Advances in Biogeochemical Processes of Antibiotics in Soil

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Abstract. Due to the widespread use of antibiotics, there is a large amount of antibiotics in the soil. After entering the soil, antibiotics will undergo a series of biogeochemical processes under the action of various environmental factors: adsorption, migration, transformation, degradation or enrichment in plants and animals. By summarizing the relevant literature, it was found that the factors that affect the biogeochemical process of antibiotics including the types of antibiotics, temperature, the types of soil and illumination.

1. Introduction
Antibiotics are mainly secondary metabolites produced by bacteria, mold or other microorganisms or artificial analogues and are mainly classified into β-lactams, tetracyclines, aminoglycosides, macrolides, sulfonamides, Antifungal antibiotics, etc. Since the discovery of penicillin by Alexander Fleming in the 1930s, antibiotics have been used extensively in life and mainly in medical applications [1] and animal husbandry [2]. According to the WHO study, the number of antibiotics used in clinical practice in China has reached 79%, and the number of cases in which multiple drugs are used together has reached 59%, and the consumptions are very large. Medical antibiotics are mainly due to medical waste and patient's excrement into the soil. In the world, more than 70% of antibiotics are used in animal husbandry. China is the country with the highest production of antibiotics. 46.1% of antibiotics are used in animal husbandry every year. Antibiotics enter animals through veterinary drugs, but most antibiotics cannot be transformed and utilized by themselves. The antibiotics are excreted in the form of excrement, which in turn pollutes the soil. Soil is the ultimate destination of pollutants such as antibiotics. In soil, antibiotics can undergo a series of physical, chemical, and biological reactions, some of which can be degraded and converted into non-toxic substances, and the other part can be absorbed by the soil and accumulates in the soil [3], and enriched in animals and plants, where the antibiotics in plants can be degraded through the food chains [4]. The article analyzes the biogeochemical processes of antibiotics in the soil in order to provide a theoretical basis for the future research of antibiotics.

2. The adsorption of antibiotics in soil
Adsorption is an important process of migration and transformation of antibiotics. It reflects the interaction between pollutants and soil. Therefore, it is very important to study the mechanism of adsorption on antibiotics. Zhang et al [5] studied the adsorption and desorption of norfloxacin and four typical soils in red soil, paddy soil, yellow brown soil and fluvo-aquic soil. It was found that the adsorption behavior of norfloxacin in the four typical soils was quite different. The pH value has a very significant negative correlation with the adsorption strength. It also shows that the adsorption capacity of antibiotics is related to types of soil and pH. Li et al [6] conducted low-concentration adsorption tests of oxytetracycline in fluvo-aquic soil. The following conclusions were obtained by using different concentrations of antibiotics and different temperatures: the percentage of adsorption was positively correlated with the initial concentration, and the temperature and average adsorption rate were negatively correlated. Adsorption process is a spontaneous, endothermic, entropy-increasing process, and warming is conducive to adsorption. The uptake of oxytetracycline by fluvo-aquic soil was positively related to the sum of the content of powder and clay. The above experiments showed...
that the adsorption of antibiotics in soil was positively correlated with the concentration of antibiotics and the sum of particles, i.e. clay content, but negatively correlated with temperature. Through the above researches, it can be concluded that the adsorption of antibiotics in soil depends on the characteristics of soil and antibiotics, including the types of soil, pH, temperature, organic matter content, and the types and concentrations of antibiotics.

3. The migration of antibiotics in the soil

The migration of antibiotics in soil is affected by many factors. Zhang et al [7] studied the soil column leaching experiments of four typical quinolone antibiotics in latosolic red soils in south China. The results showed that: the degree of soil contamination has the greatest impact on the migration of quinolone antibiotics. The concentration of contaminated soil layer and the leaching concentration of quinolone antibiotics are higher, the migration distance is longer; the weaker acid leaching solution with pH is the most favorable for the downward migration of quinolone antibiotics; the pH conditions of each solution. The content of quinolone antibiotics was the highest in the topsoil and decreased rapidly with increasing depth. The leaching time is longer, the migration ability of the quinolones is stronger. Zhu [8] did leaching experiments of sulfa antibiotics also found that the leaching time affected the migration of antibiotics, compared leaching 12h with 3h, the SDZ and SMT in the soil leachate at each sampling point were significantly increased. The above experiments show that the migration behavior of antibiotics in soil is related to the degree of contamination, pH, leaching time and the depth of the soil.

4. The degradation of antibiotics in soil

The degradation methods of antibiotics are mainly hydrolysis, photodegradation, biodegradation and chemical degradation. The main principle of degradation is that the antibiotic undergoes a series of complicated biochemical under the action of microorganisms, reactions decompose it into macromolecular compounds and continues oxidative decomposition into H2O and CO2 process.

Many scholars have studied the composting method to effectively degrade antibiotics in excreta. Arikan [9] found that the removal rate of chlortetracycline in cow dung at 25°C reached 49% after composting, but the removal rate was as high as 99% at 55°C; Wu et al[10] carried out composting experiments and found the degradation rates of chlortetracycline oxytetracycline and tetracycline at 55°C respectively reached 74%, 92% and 70%; Kim [11] found that the degradation of TCs and SAs mainly depended on added wood chips; Kuang [12] studied composting experiments in darkness and natural light. After 15 days, the degradation rates of oxytetracycline and chlortetracycline were all lower than 10% under light-proof conditions, and the degradation rate was over 90% under natural light conditions. The above experiments verified some factors that affect the degradation of antibiotics in composting experiments: the composition of the compost, the types of antibiotic, whether it is light, temperature, certain additives, etc. Therefore, it can be concluded that the compost experiment can increase the degradation rate of antibiotics, thereby improving the efficiency of composting to degrade antibiotics, and providing theoretical basis for our production practice.

Some bacteria also have the ability to degrade antibiotics, for example Hu et al [13] found that the rate of degradation of avermectin after six days of Acinetobacter can reach 76%; Mao [14] studied the bacterium Pseudomonas putida, after five days, the degradation rate of erythromycin reached 76.6%; Sun et al [15] studied the degradation of tylosin by Tylosella and found that its degradation rate was as high as 99%. These studies have demonstrated that certain bacteria have the ability to decompose antibiotics, which provides us with new ideas for studying the degradation behavior of antibiotics in the soil, providing more options for microbial degradation of antibiotics.

Wu [16] studied the oxidative decomposition of TC by the catalyst. When the pH was 4, the reaction temperature was 35°C for 4 hours, and the degradation rate reached the maximum; Chen et al [17] studied the degradation of tetracycline antibiotics by manganese dioxide and found that at a pH of 4 to 9 and a temperature of 22°C, the degradation rate was CTC>TTC>OTC; Pacheco [18] studied the
degradation of tetracycline by ozone oxidation and found that the degradation rate of tetracycline was significantly faster after the addition of a certain concentration of H$_2$O$_2$ and activated carbon.

5. Biogeochemical processes of animals and plants against antibiotics

Some plants also have absorption of antibiotics in the soil. Kumar et al [19] studied that three kinds of crops, such as corn, leaf with onion and cabbage, could absorb chlortetracycline, and the content of chlortetracycline in three kinds of objects increased with the increase of chlortetracycline content in soil. Grote et al [20] planted winter wheat on pig manure soils containing chlortetracycline, sulfadiazine, and trimethoprim, they found that chlortetracycline and sulfadiazine could be absorbed by plant roots and transferred to the stems and leaves of plants. Chlortetracycline can even enter the fruit.

Earthworm is an important part of the soil ecosystem and an important part of various food chains. It has important functions in terrestrial ecosystems. Earthworm promote the degradation of leaves residues, decomposition and mineralization of organic matter, and has mixed soil, improve soil structure and permeability, drainage and deep water holding capacity. The content of an antibiotic can be reduced after entering the earthworm. The nature of the soil can affect the cumulative amount of antibiotics in the earthworm.

Pei et al [21] studied the dynamic process of degradation of ryegrass against several typical antibiotics in soil. The study found that the degradation rate of antibiotics in ryegrass was tetracyclines> quinolones> sulfonamides, and the degradation rate of several antibiotics reached less than 20%. Through the above experiments, it was found that the degradation rate of plants against antibiotics was not very high, so the plant method can be combined with other methods to improve the degradation rate.

6. Conclusions and prospects

Antibiotics can be reduced by adsorption, migration and transformation, but the most effective method is microbial degradation, the efficiency of which is up to 90% or more; most studies are not fully applied to the actual soil under laboratory conditions, and at this stage for soil antibiotics only to consider how to degrade, and did not fully consider whether the introduced material will cause pollution to the subsequent soil; Physical and chemical methods are less used in soil and the degradation rate is low, so they should be applied to the degradation of antibiotics in water. China is the country with the largest population and largest amount of livestock and poultry in the world. The amount of antibiotics used is the highest. Nowadays antibiotics are widely used, and soil pollution is also very serious. Therefore, we can combine microbial methods with other methods to study the problem of antibiotics in soil, and provide new ideas and methods for the study of problems.

Acknowledgements
This work was financially supported by National Natural Science Foundation of China (41773093, 31470552); Liaoning Science and Non-profit Foundation (2015003017).

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