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POLYETHYLENE AS A SOURCE OF ENVIRONMENTAL POLLUTION

Annotation. Polyethylene is one of the most widely used synthetic polymers due to its strength, light weight, durability, and low production cost. However, its extensive use and resistance to natural degradation have led to significant environmental challenges. This article analyzes the main mechanisms by which polyethylene contributes to environmental pollution, including the formation of microplastics, contamination of soil and aquatic ecosystems, and its harmful effects on flora, fauna, and potentially human health.

The article also discusses the broader ecological consequences of polyethylene accumulation and highlights the urgency of addressing these issues. Furthermore, various approaches to reducing polyethylene pollution are explored, such as microbial and enzymatic biodegradation, advanced recycling methods, and the development of biodegradable polymer alternatives. Experimental results on the decomposition behavior of polyethylene under different physical, chemical, and biological conditions are presented. These findings are supported with visual data in the form of tables and diagrams, helping to illustrate the efficiency of different degradation strategies and offering insights into more sustainable plastic waste management practices.

Key words: polyethylene; plastic; physico-chemical analysis; ecosystem; pollution; experiments; polymers; process; determination; parameter; control.

Introduction

Plastic pollution is a global environmental problem, the scale of which is increasing every year. Polyethylene occupies a leading position among various types of plastics, accounting for a significant proportion of the total number of polymers produced and used. The main sources of polyethylene are packaging materials, disposable tableware, as well as construction and industrial products.

Polyethylene is resistant to natural factors such as solar radiation, oxygen and microorganisms, which makes it practically non-degradable in the natural environment. As a result, polyethylene waste accumulates in soil and aquatic ecosystems, becoming part of global pollution.

The purpose of this study is to study the environmental impact of polyethylene, conduct degradation experiments under various conditions, and identify possible measures to reduce environmental damage.

The main part.

Polyethylene (PE) is one of the most common polymers used in various industries such as packaging, construction, pharmaceuticals, and household goods. Its popularity is due to properties such as low cost, lightness, strength, and chemical inertia. However, the widespread use of polyethylene has a significant negative impact on the environment [1].

According to the Global Plastics Report (2022), the annual global production of polyethylene exceeds 1 billion tons, which is about 3.1% of the total plastic production. The main amount is used in the production of single-use packaging, the service life of which rarely exceeds several weeks. Most of the polyethylene waste ends up in landfills and damages the environment due to inadequate recycling systems.

The level of use of polyethylene waste remains low. According to the European Plastics Recyclers Europe, only about 15-20% of polyethylene waste is recycled, and the rest accumulates in the ecosystem [2].

Polyethylene residues accumulate in the soil and slow down the process of aeration and water exchange. Studies show that micro- and nanoscale polyethylene particles penetrate the soil ecosystem, disrupting the vital activity of microorganisms and altering the physical properties of the soil (2019).

Polyethylene waste accounts for a significant portion of plastic waste in the sea. They decompose into micro- and nanoplastics under the influence of ultraviolet, mechanical and chemical factors and spread throughout the aquatic ecosystem. These particles are absorbed by marine organisms and lead to bioaccumulation of harmful substances [3].

Plastic bags and other plastic products often lead to the death of animals that mistake them for food. Ingestion of plastic into the body can lead to suffocation, damage to internal organs and death of animals. According to National Geographic (2018), plastic pollution threatens more than 700 species of animals annually [4].

The latest technologies for processing polyethylene, such as Pyrolysis and chemical treatment, make it possible to obtain high-quality secondary raw materials. Their large-scale implementation requires investments and the development of waste collection infrastructure.

Biodegradable polymers such as polylactide (PLA) and polyhydroxyalkanate (PHA) are considered as an environmentally friendly alternative. However, their production still involves high costs and limited access.

Educational and legislative measures

Educational campaigns and a ban on the use of single-use plastic can help reduce environmental pollution. Examples of successful implementation of such measures are observed in the EU countries, where strict restrictions on plastic packaging have been introduced [5].

Methodology and research methods

The following methods were used to analyze the environmental impact of polyethylene:

Analysis of literary sources: scientific papers, reports and publications devoted to the problem of plastic pollution over the past 10 years have been studied. Special attention was paid to the work related to the biodegradation, recycling and environmental impact of polyethylene.

An experimental study to evaluate the physico-chemical properties of polyethylene, resistance to biodegradation, as well as the effects of micro- and nanoparticles on microorganisms.

The results of field studies aimed at studying the accumulation of polyethylene in soil, water and groundwater were used. The data was collected using standard sampling and contamination analysis protocols [6-8].

Various polyethylene processing technologies, including mechanical, chemical and thermal processing, their effectiveness and environmental impact are considered.

Experimental study to evaluate the physico-chemical properties of polyethylene, resistance to biodegradation, as well as the effect of micro- and nanoparticles on microorganisms [9,10].

Results

The experimental study consisted of several stages:

1. Physico-chemical analysis of polyethylene:

- measurement of density, molecular weight and degree of crystallization of the material;

-determination of resistance to thermal and chemical decomposition under various conditions.

Table 1- Results

Property	**Value**
Density (g/sm³)	0.91–0.96
Degree of crystallinity (%)	55–80
Melting point (°C)	110–130

2. Assessment of biodegradation:

Conducting tests for the decomposition of polyethylene in the presence of microorganisms in the laboratory and in the natural environment.

Study of factors affecting the rate of biodegradation, such as temperature, humidity, and microbial composition.

Table 2- Results

Experimental conditions	**Decomposition time (days)**
Laboratory (humidity 70%)	> 365
Natural environment (soil)	> 730

3. Investigation of the effect of micro- and nanoparticles of polyethylene on microorganisms:

Analysis of changes in the number and activity of microbial communities with the addition of polyethylene particles.

Assessment of the toxicity of nanoparticles for model organisms.

Table 3 - Results

Parameter	Control (without PE)	With PE added
Number of microorganisms (%)	100	75
Enzyme activity (units)	5.0	3.5

Study of factors affecting the biological decomposition rate, such as temperature, humidity and composition of microbes.

The results made it possible to better understand the properties of polyethylene and its impact on the ecosystem, as well as to identify the underlying problems associated with its decomposition and processing.

1.Temperature resistance of polyethylene - indicates the temperature resistance of the material (diagram 1).

2.The decomposition rate of polyethylene is a comparison of the decomposition time under laboratory conditions (diagram 2).

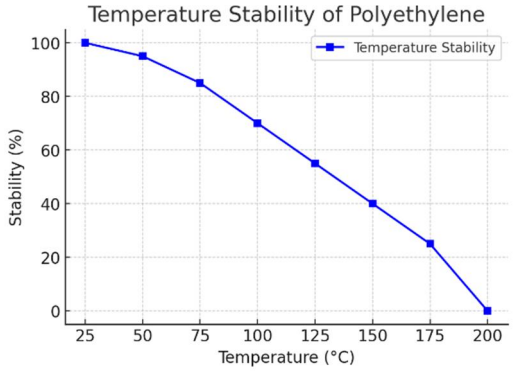

Diagram 1 - Temperature stability of polyethylene when heated to 200 °C (the graph is based on experimental data).

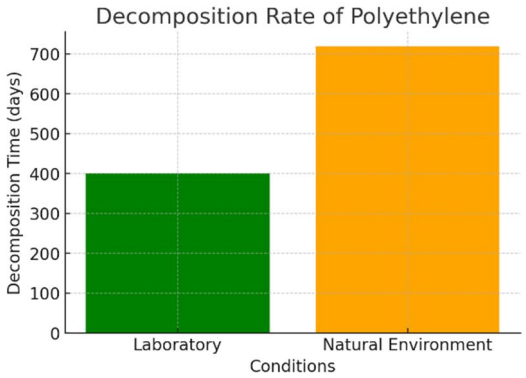

Diagram 2 - The rate of decomposition of polyethylene in various media.

Conclusion

Polyethylene plays an important role in the modern economy, but its use is associated with complex environmental problems. To reduce its negative impact, an integrated approach is needed, including the development of recycling technologies, the replacement of polyethylene with alternative materials, and active measures to reduce plastic consumption. The fight against environmental pollution by polyethylene requires the combined efforts of the state, enterprises and society. Polyethylene poses a serious threat to the environment due to its decomposability and ability to accumulate in ecosystems. Experimental studies have shown that its degradation is possible, but requires a long time or special conditions. To reduce environmental damage, you must:

- Development of polyethylene processing technologies.
- Reduce the use of single-use packaging.
- Use biodegradable alternatives.

These measures, along with environmental knowledge, can reduce environmental pollution from polyethylene and preserve natural resources for future generations.

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ПОЛИЭТИЛЕН КАК ИСТОЧНИК ЗАГРЯЗНЕНИЯ ОКРУЖАЮЩЕЙ СРЕДЫ

Аннотация. Полиэтилен является одним из наиболее широко используемых синтетических полимеров благодаря своей прочности, лёгкости, долговечности и низкой себестоимости производства. Однако его массовое применение и устойчивость к естественному разложению привели к серьёзным экологическим проблемам. В данной статье проанализированы основные механизмы, с помощью которых полиэтилен способствует загрязнению окружающей среды, включая образование микропластика, загрязнение почвы и водных экосистем, а также вредное воздействие на флору, фауну и, возможно, здоровье человека. Также рассматриваются более широкие экологические последствия накопления полиэтилена и подчёркивается необходимость срочного решения этих проблем. Изучаются различные подходы к снижению загрязнения полиэтиленом, такие как микробиологическое и ферментативное разложение, современные методы переработки и разработка биоразлагаемых полимерных альтернатив. Представлены результаты экспериментов по разложению полиэтилена в различных физических, химических и биологических условиях.

Полученные данные сопровождаются таблицами и диаграммами, наглядно демонстрирующими эффективность различных стратегий разложения и дающими представление о более устойчивых методах управления пластиковыми отходами.

Ключевые слова: полиэтилен; пластик; физико-химический анализ; экосистема; загрязнение; эксперименты; полимеры; процесс; определение; параметр; контроль.

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ПОЛИЭТИЛЕН ҚОРШАҒАН ОРТАНЫҢ ЛАСТАУШЫ КӨЗІ

Аңдатпа. Полиэтилен — беріктігі, жеңілдігі, ұзақ уақыт сақталуы және өндіріс құнының төмендігі арқасында ең кең таралған синтетикалық полимерлердің бірі. Алайда оның жаппай қолданылуы мен табиғи жолмен ыдырауға төзімділігі айтарлықтай экологиялық мәселелерге әкеліп отыр. Бұл мақалада полиэтиленнің қоршаған ортаны ластауға әсер ететін негізгі механизмдері, соның ішінде микропластиктердің түзілуі, топырақ пен су экожүйелерінің ластануы, сондай-ақ өсімдіктер мен жануарларға және адам денсаулығына келтіретін зияны талданады. Сонымен қатар полиэтиленнің жиналуынан туындайтын ауқымды экологиялық салдарлар қарастырылып, бұл мәселені жедел шешудің өзектілігі атап өтіледі. Полиэтиленмен ластануды азайтуға бағытталған түрлі тәсілдер, атап айтқанда, микробиологиялық және ферментативтік ыдырату, заманауи қайта өңдеу әдістері және биологиялық ыдырайтын полимер баламаларын жасау жолдары ұсынылады.

Полиэтиленнің әртүрлі физикалық, химиялық және биологиялық жағдайлардағы ыдырау үдерісі бойынша жүргізілген эксперименттердің нәтижелері көрсетіліп, кестелер мен диаграммалар түрінде берілген. Бұл деректер әртүрлі ыдырату стратегияларының тиімділігін көрсетіп, пластикалық қалдықтарды неғұрлым тұрақты басқару жолдарын ұсынады.

Кілттік сөздер: полиэтилен; пластик; физика-химиялық талдау; экожүйе; ластану; эксперименттер; полимерлер; үдеріс; анықтау; параметр; бақылау.