Measurement of pollutant concentration in the model solution

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Abstract. This work presents the results of the work on the determination of a pollutant in a model solution, the antibiotic cefotaxime, using the spectrophotometric method. In several series of experiments, the minimum concentrations of cefotaxime in model solutions that can be detected with a spectrophotometer PE-5400 UV were established; a feature of cefotaxime was revealed—the increase of the optical density peak in the samples when the pH is shifted to an acidic environment, especially at pH values from 0.2 to 2.0. The obtained values of optical density and absorption spectra of the model solution of cefotaxime can be used when a technique for the detection of antibiotics in various media, including urban wastewater.

1 Introduction

In the process of economic activity humanity intensively uses the most important natural resources: water, land, air, minerals, at the same time the ecological equilibrium formed on the earth during millions of years of its evolution is disturbed. The negative consequences of human activity affect the biogeophysical environment of our planet to a greater extent, but the hydrosphere is the most severely affected [1-5]. Thus, the occurrence of pharmaceutical compounds and their metabolites in the aquatic environment is a major concern worldwide [6]. The main reason for the occurrence of pharmaceuticals in water is their widespread consumption and incomplete disposal in urban wastewater treatment plants, so that drug residues enter surface water, groundwater, seawater and further affect their quality [7]. It should be noted that, depending on the type of contaminants present in wastewater (WW), the methods of its treatment are chosen. However, if wastewater has new pollutants in its composition, then to develop or upgrade the technological scheme for removal of these pollutants it is necessary first of all to estimate their quantity in the incoming waste water and only on the basis of this quantitative assessment to select the most effective, structurally available and economically expedient ways (methods) of waste water treatment based on the use [4-5].

Analysis of the presence of pollutants in the drainage and surface waters, primarily pharmaceutical pollutants, especially antibiotics, has shown that their presence endangers the nonpathogenic microbial community. Pharmaceuticals have been found in aquatic ecosystems and there is concern about their presence, potential effects on living organisms, and the reduction of effective ways to remove them from surface water bodies and SW. In

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recent years, NE, surface water and groundwater have been shown to contain various residues of pharmaceuticals [9-10]. The fate of pharmaceutical compounds is predictable on the basis of their chemical and physical properties. The disadvantage of nonbiodegradable antibiotics is that they cannot be easily degraded, so they remain in the SW and, after SW treatment, are released into the environment unchanged. In both medicine and veterinary science, antibiotics are often used to treat and prevent infections, as well as to increase the growth rates of cattle and the feed efficiency. Recent studies in Europe show that, due to conventional CB cleaning, drugs break down ineffectively. This means that up to 80% of the total amount of drugs entering treatment plants may be discharged into the aquatic environment [11].

The aim of this work was to determine whether the antibiotic cefotaxime (CFX) can be detected by the spectrophotometric method in model solutions when the pH changes.

2 Materials and Methods

Spectrophotometric method was chosen as the main research method, as the most available for most of the biochemical analysis laboratories at wastewater treatment plants (WWTPs).

Experimental studies were carried out on a spectrophotometer PE-5400 UV (Fig. 1), with the help of which it was evaluated:
- the possibility of detecting minimum CFX concentrations in model solutions with the instrument;
- The influence of pH on the determination of CFX in the model solutions.

CFX, one of the frequently used antibiotics in public health and veterinary medicine, was chosen as the object of study [11-16]. For each series of experiments, a model solution was prepared from distilled water and CFX at a concentration of 2.094 μg/dm³. The minimum concentration of CFX in the model solutions that could be detected using a spectrophotometer PE-5400 UV was 250 ng/dm³.

To evaluate the change in the optical density of CFX at different pH values (from 0.2 to 11.9), NaOH and HCl buffer solutions were added to the CFX solution tanks. The pH value was measured with a portable pH meter (Figure 2).

![Fig. 1. Design of spectrophotometer PE-5400 UV.](image)
3 Results and Discussion

After setting the detection limits of CFX in the model solutions for use with the spectrophotometer PE-5400 UV, the wavelength corresponding to the maximum value of optical density (A) for the experimental model solution with CFX concentration 2.094 μg/dm³ was determined to be 300 nm (Fig. 3).

![Dependence of optical density (A) on wavelength λ on a PE-5400 UV spectrophotometer in a model solution of the antibiotic CFX.](https://example.com/fig3.png)

To determine the effect of pH on the detection of Cefotaxime in model solutions, a series of experiments were carried out to determine the optical absorbance at different pH values (Figure 4). The spectrophotometer wavelength was set in the range of 280 to 300 nm.
nm, since previous measurement results showed that for the antibiotic in question the absorption maximum is in this range.

**Fig. 4.** Change in optical density (A) as a function of medium pH at wavelengths between 280 and 300 nm.

The analysis of the obtained dependencies shows that the optical density of the antibiotic in the model solution at pH from 6.0 to 6.4 tends to a minimum value, presumably due to the peculiarities of its chemical structure characteristic of this amphoteric type of antibiotic.

As a result of measurements, it was found that the redistribution of the ionic forms of the antibiotic CFX in the aqueous solution under study manifests itself in the spectral characteristics when the pH value changes. The position of the main absorption maximum ($\lambda = 280 \text{nm}$) was fixed in acidic medium in the pH range of the solution from 0.2 to 2.0. Increasing pH to 6.0 resulted in the appearance of antibiotic cations in the solution, which was reflected in a decrease in the intensity of optical density A.

Increase in pH to 11.9 resulted in a slight increase in optical density A. In the region of pH values from 4.0 to 8.0 the absorption maximum drop was presumably due to the presence of predominantly molecular form of CFX in the solution. The appearance of CFX cations in the solution at pH 0.2 to 2.0 and anions at pH greater than 10.0 was observed by increasing the intensity of its optical density A.

### 4 Conclusion

The spectrophotometric method, as a method of investigating the content of a pollutant in CB, namely the antibiotic CFX, has proved to be excellent. Practical measurements of absorption spectra on the spectrophotometer PE-5400 UV showed that the optical density peak (A) for the model solutions of CFX is close to the UV range, therefore for further studies and for studies by other authors it is possible to recommend to use optical instruments operating in the light range from 50 to 700 nm for investigation of the CFX content in CB and surface waters.

Measurement of the absorption intensity in model solutions of CFX antibiotic when the pH changes to acidic (range 0.2 to 2.0) results in the shift of the optical density peak to 280 nm and when the pH increases the absorption maximum was observed to decrease. Thus, to identify CFX in a multicomponent environment, a change in pH to an acidic pH should be sufficient to result in absorption peaks tending to a minimum at pH 6.0 to 6.4 in the wavelength range of 280 to 300 nm.
References