sensitive aquatic plants.

Antimicrobial Resistance (AMR), a major consequence of overconsumption and imprudent use of antibiotics, is a global health emergency. Exceeding concentrations of antibiotics expedite the emergence of multidrug-resistant superbugs, which are not only harder to treat but a threat to the existing microbial community.

Impact on humans - While the human communities residing in the vicinity of drug manufacturing facilities are the most vulnerable to the ill-effects of pharmaceuticals, the distant ones are also not exempted. Consumption of food crops, fish, meat, and water sources contaminated with pharmacological residues and dairy products (obtained from medicated livestock) can lead to bioaccumulation, antimicrobial resistance and multi-organ damage. Thus, the medicines perceived as a life savior can end up making the body even more frail, building an inescapable vicious circle.

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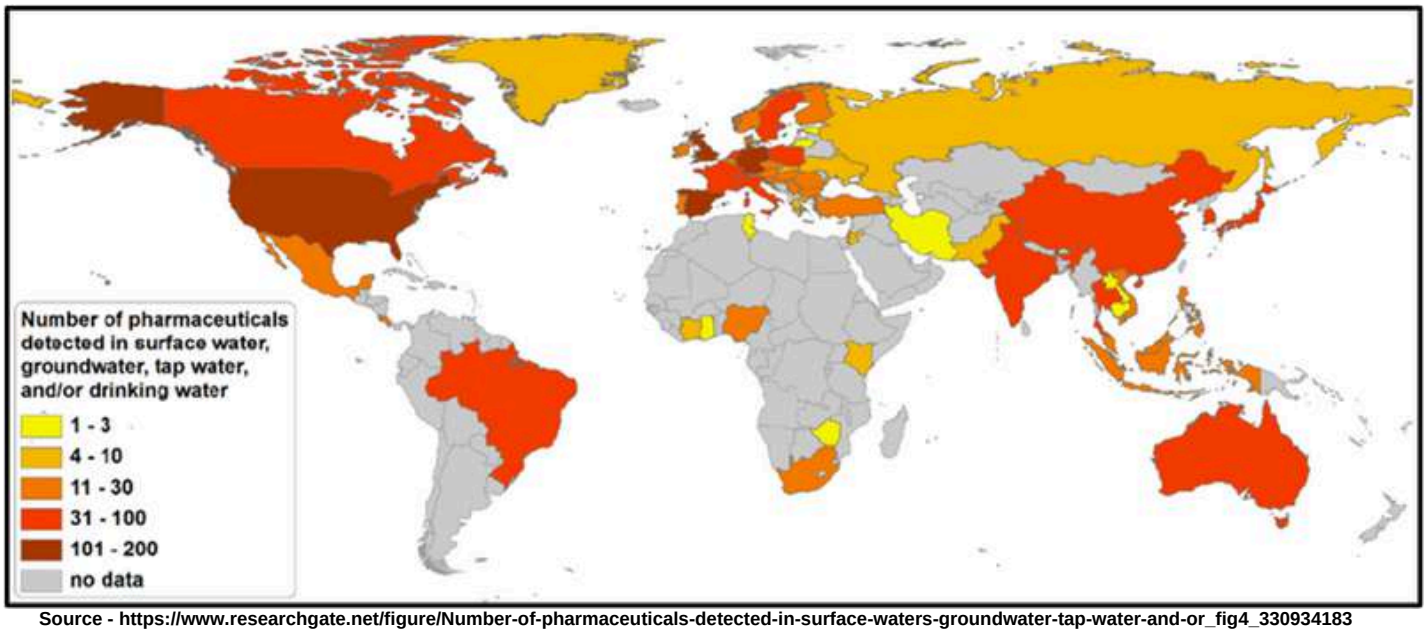

Source - https://www.researchgate.net/figure/Number-of-pharmaceuticals-detected-in-surface-waters-groundwater-tap-water-and-or_fig4_330934183

Remedy for the situation:

With over-prescription, self-medication and misdiagnosis exacerbating the existing situation, the APIs have turned into serious environmental pollutants, reaching unprecedented levels.

The environmental footprints of pharmaceuticals can be reduced by shifting towards sustainable green pharma and adopting the following practices:

- Promote disease prevention and a healthy lifestyle to reduce dependency on pharmaceuticals.
- Introduce medicine-take-back schemes for returning unused or expired medicines for their environmentally sound disposal.
- Integrate environmental sustainability into the practices and policies.
- Overcome the inadequacy of currently employed conventional waste water treatment plants (for pharmaceutical effluents) by implementing modern technologies such as advanced oxidation processes (photocatalysis, electrooxidation, ultrasound irradiation, etc.) and hybrid technologies capable of removing APIs from effluents to a large extent.
- Use medicines judiciously, preventing their overconsumption.

Burgeoning populations, rising antimicrobial resistance and the emergence of new pathogen strains are escalating the demand and production of pharmaceuticals day by day, hence making them an indispensable part of human existence. Under such prevailing conditions, transition to green pharmacy is the need of the hour.

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