Migration of antibiotics in natural aquatic environment

A A Abramova¹, E V Grakhova², V G Isakov³

¹Department “Water supply and water treatment”, Kalashnikov Izhevsk state technical University, 7, Studencheskaya, Izhevsk 426069, Russia
²Department “Industrial and civil engineering” Kalashnikov Izhevsk state technical University, 7, Studencheskaya, Izhevsk 426069, Russia

E-mail: aaa2785@mail.ru

Abstract. The article is devoted to the analysis of available information about the migration of antibiotics in natural aquatic environment. Realizing the mechanism of drug release into the environment and into the aquatic environment will further develop protective measures and mechanisms to prevent appearing of antibiotic resistance genes in the aquatic environment. For example, in Russia during 2015 - 2016 only, for medical purposes 915.65 tons of antibiotics were used. It should be noted that the main danger of antibiotics is that they do not completely collapse and do not lose their original properties after ingestion, but almost completely retain their biological activity. It leads to the fact that the active molecule of the active substance is released unchanged during physiological secretions or through the skin and is able influence the environment.

1. Introduction
In most cities of the Russian Federation, sewage system is common and sewage treatment plants receive wastewater from residential buildings, industrial enterprises, public and administrative buildings, including hospitals [1-2]. At the same time, in Russia there are no strict standards for receiving effluents containing pharmaceutical preparations, especially antibiotics.

As a result of studies conducted in many countries of the world, it was proved that penetration of antibiotics into the waste water leads to the adverse effects that result in changes in water micro flora [3-5]. The presence of antibiotics in the environment affects the growth of toxicological risks for the ecosystem, which includes humans and other species [5-7].

It is worth noting that antibiotics from urban and agricultural sources are stored in soil and water, and selective pressure from these compounds affects the microbial community, environmental functions and it leads to the emergence of antibiotic resistance genes. Thus, antibiotic migration is the key element for understanding their activity, behavior and effects of antibiotics in the aquatic environment [8].

2. Theoretical basis
For the first time, the term “antibiotic,” which means “against life,” was proposed in 1942 by an American microbiologist, a native Russian, a specialist in soil microbiology, Zelman Waxman [9]. Currently, there are more than 30,000 types of antibiotics of only natural origin in the world, which are synthesized by living creatures from various taxonomic groups. But it does not mean that all existing antibiotics are produced by living cells. Chemists learned how to improve and enhance the
antibacterial properties of natural substances, modifying them by using chemical methods. Antibiotics, obtained this way, are semi-synthetic [10-11].

The problem of spreading pharmaceuticals in the environment was first raised in the United States in the 1970s and only 10 years later in England. However, only in the mid-90s, because of constantly increasing volume of production and consumption of drugs and in connection with the active development of analytical methods, in particular, highly sensitive and highly selective chromatography and mass spectrometry for drug analysis, large-scale studies were done in this direction [6]. Nowadays, works of drugs detection in the environment, in particular in surface and wastewater, are actively carried out in many countries of the world. [7,12-17].

According to the World Health Organization (WHO), a global increasing in the consumption of antibiotics is planned from 63.2 to 105.3 thousand tons by 2030. During 2015-2016, 915.65 tons of antibiotics were used in Russia just for medical aims. Current analysis of the antibiotic market in Russia [18] shows that the forecast of the trade balance from 2019 to 2023, in physical terms, and it is already calculated in millions of tons, and can be represented in the form of a graph (figure 1).

3. Materials and methods
At first glance, one of the most significant sources of uncontrolled pouring of antibiotics into wastewater, may be drains and emissions from pharmaceutical companies. Great amount of studies around the world, including Russia are devoted to this topic. [18].

However, the environmental safety of such industries is regulated by laws, moreover, there is a tendency to reduce the environmental impact of pharmaceutical industries by:

- improving quality standards;
- increasing environmental safety of production;
- improving manufacturability and organization of the production process;
- controlling enterprises by authorized state bodies.

The greatest danger to the environment is represented by different uncontrolled sources of antibiotics that are formed by animals, and mainly by people who use drugs for medical purposes. According to Karaolia P, Michael-Kordatou I, Hapeshi E and Drosou C et al [19] it was established that antibiotics after entering the body do not completely collapse and do not lose their original properties, but almost completely save biological activity. It leads to fact that the active molecule of active substance is released unchanged during physiological secretions or through the skin and is able to influence environment.

Pharmaceutical rubbish in the form of unused drugs is another crucial source of antibiotic release into the environment. In home medicine kits, a huge amount of drugs is accumulated that remain
unused after course of treatment or purchased for stock or without direct need. The main reasons leading to the accumulation of pharmaceutical household rubbish are:

- availability of medicine;
- active advertising by pharmaceutical companies, which is aimed at increasing the consumption of drugs;
- self-treatment and self-diagnosis;
- elderly age;
- chronic diseases of people living in the house;
- small children in the family.

Gradually accumulated drugs become unusable due to bad storage conditions, or a violation of the primary packaging, or after the expiration date, so they are usually washed into the sewer or thrown away as part of household waste. So, antibiotics can be in large quantities in sewage or in solid waste landfills [20-24].

4. Results

Simplified life cycle of drugs after their using can be represented in figure 2 [8, 25-28]. It can be seen from the figure that after the use of medicines by people and their use in animal husbandry, together with physiological secretions, they inevitably fall into surface and ground waters, and after that into drinking water. To prevent drugs pouring into surface waters, it is important to learn how to identify them in urban and industrial wastewater and implement effective technologies for their removal. Antibiotic wastewater treatment methods should be added into existing urban wastewater treatment schemes. That’s why, there is a problem of determining effectiveness of urban wastewater treatment from antibiotics at each stage of treatment: mechanical, physico-chemical, biological. After that, it is necessary to choose a technology for antibiotics oxidation in wastewater (by OH radicals, ozone, chlorine, etc.), focusing on the principles of the most available technologies and considering possibility of its implementing into the classical scheme of urban wastewater treatment.

![Figure 2](https://example.com/figure2.png)

**Figure 2.** Drug cycle in environment.

As a result of studies conducted around the world, it is proved that drugs as components of pollution have a negative effect on the ecosystem, and it leads to adverse consequences:

- negative (toxic) effects on humans and hydrobiota, also ecosystems;
- human addiction to certain drugs;
- drug resistance of pathogenic microorganisms to antibacterial agents [29, 30].

Nowadays, there are no introduced technologies of removing medicinal substances from wastewater in Russian sewage treatment plants of all around the world.

5. Conclusions

The use of antibiotics leads inevitably to pouring into water bodies, which leads to critical level of antimicrobial resistance.

One of the ways to solve this problem is to study effectiveness of removing antibiotics from wastewater, including urban sewage, and to improve the existing classical treatment scheme, taking into account the best available technologies.

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