

## ULTRASONIC MODIFICATION EFFECT OF ACTIVATED CARBONS ON THE REMOVAL OF ARSENIC IN WASTERWATERS

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### SUMMARY

Arsenic contamination is a global threat and challenge humankind faces due to its carcinogenic and toxic effects on humans and environment. Typical arsenic removal methods in wastewaters are Oxidation-precipitation, Coagulation-Precipitation, Sorption and Ion-Exchange and Membrane technologies. Among these methods, one of the cheapest and the efficient methods is adsorption. Removal of arsenic by adsorption is related closely to the adsorptive behaviors of adsorbents. Activated carbons are modified via various techniques to increase the adsorptive and surficial behaviours of adsorbents in activated carbons. The techniques include physical, chemical, plasma, microwave and sonication methods. In this study, the influence of ultrasonically modified adsorbents (activated carbons) derived conventionally from *Vallisneria Spiralis* macroalgae on the removal of Arsenic heavy metal in waste water was investigated. Adsorbents were prepared by a sonication method and characterized by Scanning Electron Microscope (SEM), and Fourier Transform Infrared Spectroscopy (FTIR). These adsorbents were applied for removal the removal arsenic ions from aqueous solution by a batch technique. Adsorptions tests indicate that ultrasonically acid-pretreated (H<sub>3</sub>PO<sub>4</sub>) activated carbon promotes the arsenic removal in wastewater.

**Keywords:** Vallisneria Spiralis, Adsorption, Modification, Characterization

## 1. INTRODUCTION

Arsenic (As) is mainly a naturally occurring metalloid salt in water. The uttermost contaminant concentration in drinking water is limited to 10 µg/L. In the concentrations over this level Arsenic leads to serious problems ranging from skin diseases to internal organs failure [Das et.al., 2020]. For these reasons, Arsenic must be removed from wastewater.

Adsorption has been known to the most convenient wastewater treatment technique for the removal of Arsenic. Although adsorption is the most used treatment method for arsenic removal, coagulation, flocculation, chemical precipitation, ion exchange, membrane filtration, reverse osmosis and phytoremediation are also used.

The adsorption efficiency of the adsorbents is dependent mostly on the physical and chemical properties of the adsorbent, including surface functionality and morphology besides its size and shape. Adsorbents used in the adsorption process boast high surface area and adsorption capacities. In addition to physical and chemical methods to obtain adsorbents from proper precursors, application of sonication-aid biomass-based precursors to producing new adsorbents is a wide area of research. In recent years, Macroalgae have been proposed as precursors for activated carbon materials with a wide variety of desired pore sizes, usable/available as adsorbents, molecular sieves, catalyst and electrodes just to mention a broad range of areas of application [Tian et.al., 2016; Falco et.al., 2012; Bağda et.al., 2017].

Given the aforementioned considerations, the objective of this study was to develop a macroalgae-based activated carbon with the aid of sonication with high arsenic heavy metal recovery in wastewater.

## 2. MATERIALS AND DISCUSSION

### 2.1 Production and characterization of macroalgae-based adsorbents

The raw material, *Vallisneria Spiralis* macroalgae, was collected from the Marmara Sea in Turkey. The material washed to eliminate sea salt and other contaminants with ultra-pure water, dried at 100 °C in a drying oven, grounded and sieved to around 150 µm and stored in a plastic container. Two types of adsorbents, water-modified biochar (WM) and phosphoric acid-modified biochar (PM) for adsorption experiments were produced from raw material (RW). The RM was carbonized by pyrolysis without any chemical pretreatment at 500 °C. The carbonized carbon produced of 20 g was separately treated with ultra-pure water of 500 ml and

with phosphoric acid (H<sub>3</sub>PO<sub>4</sub>) solution at 120 W of sonication power for 90 min. The modified biochars obtained, designated as WM and PM, for water and phosphoric acid modification, respectively, were dried at 40 °C. The removal capacities of the WM and PM were evaluated by batch adsorption experiments. In these experiments, adsorbent dosage was 0.1 g L<sup>-1</sup>. The Arsenic metal solution of 100 mL loaded separately with 0.1 g of Wm and PM was stirred for 2 h. The sample solutions were filtered and analyzed by ICP-ES. The adsorption capacity (*q*) and removal (*R* %) were calculated by below formulas.

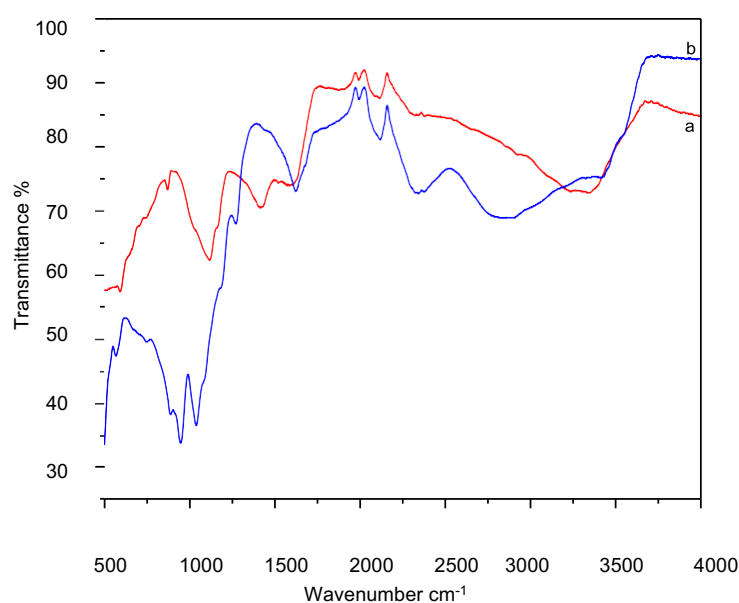
$$q \text{ (mg g}^{-1}\text{)} = (C_i - C_0) \quad 2.1$$

$$R \text{ (\%)} = (C_i - C_0) \times \frac{V}{m} \quad 2.2$$

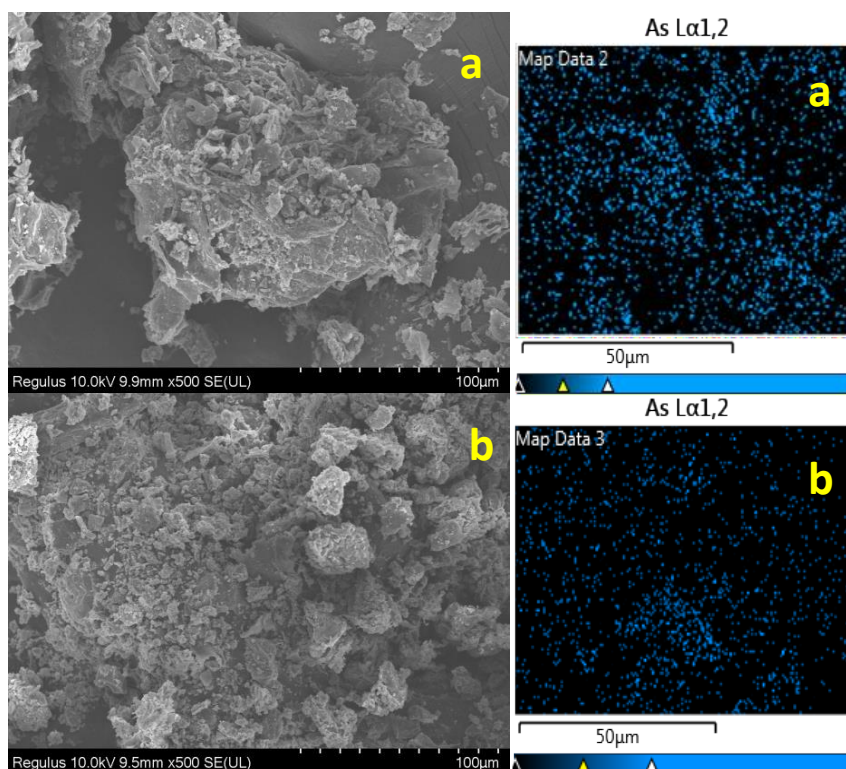
where *C<sub>i</sub>* and *C<sub>0</sub>* are initial and final concentrations, *m* adsorbent dosage (g), and *V* is the volume of solution (L).

## 2.2 Surface functional and morphological properties of adsorbents and batch adsorption experiments

The FTIR spectra of the adsorbents, WM and PM, are shown in Figure 2.1. The bands 573 and 598 cm<sup>-1</sup> are assigned to Fe–O–Fe stretching vibration. The spectrum 1044 cm<sup>-1</sup> corresponds to C=O=C of the adsorbents. The peaks at 1044 cm<sup>-1</sup> and 1276 cm<sup>-1</sup> are related to (C=O–OH) hydroxyl groups. The peak located at 1626 cm<sup>-1</sup> is a double conjugated band (C=C=C). The wide band at 3353 cm<sup>-1</sup> and 3426 cm<sup>-1</sup> can be assigned to O–H stretching vibration.



**Figure 2.1** FTIR Spectra of WM (a), and PM (b)



**Figure 2.2** Micrographs and mapping of WM (a) and PM (b)

Figure 2.2 shows the surface properties of the adsorbents. Both adsorbents exhibit rough and uneven surface. It is clear that after adsorption arsenic heavy metal ions spread the surfaces of the adsorbents in a homogenous way.

Both (WM) and (PM) adsorbents through sonication removed 87 % As (V) and 84 % As (V), respectively.

## RESULT

Two different types of adsorbents were synthesized by sonication as high adsorption efficiencies for the removal of heavy metal solution. Although the adsorbents had similar physical, chemical and morphological properties, their capabilities of removing Arsenic ions were different. It has been shown in this study that phosphorous acid-aid sonicated adsorbent (PM) has more effective to remove Arsenic ions from solutions. Herein, the authors calculated the removal percentage of heavy metal using equilibrium concentrations. The authors strongly suggest that in addition to equilibrium concentrations, the parameters such as adsorbent dosage, pH, and adsorption temperature and adsorption kinetics and adsorption isotherms be also studied further.

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