Adsorpative Removal of Hg(II) Cations from Aqueous Solution by *Traganum Nudatum* Roots

Mohamed Ackacha, Elhadi E. Saad, Hamed A. Maauof, and Shyma Reda

***Abstract*—The adsorption of Hg(II) cations onto the surface *Traganum nudatum* roots has been found to be of initial pH, adsorption time and biosorbent dose. The pH 5 is found to be the optimum for the removal of Hg(II) cations from aqueous solution. Three kinetic models such as first-order, pseudo-second order and intra-particle diffusion were used to analyze the Hg(II) cations adsorption process, and the obtained results showed that the pseudo-second-order with correlation coefficient greater than 0.9800 was more suitable than first-order. The obtained results also explained that the intra-particle diffusion is mainly one of the mean determining step of the adsorption mechanism of Hg(II) cations on *Traganum nudatum* roots.**

***Index Terms*—Adsorption, Hg(II) cations, *Traganum nudatum* roots, First-order Kinetic, pseudo-second order kinetic.**

I. Introduction

Toxic pollutants such as heavy metals released into the surface and ground water as a result of several activities include industries and agriculture [1]. Mercury is considered as one of the highly toxic metal because of its accumulation in the organisms [2]. Mercury causes different health problems such as damage of the central nervous system and chromosomes [3].

Different techniques can be used to remove heavy metals from contaminated water such as solvent extraction [4], chemical precipitation [5], ion-exchange [6], biological material [7] and activated carbon [8]. But due to high cost of the treatment, some new techniques have been tried. Among them less expensive adsorbents such as agriculture wastes: orange peel [9], apple waste [10], rice hull [11].

In the present study, *Traganum nudatum* roots were used as low cost adsorbent to remove Hg(II) cations from aqueous solution.

II. Experimental

A. Material and Equipments

Traganum nudatum roots was collected from Sebha area from the south of Libya, washed with distill water, filtered out and dried in an oven at 90 °C for 2 h. The dried *Traganum nudatum* roots was ground then a particles of diameter <125 μm was obtained. Hexamethylene tetra amine and ethylene tetra amine acetic acid (EDTA) were purchased from Merck, Germany. All other chemicals were of analytical grade without further purification and supplied by Merck, Germany. The pH of the Hg(II) cation solutions was controlled using pH meter of model 3505, Jenway Felsted, Dunmow, Essex C.46 SLB, United Kingdom. The shaker of model 501 was obtained from Stuart Scientific, United Kingdom.

B. Batch Experiments

Mercury ion solution (100 ml) with a desirable pH were placed in erlenmeyer flask with ground plastic stopper. 0.04 g of *Traganum nudatum* roots (<125 μm) was added to the erlenmeyer flask. The mixture was mixed at a constant speed of 400 rpm in a shaking water bath at room temperature. The *Traganum nudatum* roots were separated by a membrane filter (0.45 μm). The concentration of the mercury cation solution before and after adsorption was determined by titration with EDTA using xylenol orange as indicator [12]. The amounts of metal ions adsorbed q_e (mg/g) were determined using the following equation:

$$q_e = \frac{(C_o - C_e) \times V}{W} \tag{1}$$

where q_e, adsorption capacity per unit mass of *Traganum nudatum* roots at equilibrium (mg/g); C_o, initial concentration of mercury ions in aqueous solution (mg/l); C_e is the final concentration of mercury cations after adsorption (mg/l); V is the volume of mercury cations solution in contact with *Traganum nudatum* roots, (l); W is the dry weight of *Traganum nudatum* roots (g).

III. Results and Discussions

A. Effects of Initial pH on Adsorption Capacity

Many researchers have notified that the pH of aqueous medium has extremely influence on the adsorption capacity of the adsorbents [14]. The effect of initial pH on the adsorption capacity of Hg(II) cations by *Traganum nudatum* roots was evaluated at the pH range of 3-5 (Fig. 1). The highest adsorption capacity was obtained at pH 5.

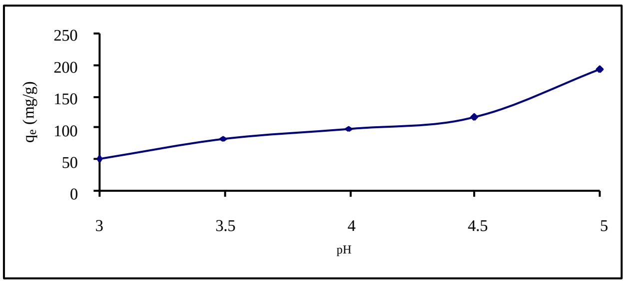

Fig. 1. Effect of initial pH on Hg(II) cations biosorption by *Traganum nudatum* roots at C_o of 200 mg/l.

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B. Effect of Contact Time on Adsorption Capacity

Effect of contact time on adsorption capacity of Hg(II) cations onto the surface of *Tragan nudatum* roots is displayed in Figure 2. As shown in Fig. 2, the adsorption capacity increase with increases contact time and reach equilibrium state after 100 minutes.

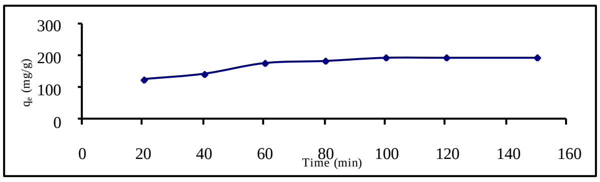

Fig. 2. Effect of contact time on Hg(II) cations biosorption by *Traganum nudatum* roots at C_o of 20 mg/l

C. Effect of Biosorbent Dose on Adsorption Capacity

The biosorbent dose was varied from 0.3 to 5 g/l. The results presented in Fig. 3 showed that, the adsorption capacity of mercury cations decreases from 173.85 to 36.50 mg/g as the biosorbent dose increase from o.3 g/l to 5 g/l. This is mainly due to overlapping of the adsorption sites as a result of overcrowding of the adsorbent particles of *Traganum nudatum* roots [13].

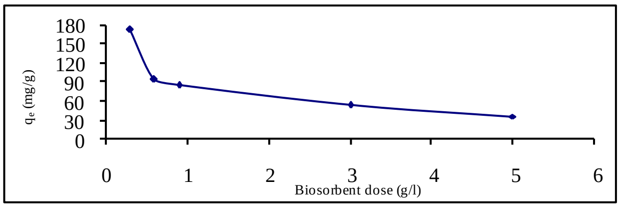

Fig. 3. Effect of biosorbent dose on Hg(II) cations biosorption by *Traganum nudatum* roots at C_o of 200 mg/l. at C_o of 200 mg/

D. Adsorption Kinetics

In order to investigate the mechanism of adsorption, kinetic models could be used to test the experimental data. First order, pseudo-second order and intra-particle diffusion models could be used in this study.The first-order equation of Lagergren [15] is generally expressed as follows:

$$log(q_e - q_t) = log\, q_e - \frac{K_1}{2.303}t \quad (2)$$

where q_e and q_t are the amounts of Hg(II) cations adsorbed on *Traganum nudatum* roots at equilibrium and at time *t*, respectively. k_1 is the first-order rate constant. The plots of log (q_e - q_t) versus t for mercury cations onto the surface of *Traganum nudatum* roots is presented in Fig. 4.

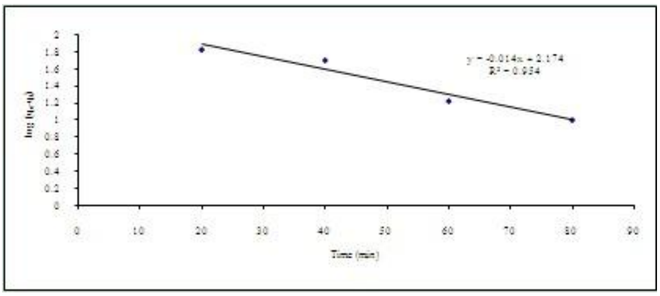

Fig. 4. First-order reaction of Hg(II) cations onto *Traganum nudatum* roots at C_o of 200 mg/l.

The pseudo-second order explained by Ho and Mc Kay as follows [16]:

$$\frac{t}{q_t} = \frac{1}{K_2 q_e^{\,2}} + \frac{1}{q_e}t \quad (3)$$

where k_2 is the pseudo-second-order rate constant. The linear plots of t/q_t versus t for mercury cations onto the surface of *Traganum nudatum* roots is shown in Fig. 5.

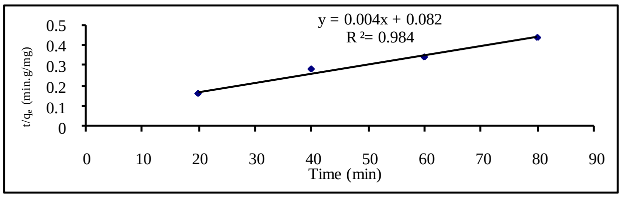

Fig. 5. Pseudo-second order reaction of Hg(II) cations onto *Traganum nudatum* roots at C_o of 200 mg/l.

The correlation coefficient shown in Figures 4 and 5 proved that the adsorption process of Hg(II) cations onto *Traganum nudatum* roots follows second order kinetic model better than first-order kinetic model.

The most commonly used technique for identifying the mechanism of the adsorption process is by fitting the experimental data to the intra-particle diffusion plot. The intra-particle diffusion model according to Weber and Morris expressed as follows[17]:

$$q_t = k_p t^{1/2} + C \quad (4)$$

where k_p is the intra-particle diffusion coefficient and C gives an idea about the thickness of the boundary layer. The linear portion of Weber and Morris plots of q_t versus $t^{½}$ is presented in Fig. 6. The deviation of the straight line from the origin point indicates that the intra-particle diffusion may not be only the rate-determing step in the removal of Hg(II) caions [18].

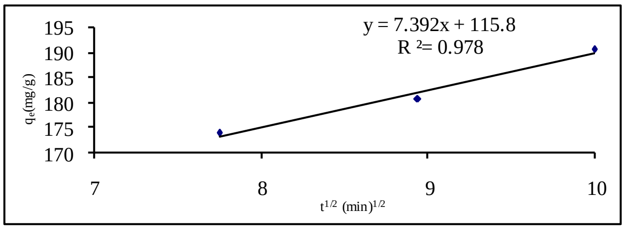

Fig. 6. Test intra-particle diffusion model of adsorption of Hg(II) cations onto *Traganum nudatum* roots at C_o of 200 mg/l.

IV. Conclusion

Traganum nudatum roots has been tried for adsorption of Hg(II) cations from aqueous solution. The maximum adsorption capacity of *Traganum nudatum* roots for the removal of Hg(II) cations was observed at pH 5. 0.3 g/l is sufficient as optimum dose of adsorbent. The adsorption of Hg(II) cations onto *Traganum nudatum* roots particles reaches the equilibrium after 100 minutes. The kinetics of adsorption will be better described by the pseudo second order model. The mechanism of Hg(II) cations adsorption on *Traganum nudatum* roots is well identified by intra-particle diffusion. .

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