

## Ecological toxicological effect of antibiotics in soil

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**Abstract:** In all drugs contaminated with the environment, antibiotic abuse has become a global problem because of its high rate of consumption in veterinary and human medicine, and antibiotic-induced bacterial resistance and toxicological damaged to organisms in the environment are increasingly being studied at home and abroad. In this paper, the residues of antibiotics in soil were introduced, and the ecological toxicological effects of antibiotics were reviewed, and a new idea was provided for future research.

### 1. Residues of antibiotics in soil

With the development of science and technology, antibiotics are used more and more widely in the animal husbandry industry, which leads to the large amount of antibiotics in the feces of animals, and then leads to higher antibiotic content in the soil, especially in the economically or agriculturally developed areas. In 20 vegetable bases in the northern suburb of Guangzhou, the highest detectable concentration of tetracycline was  $303.7 \mu\text{g} \cdot \text{kg}^{-1}$ , the highest detectable concentration of Oxytetracycline was  $903.13 \mu\text{g} \cdot \text{kg}^{-1}$ , and the highest detectable concentration of Chlortetracycline was  $103.02 \mu\text{g} \cdot \text{kg}^{-1}$  [1]. In Beijing, Shanghai and other regions, the average concentrations of antibiotics, ofl and CIP in urban soils were  $36.6 \mu\text{g} \cdot \text{kg}^{-1}$  and  $9.44 \mu\text{g} \cdot \text{kg}^{-1}$ , and the maximum concentration of SMZ in farmland soils in the suburb of Beijing was  $2. \mu\text{g} \cdot \text{kg}^{-1}$  [2]. Luan et al. used high performance liquid chromatography-tandem mass spectrometry to detect the 24 representative vegetable bases in Dongguan, it was found that the detection rate of tetracycline antibiotics was high, the highest detectable concentration was up to  $138.8 \mu\text{g} \cdot \text{kg}^{-1}$ , the highest content of Oxytetracycline was  $103.4 \mu\text{g} \cdot \text{kg}^{-1}$ , the highest content of Chlortetracycline was  $76.00 \mu\text{g} \cdot \text{kg}^{-1}$ , the highest content of doxycycline was  $44.57 \mu\text{g} \cdot \text{kg}^{-1}$ , and the highest content of chlortetracycline was  $7.2 \mu\text{g} \cdot \text{kg}^{-1}$  [3]. In farmland soil of northern Zhejiang, the average concentration of tetracycline antibiotics was  $570.00 \mu\text{g} \cdot \text{kg}^{-1}$  in the topsoil of farmland with animal manure. It was 27 times as much as tetracycline antibiotics in the topsoil of farmland without animal manure. In the subsurface soil of farmland, no residue of antibiotics was detected in subsurface soil without manure, however, the highest detectable concentration of tetracycline antibiotics in subsurface soils with manure was  $1421 \mu\text{g} \cdot \text{kg}^{-1}$ , indicating that antibiotics were prone to move down in the soil and gradually accumulated in subsurface soils [4]. Chen et al. used high performance liquid chromatography-fluorescence detectors to analyze the residues of sulfa antibiotics in soil samples from 76 vegetable bases in Anhui, and the residue of sulfa antibiotics was detected in all soil samples, the average concentration of SDZ was  $0.26 \mu\text{g} \cdot \text{kg}^{-1}$ , SM2 was  $5.4 \mu\text{g} \cdot \text{kg}^{-1}$  and SMZ was  $2.58 \mu\text{g} \cdot \text{kg}^{-1}$  [5].



## 2. Ecological toxicological effect of antibiotics

### 2.1. Plant

Antibiotics reduce the germination rate of plant seeds, inhibit spout growth and root elongation, have adverse effects on the division and differentiation of plant callus, and affect the physiological and biochemical indices of plants. All of these influences differ with the type of antibiotics, the concentration and the combination effect with other pollutants. When the concentration of 5000-25000 mg/kg inhibited the elongation of wheat bud, the concentration of oxytetracycline inhibited the elongation of wheat bud in 10000-25000 mg/kg [6]. The results showed that the toxicity of chlortetracycline to wheat root was different in different chlortetracycline morphology [7]. The mass concentration of pleuromutilin, Tiamulin Funarate and valnemulin in the range of the 0.002-0.800 mg/ml were inhibited the seedlings of red bean and maize. And with the increase of concentration, this inhibition was strengthened [8]. Some antibiotics combined with heavy metals may increase the toxicity of antibiotics, and it was found that the combined treatment of zinc and oxytetracycline significantly reduces the germination rate of maize seeds [9]. Tang et al. found that when the concentration of kanamycin was 40 mg/l, the growth of callus of saussurea medusa would be inhibited, and the concentration of kanamycin increased to 50 mg/l, the callus basically stopped growing. When the concentration of Oxytetracycline was 8.0 mg/l, the growth of the callus was inhibited, the callus appeared browning and death in 20 mg/l. While the concentration of carboxyl benzyl penicillin was more than 400 mg/l, the growth of callus was obviously inhibited [10]. The results showed that when the concentration of Kanamycin is higher, the callus differentiation of *Pogonatherum paniceum* is lower [11]. When the concentration was 15.0 mg/kg and 45.0 mg/kg, both sulfadiazine and sulfathiazole could reduce the content of chlorophyll in the leaves of rapeseed, and the  $p < 0.05$ , it means the result was significantly different from control group. The content of the chlorophyll in the leaves of the rapeseed was reduced by sulfonamide-methyl, and  $P$  was less than 0.01, difference was very significant. The typical sulfa antibiotics of SMZ, SM1 and ST inhibited the soluble protein content in the leaves of rapeseed, and the inhibition was positively correlated with dose concentration [12]. Flavonoids in plant leaves have a wide effect on the health of human body, because of its small molecular weight, human body can absorb it easily through the blood-brain barrier, then into adipose tissue to prevent the occurrence of a variety of diseases. Some studies had shown that the content of flavonoids in wheat leaves is significantly reduced with 1.5 mg/l Amox, AMP, PENG and CFZ treatment [13]. Under soil culture conditions, oxytetracycline, zinc, and common stress all had a certain inhibitory effect on POD activity, and oxytetracycline had no significant effect on CAT of green vegetables. When oxytetracycline and zinc were combined in soil, the collaboration would disrupt the CAT of vegetable [14].

### 2.2. Animals in the soil

Soil animals, as important consumers in the ecosystem material cycle, play an important role in the ecosystem. On the one hand, actively assimilate all kinds of useful substances to build themselves, on the other hand, return the excretion products to the environment. The residues of antibiotics in the soil will have a tagged effect on the soil animals, affect their mutual identification with the nest, and destroy the ecological balance in the soil. Ji et al. found that when the concentration of Chlortetracycline and Oxytetracycline reached 100 mg/kg, the growth of earthworm was inhibited, and after a period of cultivation, chlortetracycline inhibited the increase of soluble protein in earthworm. Chlortetracycline and Oxytetracycline inhibited the activity of SOD firstly and then promote it. Both kinds of antibiotics affected the expression of earthworm gene [15]. Zhao et al. found that the single streptomycin pollution in the concentration of research did not cause the death of earthworms, but when streptomycin and copper compound, streptomycin would increase the toxicity of copper, make acute toxicity effects of earthworm [16]. Mo et al. studied on the effect of antibiotics on the individual identification of termite. They used tetracycline, penicillin and streptomycin to treat the termite workers in Taiwan, the results showed that antibiotics would induce fighting behavior between induce

individual in the same nest, the size of the induction capacity is streptomycin> penicillin>tetracycline [17]. Oxytetracycline and Tylosin had no obvious influence on earthworm, collembolan and enchytraeid under the concentration from 3000 mg/kg to 5000 mg/kg [18].

### 2.3. Soil microorganism

Antibiotics can affect the respiration, activity, and function of microorganisms in the soil and change the function of the microbial community structure. Wang et al. found that tetracycline, chlortetracycline and quinolone antibiotics inhibited the respiration of soil microorganisms, and the inhibition rate is positively correlated with the concentration of antibiotics. With the increase of treatment time, the inhibition rate would gradually decrease, and the respiration of soil microorganisms would eventually recover. Chlortetracycline and quinolone antibiotics also promoted the respiration of microorganisms in the soil at certain concentrations [19]. The survey found that ciprofloxacin inhibited soil microbial activity, and the inhibition decreased with the extension of culture time. Compared with ciprofloxacin artificially added into duck manure, the ciprofloxacin fecal source inhibited microbial activity is stronger, and the species richness index (H), evenness index (rE), dominance index (Ds), and carbon source utilization richness index (S) of the microorganisms using the carbon source in the soil were significantly reduced [20]. The addition of penicillin had inhibitory effects on bacteria, actinomycetes, and fungi in tea gardens, and this inhibition increased with the increase of penicillin concentration. When the mass fraction of penicillin was 100 mg/kg, the numbers of bacteria, fungi, and actinomycetes decreased by 80%, 50%, and 50%, respectively. Tetracycline had a stronger toxic effect, and it could significantly inhibit the growth of bacteria and actinomycetes in the soil of tea gardens at low mass fractions, affect the activity of soil microorganisms [21]. Yuan et al. showed that the antibiotic residue had a significant effect on soil ammoniation within 1 to 3 days, and the ammonium nitrogen content gradually decreased after 3 days. Tetracycline and chlortetracycline residues had a stimulatory effect on soil ammoniation, while norfloxacin residues inhibited it. After 6 days, tetracycline and norfloxacin residues had a certain stimulatory effect on soil amination. Residues of chlortetracycline inhibited soil ammoniation. Residues of tetracycline had a stimulating effect on soil ammoniation, while norfloxacin and chlortetracycline residues inhibited it [22]. Boleas et al. found that the presence of chloramphenicol in soil could prolong the time for microbial degradation of cow dung in soil [23]. Thiele-Bruhn et al. found when the residue of sulfapyridine in soil reaches  $3\mu\text{g. kg}^{-1}$ , the reducing ability of soil microorganisms for  $Fe^{3+}$  would be reduced by 50% [24].

### 3. Research prospects

Although the content of antibiotics in soil is relatively low, the harm to the ecological environment can not be ignored. Antibiotics are toxic to plants, soil animals and microbes, but most of them only stay on the description of surface phenomena, and lack of indepth study on related mechanisms. The use of molecular biology methods and techniques to study the effects of antibiotics on intracellular molecules helps to reveal the ecotoxicity and toxic mechanism of antibiotics on soil microecosystem from molecular, cellular, individual and community levels. It is suggested that scholars can study the ecological toxicological effects of antibiotics in soil by these means.

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