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Original article

Using Local Plant Remains to Get Rid of Ammonia Nitrogen from Well Water in Wadiderna (Libya) after Hurricane Daniel

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ABSTRACT

A "hotspot" for research in recent years has been the mechanism of ammonia nitrogen removal from black and odorous water, particularly during the phytoremediation process. Since ammonia is thought to be a source of water pollutants and harmful to the health of city residents, the effectiveness of adsorption and removal of ammonia in Derna, Libya's groundwater was investigated. Native plants with a reputation for adsorption were chosen. These included animal remnants like charcoal and pomegranate peel. The findings demonstrated the efficiency of activated charcoal made from residues. Ammonia is eliminated by urban vegetation. In terms of adsorption capacity and ammonia-to-groundwater pollution removal, Almond Peel Activated Charcoal "APAC" outperformed Pomegranate Peel Activated Charcoal "PPAC". It is concluded that ammonia in surface and subsurface water can be treated using the "APAC" by adsorption.

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INTRODUCTION

Ammonia-nitrogen is the principal contaminant found in the primary sources of drinking water. It includes both ionized "NH_4^+" and non-ionized "NH_3" nitrogen. It comes from industrial, agricultural, and metabolic processes; it also comes from human activity in urban areas and from chloramine disinfection. Climate change and hydrogeology both have an impact on the ammonia-nitrogen concentration in surface water [1,2]. The toxicity of ammonia in water has been extensively studied: incomplete nitrification raises the levels of toxic nitrite; because of its easy chlorine combining property, more chlorine is needed during disinfection processes, which causes the content of mutagenic disinfection by-products "DBP" to change in an ascending manner [3-7]; it also causes manganese removal filters to fail as well as taste and odor issues [8]. One key sign of faecal pollution is the presence of ammonia above geogenic values [9]. Ammonia is a crucial water quality indicator. It can reveal potential contamination from sewage, animal waste, and germs [8]. According to the World Health Organization [8], the taste threshold for ammonia at an alkaline 'pH' is 35 mg/L, while the threshold for odor is roughly 1.5 mg/L. China "GB5749-2006" and the European Union [10] have guidelines for drinking water ammonia concentrations of 0.5 mg/L.A number of techniques, like as ion exchange, air stripping, biological nitrification/denitrification, and break-point chlorination, have been employed to reduce the amount of ammonia nitrogen in surface and wastewater. The process of using naturally occurring zeolite as an ion exchanger to remove ammonia is expensive [11] and necessitates additional ammonia disposal in the regenerate brine solution. Air stripping requires large stripping towers in order to remove ammonia [12].

The biological oxidation of ammonia to nitrate and subsequent reduction to nitrogen gas with bacteria constitute the biological nitrification/denitrification process [13] for ammonia elimination. The procedure requires large tankage and is vulnerable to biological disturbance. Only solutions with minimal ammonia concentrations can benefit from chlorination [14]. The creation of hydrogen and chloride ions, which raise the water's total dissolved solids content and decrease its pH, is a significant drawback of the chlorination process. Despite being widely utilized in water treatment systems, activated carbon's potential for ammonia removal has not gotten the attention it merits [15]. Adsorption is a straightforward, adaptable, and effective method for eliminating contaminants from liquid systems. The most common adsorbent for removing contaminants is activated carbon. Many raw resources, including plant bark [19], rice husk [16], coconut husk [17], waste tire [18], and vegetable waste [20]. In this study, the efficacy of using activated charcoal made from pomegranate and almond peels—both of which are considered local plant remains—to remove ammonia pollution from groundwater in the city of Derna, Libya was examined. The 10-400C temperature range has also been studied in relation to ammonia elimination.

METHODS

Adsorbate

On March 27, 2024, groundwater samples were taken from neighborhoods that had been devastated by Hurricane Daniel, which hit Derna, Libya, on October 11, 2023. The storm caused infrastructure to collapse and sewage to seep into the city's wells and groundwater basins. They were gathered. and proceed according to established protocols [21,24]. The samples were gathered in three-liter plastic canes devoid of air bubbles. When the samples were being collected, the temperature of the samples was recorded in the field. The samples were stored in a refrigerator at a $4o^{C}$ temperature. Using the Hydrotest "HT1000" Photometer equipment and the instructions found in the handbook, ammonia was measured in water samples taken both before and after the activated charcoal surface adsorption process at the Derna saltwater desalination facility.

Adsorbent

The process outlined by Srinivasakannan and Bakar [22] was utilized to create chemically activated charcoal utilizing pomegranate and almond peels. Overnight at 70˚C, pomegranate and almond peels were dehydrated in an oven. The almond and pomegranate peels were dried and then soaked in 60% phosphoric acid for the entire night. For four hours, the soaked samples were semi-carbonized at '200˚C' in a muffle furnace. After semi-carbonization, the material was cooled to room temperature and dried. For activation, the dry material was once more heated in a furnace for two hours at 500˚C. In order to completely remove the acid from the material, the Pomegranate Peel Activated Charcoal "PPAC" and Almond Peel Activated Charcoal "APAC" for pomegranate and almond peels, respectively, were repeatedly washed with distilled water. This process was repeated until the wash liquor was neutral. Finally, distilled water and a 0.1-M sodium hydroxide solution were used to wash the resultant carbonaceous material. The product was treated to size reduction so that the material passes through 75µm mesh after being dried in a hot air oven for five hours at 105˚C.

Measurement of ammonia adsorption

The studies were batch type and conducted in 50 ml conical tubes. Using a beaker, we collected 50 milliliters of groundwater sample and analyzed the initial 0.5 mg/L ammonia concentration of NH_3 before to the adsorption procedure. Addition of varying grams of adsorbents "0.1, 0.2, 0.3, 0.4, and 0.5". Using a magnetic stirrer, the adsorbent and effluent mixture was stirred for ten minutes. The example was to remove the water from it, ordinary filter paper is used for filtering. The Hydrotest 'HT1000' Photometer was used to examine the filter and sorbent at room temperature. identical actions It was carried out again using different adsorbent sizes. Testing was done to determine how different activated carbon doses and adsorption times affected the elimination of ammonia. The amount of ammonia that "PPAC", "APAC" adsorbed was determined using the following equation (1):

$$Q = (V/W)\,(C_0 - C_e) \quad \mathbf{(1)}$$

Where C0 and Ceare the initial and final concentrations of ammonia in water, Qis the quantity of ammonia absorbed per unit weight of adsorbent, Vis the volume of the liquid phase, and Wis the weight of the adsorbent. The following equation was used to compute the dye elimination percentage:

$$Removal\ \% = \frac{c_{\circ} - c_{e}}{c_{\circ}} \times 100 \quad \mathbf{(2)}$$

RESULTS

Temperature, duration, and dose effects on ammonia removal by "APAC" and "PPAC"

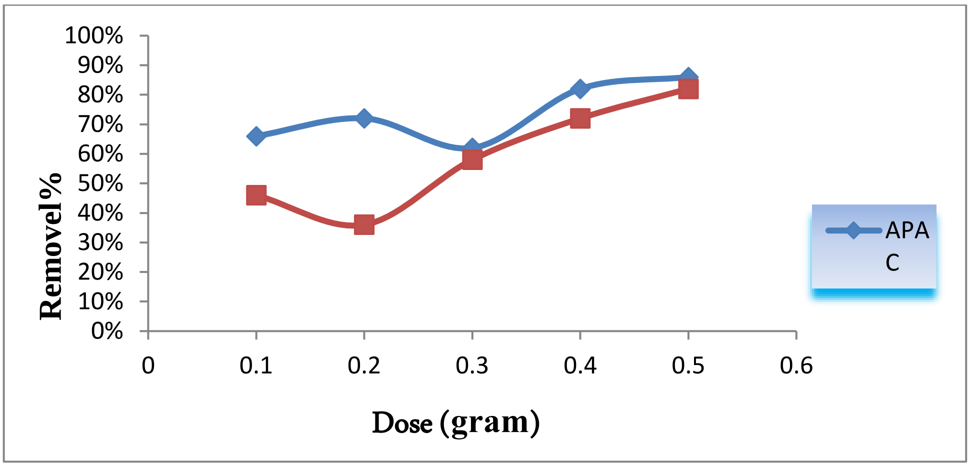

Figure 1. Relationship between percentage of ammonia removal and doses of (APAC), (PPAC)

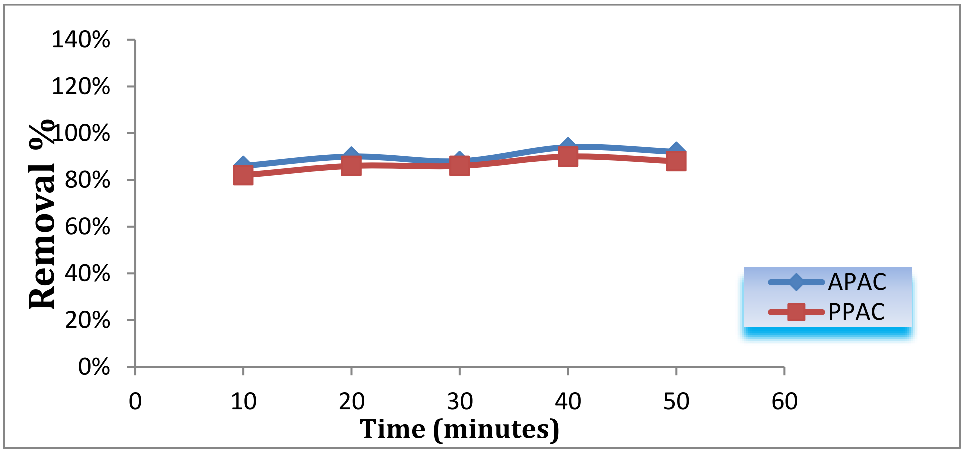

Figure 2. The relationship between the percentage of ammonia removal and time (min)

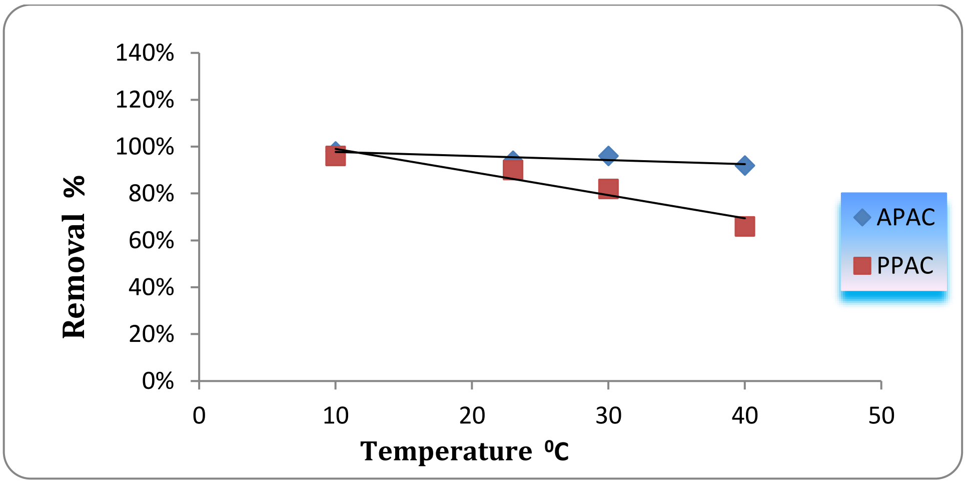

Figure 3. The effect of temperature on ammonia removal by APAC and PPAC

The best ammonia elimination values, as revealed by the results plotted in Figure 1, were 86% and 82%, respectively, at a dose weight of 0.5 grams of "APAC" and "PPAC". The adsorption time was 10 minutes, and the measurements were conducted at the same temperature of 230C.The optimum values for ammonia removal, as shown by the plotted findings in Figure 2, were 94% and 90%, respectively, during an adsorption duration of 40 minutes for "APAC" and "PPAC". Plotting the findings, Figure 3 shows that the best ammonia removal values for "APAC" and "PPAC" were 98% and 96%, respectively, at a temperature of 100C.

Langmuir adsorption isotherm

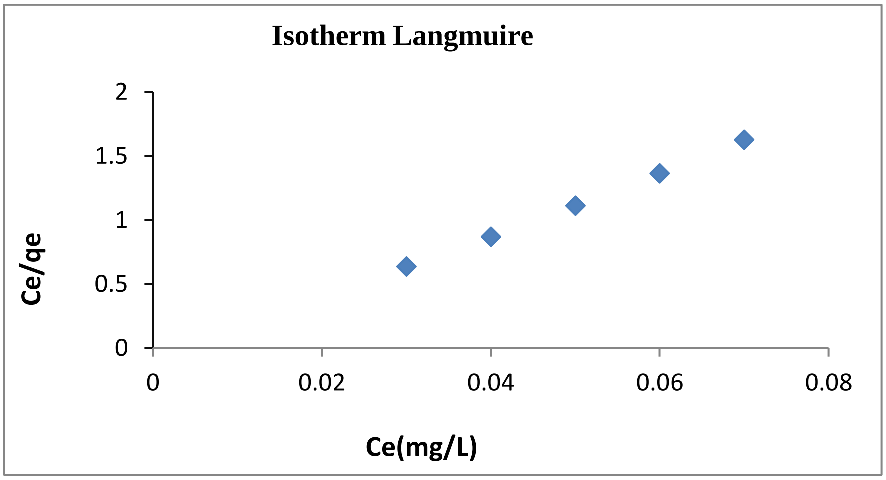

Figure 4. Langmuir adsorption isotherm onto APAC, Ce vs Ce⁄qe

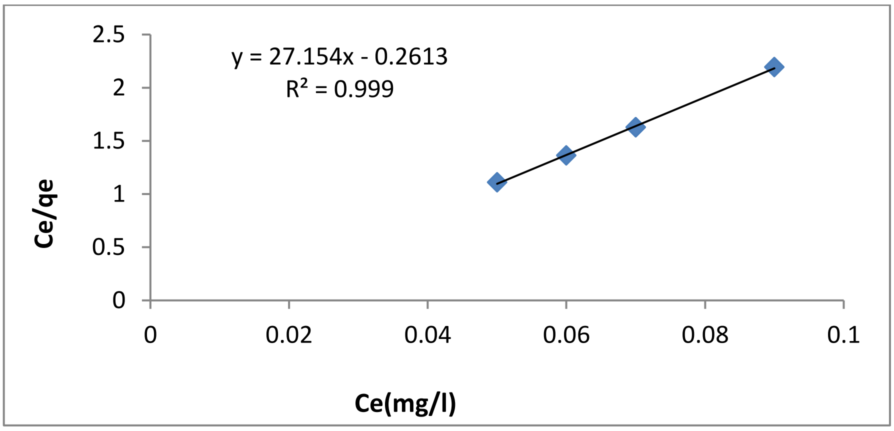

Figure 5. Langmuir adsorption isotherm onto PPAC, Ce vs Ce⁄qe

"The equilibrium equation is stated as":

$$'q_e = \frac{KL\,Ce}{1+aLCe} \quad \textbf{(3)}$$

Where KL(L/g) and aL(L/mg) are Langmuir isotherm constants, the monolayer capacity, and qe and ce are the solid-phase and aqueous-phase adsorbate equilibrium concentrations (mg/g and mg/L, respectively). The following is a typical expression for the Langmuir linear equation:

$$\frac{Ce}{qe} = \frac{1}{kl} + \left(\frac{al}{kl}\right)Ce \quad \textbf{(4)}$$

Ce against Ce⁄qe was shown linearly, demonstrating the Langmuir adsorption isotherm's suitability for ammonia adsorption. The Langmuir constants KL and aL, which are determined from the slope and intercept of the plot Ce against Ce⁄qe, correspond to the adsorption capacity and rate of adsorption, respectively. At 230C, the estimated qmax values for "APAC" and "PPAC" are 0.04 and 0.03, respectively. The adsorption efficacy of "APAC" is higher than that of PPAC utilized in this experiment, as evidenced by the results 'KL' of "APAC" and "PPAC", which are 8.82, 3.82, and aL, which are 218.3, 103.9, respectively. The estimated NH_3 adsorption isotherm on "APAC" and "PPAC" is displayed in Fig. 4–5. The Langmuir model's importance is indicated by the curve's linear character in the A plot of Ce vs Ce. The aforementioned findings suggest that "APAC" has a greater capacity for ammonia adsorption and removal than PPAC.

The equilibrium parameter, also known as the "RL" or separation factor, can be used to express the fundamental properties of the Langmuir adsorption isotherm. It is defined as follows:

$$R=1/(1+ a_l .Ci) \quad \textbf{(5)}$$

where al is the Langmuir constant and Ci is the ammonia concentration at initialization. RL > 1 Negative (RL=1) Linear (0< RL<1) Positive (RL=0) irreversible. Equation 5 was used to compute RL, which for APAC and PPAC was 0.0097 and 0.018, respectively. These values show that the key features of the 'Langmuir adsorption isotherm are favorable'.

DISCUSSION

Before being released into the environment, nitrogen from municipal wastewater must be eliminated. However, this valuable resource is currently not captured by the energy-intensive aerobic nitrogen removal techniques now in use. Alternatively, nitrogen collection as ammonia through a lower energy method like membrane distillation—which has largely been studied in lab settings thus far—could represent a major advancement [25].

The isotherm equation that is most frequently used to model equilibrium Often employed to characterize solute adsorption; the Langmuir model computes the number of molecules adsorbed onto a solid surface [23]. According to the study, utilizing native plant remnants can be a useful way to reduce nitrogen and ammonia contamination in well water [25]. These materials are a desirable alternative for emergency water treatment in post-disaster circumstances due to their great availability and low cost [26]. Currently, biological processes like deammonification by aerobic and anoxic operations are commonly used to treat waste water containing ammonia. These processes require aeration and consume a significant amount of energy, accounting for 80% of the total electrical energy used in a typical waste water treatment plant [25]. To improve the adsorption process and investigate the long-term viability and environmental effects of employing plant residues for water filtration, more research is advised.

CONCLUSION

The findings showed that the optimal temperature for ammonia removal was 100C, while the optimal time for ammonia removal was among the times 1 0, 20, 30, 40, and 50 of the minutes in the experiments. The best dose for ammonia removal among the doses of 0.1, 0.2, 0.3, 0.4, and 0.5 g taken for adsorption for "APAC" and "PPAC" was 0.5 g. This suggests based on earlier findings that the right dose for adsorption was considered and given enough time. 'Ammonia adsorption and removal are clearly impacted by adsorption and temperature increases'. According to the Langmuir isotherm, "APAC" has a greater adsorption efficacy than "PPAC". Because "APAC" removes 98% of ammonia, we advise using it to remove water contaminants from ammonia that are detrimental to health. This ratio is regarded as satisfactory at 10C, 40 minutes for adsorption, and 0.5 g of dosage.

Conflict of Interest

There are no financial, personal, or professional conflicts of interest to declare.

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استخدام بقايا النباتات المحلية للتخلص من النيتروجين الأمونيا من مياه الآبار في وادي درنة (ليبيا) بعد إعصار دانيال

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المستخلص

أصبحت آلية إزالة النيتروجين الأمونيا من المياه السوداء والروائح "BOW" موضوعاً بارزاً للبحث في السنوات الأخيرة، خاصة خلال عملية المعالجة النباتية.ونظرا لخطورة الامونيا على الحياة البشرية والحيوانية اجريت هذه الدراسة بعد اعصار دانيال وبالتحديد خلال الموسم الزراعي 2023-2024م لتقييم تأثير بقايا بعض النباتات خاصة الرمان والجوز (عين الجمل)على امتصاص الامونيا من مياه وادي درنة ،وبينت النتائج فعالية الفحم النشط المصنوع من مخلفات النباتات المحلية في المدينة في إزالة الأمونيا؛ فقد تفوق "APAC" على "PPAC" في قدرة الامتصاص وإزالة ملوثات المياه الجوفية من الأمونيا؛ وخلص إلى أن "APAC" يمكن استخدامه في علاج الامتصاص للأمونيا في المياه الجوفية والسطحية..

الكلمات المفتاحية. فحم قشور الرمان النشط، فحم قشور اللوز النشط، إزالة الأمونيا، قدرة الامتصاص، فعالية الامتصاص.