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ОБЗОР АНАЛИТИЧЕСКИХ МЕТОДОВ АНАЛИЗА ФАРМАЦЕВТИЧЕСКИХ ПРЕПАРАТОВ В ОБРАЗЦАХ ОКРУЖАЮЩЕЙ СРЕДЫ

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Одной из основных причин для беспокойства является широко распространенное присутствие в окружающей среде фармацевтических препаратов, которые могут быть вредны для живых существ. Их часто называют новыми химическими загрязнителями в водоемах, поскольку они либо все еще не регулируются, либо находятся в процессе регулирования. Фармацевтическое загрязнение окружающей среды может иметь пагубные последствия для жизнеспособности экосистемы, здоровья человека и качества воды. В этом исследовании количество оставшихся фармацевтических соединений в водах окружающей среды было определено с помощью простого обзора. Производство и потребление фармацевтических препаратов возросли из-за достижений медицины, что привело к опасениям относительно их воздействия на окружающую среду и потенциального вреда живым существам из-за их растущего присутствия. Многие страны теперь признают, что фармацевтическое загрязнение водной среды представляет угрозу для окружающей среды. Вполне возможно, что некоторые эндокринные активные препараты оказывают воздействие при чрезвычайно низких концентрациях в окружающей среде, поскольку они проявляют очень высокую биологическую активность даже при дозах W_g/день. Подготовка образцов требует ряда процедур, включая фильтрацию и экстракцию фармацевтических экологических вод, ND IT IS является важнейшим шагом в анализе окружающей среды. Предварительный концентрат используется для предотвращения неэффективности экстракции, вызванной взвешенными твердыми частицами. Несколько аналитических методов, таких как смешанная масс-спектрометрия и хроматография, использовались для идентификации и определения фармацевтических препаратов в водах окружающей среды.

Ключевые слова: аналитические методы, фармацевтические препараты, образцы окружающей среды

A REVIEW OF ANALYTICAL METHODS FOR THE ANALYSIS OF PHARMACEUTICALS IN ENVIRONMENTAL SAMPLES

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One of the main causes for concern is the widespread presence of pharmaceuticals in the environment, which may be harmful to living things. They are often referred to as emerging chemical pollutants in water bodies because they are either still unregulated or undergoing regulation. Pharmaceutical pollution of the environment may have detrimental effects on ecosystem viability, human health, and water quality. In this study, the amount of remaining pharmaceutical compounds in environmental waters was determined using a straightforward review. Pharmaceutical production and consumption have increased due to medical advancements, leading to concerns about their environmental impact and potential harm to living things due to their increasing presence. Many nations now acknowledge that pharmaceutical pollution of the aquatic environment poses a threat to the environment. It is quite possible that some endocrine active drugs have effects at extremely low environmental concentrations because they exhibit very high biological potencies

even at W_g/day doses. Sample preparation requires a number of procedures, including the filtration and extraction of pharmaceutical environmental waters, ND IT IS is a crucial step in environmental analysis. Pre-concentrate is used to prevent extraction inefficiencies caused by suspended solids. Several analytical techniques, such as hyphenated mass spectrometry and chromatography, have been used for the identification and determination of pharmaceuticals in environmental waters.

Keywords: analytical methods, pharmaceuticals, environmental samples

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INTRODUCTION

Background

Wastewater pollution can have a detrimental impact on public health and community water sources [1]. The recent detection of various contaminants in surface water bodies worldwide, such as phenols [2], polycyclic aromatic hydrocarbons [3], and pharmaceutical has presented environmentalists with a challenge. Healthcare effluents, generally produced by all parts of medical facilities, including hospitals, are a significant source of new pollutants. Among the contaminants in concern are heavy metals [4]. Because of advances in medicine, the production and use of pharmaceuticals have increased in recent decades [5]. Due to their growing in a variety of environmental components and required rise in use, pharmaceutical compounds have been categorized as emerging environmental pollutants [6]. The prevalence of pharmaceuticals in the environment, which may be dangerous to living things, has caused a great deal of concern [7-9]. Because they are either still uncontrolled or in the process of being regulated, they are frequently referred to as emerging chemical pollutants (ECPs) in water bodies. The presence of pharmaceuticals in the environment has the possibility to negatively impact human health, ecosystem viability, and water quality. In addition, acidic pharmaceuticals' physio-chemical characteristics, may cause them to pass through stages of water treatment and filtration, potentially which could harm drinking water supplies [10]. Numerous pathways allow these compounds to enter aquatic environments: human and animal excretions; drug waste from manufacturing and hospitals; and the removal of outdated or unused medications [11].

In veterinary and human medicine, about 3.000 distinct compounds are employed. In addition to the high use of over-the-counter medications like anti-inflammatory and antihistaminics, there are also a lot of prescribed drugs, particularly antibiotics and antidepressants. As a result, a wide variety of compounds have been discovered in environmental samples. At least 80% of pharmaceutical products can enter the body undisturbed after consumption. They decompose into metabolites during biotransformation, which may have greater bioactivity than the medication itself [12].

Since some endocrine active medications have very high biological potencies even at Wg/day doses, it is highly likely that they also have effects at very low environmental concentrations. For instance, at concentrations as low as 1 ng/l, the contraceptive 17K-ethinylestradiol negatively affects zebrafish (Danio rerio) reproduction. The possible environmental contamination is directly influenced by the pharmacokinetic behavior. Sewage and the environment should not generally contain drugs that are only excreted as metabolites. Therefore, it makes more sense to keep an eye on the stable principal metabolites that are excreted for those compounds. Pharmacokinetic data indicate that unchanged drug excretion rates in humans can occasionally surpass 50%. Furthermore, it is probable that microorganisms will cleave excreted metabolites produced by conjugation with glucuronic acid or other polar compounds back into the original pharmaceuticals, increasing the relevant environmental concentration. Drugs and their metabolites can be found in sewage at detectable concentrations, which is not surprising given the high rates of usage and excretion [13].

The pharmaceutical classes that have been studied the most are antibiotics. Antibiotics have been found in various aquatic environments including drinking water and wastewater. They are considered to be "pseudopersistent" pollutants because they keep adding to the ecosystem. Since they are typically not well absorbed by the body, they are eliminated through urine and feces, either unaltered or altered. The presence and persistence of increasing interest because low

antibiotic levels can encourage the growth of antibiotic-resistant bacteria. The increased emergence of pathogenic bacteria strains that are resistant to antibiotics and pose a risk to human health has been associated. It is possible for humans to acquire resistance genes or bacteria that are resistant to antibiotics from animals. Furthermore, bacteria may become resistant to both veterinary and human antibiotics that have comparable structural similarities [14].

There are various routes via which antibiotics are discharged into the aquatic environment. Following human administration, they are excreted as metabolites but also, in significant quantities, are removed into the sewage system through urine and feces in their original form as parent compounds. Numerous studies have demonstrated that pharmaceuticals are not completely removed during wastewater treatment procedures. Pharmaceuticals are thought to be a significant contributing factor to the environmental presence of wastewater treatment plants (WWTPs). Medications and their metabolites have been discovered in WWTP effluents. As a result, both surface and groundwater can be reached by them [14].

Sample preparation

The most important stage in environmental analysis is sample preparation. It is greatly impacted by matrices as well as the physical and chemical characteristics of the analytes under study. Sample preparation typically entails adjusting the pH of the solution, adding a chelator, extracting the sample, handling the extract, and preparing the sample for chromatographic analysis afterwards [10].

The pre-concentrate is done to prevent extraction inefficiencies caused by the presence of suspended solids. The next step is to extract the medications from the sample into a small amount of solvent. There are a few ways to do this, but the most popular one is solid-phase extraction (SPE). Moreover, lyophilization has been used as extraction methods [11]. The most popular strategy is the extraction of analytes from water samples. Two SPE materials can be combined in series. Target compound extraction and pre-concentration are commonly achieved using hydrophilic–lipophilic balanced polymers.

A large body of research has recently been conducted to evaluate SPE stationary phases. Methanol, acetone, and ethyl acetate are the three elution solvents that are most frequently used. The automation of SPE processes is an intriguing feature that can enhance the precision and efficiency of pharmaceutical analysis. Direct injection of untreated samples is made possible by automated SPE, which can also automatically perform several steps. These processes require less time and solvent, improve reproducibility, lower LODs (limit of detection), and minimize health risks during analysis. Sampling with SPME, doing away with the need for solvents [11].

Analytical methods

The widespread problem of drug pollution led to the investigation of numerous techniques to identify the key participants in the environmental samples [15]. More knowledge about the structure of the degradation process is required to make pharmaceutical products more stable and determine [16]. Traditional techniques for purifying water produce hazardous waste and by-products, which calls for processing that uses a lot of energy [17]. The ionization mass methods have been used for analysis, including small pharmaceutical compounds [18]. The analytical methods are a very useful tool for the medical and health fields. They are a vital and probably underappreciated component in the creation of medical equipment, despite being frequently linked to materials science and medical engineering [19]. Because spectrophotometric methods are straightforward and reasonably priced, they can help identify environmental samples [20].

Various analytical techniques are employed to identify these compounds in complex biological samples, as well as in human organisms. SPE is widely used in environmental studies to extract pharmaceuticals from aqueous matrices. When coupled with high-pressure liquid chromatography (HPLC), it offers rapid and repeatable procedures; however, the methods are not highly sensitive and are usually limited to one compound or a few that have comparable chemical structures. Newer, more sensitive spectrometric detectors, can assist lower the limits of detection. Among the most widely used methods in recent years is LC in conjunction with MS/MS, which offers great potential for identity and quantification determination as well as high stability and specificity [21]. However, the applicability of these methods can be limited by interfering compounds and matrix interferences. Additional drawbacks include the high cost of this new equipment and the potentially difficult development processes [22]. Modern analytical techniques to identify PPCPs in water systems before using GC-MS or LC-MS or GC, HPLC, or hyphenated GC. HPLC is still a superior analytical instrument for the majority of thermally sensitive PPCPs. Furthermore, derivatization procedures are nearly always necessary before analysis [23].

Literature review

Numerous studies have demonstrated the toxicity of pharmaceutical residues in aquatic environments to ecosystems [24-31]. SPE and GC-MS are two analytical techniques that Togola and colleagues have

developed for the purpose of determining pharmaceutical compounds in a range of aqueous samples. In order to guarantee the preservation of the pharmaceutical substance, conditions were examined and optimized while accounting for environment. Recoveries for the majority of pharmaceuticals under observation ranged from 53 to 99%, with variability throughout the entire process being under 15% [22]. The current analytical approach applied to water samples produced good performance by using the traditional addition process. The suggested technique proved to be an effective replacement for sorption-based micro-extraction in the study of medium-polar to polar priority pollutants. It demonstrated that monitoring PPCPs in water matrices required a small amount of sample and was sensitive, reliable, and user-friendly [23].

Pharmaceutical inputs were analyzed using a LC/MS-MS technique in the Grand River watershed of Ontario, Canada. From environmental samples, the method simultaneously extracted 27 antibiotics and neutral medicines, with detection limits ranging from 20 to 1400 ng/L. This method was used to look at the pharmacological profiles of tributaries that feed into the Grand River; only pharmaceuticals prescribed for human use in metropolitan regions were found. Furthermore, this method was used to identify surface waters that contained monensin and the human prescription drug carbamazepine [32].

Tahiri and co-workers have examined whether pharmaceutical chemicals were present in the wastewater from a regional hospital between June 2020 and June 2021 in Vlora, Albania. Using direct sampling in the waters, we determined the content of 19 preselected pharmaceutical compounds in the discharge water for this investigation. We also looked into the presence of Medicines found in Ulva Lactuca algae. Liquid chromatography has been used in conjunction with mass spectrometry to perform chemical analysis at a quantization limit of 0.1 ng/L. Antibiotics were discovered to be at the greatest concentration among the group of 19 pharmacological compounds, which also included analgesics, psychiatric medications, and beta-blockers. The range of concentrations of medicinal compounds in L is 0.2-0.24 mg/L. Ulva Lactuca algae in the effluent water near to the city treatment facility provide traces of medicines. All 19 compounds that are taken into consideration in this work have concentrations that are less than 0.1 ng/L. Lastly, the principles of the physicochemical parameters of hospital influent waters gathered over an extended period of time and in different nations were found to be within the range indicated by many research [33].

CONCLUSION

This review has shown a number of analytical methods that can be effectively used to detect the presence of leftover pharmaceutical compounds in environmental waters after sample preparation procedures are finished. In this area, the accuracy, sensitivity, and recoveries from previous studies were satisfactory. The pharmaceuticals in various aqueous matrices were determined using the analytical techniques covered above. Many environmental samples, including those from drinking waterways and rivers, as well as highly contaminated sewage, were examined. As a result, the employed techniques – HPLC, GC-MS and LC-MS are suitable for identifying pharmaceuticals in aqueous environmental samples, even at lower ng/l ranges.

The authors declare the absence of a conflict of interest warranting disclosure in this article.

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REFERENCES
ЛИТЕРАТУРА

1. **Sadiq K.A., Mohammed S.J., Ghati S.K., Jasim M.S.** Adsorption of Bromothymol Blue Dye onto Bauxite Clay. *BSJ.* 2024. V. 21. N 8. P. 2625–2634. DOI: 10.21123/bsj.2024.8783.
2. **Shamar J.M.** Determination of some phenols in Tigris River by HPLC. *Ibn Al-Haitham J. Pure Appl. Sci.* 2013. V. 26. N 1. P. 250–258.
3. **Shamar J.M.** Separation and Identification of Naphthalene, Acenaphthylene, Pyrene, Benz{a} Anthracene and 1,3,2,4-Dibenzanthracene. *J. Al-Nahrain Univ. Sci.* 2009. V. 12. N 4. P. 14–24. DOI: 10.22401/JNUS.12.4.03.
4. **Jasim W.A., Salman J.D., Jamur J.M.S.** Flame atomic absorption spectrophotometry analysis of heavy metals in some food additives available in Baghdad markets, Iraq. *Indian J. Forensic Med. Toxicol.* 2020. V. 14. N 2. P. 451–456.
5. **Джамур Дж.М.С.** Аналитические методы для оценки фармацевтического загрязнения рек мира; обзор. *Изв. вузов. Химия и хим. технология.* 2024. Т. 67. Вып. 5. С. 6-16. **Jamur J.M.S.** Analytical Techniques in Pharmaceutical Pollution of the World'S Rivers; a Review. *ChemChemTech [Izv. Vyssh. Uchebn. Zaved. Khim. Khim. Tekhnol.].* 2024. V. 67. N 5. P. 6–1 . DOI: 10.6060/ivkkt.20246705.7017.
6. **Jamur J.M.S.** Optimization of plasma-assisted desorption / ionization- mass spectrometry for analysis of ibuprofen. *Diagnostics of Materials.* 2023. V. 89. N 7. P. 21–24. DOI: 10.26896/1028-6861-2023-89-7-21-24.
7. **Frascaroli G., Reid D., Hunter C., Roberts J., Helwig K., Spencer J.** Pharmaceuticals in wastewater treatment plants: A systematic review on the substances of greatest concern responsible for the development of antimicrobial resistance. *Appl. Sci.* 2021. V. 11. N 15. P. 6670. DOI: 10.3390/app11156670.
8. **Gros M., Petrović M., Ginebreda A., Barceló D.** Removal of pharmaceuticals during wastewater treatment and environmental risk assessment using hazard indexes. *Environ. Int.* 2010. V. 36. N 1. P. 15–26. DOI: 10.1016/j.envint.2009.09.002.
9. **Roberts P.H., Thomas K.V.** The occurrence of selected pharmaceuticals in wastewater effluent and surface waters of the

lower Tyne catchment. *Sci. Total Environ.* 2006. V. 356. N 1–3. P. 143–53. DOI: 10.1016/j.scitotenv.2005.04.031.
10. **Montaseri H., Forbes P.B.C.** Analytical techniques for the determination of acetaminophen: A review. *TrAC - Trends Analyt. Chem.* 2018. V. 108. P. 122–134. DOI: 10.1016/j.trac.2018.08.023.
11. **Abujaber F., Ahmad S.M., Neng N.R., Rodríguez Martín-Doimeadios R.C., Guzmán Bernardo F.J., Nogueira J.M.F.** Bar adsorptive microextraction coated with multi-walled carbon nanotube phases - Application for trace analysis of pharmaceuticals in environmental waters. *J. Chromatogr. A.* 2019. V. 1600. P. 17–22. DOI: 10.1016/j.chroma.2019.04.035.
12. **Alula M.T., Mengesha Z.T., Mwenesongole E.** Advances in surface-enhanced Raman spectroscopy for analysis of pharmaceuticals: A review. *Vib. Spectrosc.* 2018. V. 98. P. 50–63. DOI: 10.1016/j.vibspec.2018.06.013.
13. **Ternes T.A.** Analytical methods for the determination of pharmaceuticals in aqueous environmental samples. *Trends Analyt. Chem*. 2001. V. 20. N 8. P. 419-434. DOI: 10.1016/S0165-9936(01)00078-4.
14. **Seifrtová M., Nováková L., Lino C., Pena A., Solich P.** An overview of analytical methodologies for the determination of antibiotics in environmental waters. *Anal. Chim. Acta.* 2009. V. 649. P. 158–179. DOI: 10.1016/j.aca.2009.07.031.
15. **Shamar J., Abbas S., Abbas Z.** Analytical Methods for Determination of Ketoprofen Drug: A review. *Ibn AL-Haitham J. Pure Appl. Sci.* 2022. V. 35. N 3. P. 76–82. DOI: 10.30526/35.3.2842.
16. **Jamur J.M.S.** Raman spectroscopy analysis for monitoring of chemical composition of aspirin after exposure to plasma flame. *Spectrosc. Eur.* 2022. V. 34. N 5. P. 18–22. DOI: 10.1255/sew.2022.a15.
17. **Джасим А.А., Джасим В.А., Джамур Дж.М.С.** Метод ВЭЖХ для определения остатков некоторых антибиотиков в сточных водах различных больниц в городе Багдад, Ирак. *Изв. вузов. Химия и хим. технология.* 2024. Т. 67. Вып. 6. С. 21-28. **Jasim A.A., Jasim W.A., Jamur J.M.S.** HPLC Method for the Determination of Some Antibiotic Residues in Different Hospitals Wastewater in Baghdad City, Iraq. *ChemChemTech [Izv. Vyssh. Uchebn. Zaved. Khim. Khim. Tekhnol.]*. 2024. V. 67. N 6. P. 21–28. DOI: 10.6060/ivkkt.20246706.7035.
18. **Rutten F., Jamur J., Roach P.** Fast and versatile ambient surface analysis by plasma-assisted desorption/ionisation mass spectrometry. *Spectrosc. Eur.* 2015. V.27. N 6. P. 10. DOI: 10.1255/sew.2015.a2.
19. **Jamur J.M.S.** A Subject Review on Application of Analytical Chemistry in the Mitochondrial Medicine. *IJPSN*. 2024. V. 17. N 3. P. 7406–7414. DOI: 10.37285/ijpsn.2024.17.3.10.
20. **Abbas S.M., Jamur J.M.S., Sallal T.D.** Indirect spectrophotometric determination of mebendazole using n-bromosuccinimide as an oxidant and tartarazine dye as analytical reagent. *Egypt J. Chem.* 2021. V. 64. N 9. P. 4913–4917.
21. **Фарадж Р.А., Нур Х.К., Джамель С.Х., Джамур Дж.М.С.** Метод ЖХ-МС/МС для определения мезилата иматиниба в образцах плазмы крови после адсорбции медной дубильной кислотой. *Изв. вузов. Химия и хим. технология.* 2025. Т. 68. Вып. 3. С. 27-35. **Faraj R.A, Noor H.K., Jamel S.H., Jamur J.M.S.** LC-MS/MS method for the determination of imatinib mesylate in blood plasma samples after adsorption by copper tannic acid. *ChemChemTech [Izv. Vyssh. Uchebn. Zaved. Khim. Khim. Tekhnol.]*. 2025. V. 68. N 3. P. 27–35. DOI: 10.6060/ivkkt.20256803.7121.
22. **Togola A, Budzinski H.** Analytical development for analysis of pharmaceuticals in water samples by SPE and GC-MS. *Anal. Bioanal. Chem.* 2007. V. 388. N 3. P. 627–635. DOI: 10.1007/s00216-007-1251-x.
23. **Neng N.R., Nogueira J.M.F.** evelopment of a bar adsorptive micro-extraction-large-volume injection-gas chromatography-mass spectrometric method for pharmaceuticals and personal care products in environmental water matrices. *Anal. Bioanal. Chem.* 2012. V. 402. N 3. P. 1355–1364. DOI: 10.1007/s00216-011-5515-0.
24. **Rodriguez-Mozaz S., Vaz-Moreira I., Varela Della Giustina S., Llorca M., Barceló D., Schubert S.** Antibiotic residues in final effluents of European wastewater treatment plants and their impact on the aquatic environment. *Environ. Int.* 2020. V. 140. P. 105733. DOI: 10.1016/j.envint.2020.105733.
25. **Yilmaz G., Kaya Y., Vergili I., Beril Gönder Z., Özhan G., Ozbek Celik B.** Characterization and toxicity of hospital wastewaters in Turkey. *Environ. Monit. Assess.* 2017. V. 189. 55. DOI: 10.1007/s10661-016-5732-2.
26. **Alygizakis N.A., Besselink H., Paulus G.K., Oswald P., Hornstra L.M., Oswaldova M.** Characterization of wastewater effluents in the Danube River Basin with chemical screening, in vitro bioassays and antibiotic resistant genes analysis. *Environ. Int.* 2019. V. 127. P. 420–429. DOI: 10.1016/j.envint.2019.03.060.
27. **Giebułtowicz J., Nałęcz-Jawecki G., Harnisz M., Kucharski D., Korzeniewska E., Plaza G.** Environmental risk and risk of resistance selection due to antimicrobials' occurrence in two Polish wastewater treatment plants and receiving surface water. *Molecules*. 2020. V. 25. N 6. P. 1470. DOI: 10.3390/molecules25061470.
28. **Castiglioni S., Zuccato E., Fattore E., Riva F., Terzaghi E., Koenig R.** Micropollutants in Lake Como water in the context of circular economy: A snapshot of water cycle contamination in a changing pollution scenario. *J. Hazard. Mater.* 2020. V. 384. P. 121441. DOI: 10.1016/j.jhazmat.2019.121441.
29. **Kairigo P., Ngumba E., Sundberg L., Gachanja A., Tuhkanen T.** Science of the Total Environment Occurrence of antibiotics and risk of antibiotic resistance evolution in selected Kenyan wastewaters, surface waters and sediments. *Sci. Total Environ.* 2020. V. 720. P. 137580. DOI: 10.1016/j.scitotenv.2020.137580.
30. **Kimosop S.J., Getenga Z.M., Orata F., Okello V.A., Cheruiyot J.K.** Residue levels and discharge loads of antibiotics in wastewater treatment plants (WWTPs), hospital lagoons, and rivers within Lake Victoria Basin, Kenya. *Environ. Monit. Assess.* 2016. V. 188. 532. DOI: 10.1007/s10661-016-5534-6.
31. **Ren B., Geng J., Wang Y., Wang P.** Emission and ecological risk of pharmaceuticals and personal care products affected by tourism in Sanya City, China. *Environ. Geochem. Health.* 2021. V. 43. N 8. P. 3083–3097. DOI: 10.1007/s10653-021-00828-y.
32. **Hao C., Lissemore L., Nguyen B., Kleywegt S., Yang P., Solomon K.** Determination of pharmaceuticals in environmental waters by liquid chromatography/electrospray ionization/tandem mass spectrometry. *Anal. Bioanal. Chem.* 2006. V. 384. N 2. P. 505–513. DOI: 10.1007/s00216-005-0199-y.
33. **Tahiri V., Denaj A., Prenga D.** Assessment of the Presence of Pharmaceutical Compounds in Wastewaters and in Aquatic Environment. *J. Human Earth Futur.* 2023. V. 4. N 3. P. 290–302. DOI: 10.28991/HEF-2023-04-03-03.

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