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Article

Illizi Groundwater treatment by Acacia gum: organic pollution removal

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Abstract: The aim of this study was the organic pollution removal from Illizi groundwater using Acacia gum powder as a bio-adsorbent; The adsorbent characterization by DRX showed that this powder has no mineral composition, the FTIR analysis completely agreed with that. The groundwater analysis indicated that Acacia gum improved the pH value to normal value for drinking water and removal a high quantity of organic pollution (oil); This treatment didn't change the Excellent class of irrigation.

Keywords: Acacia gum; FTIR; Adsorption; Groundwater; Organic pollution

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1. Introduction

According to the results of the toxic pollutants increase on water, it exists a directed major concern toward finding reliable and practical solutions in order to reduce its damaging effects on the environment, furthermore it protects human health and environments. In this context, several technologies such photocatalysis, advanced chemical oxidation, membrane separation technologies, and adsorption process were developed [1].

Adsorption for water treatment have had a long and productive history from BC, it is a surface phenomenon that is defined as the increase in concentration of a particular component at the surface or interface between two phases. The basic terms shown in figure1; The solid material is referred to as adsorbent, the species that will be adsorbed are named adsorbate. In wastewater treatment, adsorption of organic solutes has been a primary concern in recent years [2-4].

Acacia gum, as a natural adsorbent, is a complex arabinogalactan type polysaccharide which is obtained from the stem and branches of Acacia trees (Figure 2); Acacia trees are abundant in central Sudan, central and West Africa, and tropical and semitropical areas of the world; Even though there are more than 1000 species of the genus Acacia gum, only two are significant for commercial purposes: Acacia senegal and Acacia seyal; In modern times, Acacia gum is widely used by industries for its nutritional, pharmaceutical, cosmetic, and surface properties [2], [5-8].

The physical properties of Acacia gum may vary depending on the origin and age of trees, the exudation time, and climate. Treatment of Acacia gum after collection such as washing, drying, and bleaching in the sun and storage conditions effected the physical properties of Acacia gum [5], [9].

Acacia gum improves the antioxidant capacity because it contains several types of amino acid residues such as lysine, tyrosine, and histidine; It effects renal functions through reduction in blood creatinine and urea nitrogen concentrations in diabetic nephropathy patients; It significantly decreased fasting blood glucose levels and glycosylated hemoglobin together with a significant reduction in blood uric acid and total protein concentrations; Acacia gum, as a dietary fiber, helps to reduce body weight and fat deposition. Due to these biological properties of Acacia gum, it may be an efficient agent in water treatment with the adsorption process, although its high-water solubility and a relatively low viscosity compared with other gums [5].

The objective of this work was to show the capacity of Acacia gum powder as natural efficient adsorbent through organic water pollution removal from Algerian groundwater, Illizi by adsorption phenomena.

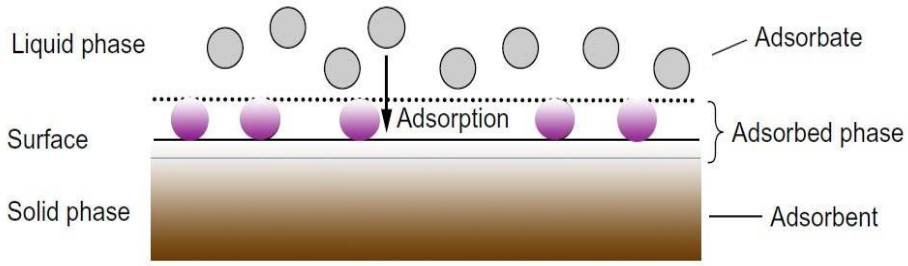

Figure 1. Basic terms of adsorption [4]

Figure 2. Natural Acacia gum on the tree.

2. Materials and Methods

2.1. Acacia gum preparation

The used acacia gum was obtained from commercial source. Acacia gum powder was prepared by grinding on a porcelain mortar and pestle then sieving by sieve shaker (AS 200, RETSCH, France) to a minimum size < 50, and was dried at 40°C for 5 hours. For Acacia gum powder characterization, XRD and FTIR were used; XRD pattern was obtained by D8 advance diffractometer (Brucker, Germany) with u-K radiation (◎ = 1.54050 Å) and a scanning speed of 0.004°/S, the analysis of its vibrational spectra was done with Fourier transform infrared spectroscopy using FTIR-Shimadzu 8400s in the range 400-4000 cm^{-1} as potassium bromide pellet.

2.2. Groundwater treatment

The groundwater samples for this study were from Illizi region, Algeria (DMS coordinates of the place: 26°30'33.965'' N 8°28′23.778′′E). This groundwater has been polluted with oil by extraction local wells.

Groundwater samples for this study was from Illizi region, Algeria (DMS coordinates of the place: 26°30'33.965'' N 8°28'23.778''E). This water has been polluted with oil by extraction local wells. For the adsorption assays, 250 mL maximum capacity leak-proof reaction bottles were used. In each bottle, 100 mL of groundwater and 15 mg of Acacia gum powder were added. The tests were kept in a mechanical shaker for 24 hours at a room temperature of 22°C. After the equilibration period, all the solid materials were filtered.

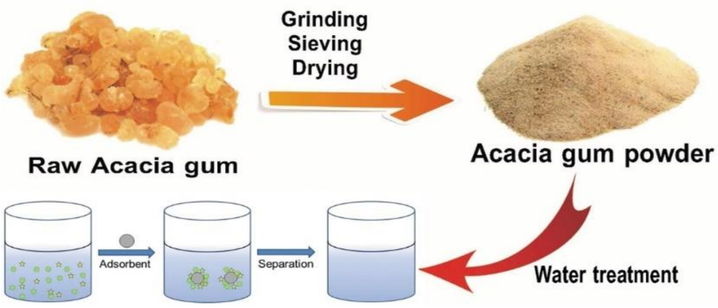

Figure 3. Schema of groundwater treatment by acacia gum.

2.3. Groundwater treatment

The groundwater suitability for irrigation was determined by using the Wilcox Diagram, where the classification of irrigation water is based on different ranges of electrical conductivity (0-800, 800-2000, 2000-3000 and > 3000 micromhos cm^{-1}) and on sodium adsorption-ratio (% Na^+) which is defined by the relation showed in Eq.1, where all the ions are expressed in $meq.L^{-1}$.

$$\%Na = \left(\frac{(Na^+ + K^+)}{(Ca^{2+} + Mg^{2+} + Na^+ + K^+)}\right) * 100 \qquad \text{Eq.1}$$

Generally, the Wilcox diagram shows the different water classes as Class I "Excellent", Class II " Good", Class III " Eligible", Class IV " poor" and Class V " bad" (Figure 4). Hence, this diagram shows a decreasing water quality trend with an increase in the concentration of sodium percentage and the electrical conductivity [9].

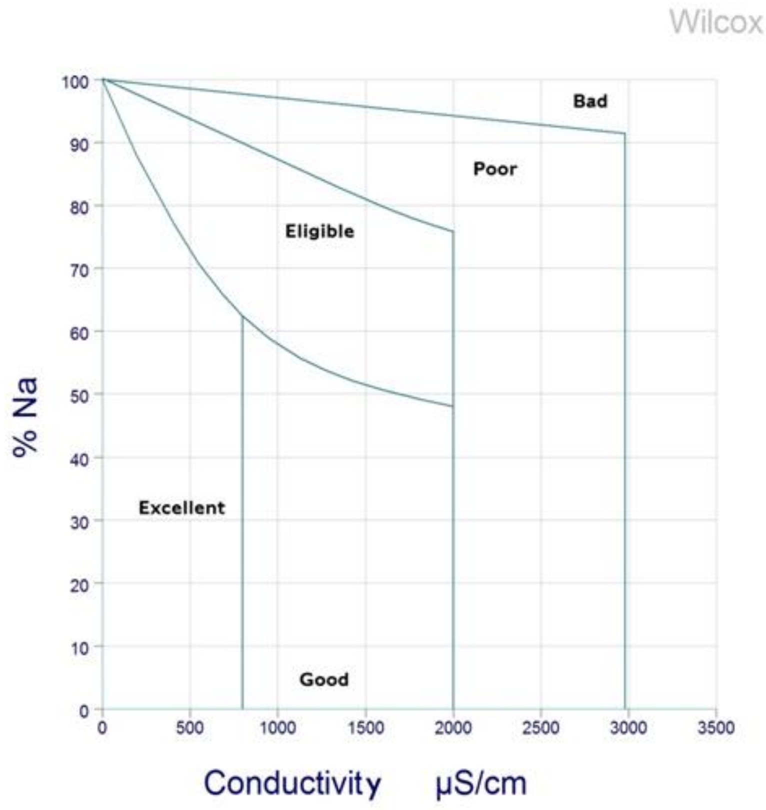

Figure 4. Wilcox Diagram for Conductivity and Sodium percentage.

3. Results

This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn.

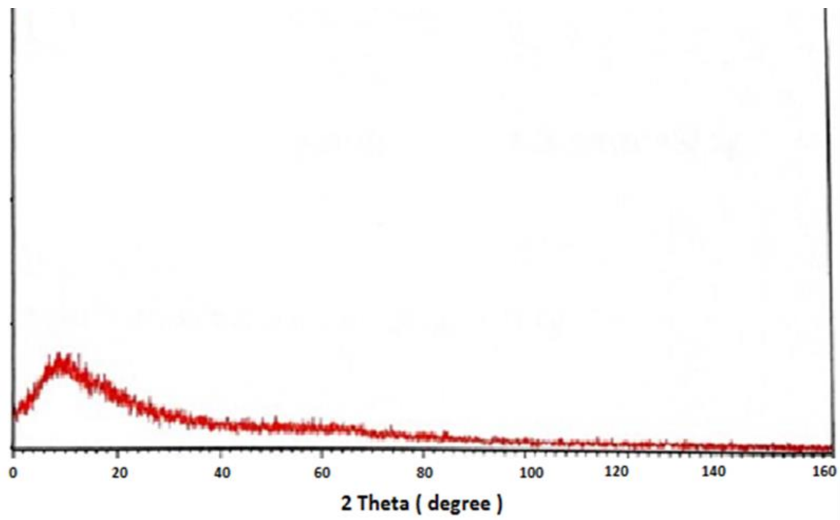

Figure 5. XRD spectrum of Acacia gum.

3.1. Acacia gum characterization

3.1.1. XRD Characterization

The X-ray diffractogram of the used Acacia gum (Figure 5) has showed no reflection in all the 2-scanning due to the amorphous powder that had no mineral composition.

3.1.2. FTIR Characterization

FTIR study of these adsorbent Acacia gum helps in the identification of the bands various forms which are present in the surface of Acacia gum. The broad adsorption at 3500-3600 cm^{-1} which is correspondent to the free hydroxyl groups (O-H) appears the existence of water. This water refers to the hydration in the adsorbent Acacia gum. The peak around 2852-2900 cm^{-1} corresponds to C-H band of aliphatic $-CH_2$ group. Another peak around 1730-1750 cm^{-1} corresponds to C=O of aliphatic aldehyde groups. The appearance of symmetric and asymmetric COO^- band at respectively 1600-1700 cm^{-1} and 1420-1500 cm^{-1}. The presence of band at 1080-1220 cm^{-1} of C-O elongation vibration indicates the possibility of the ester appearance.

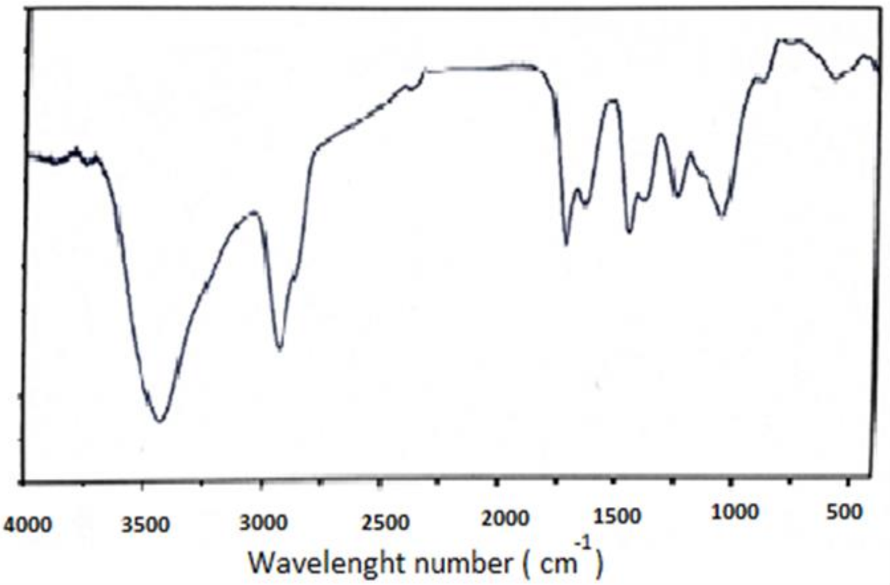

Figure 6. FTIR Spectrum of Acacia gum.

3.2. Groundwater characterization

3.2.1. pH variation

Table 1 shows that before the pollution of the groundwater pH was 7.68 which is a normal value for drinking water. The polluted groundwater pH value was 5.15 that means this water is a polluted water owing to the standard values of pH for drinking water, which is always between 6.5 to 9.5, but after the treatment we obtained that Acacia gum improved the pH value (6.70) and the resulted value was normal for drinking water.

Table 1. pH values for unpolluted, polluted, and treated Groundwater.

Groundwater	Unpolluted	Polluted	Treated
pH	7.68	5.15	6.70

3.2.2. Organic pollution variation

The filtration process showed a high capture of adsorbent powder particles and other grain contaminants in the wastewater after the adsorption treatment, yet this physical separation method cannot eliminate all the quantity of Acacia gum, due to the Acacia gum solubility in treated water. For this case of study, a specific method was used to characterize groundwater before and after the treatment; Table 2 and Figure 7 show that Acacia gum had a high removal efficiency due to the reduction of UV-absorbance of each wavelength related to organic pollution (201; 228 and 260 nm).

Obviously, the experimental results indicate the presence of Carbon-Carbon conjugated bonds of the petroleum molecules structure at the range [200 -260 nm], these high gaps of UV-absorbance were because of the petroleum removal efficiency by Acacia gum adsorbent.

Table 2. UV-absorbance before and after treatment.

Wavelength (nm)	**201**	**228**	**260**
Polluted Groundwater Absorbance	11	10	3
Treated Groundwater absorbance	0.5	3.2	1.5

3.2.3. Organic pollution variation

The filtration process showed a high capture of adsorbent powder particles and other grain contaminants in the wastewater after the adsorption treatment, yet this physical separation method cannot eliminate all the quantity of Acacia gum, due to the Acacia gum solubility in treated water. For this case of study, a specific method was used to characterize groundwater before and after the treatment; Table 2 and Figure 7 show that Acacia gum had a high removal efficiency due to the reduction of UV-absorbance of each wavelength related to organic pollution (201; 228 and 260 nm).

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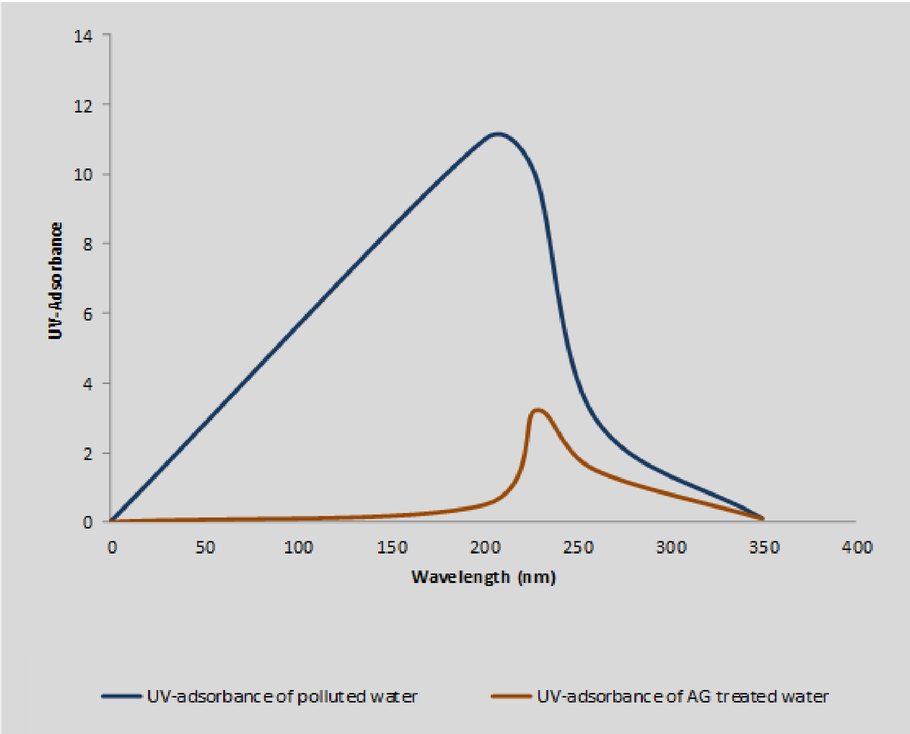

Figure 7. Absorbance of Groundwater before and after treatment.

3.3. Groundwater classes for irrigation

As shown in figure 8, the diagram covering the studied samples indicates that these waters present values from 53% to 62% of sodium percentage. Despite the fact that these high sodium percentages are undesirable because of its reduction of water quality, all samples were classed as "Excellent" for irrigation. It can be concluded that organic pollution and the used absorbent didn't change the class of irrigation of the studied groundwater.

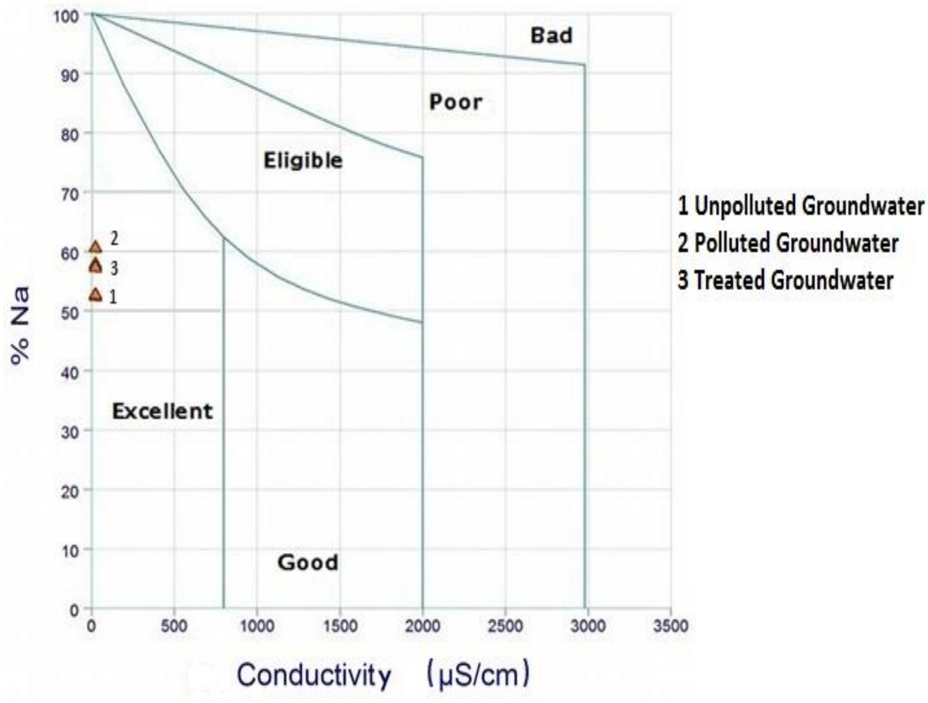

Figure 8. Wilcox diagram showing the suitability of groundwater for irrigation.

5. Conclusions

Acacia gum powder showed a high removal of organic pollution (oil) although acacia gum solubility in water. The organic pollution and the used adsorbent keep the same excellent class for irrigation; The treatment decreased the sodium percentage from 61% to 58% in the same conductivity.

Acknowledgments

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