Original Article
Bulletin of Pure and Applied Sciences.
Chemistry , Vol.42 C, No.2
July-December 2023: P.101-105

http://www.bpasjournals.com/chemistry
DOI: 10.48165/bpas.2023.42C.2.6
Print version ISSN 0970 4620
Online version ISSN 2320 320X

Removal of Phenol from Waste Water Using Various Agricultural Waste Adsorbents

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Received on 21.08.2023, Revised on 27.09.2023, Approved on 10.10.2023, Accepted on 27.11.2023, Published on 23.12.2023

ABSTRACT
Phenolic compounds are categorised as hazardous pollutants that contaminant groundwater. The principal objective of this article was to organising effective adsorbents for the removal of phenol and it's derivative. In this review article, a compelling amount of published paper were consulted in order to provide information about various agricultural waste adsorbents. Agricultural waste adsorbents have been modified by thermal and chemical process to enhance the surface area properties. This article has suggested that increasing the adsorbent dosage increases the adsorption capacity. The pH, adsorption capacity, reduction efficiency and temperature have been investigated for various adsorbents in this article. This study proved that agricultural waste adsorbents are effective in removal of phenol from waste water.

Keywords: Phenolic Compounds, Agricultural Waste Adsorbents, Adsorption Capacity

How to cite this article: Kumari A., Yadav M., and Kumar N. (2023). Removal of Phenol from Waste Water Using Various Agricultural Waste Adsorbents. *Bulletin of Pure and Applied Sciences-Chemistry,* 42C (2), 101-105.

1. INTRODUCTION

The most important natural resource on the earth for human beings, animals, and plants is water. As the world population is increasing the demand for clean water is also increasing. But due to the activities of industries like mining, pharmaceuticals, dye manufacturing industries, pesticides have introduced organic and inorganic contaminants into water systems [1]. The common contaminants are organic molecule such as phenols and dyes, heavy metals,

ammonia and sulphates. There are various methods exists for the removal of contaminants from water systems such as filtration, coagulation, sedimentation, floatation, solvent extraction, membrane technology. But the most efficient and low cost method is adsorption process [2]. This process is very simple to prepare and easy to design. It is thermally stable and this process can also regenerate the solid materials via thermal desorption [3]. Adsorption is a process where a material (adsorbate) is adsorbed on the surface of a solid material (adsorbent). Since adsorbents have larger surface area and highly porous, activated carbon have been studied broadly.

The major contaminants in water today is phenol and it's derivative because of high concentration of phenol in water causes skin damage, cardiovascular disease, muscle tremors etc. The world health organisation recommended that the phenol concentration in clean water does not exceed 1 ppb [4]. Therefore, removal of phenol and it's derivative from waste water is an intriguing research topic. This article highlights selected adsorbents in removal of phenol and it's derivative from water using adsorption method.

2. PREPARATION OF ADSORBENTS

A review article shows variety of agricultural waste products such as shells, husk, fruits, stems, coconut, banana, mango peels etc [19]. They all have a common functional group that is hydroxyl ion which is capable of binding pollutants from waste water. The waste is either physically or chemically treated to increase the surface area of adsorbents which leads to increase in adsorption capacity. The physical activation methods are generally used because it's easy and requires less handling. In this method, raw waste is carbonised at 450°C to remove bulk of matter. Then carbon is heated either in presence of carbon dioxide or steam. In the chemical process, the dried waste is charred with suitable activating agent such as sulphuric acid, nitric acid etc in 1:1 weight ratio and kept for 24 h to immerse. Then the char is subjected to pyrolysis at high temperature for few hours. The pyrolyzed material is allowed to cool at room temperature for 24 h. The carbon is cooled, weighed and stored in airtight container for further process.

3. TYPES OF ADSORBENTS

Adsorption by activated carbon is most efficient technology due to its larger surface area and high porosity. Activated carbon from agricultural waste material shows high adsorption efficiency as compared to commercial activated carbon. This article focuses on low cost activated carbon such as banana peel [5], sugarcane bagasse [6], borassusflabellifer fruit husk [7], coconut husk [8], orange peel [9], mango peel [10] and rice husk [11].

Banana Peel

Banana peel is a promising adsorbent for the removal of phenol from waste water. It is widely available in India. Banana is produced in large quantities annually and banana peel accounts for about one third of the fruit weight, it is discarded as waste. It has adsorption capacity mostly within 1-100 mg/g. Most studies showed that banana peel can be reuse up to five cycles and above. The regular banana peel powder had an average particle size and diameter of 978 ± 37 nm and 602 ± 13 nm respectively [12]. The research articles showed that the increase in the banana peel dosage from 10 to 30g/L significantly increased the phenolic compounds adsorption rates from 60 to 88%. The grafted banana peels have the highest adsorption capacity for phenol. Thermodynamic study shows that the adsorption of phenol is exothermic and spontaneous. Phenol Adsorption is inversely proportional to the temperature.

Sugarcane bagasse

Sugarcane bagasse is the major by-product of the sugar cane industry. Due to its abundant availability, it can use as a low cost adsorbent in removal of various contaminants from waste water. Sugarcane bagasse derived activated carbon can be produced by pyrolysis at various temperatures. Among many sugarcane bagasse, the one which was thermally activated at 600 °Chas highest removal efficiency. Many

studies showed that sugarcane bagasse activated carbon is appropriate adsorbent for removal of phenol from waste water. Studies showed that it has removal efficiency of about 60 % after 60 min at 60 °C and pH of 12[13]. It has adsorption capacity of 57.7 mg/g. Sugarcane bagasse was chemically treated with nitric acid and NaOH to further enhance its adsorption capacity. Removal efficiency of 96.1% has seen in the nitric acid treated sugarcane bagasse.

Borassusflabellifer fruit husk

Borassusflabellifer is also known as Palmyra in India. There are 85.9 million palmyra trees in India. About 51 million trees are in Tamil Nadu state alone. After removing the sprout, the fruit husk is thrown as waste. These wastes takes long time to decompose and makes environmental pollution hence it is important to convert it into useful product. The activated carbon from B. flabellifer was prepared by pyrolysis, sulphuric acid and zinc chloride activation method. The adsorption percentage of phenol by zinc chloride B. flabellifer fruit husk is maximum that is 95% with minimum carbon dosage of 80 mg at pH of 8. Cost analysis showed that it is economically viable activated carbon.

Coconut Husk

Coconut trees are widely available in southern states of India. Millions of coconut husk are thrown as waste annually. It was found that activated carbon from burning coconut husk in electric furnace at different temperatures is a low cost process. The maximum activated carbon from coconut husk was found at 700 °C. The equilibrium time for adsorption of phenol onto coconut husk activated carbon is 120 minutes. The maximum adsorption capacity is 19.02 mg/g. The removal efficiency was achieved 92% for a dosage of 10 g/L [14]. Many studies showed that adsorption of phenol by coconut husk was favourable in acidic conditions. Many studies have been suggested the increase in removal efficiency by adding rice husk into coconut husk.

Orange Peel

Orange peel is an eco-friendly plant waste product containing biodegradable organic compounds, 23% sugar, 25% pectin, 22% cellulose, and 11% hemicellulose. The thermal activated carbon from organic peel at 700 degree Celsius is highly porous biochar. The maximum adsorption capacities of about 99.2% have been shown at pH 7 and adsorbent dose of 0.08 g. The contact time is about 120 min for initial phenol concentration 100 mg/L. Reusability study showed that adsorbent can be used for up to five cycles having an adsorption efficiency of more than 50%.

Mango peel

Mango peel is widely available agricultural waste with very few uses. Many studies have shown that mango peel was activated by hydrochloric acid, sulphuric acid and phosphoric acid. Although the good results was given by sulphuric acid activated mango peel. pH 7 was more favourable for removal of phenol using sulphuric acid activated mango peel while pH 4 was favourable for removal of phenol using phosphoric acid activated mango peel. The BET surface area for unactivated mango peel was found to be 9.61 m^2/g[15]. After it was activated with sulphuric acid the surface area increases up to 64 m^2/g. There is a lot of scope for improving the efficiency by finding a better activating agent.

Rice husk

Rice is second largest product cereal in the world. Hence rice husk is locally available at almost no cost. Rice husk contains silica-cellulose structural arrangements which makes it a good adsorbent as compared to other agricultural waste adsorbent. The adsorption capacity of rice husk is 28 mg/g. The thermally activated rice husk in removal of phenol has reduction efficiency of 36-64% while the chemically activated rice husk in removal of phenol has reduction efficiency of 28% [16]. Studies have shown that adsorption capacity of rice husk increases with increase in adsorbent dosage and decrease in initial concentration of phenol.

4. APPLICATION OF LOW COST ADSORBENTS

Adsorbents made from agricultural waste, industrial by-products, natural materials can be used with little processing. It can improve economic value, help industries to reduce waste disposal and provide an alternative to activated carbon. Many studies have suggested that various low cost adsorbents have been investigated worldwide [17]. For low cost adsorbents, agricultural waste is one of the rich sources. It is suggested that after chemical modifications, the low cost adsorbents from agricultural waste shows outstanding removal efficiency of phenol from waste water. Research showed that adsorption capacity of orange peel in removal of phenol is 158 mg/g while adsorption capacity of activated carbon in removal of phenol is 146 mg/g [18]. Therefore low cost adsorbents can be a good alternative to activated carbon for the purification of contaminated water.

5. CONCLUSION

Among various methods of water purification, adsorption method is cost effective and efficient one. A study has engaged a vast amount of cheaper adsorbents to reduce water contaminants. Agricultural waste adsorbents continue to be interesting field of research for now and foreseeable future. There is a lot of scope for improving the adsorption capacity by activating agricultural waste chemically and thermally. Research has engaged to find a variety of activating agents and new preparation techniques. There is a lot of scope to modify agricultural waste and improve reduction efficiency.

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