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Effective Decolorization and Turbidity Removal of Canal Water using Activated Carbon Prepared from Local Agricultural Wastes

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Abstract

Beside the known capability of the activated carbon in color removing, it can be also exploited in turbidity removal. In this study, activated carbon was prepared from two local agricultural wastes; corncob and sawdust, through a chemical activation using phosphoric acid and potassium hydroxide with thermal treatment. The activated carbon was characterized using scanning electron microscopy (SEM), X-ray diffraction (XRD), and Fourier-transform infrared spectroscopy (FTIR). Also, ash and moisture content, apparent bulk density, fixed carbon, pores volume and surface pH were determined. From the obtained results, it could be concluded that both wastes are adequate to prepare effective activated carbon. However, due to embedding high amount of silica, corncob activated carbon reveals higher ash content and apparent bulk density compared to the sawdust one, while the later displays higher fixed carbon and pore volumes. The pH values of Corncob and sawdust carbon were; 7 and 5, respectively. The produced activated carbons were utilized in color and turbidity removal of raw water samples obtained from the Ibrahimiya canal, a long and important drinking water supplying stream in Minia region. The maximum removal efficiencies for turbidity were, 98% and 90% and for color were 87 % and 78% by using corncob and sawdust activated carbon, respectively at a hydraulic retention time of 30 min. The results indicated that both adsorbents are efficient and can be utilized individually to remove the turbidity and color from the wastewater, but the corncob activated carbon is more effective than the sawdust one.

Keywords: Corncob; Sawdust; Activated carbon; Agricultural wastes; Water treatment

Introduction

Although, the Egyptian government has issued several strict environmental regulations to protect the Nile river and the associated canals from receiving industrial and domestic wastewaters, many violations occur especially in the canals and streams [1]. Ibrahimiya canal is one of the longest canals in the world (350 km), It supplied perennial irrigation to 580,000 acres (2,300 km^2) and flood irrigation to another 420,000 acres (1,700 km^2). The discharge of the canal varied between 30 and 80 m^3/s in summer and between 500 and 900 m3/s in flood. Therefore, it is a main supplier for the drinking water for many villages and countryside [2]. This long distance makes this important canal competent to receive many and large kinds of pollutants. The presence of colored material in water streams results in a risk of Eco toxicity and potential danger of bioaccumulation. Human health could be affected by the transportation of these contaminants through the food chain [3].

Beside the colored material, turbidity arise not only a health problem but also a major concern during treatment of the wastewater using membrane technology.

There are various methods used in wastewater treatment technology, which can be classified into three main categories: primary, secondary, and tertiary treatment. Each of these methods is designed to remove specific contaminants from the wastewater. Primary treatment is the first stage in wastewater treatment, and it involves the physical removal of solids and organic matter from the wastewater. The primary treatment process involves the use of screens, sedimentation tanks, and clarifiers to remove large particles, suspended solids, and heavy organic matter from the wastewater. Secondary treatment is the second stage in wastewater treatment, and it involves the biological treatment of the wastewater. This process involves the use of bacteria and other microorganisms to break down the

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remaining organic matter in the wastewater. Tertiary treatment is the third stage in wastewater treatment, and it involves the advanced treatment of the wastewater to remove any remaining contaminants. This process involves the use of filtration, disinfection, and other methods to remove pathogens, nutrients, and other contaminants from the wastewater. The most common methods used in tertiary treatment include sand filtration, UV disinfection, and membrane filtration. Advanced treatment is a fourth stage of wastewater treatment, which is not commonly used in conventional wastewater treatment plants. This process involves the use of more advanced methods to remove specific contaminants, such as heavy metals, pharmaceuticals, and other emerging contaminants. Advanced treatment methods include reverse osmosis, activated carbon adsorption, and advanced oxidation processes. Membrane technology is an essential treatment process in the commercial drinking water supplying units; e.g. RO. Membrane fouling by natural organic matter (NOM) is a major concern in the application of membranes in water treatment processes. Several studies concluded that the colloidal fraction of NOM contributes most significantly in fouling of microfiltration (MF)/ultrafiltration (UF) membranes [4, 5]. As an effective alternative to coagulants, activated carbon (AC) has been proposed for removing the organic matters in a wider range compared to the conventional coagulants. For instance, Levine et al. reported that the AC can remove organic material of wide ranging molecular weight (0.5×10^2-10^9 Da) while the determined range was (0.5×10^8-10^9 Da) in the case of the coagulation methodology [6]. Moreover, Hatt et al could achieve up to 95 % of turbidity removal by using the AC [7]. Accordingly, several reports introduced the AC as effective material to reduce the modified fouling index (MFI) for different wastewater sources [8, 9]. Adsorption process is a very effective method in wastewater treatment because of its simple operation, economic, low secondary pollution and environmental protection [10]. Beside the adsorption capacity, the activated carbon can remove the NOMs via development a thin film from the local microorganisms. This film breaks down the readily available biodegradable organic matters, enhancing its removal and so suppressing the biological fouling through restricting this food source for the microorganisms [11, 12]. AC also could be utilized in important applications including water treatment, water desalination, wastewater treatment and air purification [13-16].

Activated carbon (AC) is the name for a big group of porous materials based on a carbonic matrix. The surface area of only 1 gram of (AC) is in excess of 500 m^2, as typically determined by adsorption of nitrogen gas [17]. Carbonization and activation are two important steps involved in the preparation of activated carbon. Carbonization is the first step in the preparation of activated carbon. It involves heating the carbonaceous material (e.g. biomass) in the absence of air to a high temperature (typically between 500 and 900 °C) to drive off volatile compounds and convert the material into a carbon-rich residue. During carbonization, the material is transformed into a porous, carbonaceous structure with a high degree of internal surface area, but it is not yet activated [18-21].

Activation is the second step in the preparation of activated carbon, which involves exposing the carbonized material to an activating agent such as steam, carbon dioxide, or a mixture of the two; this process is called physical activation. The activation process causes the carbon structure to undergo further modification, resulting in the development of an even higher degree of porosity and surface area, which leads to enhanced adsorption capacity. The activation process creates new pores and enlarges the existing ones, which in turn increases the surface area of the material. Beside the physical activation, chemical activation is also utilized. Chemical activation involves treating the carbonized material with an activating agent (e.g. potassium hydroxide and phosphoric acid) at a relatively lower temperature [22]. Moreover, there are other techniques were proposed for activated carbon production. For instance, combination of physical and chemical activation was proposed [23]. This method involves a combination of the physical and chemical activation techniques, in which the raw material is first carbonized and then activated with a chemical. Microwave activation process was also introduced [24]. In this method, the raw material is heated using microwaves, which causes it to develop a highly porous structure and increases its surface area. Furthermore, electrochemical activation technique was suggested [25]. In this method, an electric current is used to activate the carbon, which causes it to develop a highly porous structure and increases its surface area. The type of activation used depends on the properties of the carbon source and the desired end use of the activated carbon. However, in contrast to many activation techniques, in the chemical activation, carbonization and activation are un-separated steps, whereas in the other processes, they are independent [26].

Carboxyl, carbonyl, lactone, phenol and quinone are the main functional groups responsible for adsorbing contaminants. Oxygen, hydrogen, nitrogen and sulfur are also present in the form of functional groups or chemical atoms in the AC structure. The unique adsorption properties rely upon the existed functional groups of AC, which are mainly derived from activation processes, precursors and thermal purification [16, 27]. Accordingly, many types of activating agents were used in the chemical activation such as phosphoric acid, sulfuric acid, potassium

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hydroxide, sodium hydroxide etc. to add different function groups. Moreover, the change in the properties of this activation controls the porosity and the pores volume distribution in the carbon [28-30].

Phosphoric acid (H_3PO_4) is widely used in the preparation of AC from lignocellulosic products due to its advantages such as non-polluting character and ease of remove by extraction with water [31]. Moreover, H_3PO_4 makes physical and chemical modifications to the botanical structure by penetration, swelling of particle and biomass partial dissolution, cleavage of bond and reformation of new polymeric structures that resistant to thermal decomposition [32].

Generally, activated carbon may be obtained from various sources and its physical and surface properties depend on type of starting material, procedure and conditions of the product preparation. The commercial AC which used as preferred adsorbent is expensive [33]. So many researches have investigated the feasibility of using cheap alternative materials like oil palm, rice husk, bamboo stem, fungus bran, mulberry leaves [32, 34], date pits, pearl millet husk, sawdust, coir pith, coconut shell, olive stone, crude oil residue, tropical grass, almond shells, pine bark, wood waste, buffing dust of the leather industry etc., as carbonaceous precursors for water and wastewater treatment [35].

The supply of agricultural biomass from different sources during the production of food and feed is increasing around the world. These agricultural products create a substantial quantity of waste, So the production of AC from agricultural wastes will not only greatly reduce the cost of adsorbent preparation, but also benefit to protect the environment [34, 36]. AC can also be produced from sawdust, which is a waste byproduct of wood used in furniture, construction work and in the removal of unwanted materials from water [36]. Sawdust is low in ash content 0.08% wt and high in carbon content ranges from 77.51% to 93.59% wt. [37].

In this study, corncob and sawdust, as locally available agricultural wastes, were utilized as raw materials to prepare effective activated carbon using chemical activation with H_3PO_4 and KOH and thermal heating. The produced activated carbons were applied as adsorbents to remove the color and turbidity from the Ibrahimiya canal raw water. The results are promising and strongly recommend this cheap material to be utilized in water treatment technology. We at EJCHEM believe a template should help you, not hinder you, in authoring your paper. It should follow you in how you want to write your paper, not force you to fill in bits and pieces of text. It should allow you to type any text, copy from previous versions, or load an already existing plain text to be formatted. You will therefore find no dialog boxes or fill-in screens. You will not need to remember shortcut keys, to use lists of styles, bother

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Experimental part
2.2 *Materials and methods*
Corncob feedstock and sawdust (14 meshes) were gotten from Minia city area. Phosphoric acid (85%) was purchased from Fisher Scientific and KOH (>99%) from Sigma Aldrich. Low carbon steel crucibles were used to perform activation for small scale samples. Carbon washing was carried out in a Buchner Funnel.
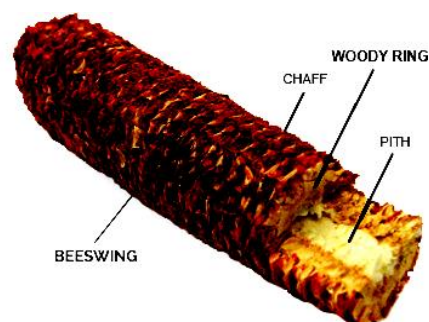
Figure 1 Cross section of corncob

Figure 1 demonstrates a cross section of the corncob. This agricultural waste was collected from countryside farms near Minia city. First it was washed several times with distilled water to remove all foreign materials, dirt and fibers then left to natural dry. After, that it was crushed into small pieces using a hammer and dried at 110 °C for 3 h in a drying oven until it was completely dry. Phosphoric acid (63%) was prepared and mixed thoroughly with corncob feedstock in a 4:6 weight ratios (corncob: H_3PO_4) then allowed to undergo hydrolysis overnight at 45°C. In a proper container, layer-by-layer sand and the treated corncob granules was built starting and ending by a sand layer, and finally a mud layer was used as a cover [16]. Then, loaded container was put into the muffle furnace where the hydrolytic solid was pyrolyzed at 500°C for 1h to produce carbon char which was then washed by distilled water. The activating agent (KOH) was added to the char in a weight ratio of 3:1 (KOH: char). The samples were kept in the furnace at 790°C for 1h and the resulting char was then washed with distilled water. After that the carbon was kept in an oven at 140 °C for 5 h to dry. Fig. 2 shows a schematic diagram for the used

experimental procedure to prepare activated carbon from the corncob.

For sawdust, the waste sawdust was collected from a local sawmill. It was sieved to obtain the desired size fraction (2 and 3 mm). Distilled water was used for washing the sieved sawdust to remove any impurities or residues such as dust, oil and ash. It was dried in an oven for 24 h at 100 °C. Then raw material was impregnated in phosphoric acid (H_3PO_4) in a ratio of 1:3 (sawdust:H_3PO_4) and it was left overnight. The remaining steps were done similar to aforementioned procedure used with corncob.

Color and turbidity removal experiments have been performed by adding 0.5 g of the prepared activated carbon to 100 ml of the raw wastewater and the slurry was left in agitator for different times. Later on, the slurry was filtered and the produced liquids was subjected to measure the remaining dye and turbidity in spectrophotometer and turbidity meter, respectively. It is noteworthy mentioning that both instruments were calibrated before use.

1. Characterization

The surface morphology of the as-obtained powder was studied using the JEOL JSM-5900 scanning electron microscope (JEOL Ltd., Japan). A Rigaku X-ray diffractometer (Rigaku Co., Japan) with Cu Kα (λ=1.54056 Å) radiation over a 2θ range from 5° to 90° was used to characterize the phase and crystallinity of the prepared nanomaterials. Fourier transfer analyses were done using Shimadzu 8300 spectrometer and the spectrum was recorded in a spectral range of 400- 4000 cm^{-1}. The samples were grinded to form a fine powder using 100 mg KBr. Then it was compressed into a thin pellet under 7 tons for 5 min.

The carbon yield was estimated as follow: the char material was weighed and used to obtain the percentage yield of carbon using the formula:

$$\% \text{ Yield of carbon} = \frac{weight\ of\ char}{weight\ of\ raw\ material} \times 100 \quad (1)$$

The bulk density was determined by weighing clean and dry 10 ml centrifuge tube (W_1), and then it was filled with the different AC samples (tap tube as it is filled until sample fills to the mark) and weighed (W_2). The difference in the weights gave the weight of the AC powder in the bottle. The bulk density of the AC powder was calculated using the equation:

$$\text{Bulk density} = \frac{weight\ of\ powder\ in\ the\ bottle}{Volume\ of\ bottle} = \frac{W2-W1}{Volume\ of\ centrifuge\ tube} \quad (2)$$

The pore volumes and the porosity of the AC were obtained using the formulas:

$$\text{Pore volume} = \frac{weight\ of\ water}{Density\ of\ water} \quad (3)$$

Therefore, the porosity is:

$$\text{Porosity} = \frac{Pore\ volume}{Total\ volume} \quad (4)$$

The moisture content was determined using the ASTM D2867-09 method 24. Clean empty crucible was oven dried at 110°C, cooled in a desiccator and weighed (W_1). Known weights of each powdered air-dried AC powder was put into the crucible, weighed (W_2) and dried in an oven maintained at about 110°C; the dried AC was constantly reweighed at 30 min interval until the weight of the carbon became constant. The crucible was taken out, cooled in a desiccator and weighed again (W_3). The loss in weight of the AC was used to calculate the moisture content (X_o) of the AC from the relationship:

$$X_0 = \frac{W2-W3}{W2-W1} \times 100 \quad (5)$$

The ash content of the AC was determined according to the ASTM D2866-94 method25. Clean empty crucible was oven dried at 110°C, cooled in a desiccator and weighed (W_1). Known weights of each powdered air-dried AC powder was put into the crucible, weighed (W_2) and transferred into a preheated muffle furnace set at a temperature of 800°C. The furnace was left on for 1h then the crucible and its content was transferred to a desiccator and allowed to cool, later on it was reweighed (W_3). The percentage ash content of each AC sample (dry basis) was obtained from the equation:

$$\text{Ash\%} = \frac{Wash}{W0} \times 100 = \frac{W3-W1}{W2-W1} \times 100 \quad (6)$$

Where: W_{ash} = weight of ash (grams).

The prepared activated carbons have been utilized to remove the color and turbidity from raw water collected from the Ibrahimiya canal. Table displays the initial characterization of the used water

Table 1 Initial characterization of Ibrahimiya canal raw water

Water quality parameter	Value
Chemical Oxygen Demand (COD)	22.8 ±1.3
pH	7.9 ±0.3
Turbidity (FNU)	1.8± 0.01
Total Dissolved Solids (TDS) (mg/l)	270±6.2

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3. Results and discussion

3.1 *Physiochemical properties of the prepared ACs*

Overall, the physiochemical properties of the AC such as the carbon yield, bulk density, porosity, moisture content, ash content and pH are very important to check the quality and consequently the expected activity in selected applications. These characteristics have been evaluated according to the standard methods; moreover, the introduced results were the average of multiple results. The obtained characterizations were summarized in Table 2. From the obtained results, the sawdust reveals more fixed carbon compared to that prepared from corncob; consequently, the later possesses less ash content (5.23 wt %) than sawdust AC (8.06 wt %) as it is tabulated. This finding can be assigned to presence of more inorganic constituents in the corncob with respect to the sawdust. This hypothesis was confirmed by the XRD analyses as it will be discussed below. The obtained apparent bulk density measurement states that the sawdust produces AC owing smaller bulk density (0.33 ± 0.01 g/cm^3) compared to corncob; 0.44 ± 0.01 g/cm^3. However, both values lie within the range of the reported AC produced from the agricultural waste [38, 39]. On the other hand, the total pores came compatible with the apparent bulk density as it can be observed in the table. Typically, as the pores represent the voidage so there is a reverse proportion between the total pore and the apparent bulk density. Therefore, the determined pore value for the sawdust AC (0.22 ± 0.05 cm^3/g) was higher than the corncob one; (0.19 ± 0.05 cm^3/g). Consequently, it is expected that the sawdust AC has higher surface area compared to the corncob one.

3.2 *Surface morphology*

Scanning electron microscopy (SEM) is widely used to study the surface morphology, including the pore structure, surface structure and pore arrangement on a material surface. The morphological study by SEM of the produced activated carbon shown in the Figures 3 and 4 reveals a good porous structure. In both samples, it was found that there are holes and cave type openings on the surface of the specimen that would definitely have increased the surface that are available for the adsorption process. In details, for the corncob AC, different SEM images are shown in Fig. 3. From the figure, the produced AC is porous with honeycomb shape in some areas; also irregular holes are seen in other areas. It also shows that when corncob is carbonized, it forms a tubular like channel structure of 20 µm diameter and 100 µm in length. Each macropore is again divided into sub macropores of 1-5 µm sizes. It can be inferred that these pores were existed in the initial raw material which facilitates diffusion of H_3PO_4 molecule into the pores and thereby increases the H_3PO_4−carbon reaction during the activation process. This in turn results in a good pore development which enlarges the micropore surface area and pore volume. Activation process was able to create pore structure within the carbon, indicating higher surface area. SEM image shown in Fig. 3 illustrated that the external surfaces of this corncob AC show large cavities and are very irregular, indicating that the porosity of the material was produced by aggressive attack of the reagent (H_3PO_4) during activation.
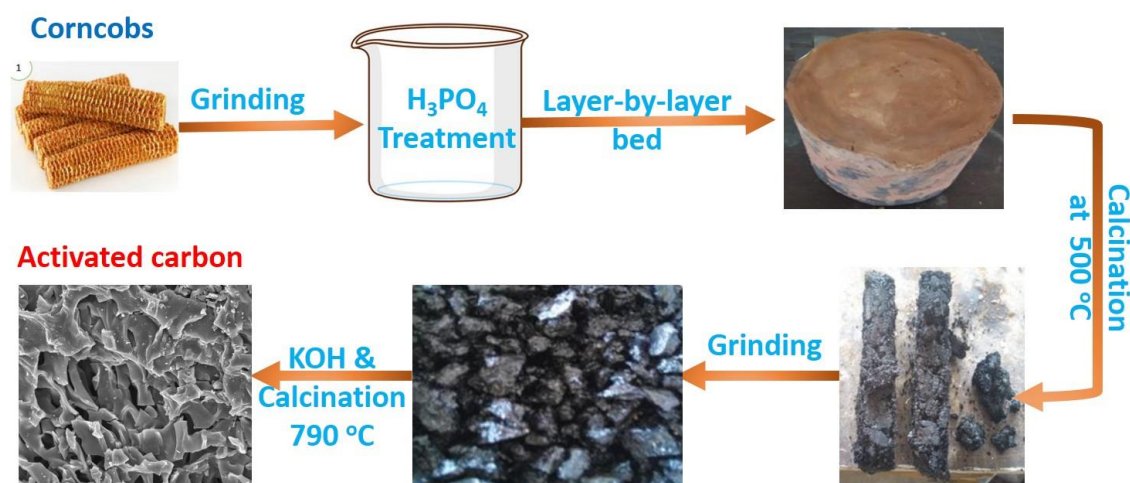

Figure 2 Schematic diagram for production methodology of Activated carbon from corncob agricultural waste.

Table 2. Prepared Activated Carbon Characterization

	Fixed carbon (%)	Apparent bulk density (g/cm^3)	Total Pore volume (cm^3/g)	Moisture content (%)	Ash content (%)
Sawdust	94.77 ± 0.5	0.33 ± 0.01	0.22 ± 0.005	< 1	5.23 ± 0.05
Corncob	91.94 ± 0.5	0.44 ± 0.01	0.19 ± 0.005	< 1	8.06 ± 0.05

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Activation at 500 °C with H_3PO_4 resulted in the creation of more pores and a substantial removal of volatiles. It seems that the pores and cavities on the surfaces of carbons resulted from the evaporation of H_3PO_4 during carbonization, leaving the space previously occupied [40]. Therefore, the H_3PO_4 is an effective activating agent to obtain AC having high surface area. Investigation of the surface morphology of the sawdust AC is shown in Fig. 4 which shows a great difference compared with that obtained from the corncob. Typically, the sawdust AC has a smooth surface, while corncob AC displays a much rough and more irregular surface structure. This indicates a gross attack on the exterior surface and interior pore wall at high temperature and burn-off. As a result, it effectively creates new pores and increases the total pore volume and surface areas (i.e., greater adsorption capacity).

3.3 *FTIR Analyses of the Activated Carbon*
Fourier Transform Infrared Spectroscopy (FTIR) is a technique that uses infrared light to ascertain the properties of a solid, liquid, or gas and provides information on the chemical structure of the materials. It was carried out in order to identify the functional groups present in the chemical compounds. Functional groups of adsorbents not only affect the adsorption behavior, but also dominate the adsorption mechanism [41]. The peaks appearing in the FTIR spectrum were assigned to various functional groups according to their respective wave numbers. The surface of the AC generally consists of functional groups which are oxygenated sites and possibly of the amino sites [42, 43]. One of the most vital parameters that influence the uptake of metal ions from aqueous solutions by AC is the carbon-oxygen and carbon-hydrogen functional groups present on the AC surface. The spectra analysis for hydrolysate corncob and saw dust AC samples are shown in Figures 5 and 6, respectively. It was shown that the corncob precursor contained more bands than the AC, and there were only slight differences between the ACs. In the figures, the bands at 3429 and 1080 cm^{-1} are assigned to O-H bonds and C-OH stretching of phenolic groups, respectively[44]. The bands observed in the region between 1700 cm^{-1} and 1490 cm^{-1} can be attributed to C=C symmetrical stretching of pyrone groups and C=O of carboxylic groups [45-48]. Moreover, Chiang et al. [49] noted that the alkaline treatment increased the amount of oxygen functional groups, especially, phenolic groups. In addition, carbon skeleton vibrations, which are characteristic in AC, were observed. The absorbance peak at about 1510 cm^{-1} may have been due to C-O stretching in carbonyls, carboxylic acid, and lactones. Moreover, the absorbance bands of hydrochar between 750 cm^{-1} to 1000 cm^{-1} and 1100 cm^{-1} to 1600 cm^{-1} were different with ACs that

confirmed the chemical transformation occurred during the phosphoric acid activation process. The noticeable chemical difference between the starting material and produced AC was also observed by Myglovetsa et al. [50]. It can be observed from the figures that all the samples showed a similar pattern revealing the O-H, C-H and C-C bond stretching. The band at around 3450 cm^{-1} represents the O-H stretching vibration mode of hydroxyl functional groups, while the band at around 2921 cm^{-1} can be assigned to the C-H symmetric and asymmetric vibration mode. Comparatively, the corncob activated carbon contains higher OH groups compared to the sawdust AC; the spectrum of the later is almost free from the OH representing band. The band at around 1631 cm^{-1} may be due to C=C stretching vibration mode of olefinic C=C bonds, which is also reported in the literature by Yang et al.[51].

3.4 *X-ray Diffraction Analyses*
X-ray Diffraction (XRD) was used to check the chemical composition of the prepared activated carbon from the exploited agricultural wastes. As shown in Fig. 7, appearance of strong diffraction peaks at two theta values of 20.8°, 26.6°, 36.5°, 50.1°, 59.9° and 68.2° corresponding to (100), (101), (110), (112), (211) and (203) crystal plans, respectively conclude presence of quartz (SiO_2) according to the Joint Committee on Powder Diffraction Standards; JCPDS) - International Centre for Diffraction Data (ICDD); card number 46-1045. This finding was obtained in both samples, however the quartz representative peaks are strong in case of the corncob AC which indicates existence in relatively higher content compared to the sawdust AC. Consequently, the corncob AC reveals higher ash content compared to the sawdust-based AC as it was summarized in table 2. Presence of silicon element in many agricultural wastes were confirmed by other researchers [52]. Observing a broad diffraction peak reveals a predominantly amorphous structure with AC derived from other lignocellulosic raw materials [53, 54]. Accordingly, the appearance of the peak at around 24° signifies an increasing regularity of crystalline structure, which will result in a better layer alignment and amorphous percentage [55]. The crystallinity recorded by corncob was 8.5% with 91.5% amorphous. These values were closed to previous study which used AC derived from different lignocellulosic raw materials[56, 57]. From XRD, the d002 and *Lc* value became slightly smaller as the surface area increased, this was due to the material structural ordering [58]. The d002 value was in the range of 0.34–0.35 nm. These values were larger than that of graphite (0.335 nm). For these ACs, the broad peaks were assigned to the reflection from graphite (002) and (100) planes, respectively.
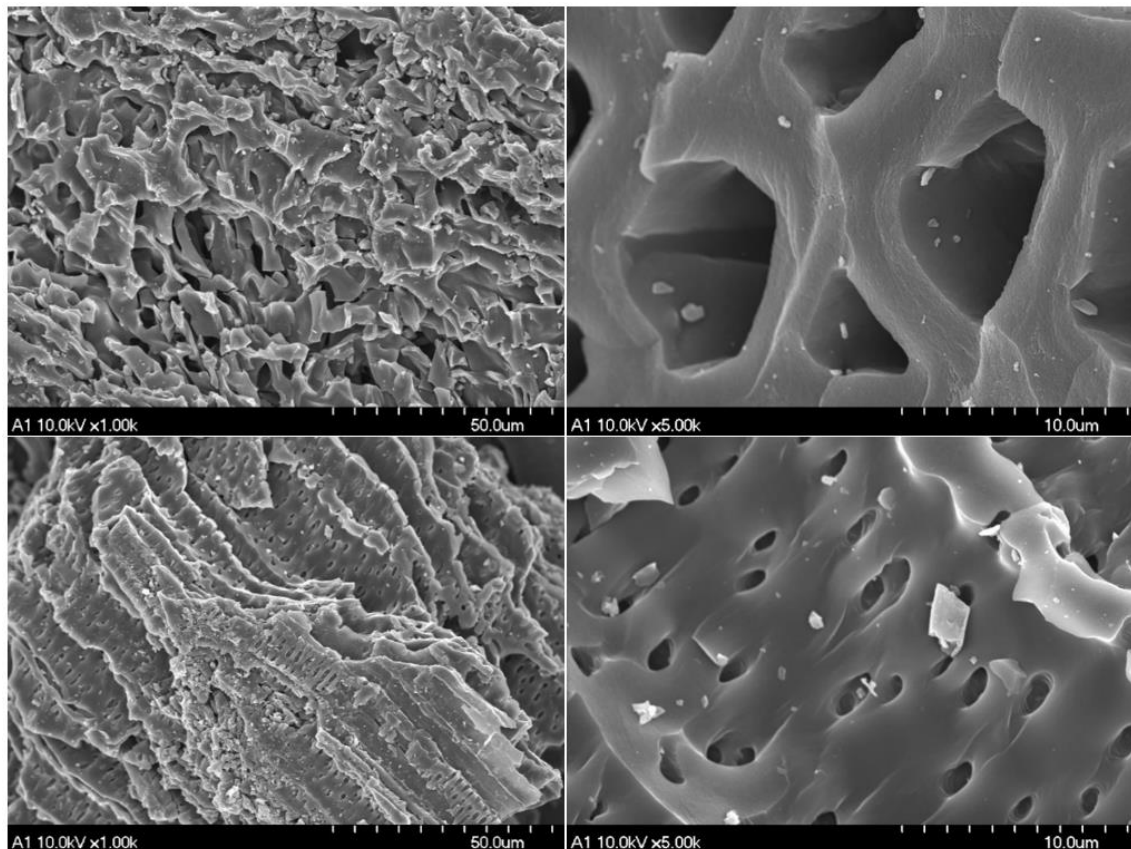
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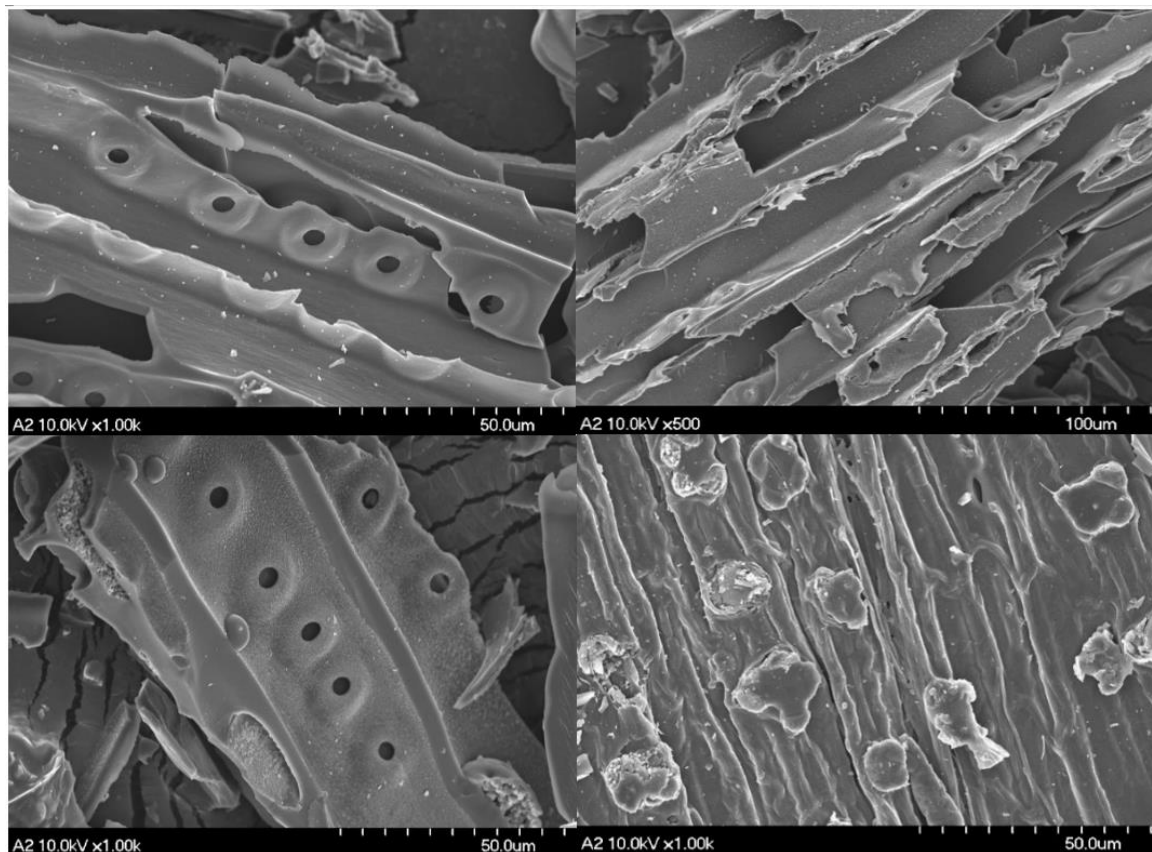Figure 3 Different SEM images for the corncob activated carbon

Figure 4 Different SEM images for the sawdust activated carbon
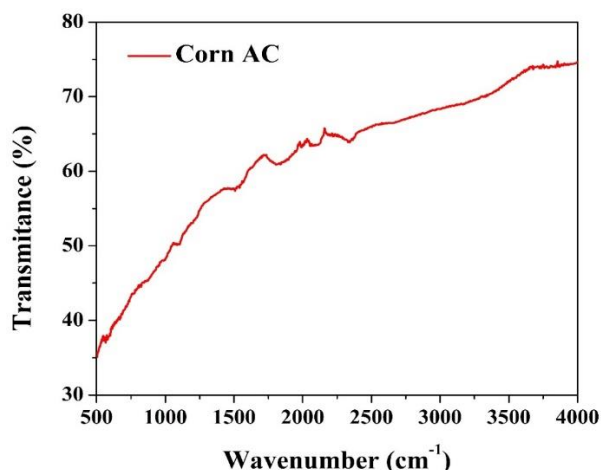
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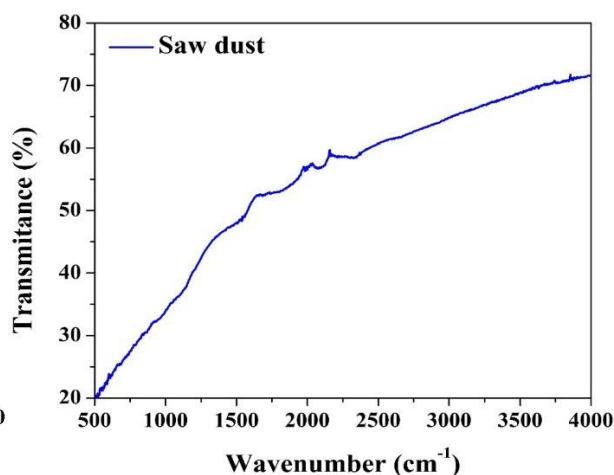Figure 5 FTIR spectrum of the corncob AC

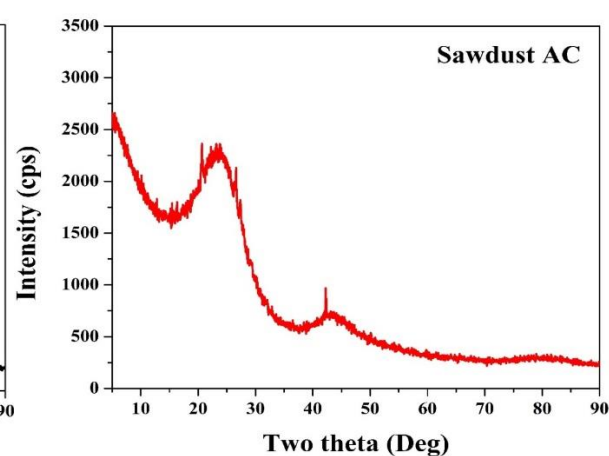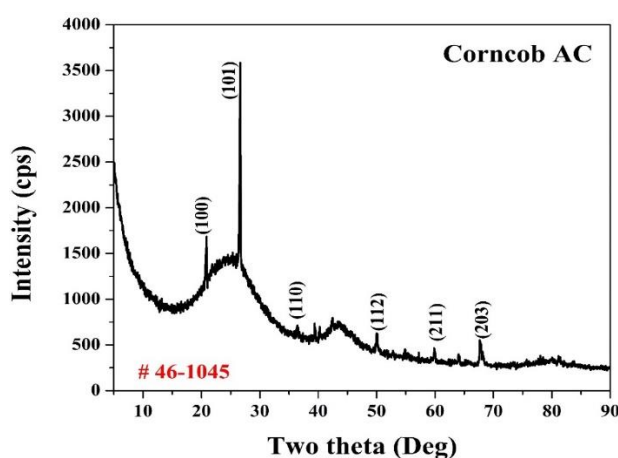

Figure 6 FTIR spectrum of the sawdust AC

Figure 7 X-ray diffraction patterns for the obtained activated carbon from corncob and sawdust

3.6 *Determination of pH*

It was reported that the pH of most commercial carbons is due to inorganic constituents originating from the precursor or added during manufacture[38, 59]. The pH variation among carbons may be explained by the percent ash content and by the specific mineral content. Carbons with pH of about 7 had low ash contents, while those with a pH rather than 7 showed a high ash content.

Figure 8 shows the pH values for the prepared activated carbon aqueous suspension within 1 h soaking time. From each type of produced activated carbon, 1 g was weighed and dissolved in 3 ml of de-ionized water. The mixture was heated and stirred for different times to ensure proper dilution of the sample. The solution was filtered out and its pH was determined using a digital pH meter. As shown in the figure, the sawdust AC reveals an average pH value of around 7 that may be attributed to the low ash content in the sample. On the other hand, the AC prepared from the corncob shows a pH value in the acidic value (around 5). Concerning that the two materials were prepared by the same procedure, it can be claimed that the low pH value corresponding to the corncob AC can be assigned to the initial raw

materials. The high ash content may explain their richness in different functional groups which may have contributed to the relatively low pHs. It is noteworthy mentioning that the high pH value activated carbon indicates existence of high mineral content [60]. Such high leachable mineral contents are unacceptable when the carbons are to be used for commercial decolorisation. Consequently, more extensive washing with acid would be necessary to reduce the amount of water soluble minerals to a level similar to that of the reference carbon [38]. Therefore, it can be claimed that the prepared AC are commercially favorable from the pH value point of view.

3.8 *Turbidity removal test*

Percentages of turbidity removal from Ibrahimiya canal raw water using corncob and sawdust activated carbons are shown in Fig. 9. The graph shows that turbidity removal of corncob is higher compared to sawdust AC. At 30 minutes hydraulic retention time (HRT), corncob AC gave the highest removal value which was 98% then sawdust 90%. The HRT 30 minutes gave the optimum contact time and the optimum effectiveness rate of AC to adsorb the

suspended organic content in the water. Obviously, through observation the functionality of AC was decreased as HRT increased above 30 minutes, because the pore surface area was slightly saturated and consequently efficiency of its performance to adsorb decreased. So the removal of turbidity decreased after the optimum retention time. Both types of AC presented the lowest percentage removal of turbidity at 60 minutes of HRT.
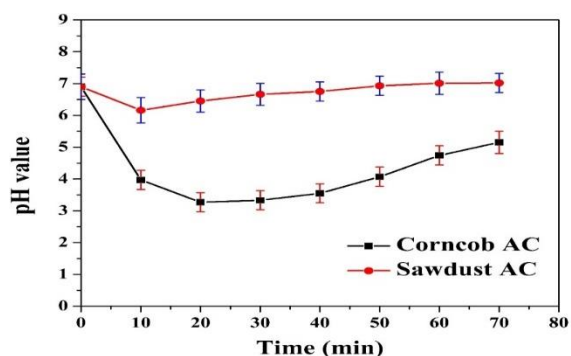

Figure 8 pH of the prepared activated carbon from the selected agricultural wastes

Indeed, adsorption is an effective and relatively economical wastewater treatment technology. The adsorption process is particularly effective in removing organic compounds, such as dyes, phenols, and other toxic pollutants. Activated carbon is often used as an adsorbent due to its high surface area and porosity, which allows it to effectively adsorb a wide range of contaminants. Compared to other wastewater treatment technologies such as membrane filtration or biological treatment, adsorption is generally considered to be more cost-effective. The adsorbent material can be regenerated and reused multiple times, reducing the overall cost of the treatment process. Adsorption is widely used in industries such as food processing, pharmaceuticals, and chemicals. For example, activated carbon is commonly used to remove organic contaminants from wastewater in the food processing industry. Resins are used in the pharmaceutical industry to remove impurities from drug formulations. Another advantage of adsorption is that it can be used in combination with other treatment technologies, such as biological treatment or membrane filtration. Adsorption can also be used to treat industrial wastewater that contains a low concentration of contaminants, making it a cost-effective option for many applications. Overall, adsorption is a widely used and effective technology for the treatment of industrial wastewater. Its effectiveness, versatility, and ability to be combined with other treatment technologies make it an attractive option for many industries. Among the used adsorbents, activated carbon is the most widely used industrially. However, the price of the commercial activated carbon is relatively high. Therefore, the proposed activated

carbon in this study can add a significant advantage for the adsorption process to be utilized as it can be produced from biomasses wastes with relatively simple procedure.
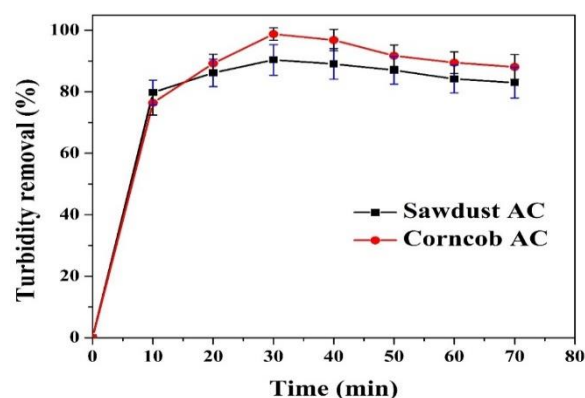

Figure 9 Turbidity removal percentages from Ibrahimiya canal raw water using the prepared activated carbons from sawdust and corncob

3.9 *Color removal test*
Among the treatment options used for color removal from industrial effluents, adsorption appears to have a considerable potential. It has been found that the performance of the adsorbents depends on their textural properties as porosity and surface area [61]. Adsorption on activated carbon is a well-known process for micro-pollutants removal [18]. Percentage of color removal from Ibrahimiya canal raw water using corncob and sawdust produced activated carbons was shown in Fig. 10. The graph shows that color removal of corncob is higher compared to sawdust. Moreover, with this higher removal percentage, the maximum adsorption was obtained at 15 minutes HRT in case of the corncob activated carbon, while to get the maximum color removing, 35 min HRT is needed. Interestingly, the percentage of color removal is highly accepted for both samples. It reaches to around 87 and 78 % in case of the activated carbon obtained from corncob and sawdust, respectively.
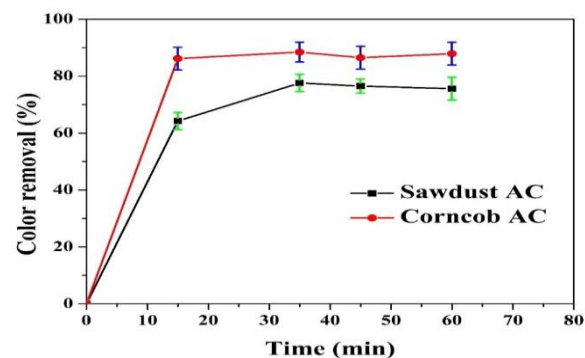

Figure 10 Color removal percentages from Ibrahimiya canal raw water using the prepared activated carbons from sawdust and corncob

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4. Conclusion

It can be concluded that high surface area and high micropore volume activated carbons can be prepared from popular corncob and sawdust agricultural wastes by chemical activation using H_3PO_4. The activated carbon morphology as well as the other physiochemical characterizations are directly dependent on the utilized agricultural waste precursor. The surface area was obtained with the pores which were mainly microporous in the samples activated chemically. The prepared activated carbons would be a good adsorbent in adsorption application from solutions. This observation is supported by the textural characteristics of the obtained carbons and the performance as adsorbent to remove color and turbidity from raw water (Ibrahimiya canal, Minia area).

Conflict of Interest/Competing Interest.

The authors declare that they have no conflict of interest. Also, they have no competing interest.

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