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Optimal resource utilization and advanced water treatment solutions

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Abstract. This paper explores the concept of environmental protection, focusing on the principles of geoecology, optimal resource utilization, and advanced water treatment solutions. Environmental protection refers to the responsible and sustainable management of natural resources while preserving and protecting the environment. Water treatment plays a crucial role in environmental protection as access to clean and safe water is essential for human well-being and ecosystem health. Currently, one of the main environmental issues in the world is the protection of the environment through the disposal of industrial waste and its rational processing, which in turn affects the improvement of the well-being of the population. It should be noted that the rapid development of industrial enterprises is accompanied by the formation of a significant number of various wastes, including wastewater. Purification of wastewater from pollutants is significant from an environmental and economic point of view.

1 Introduction

Biochar, which is derived from the carbonization of biomass in an oxygen-limited environment, is recognized for its significant contributions to both environmental improvement and energy generation. Biochar possesses desirable attributes such as a large surface area, ample pore volume, and diverse surface functional groups. As a result, it can be utilized in a wide range of applications, making it advantageous compared to materials obtained through alternative chemical processes. Moreover, biochar is cost-effective and readily available from various sources.

Biochar is a carbon-rich, porous material produced through the process of pyrolysis. It is derived from organic biomass sources, such as agricultural waste, wood chips, or plant residues, that are heated in a low-oxygen environment. During pyrolysis, volatile compounds are driven off, leaving behind a stable carbon-rich residue, which is the biochar.

These biochar-derived products hold great potential as sustainable energy resources. The production of biochar is influenced by different operating conditions and process parameters, which are defined during thermochemical processes. Consequently, the resulting products exhibit diverse physical and chemical properties. In large-scale industrial applications, the

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physicochemical characteristics of biochar are crucial. For instance, biochar that contains a low carbon content and high ash content is unsuitable for energy-related applications.

Wastewater treatment is an essential process in maintaining environmental sustainability and ensuring the availability of clean water resources. With the increasing industrial activities and population growth, the generation of wastewater containing various pollutants has become a significant concern. One effective approach for wastewater treatment is adsorption, which involves the removal of contaminants from water by binding them to a solid material called an adsorbent.

Adsorption is a widely used method due to its versatility, effectiveness, and cost-efficiency. It involves the attraction and attachment of pollutants to the surface of the adsorbent, thereby reducing their concentration in the water. The adsorbent materials can be natural, such as activated carbon, zeolites, or various types of clays, or synthetic, including resins and polymers specifically designed for adsorption purposes.

The adsorption process offers several advantages for wastewater treatment. Firstly, it can effectively remove a wide range of pollutants, including organic compounds, heavy metals, dyes, and other contaminants. Secondly, it is a versatile technique that can be applied to different types of wastewater, such as industrial effluents, municipal sewage, and agricultural runoff. Additionally, adsorption can be easily integrated into existing treatment systems or used as a standalone method.

The success of adsorption as a wastewater treatment approach depends on various factors, including the choice of adsorbent material, contact time, pH, temperature, and concentration of pollutants. The selection of an appropriate adsorbent is crucial, as it determines the efficiency of pollutant removal. Factors such as surface area, pore size, and surface chemistry of the adsorbent affect its adsorption capacity and affinity for specific contaminants.

In recent years, significant research efforts have been directed towards exploring novel adsorbent materials and optimizing adsorption processes for wastewater treatment. This includes the development of hybrid adsorbents, functionalized materials, and advanced techniques like magnetic adsorption and membrane adsorption. These advancements aim to enhance the adsorption capacity and selectivity, improve the regeneration of spent adsorbents, and minimize the environmental impact of the treatment process.

2 Materials and methods

The study [1] determined the composition of pine, fir, larch, spruce, and cedar wood, highlighting their various components. However, there is a lack of information regarding the quantitative chemical composition and capacitive characteristics of conifer cones, which are also considered renewable plant material. The research examined fir and pine cones obtained from the Polotsk forestry, which were processed into particles measuring 0.2-1.0 mm.

Chemical analysis of the cones followed established methods [2, 3]. By modifying the fir and pine cones using concentrated sulfuric and phosphoric acids, a series of ion exchange materials were produced. The total static exchange capacity (TSEC) was determined in accordance with GOST 20255.1-84. Table 1 presents data on the content of specific components in ordinary spruce cones (Picea excelsa). Table 2 outlines the main characteristics of the sorbents.

The study also revealed that fir cones contain organic substances capable of reducing Fe^{3+} to Fe^{2+} after being treated with estrogen. Considering the accessibility, affordability, and stability of iron (III) compounds compared to iron (II) compounds, as well as their availability from various industrial waste, fir cones were explored as a viable reducing agent to convert a portion of iron (III) in a solution to iron (II), achieving the necessary Fe(II): Fe(III) ratio for magnetite production. The extraction process was conducted using a 1:1 mixture of alcohol and toluene in a Soxhlet apparatus. Ground cones were brought into contact with a

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solution of iron (III) chloride, and the temperature-dependent concentration of Fe^{2+} ions was determined (described by the equation y=0.06191nx-0.1689), where y represents the concentration of Fe^{2+} ions, and x represents the temperature. Importantly, the amount of reduced iron (II) remained consistent within the pH range of 1 to 2, regardless of the initial $FeCl_3$ solution.

Thus, the study demonstrates that chemically modified cones from coniferous trees can serve as effective ion exchangers, while fir cones can be utilized as reducing agents in the production of magnetic materials for magnetically loaded sorbents. The research on the field chemical composition of cones was carried out using known methods [4 - 6].

a b

c

a- pine cones; b- pine cones powder; c-biochar.

Fig. 1. Optical images of pine cones.

The findings in Table 1 indicate that ordinary spruce cones consist primarily of lignin and cellulose.

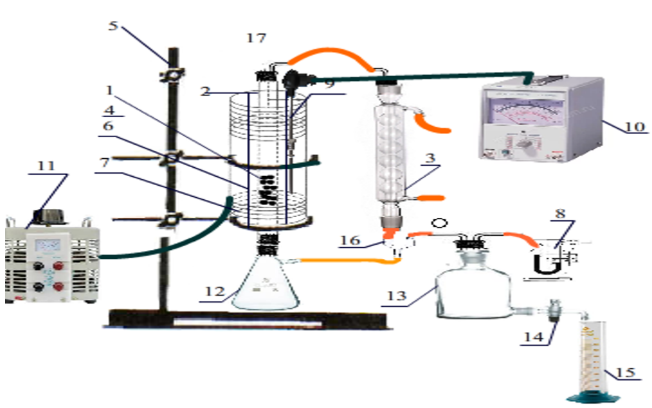
Table 1. Chemical composition of cones.

Chemicals	**Content (wt .%)**
Extractive substances	5.2±0.5
Ash	0.4±0.1
Cellulose	43.8±2.0
Hemicellulose	27.2±0.1
Lignin Klasona	21.5±1.2
Acid soluble lignin	0.6±0.1

Samples of activated carbon from pine cones without pretreatment were used as adsorbents. The water content in air-dried materials was determined by the gravimetric method, it was 3–5%.

The pyrolysis of nut shells involves a series of chemical reactions that result in the decomposition of complex organic compounds into simpler molecules. While the specific reactions and products can vary depending on the type of nut shell and the pyrolysis conditions, here are some general reactions that can occur:

- Dehydration: At the beginning of the pyrolysis process, water and other volatile compounds present in the nut shell are driven off. This step involves the removal of moisture and other volatile components.
- Depolymerization: The high temperatures of pyrolysis break down the complex polymers present in the nut shell into smaller molecules. This process involves the cleavage of chemical bonds, resulting in the formation of simpler compounds.
- Decarboxylation: Carboxylic acids, which are organic compounds containing a carboxyl group (-COOH), can undergo decarboxylation during pyrolysis. This reaction involves the removal of a carbon dioxide (CO_2) molecule, resulting in the formation of a simpler organic compound.
- Deoxygenation: Oxygen-containing functional groups, such as hydroxyl (-OH) and carbonyl (C=O) groups, can be removed from the nut shell molecules during pyrolysis. This deoxygenation process leads to the formation of compounds with a higher carbon-to-oxygen ratio.
- Carbonization: As the pyrolysis temperature increases, the organic matter in the nut shell decomposes further, leaving behind a solid carbonaceous residue known as biochar. Carbonization involves the breakdown of complex organic molecules into carbon-rich compounds.
- Secondary reactions: Alongside the primary decomposition reactions, secondary reactions can occur, leading to the formation of various byproducts. These byproducts include gases such as carbon monoxide (CO), carbon dioxide (CO_2), methane (CH_4), and hydrogen (H_2), as well as a range of volatile organic compounds.



1-test sample; 2- reactor; 3-water cooler; 4-electric stove; 5-tripod; 6- oven pack; 7- thermal insulation; 8-pressure gauge; 9- thermocouple; 10- millivoltmeter; 11- LATR; 12-condensate collector; 13- aspirator; 14- tap; 15-dimensional cylinder; 16- phase separator; 17 - reactor cover.

Fig. 2. Educational equipment Raw material pyrolysis process.

3 Results and discussion

It's important to note that the specific reactions and products can vary depending on factors such as the type of nutshell, heating rate, residence time, and temperature profile during pyrolysis. These factors influence the overall chemistry of the process and the resulting product composition. The raw material, pine cones, was subjected to preliminary heat treatment without air access in a pyrolysis installation, heated to 800 °C, respectively, at a rate of 10 °C/min and maintained at this temperature for 1 hour.

The adsorbate was wastewater from an oil and fat plant which located in the city of Urgench (Republic of Uzbekistan). The wastewater consists mainly of soap residues, fats, dyes, etc.

Adsorption was carried out at room temperature. The adsorbent weight was 2.5, 3.0, 4.0, 5.0 g, the solution volume was 50 ml, the concentration of working water solutions was 5, 6, 8, 10 mg/l, the adsorption time was 30 min.

Water turbidity was determined using Lovibond ® TB 211 IR, which is designed for accurate and rapid analysis. Scattered light was measured at an angle of 90° in accordance with EN ISO 7027. Both colorless and colored water samples can be measured, because it is performed using infrared light.

Increasing the adsorbent concentration leads to an increase in the degree of water transparency. Thus, at a concentration of 5 mg/l, the turbidity value decreases from 29.9 to 4.07, and at a concentration of 10 mg/l [7-10].

Fig. 3. Waste water before and after purification by using adsorbent.

The results of the study indicate the feasibility of carrying out the adsorption process for treating wastewater from oil and fat enterprises at a concentration of 10 mg/l to obtain deeply purified water.

4 Conclusion

The specific reactions and products of pyrolysis can vary depending on various factors such as the type of nut shell, heating rate, residence time, and temperature profile. These factors play a crucial role in determining the overall chemistry of the process and the composition of the resulting products.

Overall, the study demonstrates the effectiveness of using activated carbon derived from pine cones as an adsorbent for treating wastewater from oil and fat plants. These findings highlight the potential of using pine cone-derived activated carbon as an effective and environmentally friendly adsorbent for treating wastewater in oil and fat industries. Pine cones, a readily available and renewable resource offer a sustainable solution for water purification. Further research and optimization of the adsorption process could enhance its efficiency and broaden its application in wastewater treatment systems. The findings suggest that the adsorption process can be a viable method for treating wastewater from oil and fat enterprises, particularly when aiming to obtain deeply purified water. Further research and optimization may be necessary to explore the potential of this method on a larger scale.

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