



Review

The Research Status, Potential Hazards and Toxicological Mechanisms of Fluoroquinolone Antibiotics in the Environment

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Abstract: Fluoroquinolone antibiotics are widely used in human and veterinary medicine and are ubiquitous in the environment worldwide. This paper recapitulates the occurrence, fate, and ecotoxicity of fluoroquinolone antibiotics in various environmental media. The toxicity effect is reviewed based on in vitro and in vivo experiments referring to many organisms, such as microorganisms, cells, higher plants, and land and aquatic animals. Furthermore, a comparison of the various toxicology mechanisms of fluoroquinolone antibiotic residues on environmental organisms is made. This study identifies gaps in the investigation of the toxic effects of fluoroquinolone antibiotics and mixtures of multiple fluoroquinolone antibiotics on target and nontarget organisms. The study of the process of natural transformation toward drug-resistant bacteria is also recognized as a knowledge gap. This review also details the combined toxicity effect of fluoroquinolone antibiotics and other chemicals on organisms and the adsorption capacity in various environmental matrices, and the scarcity of data on the ecological toxicology evaluation system of fluoroquinolone antibiotics is identified. The present study entails a critical review of the literature providing guidelines for the government to control the discharge of pollutants into the environment and formulate policy coordination. Future study work should focus on developing a standardized research methodology for fluoroquinolone antibiotics to guide enterprises in the design and production of drugs with high environmental biocompatibility.

Keywords: fluoroquinolone antibiotics; ecotoxicity; residues; human consumption; oxidative stress-related mechanism; antibiotic resistance



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1. Introduction

Antibiotics are widely used in medicines for treating bacterial infections in both people and animals due to their biologically active antibacterial, antifungal, and antiparasitic activities [1,2]. Fluoroquinolone (FQ) antibiotics are the most commonly used antibiotics in animal agriculture, animal aquaculture, and human medicine, owing to their broad antimicrobial activity in the treatment of the urinary, gastrointestinal, abdominal, and respiratory tracts [3]. FQ antibiotics are popular in antimalarial drug and synthetic antibacterial drug animal agriculture and aquaculture [4]. The first- and second-generation FQ antibiotics entered the market one after another, including nalidixic acid, ciprofloxacin, lomefloxacin, enrofloxacin, ofloxacin, and norfloxacin [5,6]. Byproducts and effluent have dramatically increased in recent years with the production of FQ antibiotics. FQ antibiotics enter the environment by different routes, including processing, use, and disposal [7]. The effluent from municipal plumbing and farm water is discharged without treatment into local waterways, which also increases the concentration of antibiotics in the water. FQ antibiotics are considered one of the major contaminant antibiotics due to the difficulty of removing

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