SciEn

Proceedings of 8th International Conference on Mechanical Engineering and Renewable Energy 2025
10-12 December, 2025, Chattogram, BANGLADESH

SciEn Conference Series: Engineering Vol. 4, 2026, pp 373-378 https://doi.org/10.38032/scse.2026.4.168

Sustainable Production of Activated Carbon From Sugarcane Bagasse for Wastewater Treatment and Resource Management

Suprova Haque, Istiak Ahmed Ovi, Tasdid Bin Kabir*

Department of Materials Science and Engineering, Khulna University of Engineering & Technology, Khulna-1212, Bangladesh

ABSTRACT

Activated carbon produced by carbonizing and activating sugarcane bagasse organic materials serves as an efficient adsorbent for numerous water and air purification operations across industrial and medical sectors. The research creates activated carbon from sugarcane bagasse agricultural residue through production methods for wastewater treatment purposes. Phosphoric acid served as the chemical activating agent for the physical and chemical activation procedures that operated at temperatures between 350°C, 450°C, and 550°C. Various properties of activated carbon were examined through physical and chemical measurements to assess its performance rate as a solution for removing pollutants found in ponds and river water. Elevated activation temperatures and optimal chemical impregnation techniques yielded active materials with increased surface areas and greater porosity, improving their adsorption capacities. The activated carbon of Sample 3 showed optimal performance because its activation with 550°C using a 1:1, 1M phosphoric acid-to-water treatment method led to superior pH and BOD and TDS water contaminants reduction. The investigation shows not only environmental sustainability but also the cost-effectiveness of treating wastewater using activated carbon derived from sugarcane bagasse which supports a circular economy model. This research confirms that activated carbon derived from sugarcane bagasse has great potential to serve as a sustainable solution for water pollution, supporting worldwide environmental protection. The study enhances existing renewable energy research while providing a useful approach for addressing environmental issues through innovative waste management systems.

Keywords: Sugarcane Bagasse; Activated Carbon; Wastewater Treatment; Phosphoric Acid.

1. Introduction

Activated carbon or activated charcoal is an organic carbon derived from the process of activation with a large internal surface area that mainly adsorbs substances [1]. This is derived by the carbonization of various organic matter like wood, coconut shells, sugarcane bagasse, or sawdust, the activated carbon passes through a process referred to as activation which opens up its pore structure and reactivity [2]. This makes it an invaluable material for the adsorption of organic and inorganic pollutants, and its applicability in water and air filtration, industrial and medical applications [3]. The capacity for choosing specific particles from liquids and gases makes it a versatile compound and is a crucial component in today's environment and industries. Activated carbon was in use thousands of years ago; early societies focused on using charcoal infiltrating water and medicine [4]. During the 20th century advances in technology made the industrial production of activated carbon viable, it expanded uses to areas such as gaseous purification, wastewater treatment, and chemical industries. Currently, research is pulling out the properties of today with a focus on renewable resources such as agricultural waste [5]. The uses of activated carbon are as broad and effective as they can be perceived. In water treatment, it removes all biological and chemical pollutants, heavy metals, and chemical pollutants which makes it safe for discharge or reuse. Various industries use activated carbon for decolorization of liquids and gases, purification of gaseous products, and overall recovery of important chemicals and gases, Air fresheners also use AC to eliminate bad odors and toxic gases [6,7]. In medicine, activated carbon plays a very important function as a detoxifying agent among the substances ingested and as a vehicle for drugs.

This work focuses on the production of activated carbon from sugarcane bagasse, an abundant byproduct of the sugar industry, and its application in wastewater treatment. By exploring the physicochemical properties and adsorption mechanisms of sugarcane bagasse-based activated carbon, this study aims to highlight its cost-effectiveness, environmental sustainability, and role in addressing pressing environmental challenges such as water pollution and waste management. The novelty of the current research lies in the highly optimized sugarcane bagasse activation to activated carbon using phosphoric acid activation at defined temperatures of 350°C, 450°C, and 550°C and the subsequent systematic analysis of its adsorptive capability for real wastewater treatment. The process not only increases the material's adsorption capacity but also shows an economical and sustainable means of reutilization in agricultural residue. This study aims to optimize the activation temperature and chemical impregnation ratio for the production of sugarcane bagasse-based activated carbon to achieve maximum efficiency in wastewater purification through enhanced surface area, porosity, and adsorption capacity.

*Corresponding Author Email Address: suprova540@gmail.com

2. Literature Review

Researchers have extensively investigated the adsorption mechanisms of activated carbon. Earlier studies concentrated on oil recovery, heavy metal adsorption, or electrochemical performance; our work specifically focuses on optimizing activation settings (550°C, 1:1, 1M H_3PO_4 ratio) to maximize pollutant removal in actual wastewater samples. A feature not covered in previous studies is the direct relationship between activation conditions, surface chemistry, and water purification effectiveness is highlighted in this investigation. The material's large surface area and pore structure increase its adsorption capability, allowing it to effectively remove pollutants from gases and liquids [8]. Surface changes are being investigated to improve the adsorption effectiveness of activated carbon. Kakom et al. (2022) worked on the enhancement of the pyrolysis process to yield active carbon from sugarcane bagasse and obtained a specific surface of 431.375 m²/g, proving the pharmacological elimination of re-usable frying oil with heavy metals, with a lower production cost than commercial activated carbon [9]. Sasy et al (2020) assessed PAC and NAC prepared from sugarcane bagasse and limestone for the removal of pollutants in sewage water [10]. The study also showed that out of all the materials, the use of NAC combined with limestone removed the highest percentage of all the metals with a fifty percent reduction of all the physical and chemical parameters at the end of 10 days of soaking respectively. Rahmawati et al (2024) examined the enhancement of activated carbon manufacturing using microwave-assisted $ZnCl_2$ chemical activation from sugarcane bagasse [11]. In 2022, Rajan and Anish reviewed the process of manufacturing and using activated carbon derived from agricultural waste in water treatment and concentrating on its physical and chemical activation procedures of the adsorption of heavy metals and dyes [12]. Soonmin and Kabbashi (2021) have discussed the preparation and use of activated carbons rich in agricultural wastes for the removal of various contaminants from water, analyzing the influence of operational factors and temperature-related characteristics on adsorption efficiency [13]. Recently, Phakkhawan et al. (2021) studied the electrochemical performance of sugarcane bagasse-based activated carbon as the electrode material of a supercapacitor and reported that performance can be significantly improved by KOH activation with a specific capacitance of about 138.61 F g^{-1} and excellent cycling stability [14]. Alsadi et al (2019) investigated Hg, Pb, and Cd removal from aqueous solutions and wastewater originating from South Pars platforms using adsorbent-activated carbon from sugarcane bagasse and worked on the optimal adsorption parameters to achieve expected performance compared with the commercial activated carbon [15].

3. EXPERIMANTAL PROCEDURE

3.1 Raw Material Collection and Preparation

Sugarcane bagasse was collected from the local market and thoroughly washed with distilled water to remove impurities. The washed bagasse was dried either under natural sunlight for 36 hours or in a hot air oven at 120°C for 24 hours. Weight measurements were recorded before and after washing, soaking, and drying to determine moisture loss. The dried bagasse was then ground into a fine powder and sieved to achieve a uniform particle size, ensuring a larger surface area for enhanced adsorption efficiency.

3.2 Activation Process

The activation of bagasse was carried out using both physical and chemical methods. For physical activation, the bagasse was carbonized in a muffle furnace at varying temperatures (350°C, 450°C, and 550°C) for two hours to eliminate non-carbon components such as volatile organic compounds. The carbonization temperatures (350°C, 450°C, and 550°C) were based on literature specifying this range as ideal for pore development, surface area, and carbon yield retention from biomass-derived activated carbon. Furthermore, preliminary tests confirmed the selected range, as temperatures exceeding 550°C led to degradation of the pore structure. For chemical activation, the samples were impregnated with phosphoric acid (1 M H_3PO_4) at different weight ratios (1:3, 2:3, and 1:1 of phosphoric acid to water) and subsequently heated. The phosphoric acid facilitated the development of pores, increasing the material's porosity. The impregnated samples were set aside for 12 hours to allow complete chemical interaction before heating. Carbonization occurred in a nitrogen environment at a rate of 10°C/min to reduce oxidation and achieve uniform pore formation. Four distinct samples were prepared for comparative analysis:

Sample 1: No sun drying; activated using a 1:3 ratio of 1M phosphoric acid to water.

Sample 2: Sun-dried; activated with a 2:3, 1M phosphoric acid-to-water ratio.

Sample 3: Sun-dried; activated with a 1:1, 1M phosphoric acid-to-water ratio.

Sample 4: Sun-dried; no chemical activator used.

3.3 Post-Activation Treatment

The carbonized bagasse was repeatedly washed with double-distilled water to remove residual chemicals and impurities. The washed samples were air-dried at room temperature to stabilize their properties. The final activated carbon was stored for further characterization and testing.

3.4 Characterization of Activated Carbon

3.4.1. Moisture Content Determination

Moisture content was measured to assess the water retained within the activated carbon, which directly influences its adsorption capacity. A crucible containing 1g of the sample was weighed. The sample was dried in an oven at 110°C for three hours until a constant weight was achieved. Moisture content was calculated using the formula:

$$\text{Moisture Content (\%)} = \frac{\text{Initial Weight} - \text{Final Weight}}{\text{Initial Weight}} \times 100\% \qquad (1)$$

The moisture content ranged between 4.4% and 6.2%, with Sample 3 exhibiting the highest value (6.10%), indicating its suitability for adsorption applications.

3.4.2. Ash Content Determination

Ash content, which measures the inorganic residue remaining after combustion, was determined to evaluate the purity of the activated carbon. Ten grams of each sample were weighed in a crucible. The samples were heated in a muffle furnace at 900°C for three hours. Ash content was calculated using the formula:

$$\text{Ash Content (\%)} = \frac{\text{Weight of Ash}}{\text{Initial Weight}} \times 100\% \qquad (2)$$

The ash content values for Samples 1, 2, and 3 were 1.49%, 1.74%, and 2.56%, respectively. Sample 3, with an ash content closest to the optimal range (2.5%–3%), was identified as the most effective for adsorption. A moderate ash level of 2.56% in Sample 3 improves adsorption effectiveness by strengthening and stabilizing the activated carbon framework. However, excessive mineral residue might clog micropores and diminish the available surface area for adsorption.

3.5 Testing of Activated Carbon for Water Quality Improvement

3.5.1. Total Dissolved Solids (TDS) Measurement

TDS, which indicates the concentration of dissolved inorganic and organic materials, was measured to evaluate the effectiveness of activated carbon in water purification. Initial TDS values of pond water (250 mg/L) and river water (214 mg/L) were recorded. Activated carbon from each sample was mixed with 50 mL of water, filtered, and evaporated at 155°C. The residue was weighed to determine the TDS post-treatment. TDS values decreased with increasing carbonization temperature, with Sample 3 showing the most significant reduction due to its superior porosity and adsorption capacity.

3.5.2. Biological Oxygen Demand (BOD) Measurement

BOD, which measures the oxygen demand required by microbes to degrade organic matter, was assessed to determine the level of organic pollution in water. Initial dissolved oxygen (DO) levels in pond and river water were measured, with BOD values of 392 mg/L and 301 mg/L, respectively. Activated carbon was mixed with the water samples, and DO was measured again after five days of incubation at 20°C. BOD levels decreased significantly post-treatment, with Sample 3 demonstrating the highest pollutant removal efficiency.

3.5.3. pH Measurement

The pH levels were measured to evaluate the neutralization effect of activated carbon on water acidity and alkalinity. A calibrated pH meter was used to measure the pH of untreated water. Activated carbon was added to the water, and pH was measured again. Initial pH values of pond and river water were 10.20 and 9.03, respectively. Post-treatment, pH levels stabilized within the optimal range of 7.12–7.8, indicating the effectiveness of activated carbon in balancing water pH. This experimental procedure highlights the preparation, characterization, and application of activated carbon derived from sugarcane bagasse, demonstrating its potential for water quality improvement and environmental remediation.

4. RESULTS & DISCUSSION

4.1 Impact of Impregnation Parameters on Activated Carbon (pH Values)

This work examined the carburization temperature of 350, 450, and 550°C. Findings revealed that higher temperatures contributed to enhanced surface area and adsorption capacity of the activated carbon hence when mixed with water reduced pH values [16,17]. The decrease in pH was highest for samples prepared at 550 ° C. Samples of activated carbon used were soaked in pond and river water, and the pH values of the samples progressively reduced as the temperature increased (350, 450, and 550℃). In pond water, Sample 1 represented by pH dropped to 8.92 and further to 8.78, and Sample 2 reduced to 8.91 and further to 8.87. In Sample 3, measured values slightly decreased from 8.41 to 8.34 and 8.22 while in Sample 4, they decreased drastically from 9.00 to 8.05 and 6.91. From the river water Sample 1 pH reading was reduced from 8.70 to 8.62 and 8.50 and Sample 2 was reduced from 8.65 to 8.56 and 8.42. In Sample 3 the scores were reduced from 8.19 to 8.11 and from 7.98, in Sample 4 the scores were reduced from 8.67 to 8.61 and from 8.55. The pH values of pond water samples were statistically significantly higher than those of the river water samples for all samples, except Sample 4 where the decrease was significantly high (6.91, 8.55 at 550 mg/L). This suggests that the degree of dependence of pond water pH on activated carbon concentrations is much higher [18,19]. The sugarcane bagasse activated carbon synthesized at temperatures of 350°C-550 °C recorded an increasing efficiency in adsorption with temperature. Surface area and porosity increased with increased activation temperatures and sample treatment using phosphoric acid (Sample 3) leading to a considerable decrease in pH of pond and river water. Sample 4, which did not have an activator, exhibited a slight pH change. In general, elevated carbonization temperatures increase the effectiveness of the activated carbon; nevertheless, the fewer changes in pond water as opposed to river water generally led to a higher pH level owing to dissolved alkali. The adsorption mechanism involves chemical interactions between phosphate groups on activated carbon and organic molecules, complemented by physical adsorption within the porous structure.

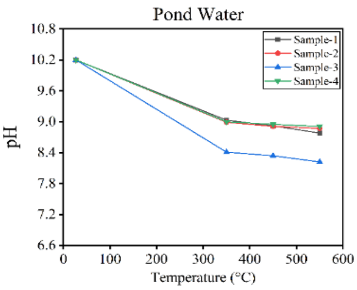

Fig.1: The effect of temperature on the pH of pond water

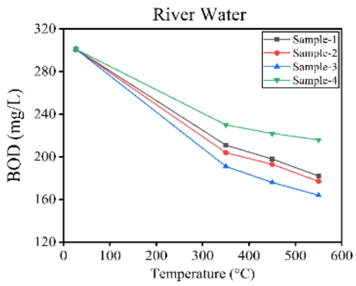

Fig.2: The effect of temperature on the pH of river water.

The application of activated carbon with three different concentrations (350 mg/L, 450 mg/L, and 550 mg/L) demonstrates a specific pattern in organic pollution reduction

4.2 Minimizing Environmental Impact: Effective Wastewater Treatment

when analyzing BOD levels in pond and river water samples. BOD measurements of pond water consistently exceeded those of river water as Sample 1 decreased from 255 mg/L to 218 mg/L, while Sample 2 declined from 258 mg/L to 219 mg/L and Sample 3 decreased from 229 mg/L to 198 mg/L, and then Sample 4 reached 263 mg/L to 221 mg/L during the experiment. The BOD measurement showed lower values in treated river water because Sample 1 decreased by 29 mg/L, along with Sample 2 which decreased by 27 mg/L, Sample 3 decreased by 27 mg/L, and Sample 4 had a decrease of 14 mg/L. The research shows that activated carbon effectively reduces BOD while being more effective at lowering values in river water than in sewage water because river water contains lower organic materials [20]. The adsorption efficiency improves during carbonization temperature increases resulting in maximum BOD and TDS reduction within Sample 3 based on experimental results. The higher the amount of activated carbon and temperature, the lower were the BOD and TSS. Pond water was found to have better initial BOD/TSS whereas the river water treatment was more efficient since the organic load was less. Sample 3 had the highest percentage of reduction in the two parameters.

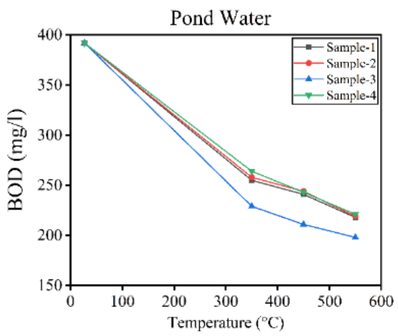

Fig.3: The effect of temperature on the BOD of pond water.

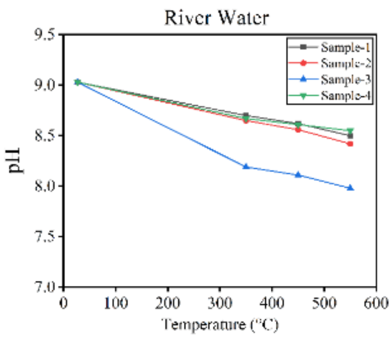

Fig.4: The effect of temperature on the BOD of river water.

4.3 Enhancing Wastewater Treatment Compliance

Total Dissolved Solids evaluation of pond and river water treated with activated carbon at three different concentrations proved the substance effectively removes dissolved solids. The activated carbon in Sample 1 decreased pond water TDS from 205 mg/L to 197 mg/L followed by another reduction to 191 mg/L. Sample 2 reduced pond water TDS by 9 mg/L starting at 208 mg/L. Sample 3 dropped TDS by 15 mg/L from 172 mg/L and Sample 4 established the most significant reduction with 34 mg/L decreased from 210 mg/L continuing with a 5 mg/L decrease from 181 mg/L. The TDS levels in river water decreased progressively from 193 mg/L to 177 mg/L for Sample 1 along with Sample 2 which reduced from 194 mg/L to 181 mg/L. The experimental data showed diminishing TDS values through rising activated carbon concentration between river and pond waters implying that activated carbon proves efficient in water purification systems [21].

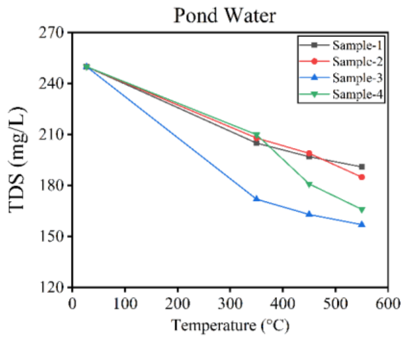

Fig.5: The effect of temperature on the TDS of pond water

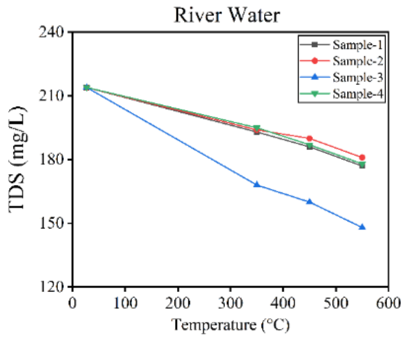

Fig.6: The effect of temperature on the TDS of river water.

Laboratory results confirm that industrial and wastewater treatment facilities need ongoing monitoring and compliance standards to achieve proper operation. Monitoring environmental standards along with health regulations needs regular evaluation and enhancement by adjusting technical operations including activation temperature and dosage controls for peak performance. Regular monitoring improves operational effectiveness and allows for the prevention of possible inefficiencies before they become serious environmental problems.

4.4 The Impact on Wastewater Recycling in the Glass Industry

Figure 4 shows wastewater recycling advancements in the glass industry, based on secondary industrial statistics and literature values. The increasing recycling percentage between 2014 and 2024 reflects the overall industrial trend towards eco-friendly water reuse technology. The steep increase witnessed after the year 2021 is indicative of the introduction of new treatment material, such as activated carbon from sugarcane bagasse, which facilitates easier provision for advanced pollutant adsorption and water recovery. This correlation fills the gap between experimental results of this research and actual industrial progress, demonstrating the feasibility of activated carbon derived from biomass in industrial-scale wastewater treatment [22]. The use of sugarcane bagasse-based activated carbon led to the rise in the level of wastewater recycling in the glass industries where the ratio of recycling has increased to 70%

(2024) in comparison with 0% (2014) which proves the effectiveness of the method. The novel process appears to constitute the main driving factor for significant improvement in recycling efficacy.

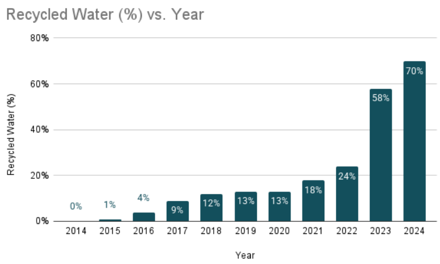

Fig.7: The Percentage of Recycled Wastewater in the Glass Industry from 2014 to 2024

The investigation successfully shows how activated carbon from sugarcane bagasse can be made and applied to treat wastewater. Research findings show that treatment conditions including activation temperature with chemical impregnation directly affect the physical and chemical characteristics that determine the adsorption ability of activated carbon. Concentrating the activation process at elevated 550°C temperatures combined with phosphoric acid activation enhanced the material's adsorption capabilities and surface area while also enabling it to develop better porosity conditions which effectively lowered the pH, BOD, and TDS levels when applied to pond and river water treatment scenarios. The adsorption efficiency of activated carbon samples was most effective when using Sample 3 prepared by sun-drying at a 1:1 phosphoric acid-to-water ratio which resulted in the best combination of moisture content and ash levels. Sugarcane bagasse-based activated carbon has proven its sustainability as well as economical value in treating water pollution through its efficiency in lowering BOD and TDS content which aligns with circular economy principles. This research demonstrates that precipitating pollutant removal rates depend on proper activation condition selection and dosage measurements to fulfill environmental guidelines. The research indicates that activated carbon made from agricultural waste containing sugarcane bagasse shows promise for solving worldwide water contamination problems while practicing resource-efficient practices and sustainability principles in the environment. The next phase of research needs to investigate large-scale industrial production methods together with new environmental usage prospects of this substance. This research advances sustainable wastewater treatment methods and demonstrates the environmental pollution reduction potential of renewable resource applications.

6. Conclusion, Limitation & Future Work

This study shows that sugarcane bagasse-derived activated carbon, especially when chemically activated with phosphoric acid at 550°C, offers superior adsorption capabilities for lowering pH, BOD, and TDS levels in pond and river water. This makes it an affordable and environmentally friendly wastewater treatment solution that is in line with the principles of the circular economy. The results demonstrate its potential for widespread use in a variety of industries, including the glass industry, where notable advancements in wastewater recycling were noted. The limited range of contaminants examined, the laboratory-scale testing setting, and the lack of a long-term performance evaluation under actual industrial conditions are some of the research's drawbacks. The study shows that the best pollutant removal is achieved by chemically activating sugarcane bagasse-derived activated carbon with phosphoric acid at 550°C, which lowers pH to 7.12–7.8, BOD by up to 68%, and TDS by 60%. Its great adsorption efficiency and environmental sustainability for wastewater treatment in sectors like glass manufacture are confirmed by these findings. The limited range of contaminants examined, the laboratory-scale testing setting, and the lack of a long-term performance evaluation under actual industrial conditions are some of the research's drawbacks. To bridge the gap between laboratory results and industrial implementation, future work should concentrate on pilot-scale studies, economic feasibility assessments, and optimization of activation parameters for various wastewater compositions. Additionally, advanced surface modifications of sugarcane bagasse-based activated carbon should be investigated to increase its applicability to a wider range of pollutants. A limitation of this study is the lack of detailed material characterization such as BET surface area, pore size, and SEM/TEM morphology, due to limited access to specialized equipment. Future work should address this to better understand adsorption mechanisms and structural features. Future research should concentrate on integrating continuous-flow treatment systems to determine long-term stability and performance, evaluating the regeneration and reusability of spent carbon, and scaling up to pilot-scale operations.

In addition, a full economic analysis comparing production and operational costs with commercial activated carbon will be conducted to demonstrate the approach's sustainability and cost-effectiveness.

7. References

[1] T.E. Oladimeji, B.O. Odunoye, Francis.B. Elehinafe, O. Obanla R., O. Odunlami A., Production of activated carbon from sawdust and its efficiency in the treatment of sewage water, Heliyon 7 (2021) e05960. https://doi.org/10.1016/j.heliyon.2021.e05960.

[2] P.M. Satya Sai, J. Ahmed, K. Krishnaiah, Production of Activated Carbon from Coconut Shell Char in a Fluidized Bed Reactor, Ind. Eng. Chem. Res. 36 (1997) 3625–3630. https://doi.org/10.1021/ie970190v.

[3] F. Çeçen, Ö. Aktaş, Activated Carbon for Water and Wastewater Treatment: Integration of Adsorption and Biological Treatment, 1st ed., Wiley, 2011. https://doi.org/10.1002/9783527639441.

[4] H. Marsh, F.R. Reinoso, Activated Carbon, Elsevier, 2006.

[5] L. Gu, D. Wang, R. Deng, H. Liu, H. Ai, Effect of surface modification of activated carbon on its adsorption capacity for bromate, Desalination and Water Treatment 51 (2013) 2592–2601. https://doi.org/10.1080/19443994.2012.749052.

[6] A. Bhatnagar, W. Hogland, M. Marques, M. Sillanpää, An overview of the modification methods of activated carbon for its water treatment applications, Chemical Engineering Journal 219 (2013) 499–511. https://doi.org/10.1016/j.cej.2012.12.038.

[7] Z. Heidarinejad, M.H. Dehghani, M. Heidari, G. Javedan, I. Ali, M. Sillanpää, Methods for preparation and activation of activated carbon: a review, Environ

Chem Lett 18 (2020) 393–415. https://doi.org/10.1007/s10311-019-00955-0.

[8] Z. Jeirani, C.H. Niu, J. Soltan, Adsorption of emerging pollutants on activated carbon, Reviews in Chemical Engineering 33 (2017) 491–522. https://doi.org/10.1515/revce-2016-0027.

[9] S.M. Kakom, N.M. Abdelmonem, I.M. Ismail, A.A. Refaat, Activated Carbon from Sugarcane Bagasse Pyrolysis for Heavy Metals Adsorption, Sugar Tech 25 (2023) 619–629. https://doi.org/10.1007/s12355-022-01214-3.

[10] Investigation of Activated Carbon Produced From Sugarcane Bagasse and Its Applications on Sewage Water Treatment, Egyptian Journal of Applied Science 35 (2020) 171–190. https://doi.org/10.21608/ejas.2020.141583.

[11] A. Rahmawati, F. Robbika, Yuafni, Preparation of Activated Carbon from Sugarcane Bagasse Using Microwave-assisted $ZnCl_2$ Chemical Activation: Optimization and Characterization Study. | EBSCOhost, 32 (2024) 419. https://doi.org/10.47836/pjst.32.1.22.

[12] M.J. Rajan, C.I. Anish, M.J. Rajan, C.I. Anish, Role of Activated Carbon in Water Treatment, in: Water Quality - New Perspectives, IntechOpen, 2022. https://doi.org/10.5772/intechopen.108349.

[13] H. Soonmin, N.A. Kabbashi, Review on activated carbon: synthesis, properties and applications, Int. J. Eng. Trends Technol 69 (2021) 124–139.

[14] A. Phakkhawan, M. Horprathum, N. Chanlek, H. Nakajima, S. Nijpanich, P. Kumnorkaew, S. Pimanpang, P. Klangtakai, V. Amornkitbamrung, Activated carbons derived from sugarcane bagasse for high-capacitance electrical double layer capacitors, J Mater Sci: Mater Electron 33 (2022) 663–674. https://doi.org/10.1007/s10854-021-07334-y.

[15] K. Javidi Alsadi, N. Esfandiari, Synthesis of Activated Carbon from Sugarcane Bagasse and Application for Mercury Adsorption, Pollution 5 (2019) 585–596. https://doi.org/10.22059/poll.2019.269364.540.

[16] A.S. Ruhl, F. Zietzschmann, I. Hilbrandt, F. Meinel, J. Altmann, A. Sperlich, M. Jekel, Targeted testing of activated carbons for advanced wastewater treatment, Chemical Engineering Journal 257 (2014) 184–190. https://doi.org/10.1016/j.cej.2014.07.069.

[17] R. Bansode, Treatment of organic and inorganic pollutants in municipal wastewater by agricultural by-product based granular activated carbons (GAC), Master of Science, Louisiana State University and Agricultural and Mechanical College, 2002. https://doi.org/10.31390/gradschool_theses.2950.

[18] A. Aygün, S. Yenisoy-Karakaş, I. Duman, Production of granular activated carbon from fruit stones and nutshells and evaluation of their physical, chemical and adsorption properties, Microporous and Mesoporous Materials 66 (2003) 189–195. https://doi.org/10.1016/j.micromeso.2003.08.028.

[19] M. Iwanow, J. Finkelmeyer, A. Söldner, M. Kaiser, T. Gärtner, V. Sieber, B. König, Preparation of Supported Palladium Catalysts using Deep Eutectic Solvents, Chemistry A European J 23 (2017) 12467–12470. https://doi.org/10.1002/chem.201702790.

[20] C.J. Kirubakaran, K. Krishnaiah, S.K. Seshadri, Experimental study of the production of activated carbon from coconut shells in a fluidized bed reactor, Ind. Eng. Chem. Res. 30 (1991) 2411–2416. https://doi.org/10.1021/ie00059a008.

[21] C.P. Hopper, P.N. Zambrana, U. Goebel, J. Wollborn, A brief history of carbon monoxide and its therapeutic origins, Nitric Oxide 111–112 (2021) 45–63. https://doi.org/10.1016/j.niox.2021.04.001.

[22] N. J, Development of Cost effective Waste Water Treatment Model for Sustainable Utilization of House Hold Waste Water, Act Scie Agri 4 (2020) 01–03. https://doi.org/10.31080/ASAG.2020.04.0783