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Antibiotics in the Environment: Mini Review

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Abstract:

Knowledge of pharmaceuticals in the environment is merely minute. Pharmaceuticals can enter the aquatic environment through the sewage treatment systems when they are excreted by people, or if they are disposed in the home. They can also enter sewage treatment works or waterways as a result of discharges from pharmaceutical manufacturing plants or medical establishments. The emission routes of veterinary drugs and feed additives to surface water are more complex than those of human pharmaceuticals. Emission to the surface water can take place either directly, when the animals are kept on pasture or indirectly by run-off and leaching through the soil. From an environmental side, the major effect of antibiotics is the toxic effect that may be exerted on aquatic organisms and disruption of the ecological balance. In addition, the presence of antibiotics in natural systems leads to the development of multi-resistant strains of bacteria. This paper outlines the different anticipated exposure routes to the environment, present knowledge of occurrence, fate and effect of pharmaceuticals.

Keywords: antibiotic, pharmaceutical, degradation, environment

1.0 Introduction:

Pharmaceutical industry, which includes four different types of manufacturing processes, fermentation, chemical synthesis, extraction and formulating, often generates high-strength wastewater changing in character and quantity depending upon the manufacturing processes and season (Grismer and Shepherd, 1998). Among the wastewaters from different operations in this industry, formulation effluent that rises from washing of equipment is characterized by small effluent flow and low pollution load. However the effluents originating from the formulation of antibiotics have low biodegradability since they contain a very high proportion of active substance.

Pharmaceuticals can enter the aquatic environment via the sewage treatment systems when they are excreted by people, or if they are disposed in the home. They can also enter sewage treatment works or watercourses as a result of discharges from pharmaceutical manufacturing plants or medical establishments. The degree of discharge from sewage treatment works depends on how they are affected by the treatment process. Pharmaceuticals can be discharged into watercourses as the both the original substances and breakdown products.

The meaning of the word antibiotic is against life. It is less accurate than the word antimicrobial which means against microbes. Antimicrobials are used in human medicine and animal agriculture to reduce disease and death. They are used to treat diseases and as growth promoters. Antibiotics used for growth promotion, lessen the effects of sub-clinical disease and the efficiency of food use for growth are improved. They are not effective when disease is absent. Antibiotics may enter the environment in wastewater, or when human waste solids and animal manures are applied to cropland as plant fertilizer. Some antibiotics degrade quite slowly and may be present in land-applied bio-solids. The continual land application of bio-solids could cause the rates of antibiotic accumulation in soils to exceed the rates of degradation (Derksen *et al*., 2004).

Understanding the fate and transport of antibiotics in the environment is vital to evaluate their impact

and risks to ecosystems. Sorption by soil plays a determinant role in controlling transport, bioavailability and fate of antibiotics in the environment. The complicated chemical structures of antibiotics lead to multiple interactions with soils. Generally, soil organic matter and minerals are the two soil components responsible for holding antibiotics.

The occurrence of antibiotics in the environment has consequently received considerable attention. It has been established that antibiotics are poorly absorbed by the human body, and therefore are excreted either unchanged or transformed, via urine and feces (McArdell et al., 2003). Several studies have shown a relationship between local sales of human pharmaceuticals and their concentrations in STP influents (Halling- Sørensen et al., 1998).

2.0 Fate of Pharmaceuticals:

The fate of human and veterinary pharmaceuticals in the environment is presented in Figures 1 and 2, respectively. Human pharmaceuticals can enter the environment after production and small amount of non-consumed pharmaceuticals (Figure 1). However, the domestic route makes the largest contribution. In this route, the human pharmaceuticals and their metabolites are, after consumption, excreted via urine and faeces and are then discharged to the surface water after biological treatment in a sewage treatment plant (Derksen *et al*., 2004).

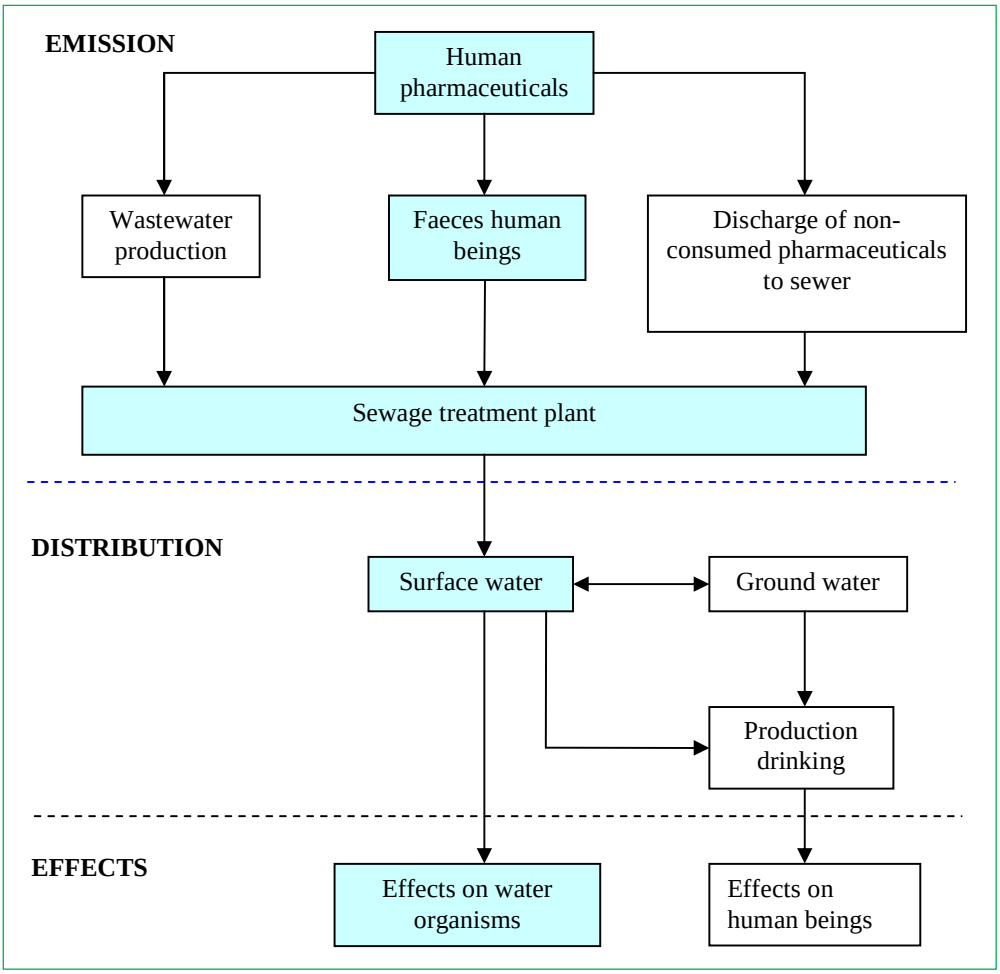

Figure 1: Fate of human pharmaceuticals. The quantitatively most important routes to surface water are colored (adapted from Derksen *et al*., 2004)

The emission routes of veterinary drugs and feed additives to surface water are more complex than those of human pharmaceuticals (Figure 2). Emission to the surface water can take place either directly, when the animals are kept on pasture or indirectly by run-off and leaching through the soil. The manure of intensively farmed animals is stored temporarily in a manure tank, after which the manure is spread on agricultural land or grassland. During the storage of manure, biodegradation can take place. The extent of run-off and leaching depends on climatological conditions, chemical and physical properties of the substance, type of animal and agricultural practice (Derksen *et al*., 2004).

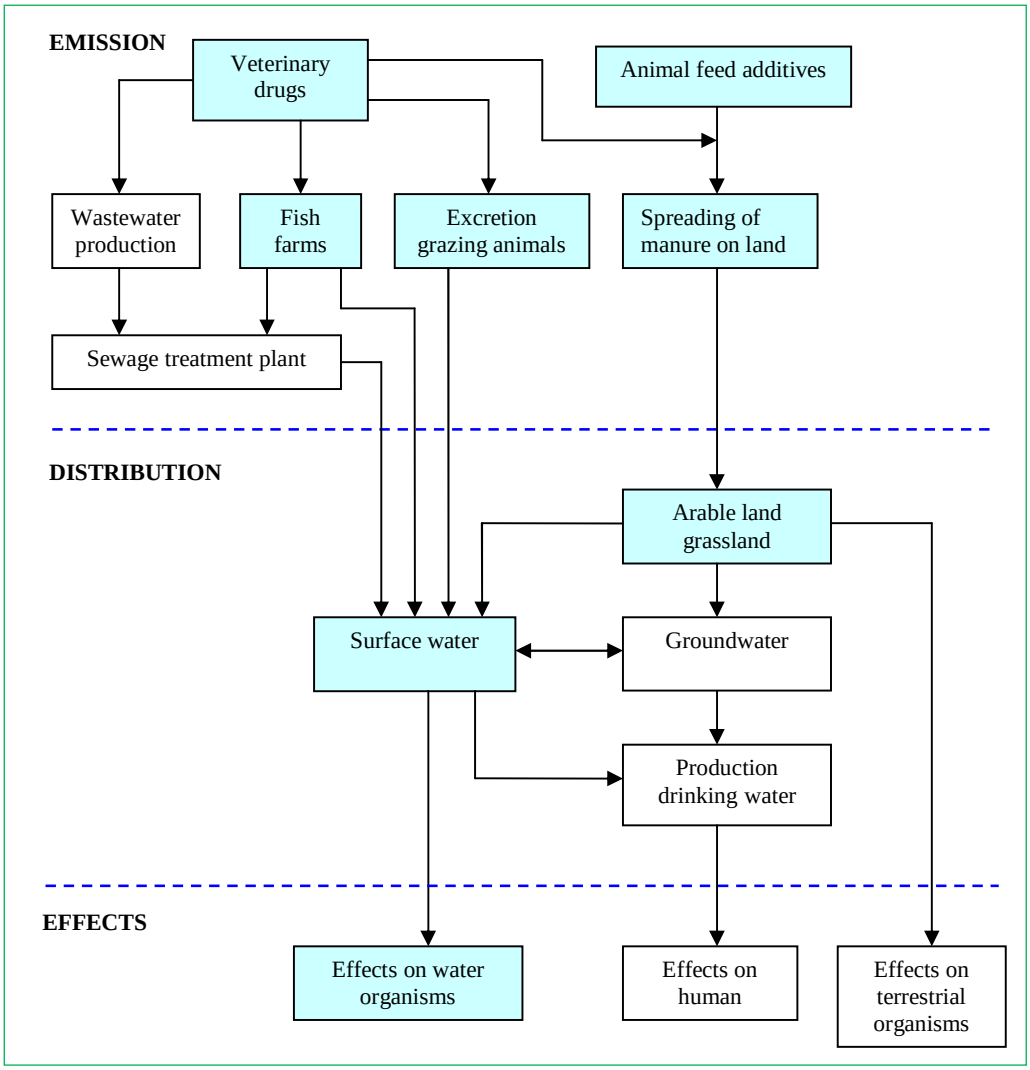

Figure 2. Fate of veterinary drugs and animal feed additives. The quantitatively most important routes to surface water are colored (adapted from Derksen *et al*., 2004).

3.0 Effects of Antibiotics:

Effect of antibiotics can be divided into the followings:

1) Toxic effect on aquatic organisms and disruption of the ecological balance (Lansky and Halling-Sørensen, 1997).
2) Presence of antibiotics in natural systems leads to the development of multi-resistant strains of bacteria (Halling- Sørensen *et al*., 1998). Resistant bacteria may be selected by antibiotic substances in the following:

- Hospital effluent, municipal sewage, aeration tanks, the anaerobic digestion process or in soil.
- Furthermore, resistant bacteria are excreted and discharged into sewage or soil and other environmental compartments (Kümmerer, 2003). Resistant and even multi-resistant pathogenic bacteria have been detected in wastewater and STPs, as well as in other environmental compartments (Guardabassi *et al*., 1998; Witte, 1998).
- Resistance can be transferred to other bacteria living in other environments such as ground water or drinking water.

As for the fate and effects of antibiotics against bacteria and other organisms in the environment, it is not clear whether the standardized tests used for risk assessment of chemicals are appropriate for antibiotics and other pharmaceuticals. Studies using test systems indicate that various antibiotics remain active against different groups of bacteria present in waste water (Kümmerer, 2001).

4.0 Managing Antibiotics:

The emission of antibiotics into the environment should be reduced. The following methods are proposed:

1) Unused therapeutic drugs should not be flushed down the drain.
2) Doctors and patients and pharmacists play an important role in reducing the release of antibiotics, other pharmaceuticals, and disinfectants into the environment.
3) The environmental significance of therapeutic drugs, disinfectants and diagnostics should be included in the undergraduate curricula of medical students and pharmacists.
4) Patients should be made aware that antibiotics help against bacterial diseases but not against the common cold, which is caused by viruses. This holds also for the agricultural use of antibiotics and their use in fish farming and elsewhere, e.g. as pesticides.

5.0 Conclusions:

The occurrence, fate, effects and risks associated with the release of antibiotics and other drugs into the environment is not well defined. There is still a lack of fundamental data on the occurrence, fate and effects of antimicrobials in the environment needed for proper risk assessment and risk management. It is important to obtain better database of the sources, fate and effects of both antibiotics and resistant bacteria in the environment. This information is necessary in the long run and successful measures for risk assessment and proper risk management are to be taken.

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