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PHYSICOCHEMICAL CHARACTERIZATION AND APPLICATION OF BIOMASS-DERIVED ACTIVATED CARBON FOR SUSTAINABLE WASTEWATER TREATMENT IN THE ALGERIAN SAHARA

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ABSTRACT

This study explores the potential of activated carbon synthesized from locally available agricultural waste for the treatment of wastewater contaminated with organic pollutants. Activated carbon was prepared from TEMJOUHERT (TMG) date palm kernels originating from the Ghardaia region (Algeria) via chemical activation using phosphoric acid (H_3PO_4 , 85%). The synthesis yield reached 28.56%. The adsorbent was characterized in terms of bulk density, ash content, iodine number, surface functional groups (Boehm titration), and point of zero charge (pH_{pzc}). Morphological and textural properties were investigated by SEM and BET analyses, revealing a high specific surface area ($639.92 \text{ m}^2 \text{ g}^{-1}$) and a micropore volume of $0.4208 \text{ cm}^3 \text{ g}^{-1}$. The adsorption performance was evaluated using real wastewater samples collected from the Atteuf (Kef Doukhane) area. Under optimal operating conditions (1 g adsorbent per 100 mL, 90 min contact time, 250 rpm), removal efficiencies of 84.75% for PO_4^{3-} , 85.21% for COD, and 74.55% for NH_4^+ were achieved. These results confirm the suitability of date palm kernel-derived activated carbon as an efficient and sustainable adsorbent for wastewater treatment.



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I. INTRODUCTION

Water pollution is a major problem that poses a real danger to human life and aquatic life. It can affect surface waters and groundwater. The origins of water pollution are varied but intimately linked to human activity: domestic, urban, industrial, and agricultural pollution. [1] The situation gets worse when it comes to non-biodegradable and/or toxic pollutants, considered the most dangerous harmful elements for both humans and the environment. The presence of organic pollutants in wastewater minimizes the performance of biological treatment systems and consequently reduces the possibility of reusing this water even in the least demanding fields in terms of quality. It is for this reason that these heavy metals and organic compounds are removed from effluents before any attempt at biological treatment.[2] The search for alternative or complementary methods for wastewater treatment has led, in recent years, to the emergence of new technologies. Currently, the adsorption technique is the most favorable method for the removal of organic pollutants in aqueous solutions. This technique has become a preferred analytical method, economical, very effective, and simple to use.

Research then shifted towards treatment processes using natural materials such as agricultural products, especially by-products of the date palm (leaves, trunk, pits, pedicels, etc.), due to their availability and low costs. It is within the framework of the valorization of this resource that this work is situated. It involves preparing activated carbon from local date pits and using it in the treatment of urban wastewater. The great diversity of palm trees and their dates in the Algerian desert, which results in significant waste, necessitates their utilization in various fields, especially in the production of adsorbent materials. In this study, we targeted the Ghardaia region, which is considered one of the largest Algerian cities in date production, where date pits were used to treat wastewater from the same region, which is one of the most important industrial areas in the country. In water treatment, adsorption is a surface phenomenon by which atoms or molecules constituting the impurities in the water to be treated adhere to the solid surface of a substrate through various processes. [3], [4]

The use of inexpensive or commercially valueless bio-adsorbents to remove organic matter from aqueous solutions has proven that they can compete with expensive traditional adsorbents. In this regard, one can mention: treated olive pulp, tree fern, tea waste, kudzu, palm fibers, wood, or even sawdust. [5] The European Council of Chemical Industry Federations (E.C.C.I.F) [6], defines activated carbons as carbonaceous products with a porous structure that has a very large internal contact surface. These materials are capable of adsorbing a wide variety of substances on their internal surfaces, and are consequently called adsorbents. Activated carbon, in its broadest sense, is a term that encompasses a wide range of amorphous carbon materials that exhibit very high porosity and a significant inter-particulate surface area [7-9] Microporous adsorbents are more usable in various fields such as the treatment of pollutant discharges from urban wastewater; because of their adsorption capacity linked to their large specific surface area and porosity. Therefore, our study focuses on the preparation of an adsorbent "activated carbon" from agricultural waste, specifically the pits of local dates, and its use in the treatment of urban wastewater in the municipality of Kef Doukhane El-Atteuf, wilayat of Ghardaïa.[10]

II. MATERIALS AND METHODS

II.1 PREPARATION OF ACTIVATED CARBON

The production of activated carbon is done by the activation method, and it is activated before pyrolysis.

II.1.1 Collection and washing of date pits

With the aim of valorizing local materials into activated carbon, we used date pits from the Ghardaïa region of Algeria as a precursor, harvested in October 2021.

Variety: TEMJUHART
Harvest date: September
Distribution: El-Méniaa; Metlili, Ouargla....
Fruit shape: ovoid
Seed Shape: ovoid or straight
Fruit color: red and black
Seed color: Beige
Seed / Fruit: 1/2 to 2/3
Weight of 20 seeds: 16 to 30g



Figure 1: Description of the date studied
 Source: [11]

II.1.2 Preprocessing of date pits

II.1.2.1 Washing and drying

The date pits were collected, then they were scraped with a knife to remove all the fibers present on the surface. Then, they were washed with tap water several times and then with distilled water. After washing, they were dried in an oven at 105°C for 24 hours.

II.1.2.1 Crushing and sifting

The cleaned date pits are then crushed and sifted to retain only a uniform fraction between (0.4 and 0.1 mm). The retained powder was stored in a desiccator.

II.1.3 Chemical Activation

For the activation, we used concentrated phosphoric acid "85%" as the activating agent, and we impregnated a determined mass of crushed date pits in a water-acid mixture with a 1/1 volumetric ratio according to Hazourli's protocol. [12] The reaction mixture is maintained at 100°C for 1 hour in the oven. The start of the contact time is set from the moment the temperature reaches 100°C. After activation, the residues were collected, then filtered to eliminate all traces of phosphoric acid before carbonization.

II.1.4 Carbonization

Carbonization is carried out in the chamber of an electric oven preheated to 600°C, the obtained charcoal is placed in closed porcelain capsules to prevent any loss of mass and gas diffusion. This temperature is maintained for a duration of 3 hours to obtain a dry residue free of resins or other non-carbon compounds. [9]

II.1.5 Neutralization

The two obtained charcoals were washed with a hydrochloric acid solution (5%) and stirred, then washed with distilled water and stirred several times, and the water was filtered until the rinsing water was neutralized to reach a pH range between (6 and 7). This procedure allowed to clean the microporosity of an activated carbon. Before conducting the adsorption tests, the treated charcoal is dried in an oven at 105°C for at least 8 hours.[9]

II.2 TEXTURAL CHARACTERIZATION AND DETERMINATION OF PHYSIOCHEMICAL INDICES OF ACTIVATED CARBON

The knowledge of the physico-chemical and structural properties of any material is necessary to contribute to the understanding of many phenomena such as adsorption, desorption, or others. We present some of the most important characteristics of activated carbon made from date pits.

II.2.1 Physico-chemical analysis

To better visualize the quality of the CA, physico-chemical analyses were conducted. The parameters to be analyzed are:

II.2.1.1 Yield (Y%)

The yield reflects the loss of mass of the biomass during carbonization. The mass (in grams) of the obtained charcoals was determined. The yield of the preparation was determined according to the following formula:

$$Y(\%) = \frac{\text{mass coal}}{\text{mass biomass}} \times 100 \quad (1)$$

II.2.1.2 pH (potential of hydrogen)

In 100 ml of distilled water, introduce 1 g of activated carbon into a flask and place the flask on a stirrer, then measure the pH with a pH meter.[13]

II.2.1.3 Humidity rate « H% »

When the prepared activated carbons are in constant contact with the air or during their storage, the solids become charged with a certain humidity due to the diffusion of water molecules into the structure and on the surface of the solid. The evaluation of the humidity rate can be indicative of the hydrophilicity of this solid. The relationship below allows to obtain the relative humidity rate H (%) for the different activated carbons prepared.[14]

$$H(\%) = \frac{(P_1 - P_2)}{P_1} \quad (2)$$

II.2.1.4 Cinder rate (C%)

It is about the inorganic, inert, amorphous, and unusable part present in activated carbon; the cinder rate is determined by the method described in the literature. [15] The cinder rate is determined as below :

$$C(\%) = \frac{m_3 - m_2}{m_1} \times 100 \quad (3)$$

Where:

M1: the mass of the used carbon in (g)

M2: the mass of the empty crucible before carbonization in (g)

M3: the mass of the crucible filled after carbonization in (g).

II.2.1.5 Activation Rate (AR%)

The yield is an important quantitative characteristic for the activated carbons. It reflects the mass loss during pyrolysis. This mass loss indicates the degree of activation usually referred to as burn-off [16], [17]. The expression of mass yield is given by the following formula:

$$AR(\%) = \frac{\text{initial mass} - \text{final mass}}{\text{initial mass}} \times 100 \quad (4)$$

II.2.1.6 Apparent density

The density is a ratio of the particle mass to its volume, which encompasses all solid fractions and pores; the density was determined using the graduated test tube method. The following relationship allows for the determination of the apparent density D (%).

$$D(\%) = \frac{(W_1 - W_0)}{100} \quad (5)$$

W₁: the weight of the filled test tube (g).

W₀: the weight of the empty test tube (g).

II.2.1.7 Determination of surface functions by the Boehm Method

A quantitative method determines the acidic and basic functional groups on the surface of activated carbons. It involves acid-base titration.[9].

A mass of 0.1 g of carbon is brought into contact with 50 ml of each of the aqueous solutions of sodium hydroxide (NaOH) and hydrochloric acid (HCl) at 0.1 M. Each solution is stirred for 4 hours at a constant speed of 200 rpm at room temperature. Subsequently, the different solutions are filtered. Then, 10ml of the filtrate from each of the solutions were titrated. The basic solutions are titrated with hydrochloric acid at 0.1 M and the acidic solution with sodium hydroxide at 0.1 M. The searched function is given in milliequivalents per gram by the following formula:

$$N_{eq} = N_i V_i - N_f V_f \quad (6)$$

N_{eq} : Number of gram equivalents that have reacted.

$N_i V_i$: Number of gram equivalents before the reaction.

$N_f V_f$: Number of gram equivalents after the reaction.

In fact, NaOH measures carboxylic, lactone, and phenolic functions. As for the basic functions, they are neutralized by the hydrochloric acid solution.

II.2.1.8 pH measurement at the point of zero charge (pHpzc)

In general, an adsorbent possesses ion exchange properties on its surface. There is a relationship between the exchange capacity and the surface charge carried by the adsorbent. The zero charge point represents the pH at which the number of negative charges is equal to the number of positive charges on that same surface (it is also called the isoelectric point). [18] A simple and quick way to determine the pH_{pzc} is to place distilled water in closed flasks and adjust the pH of each (values between 2 and 12) by adding NaOH or HCl solution. (0.1M). Then, 100 mg of the material sample to be characterized is added to each flask. The suspensions must be kept agitated, at room temperature, for 24 hours, and the final pH is then determined. The value of pH_{pzc} can be derived from the curve pH_{final}=pH_{initial}. This value corresponds to the point of intersection of the curve with the line given by the equation pH_{final}=pH_{initial}. [19]

II.2.1.9 Iodine index

The iodine index test aims to determine the carbon's ability to adsorb small molecules. It characterizes the micropores accessible to small particles. We put 10 ml of a 0.1N iodine solution in a flask and titrate with a 0.1N sodium thiosulfate solution, in the presence of a few drops of a starch paste solution as an indicator, until the color disappears, and note the volume which is called « V_b ». In a 100ml beaker, introduce 0.05g of carbon. Add 15ml of the 0.1N iodine solution to the pipette and stir the mixture for 5 minutes before being filtered. A volume of 10ml of the filtrate is taken and placed in a beaker. From the burette, a 0.1N sodium thiosulfate solution is gradually added to the Erlenmeyer containing the filtrate until the solution is completely decolorized. We use starch paste as a color indicator and at other times, we note the volume of thiosulfate, which is referred to as "V_s". The iodine index can be calculated using the following formula [20]:

$$Id = \frac{(V_b - V_s) \cdot N \cdot (126.9) \cdot \left(\frac{15}{10}\right)}{M} \quad (7)$$

Where:

(V_b-V_s): difference between the results of the titration on test in white and on test with adsorbent in (ml of sodium thiosulfate 0.1N).

N: normality of the sodium thiosulfate solution (mol/l).

126.9: the atomic mass of iodine.

M: the adsorbent mass (g).

II.2.1 Morphological analysis by scanning electron microscope

The morphologies of the activated carbon samples were carried out at the Plateau Techniques d'Analyses Physico-chimiques-Laghouat (PTAPC- CRAPC) using a scanning electron microscope. [Eucentric goniometer stage, 5-axes motorized].

II.2.2 Porosity

Pore structure of the different prepared activated carbon was evaluated by measuring nitrogen adsorption-desorption isotherm at 77K using an automatic instrument [micromeritics instrument, Module ASAP 2020 Plus V2]

II.3 WASTEWATER TREATMENT

To study the effectiveness of the adsorption of pollutants from urban wastewater by different adsorbents, the contact time was set at 90 minutes, with volumes of 100 ml of the water to be treated being in contact with a mass of 1 g of the adsorbent. The experimental conditions are similar to recent studies that optimize conditions in the field of urban wastewater treatment. In the analysis of the obtained wastewater samples, pollution parameters were chosen to study their adsorption and reduction on the prepared activated carbon.

II.3.1 COD « Chemical Oxygen Demand »

Chemical oxygen demand is the consumption of dioxygen by strong chemical oxidants to oxidize the organic and mineral substances in water. we can say by another definition COD is the concentration of dioxygen O_2 equivalent to the amount of dichromate $Cr_2O_7^{2-}$ consumed by dissolved and suspended matter when a water sample is treated with this oxidant under defined conditions.[21]

II.3.2 Ammonium « NH_4^+ »

0.2 ml of the wastewater sample is added to the LCK 303 cuvette test in the range of 2–47 mg/L of $N-NH_4^+$, it is stirred, and then cooled to room temperature for 15 minutes before reading on the spectrophotometer [22].

II.3.3 Orthophosphate « PO_3^{4-} »

In flasks, we take sample volumes of "5/10/20/40 ml" and then add "1 ml" of ascorbic acid with "2 ml" of molybdate acid. A color ranging from blue to indigo blue is observed. Let it rest for 20 minutes before reading it in the spectrophotometer [23].

II.3.4 Calculation of the adsorbed quantity (Q)

After determining the residual concentration of the pollutant. The amount adsorbed is determined by the following relationship:

$$Q \left(\frac{\text{mg}}{\text{g}} \right) = \frac{C_0 - C_s}{m} * V \quad (8)$$

Q: Quantity of the adsorbed pollutant by the adsorbent (mg/g).

C_0 : initial concentration of the pollutant in the aqueous phase (mg/L).

C_s : residual concentration of the pollutant in (mg/L).

m: Mass of adsorbent (g)

III. RESULTS AND DISCUSSION

III.1 PHYSICOCHEMICAL CHARACTERIZATIONS OF THE PREPARED ACTIVATED CARBONS

III.1.1 Immediate analyses: Yield, degree of activation and cinder rate, humidity rate, density, and pH

The prepared activated carbon is obtained in powder form of a dark black color. The tests for determining the physical properties are grouped in Tables 1.

Table 1: The physical properties of prepared activated carbon.

The analyzed parameters	
H %	0.16
C %	9.44
R %	28.56
AR %	71.43
D(g/cm ³)	0.588
pH	6.35

Source: Authors, (2026).

Globally, it is noted that the yield of the activated carbon TMG preparation is 28.56%. this value is higher compared to the results obtained by Bechki in 2018 [2], where the yield ranged between 21.5% and 26.5%; With these results, we observe the significant influence of the activation agent and the pyrolysis temperature on the mass yield. These values could be explained by the significant loss of volatile materials due to the effect of temperature in the presence of acid. The activation rate value of TMG is significant. This development confirms the observations of a number of authors, including Kouadio (Kouadio et al. 2019) and Bechki [2]. which states that the activation rate increases with temperature. The activation rate obtained during this study is around 71.43% for TMG. The activation rate values that are below 50%; this observation would indicate that the activated carbons do not tend towards microporosity and mesoporosity [24] . Concerning the cinder rate, Table 1 shows that this cinder rate is 9.44% for TMG.

The cinder rate can affect activated carbon because cinder constitutes an inactive load that reduces the overall activity of the activated carbon. And which also restricts the reaction efficiency, including the adsorption capacity of activated carbon, by obstructing the pores and occupying the adsorption surface [24]. According to many authors, the best activated carbons are those with low cinder rate [25] In addition, for humidity rate; according to our results, we can observe that the obtained TMG activated carbon is slightly humid with a rate of 0.16%; this is due to the drying and proper preservation of the samples. The pH values of the prepared activated carbon range between 6.3 and 6.5. The residual quantities of phosphoric acid after washing would be the cause of these pH values. The density of TMG is similar to the results obtained by Belaid [26]. In this study, the activated carbon has a density of 0.588 g/cm³.

III.1.2 pH of zero point charge (pHpzc) and analysis of surface functions

The nature of activated carbon can be acidic, neutral, or basic depending on the pHpzc. The pHpzc depends on the origin of the precursor and the preparation method. (chemical or physical). The pHpzc is a good indicator of the chemical and electronic properties of functional groups [18] The pHpzc is obtained from the curve of the final pH as a function of the adjusted initial pH. The pH_{PZC} corresponds to the point of intersection of the curve with the line given by the equation $\text{pH}_{\text{final}} = \text{pH}_{\text{initial}}$. (Figure 2). This figure shows that the pHpzc of TMG activated carbon used in this study is equal to 6.31. Activated carbon thus presents an acidic surface that releases H^+ ions.

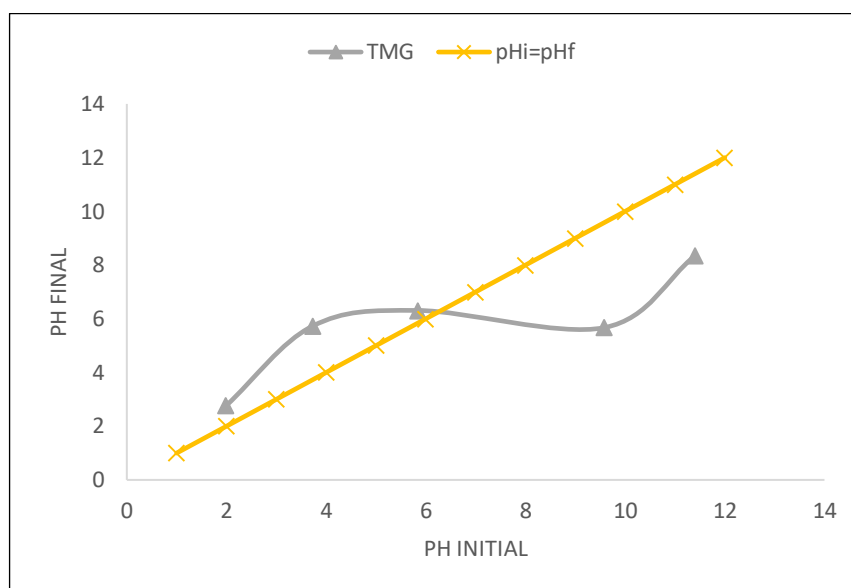


Figure 2: The isoelectric point of TMG activated carbon.

Source: Authors, (2026).

The Boehm titrations revealed that the two activated carbons used in this study have a higher quantity of acidic functional groups (2.8 meq.g^{-1}) compared to basic functional groups (1.05 meq.g^{-1}) for TMG. This is confirmed by the acidic nature indicated by the pH value ($\text{pHpzc} = 6.31$). [18] The quantity of functional groups (meq/g) is calculated using the following relation [27]:

$$\text{The quantity of functional groups (meq / g)} = \frac{N_{\text{reacts}}}{m_{\text{CA}}} * 100 \quad (9)$$

N_{reacts} : Quantity (acidic or basic) that reacts

m_{CA} : mass of activated carbon (g)

The dosage results are presented in Table 2

Table2: The quantity of acidic and basic functional groups in (meq/g).

function	TMG
Total acidity (meq/g)	2.8
Total basicity (meq/g)	1.05

Source: Authors, (2026).

III.1.3 Determination of the iodine index

The results obtained for the iodine index of our activated carbon TMG $2,508.84 \text{ mg/g}$ are higher compared to other studies, such as the activated carbon prepared with a grain diameter of "300 micrometers" [25], which has an iodine index of 2039.85 mg/g . The difference in the results obtained may be related to the method of preparation, and on the other hand, the literature indicates that when the size of the carbon decreases, the quantity of iodine adsorbed increases [28].

III.1.4 Characterization of the texture of activated carbon

The texture of activated carbon is defined by its specific surface area, its pore volume, the shape of its pores, and the distribution of pore diameters. However, for more details on the morphology of the particles, it is necessary to complement the analysis with scanning electron microscopy (SEM).

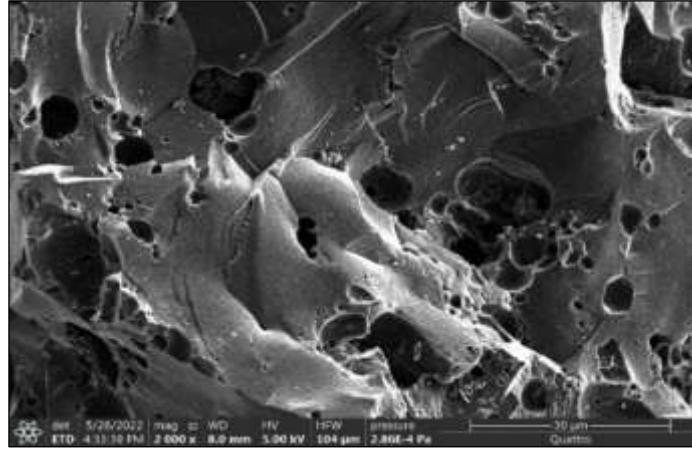


Figure 3: SEM image of pore distribution for TMG activated carbons.

Source: Authors, (2026).

For activated carbon, we clearly observed the pores, and with higher magnification, it shows the continuity of cavities within the pores at different scales. On the other hand, the SEM image of TMG (figure 3 scale 50 μm) shows the pores in the form of wide slits with a small number of large diameter pores (mesopores).

III.1.5 Porous Texture Observed By Adsorption/Desorption Of N_2 At 77k

The adsorption isotherm obtained allows access to the specific surface area of the sample determined according to the BET method. The adsorption and desorption isotherm of nitrogen N_2 at 77K obtained on activated carbon is shown in Figure 4.

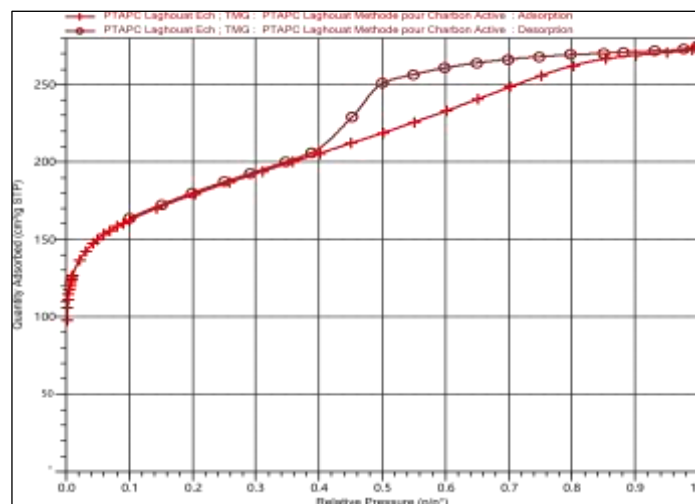


Figure 4: Nitrogen adsorption isotherm for the TMG activated carbon.

Source: Authors, (2026).

The adsorption isotherm obtained is essentially of type I according to the BDDT classification [25], so TMG activated carbon is a microporous material where cooperative filling can occur in larger micropores with the presence of weak hysteresis. The shape of the desorption curve indicates the presence of mesoporosity associated with a small contribution of mesopores and the eventual appearance of a capillary condensation phenomenon. The external surfaces (mesopore surface) and internal surfaces (micropore surface), as well as the volume of the micropores, were estimated using the t-plot method, and the total pore volume was directly calculated from the volume of nitrogen maintained at the highest relative pressure of 0.95.

Table 3: Textural characterization of activated carbon prepared by chemical activation.

Properties	Method	TMG
S_{BET} (m^2/g)	BTE	639.9190
Pore size (nm)		2.6181
V_{T} (cm^3/g)	Single point adsorption	0.418839
V_{P} (cm^3/g)	DFT	0.39439
S_{ext} (m^2/g)	t-plot	362.9708
S_{micro} (m^2/g)		276.9482
V_{micro} (cm^3/g)		0.117682

Source: Authors, (2026).

According to Table 3, the specific surface area is equal to 639.9190 m²/g. This value is justified by the influence of phosphoric acid H₃PO₄ on the development of the porosity of the carbons, as the texture of the crushed date pits before impregnation and chemical activation is weak according to the literature. [12], [25], [29], [30] The micropore volume is very important 0.418839 cm³/g, and for the average diameter, it is 2.6181 nm. All the texture parameters of the activated carbons, such as the specific surface area and the pore volumes (total and microporous), were very significant and larger values.

III.2 ADSORPTION OF SOME POLLUTANTS FROM WASTEWATER BY PREPARED ACTIVATED CARBONS.

To carry out this work, we measured the compositions of wastewater from the Atteuf region "Kef EL Doukhane" before proceeding to treat it.

Table 4: The composition of raw wastewater from the STEP of « Kef El Doukhane ».

Composition of raw water	Input value « April 2022 » (mg/l)
COD	683
BOD 5	91
PO₄³⁻	1.64
NH₄⁺	42.2

Source: Authors, (2026).

The composition results found show that the water is highly polluted. During the pollutant adsorption tests, the influence of adsorbent mass on the adsorption of all dissolved pollutants was studied.

III.2.1 Adsorption of COD

To study the influence of the mass of the prepared activated carbons, we use different masses ranging from 0.25 to 1g in a volume of 100 ml of raw water at room temperature for 90 minutes. The concentration of COD at the sampling point is C₀ (mg/l) = 163 mg/l. The values of the adsorbed quantities and the removal efficiency are indicated in Table 5.

Table 5: The efficiency of TMG and the amount of COD adsorbed

	Mass (g)	Results (mg/l)	International Discharge Standard mg/l	E %	Q (mg/g)
TMG 1	0.25	35.3	90 >	78.34	51.08
TMG 2	0.5	31.2		80.85	26.36
TMG 3	0.75	27.4		83.19	18.08
TMG 4	1	24.1		85.21	13.89

Source: Authors, (2026).

First, the concentrations obtained are below the international discharge standards, so the adsorption phenomenon is very effective. The elimination of COD increases with the increase in the amount of adsorbent up to 1 g for TMG, indicating that the increase in active carbon sites leads to a higher rate of COD absorption. In contrast, for the amount of adsorbed pollutants, it is observed that it decreases with the increase in the mass of the adsorbent. The elimination efficiency and Q are very important for the most effective TMG with a maximum adsorbed COD amount (51.08mg/g) for a mass of 0.25g and an efficiency of 85.21% for a mass of 1g. The percentage of COD removal found remains very significant compared to the results of other researchers "83.88%, 79.74%, 70.8% for CGB1, CGE1, and CMB1 respectively [26].

III.2.2 Adsorption of NH₄⁺ and PO₄³⁻

The same operating conditions for determining the COD removal efficiency are applied to all parameters. The concentrations of NH₄⁺ and PO₄³⁻ at the sampling point are 37.10 mg/l and 1.64 mg/l respectively.

Table 6: Influence of the mass of activated carbons on the adsorption of NH₄⁺ and PO₄³⁻.

Mass (g)	NH ₄ ⁺			PO ₄ ³⁻		
	Résultats (mg/l)	E%	Q (mg/g)	Résultats (mg/l)	E%	Q (mg/g)
0.25	11.1	70.08	10.4	0.250	84.75	0.556
0.5	10.4	71.96	5.34	0.394	75.95	0.2492
0.75	9.99	73.07	3.61	0.370	77.43	0.1693
1	9.44	75.55	2.766	0.609	68.86	0.1031

Source: Authors, (2026).

According to Table 6, we can conclude that the maximum value is "75.75%" for prepared carbon, and the best amount adsorbed was marked with a mass of 0.25g of TMG. The initial concentration of PO₄³⁻ C₀= 1.64 (mg/l), the adsorption results and yields are presented in Table 4. After examining the results of phosphorus removal, we find that the higher the mass, the lower the phosphorus removal rate. This may be related to the method of activating the charcoal, as we used a phosphoric acid activation agent with a concentration of 85%. And the higher the mass, the higher the phosphorus ratio in the activated sites, so the highest removal rate was observed at a mass of 0.25 grams of TMG, with a value of "84.75%".

IV. CONCLUSION

Date stones of TIMJUHART are suitable for activated carbon production using phosphoric acid activation for activation temperature at 600°C for 3 h. the using of such activated carbons as adsorbents for organic and inorganic pollutants depends simultaneously on the nature of date stones variety and its origin. In this case, date stones coming from Ghardaia region seemed to be workable in wastewater treatment. SEM micrographs show high porosity production. The surface area and micropore volumes for TMG were respectively 639.9190 m²/g and 0.4188 cm³/g.

V. AUTHOR'S CONTRIBUTION

Conceptualization: Imane Raache, Ghania Annou.

Methodology: Imane Raache, Ghania Annou.

Investigation: Imane Raache, Ghania Annou.

Discussion of results: Imane Raache, Ghania Annou.

Writing – Original Draft: Imane Raache, Ghania Annou..

Writing – Review and Editing: Imane Raache, Ghania Annou.

Resources: Imane Raache, Ghania Annou..

Supervision: Imane Raache, Ghania Annou..

Approval of the final text: Imane Raache, Ghania Annou.

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