Kinetic and Batch Equilibrium Adsorption of Nickel (II) and Copper (II) Ions from Aqueous Solution On to Activated Carbon Prepared from *Balanites aegyptiaca* Shells

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Authors' contributions

This work was carried out in collaboration between all authors. Author HM designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors LAN and CT managed the analyses of the study. Authors BBL, IDN and JMK managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The adsorption capacity of Nickel (Ni^{2+}) and Copper (Cu^{2+}) ions from an aqueous solution by activated carbon prepared from *Balanites aegyptiaca* shells. Prepared activated carbon was characterized by Fourier transform infra red spectroscopy FTIR, and by determination of the iodine number and the carbonization yield. To implement the adsorption capacity of activated carbon, of

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the contact time, adsorbent mass, pH, initial concentration of the adsorbate and the addition of the sodium chloride electrolyte (*NaCl*). To analyze the adsorption mechanism, Langmuir isotherms, Freundlich models were studied. Dubinin-Kaganer-Radushkevich (D-K-R) as well as the kinetic models of pseudo-first order, pseudo-second order, Elovich and intra particulate diffusion. The iodine index gave a value of 550.11 mg/g. The adsorption equilibrium is quickly reached at the end of 10 min and 12 min for Ni^{2+} and Cu^{2+} ions respectively. The maximum adsorbed quantities are of 540 mg/g and 491 mg/g for Ni^{2+} and Cu^{2+} ions respectively. These values are slightly higher than the quantities calculated by the Langmuir model, which implies better adsorbates adsorption on the activated carbon. Adsorption took place in an acidic medium with optimal pH values of 4 and 5 for the Ni^{2+} and Cu^{2+} ions respectively. The pseudo-first order and pseudo-second order models describe the kinetics adsorption of Ni^{2+} and Cu^{2+} ions respectively. The addition of *NaCl* electrolyte showed a very significant increase in the adsorbed quantities, because of increase in the ionic force of the solution. This study revealed that activated carbon obtained from *Balanites aegyptiaca* shells is a good adsorbent for the elimination of Ni^{2+} and Cu^{2+} ions from aqueous solution.

Keywords: Adsorption; Nickel; Copper; Activated carbon; Balanites aegyptiaca; sodium chloride.

1. INTRODUCTION

The environmental protection became a planetary combat at the beginning of the 21st century with the emergence of the country called "pays en voie de development" and the climatic changes observed these twenty last years. Because industry became greedy out of raw materials, it caused in particular an unrestrained race towards the massive exploitation of the mining natural resources. The exploitation of these mines mainly contributed to the side of the processing industries of metals to an increase without precedent of environmental pollution. Heavy metals have a strong toxicological impact on the plants and the man either by inhalation, or by ingestion of products for current human consumption [1].

In environmental sciences, nickel (Ni) and copper (Cu) make party of heavy metals associated with the concepts of pollution and of toxicity are generally [1].The acceptable contents of copper and nickel in drinking water must be lower respectively than 0.3 mg/L and 0.02 mg/L according to WHO (2010). Beyond these thresholds, copper and *nickel* become toxic. Copper is mainly responsible for poisonings and can consequently cause the effects like nauseas, diarrheas. The deterioration of the red globules, the lungs, the liver and the pancreatic functions are the most current symptoms of a poisoning by copper [2]. Nickel presents more risks to develop a lung cancer, larynx cancer and prostate cancer. Copper turned out to be especially toxic for photosynthetic efficiency in *C. reinhardtii.* and nickel had effects on the photosynthetic efficiency .

With the aim of answer the increasing degradation of the quality of water, many methods of treatments were setting-up, adsorption on an adsorbent material in particular. The activated carbon constitutes adsorbing material more used because of its effectiveness, of its implementation easy and its less expensive cost. It results mainly from the hard or soft vegetable biomass. The aim of this study is to prepare the activated carbon starting from the hulls of *Balanites aegyptiaca* being able to be used for the urban and industrial effluent, waste and drinking water treatments. The choice of *Balanites aegyptiaca* is justified by the underdevelopment of hulls of this tropical fruit, by the populations of north and far-north Cameroon after consumption of their pulp [3]. This study would make it possible to consider the valorization of a local material in the manufacture of the activated carbon, thus leading to the reduction of the national imports of this product. Its scope encompasses the improvement of the quality and the added value of *Balanites aegyptiaca*, as well as the development of local materials likely to be used for the environmental protection [4,5-6].

The adsorption of the Ni^{2+} and Cu^{2+} ions by the prepared activated carbon was studied by the analysis of the effect of the parameters such as agitation time, adsorbent mass, pH of the solution, initial concentration of the adsorbate and the addition of sodium chloride electrolyte. Langmuir, Freundlich and Dubinin-Kaganer-Radushkevich (D-K-R) adsorption isotherms, as well as the kinetic models of pseudo-first order, pseudo-second order, and intraparticle diffusion and of Elovich were studied to describe the adsorption mechanism brought into play [5].

2. MATERIALS AND METHODS

2.1 Preparation of Activated Carbon

2.1.1 Shells pretreatment and treatment

The *Balanites aegyptiaca shells* were collected from the localities of Garoua (northern region of Cameroon). They were washed with running water, then rinsed with distilled water and dried at 105°C crushed in a mill (RETSCH; series number N82508001), and were sieved to obtain a material size ranging between 0.5 and 1mm.

2.1.2 Chemical activation with orthophosphoric acid

The finished and sieved product was then impregnated by $H_3 PO_4$ for 10 % in a ratio of biomass to acid of 1/1 in mass and dried at 105°C in a carbolite furnace [3].

2.1.3 Carbonization

The activated material was carbonized at 400°C with average activation time of 2H in a furnace (CARBOLITE FURNACES) [3]. The obtained product was washed until neutral pH, and then dried at 105°C to obtain the activated carbon.

2.2 Characterization of the Activated Carbon

2.2.1 FTIR spectroscopy

The functional surface groups of the prepared activated carbon were determined by FTIR spectroscopy.

2.2.2 Iodine index

The iodine index gives an indication on the porosity of the prepared activated carbon [3].

2.2.3 Burn-off

Quantitative characteristic for the activated carbon. It reveals the mass loss during carbonization [3].

2.3 Batch adsorption Measurement

2.3.1 Preparation of the solutions

The original solutions of Ni^{2+} and Cu^{2+} ions of concentration 5000 ppm were prepared respectively from $NiCl_2$. $6H_2O$ and $CuCl_2.2H_2O$ salts. The various standard solutions used were prepared by dilution of the original solutions.

The adsorption study of the Ni^{2+} and Cu^{2+} ions was carried out in a batch system respectively at pH 4 and 5 and at room temperature (25 ± 2°C), for an adsorbent mass of 0.010± 0.001g, and a volume of 20 ml of solution of adsorbate contained in an engine of 250 ml under agitation. The solution concentrations were measured out by UV-VISIBLE spectrophotometry.

2.3.2 Adsorption parameters

Agitation Time: We successively introduced into engines of 250ml, activated carbon mass of 0.01g and 20mL of solution of adsorbate of concentration 1600ppm to the pH 4 and 5 respectively for the solutions of Ni^{2+} and Cu^{2+} ions. The mixtures were related to constant agitation for progressive lengths of time from 2 to 20 min.

Mass adsorbent: masses varying from 0.01 to 0.09 g of activated carbon were introduced into the system containing 20 mL of Ni^{2+} and Cu^{2+} solutions of concentration 1600 ppm, then stirred for a time of balance of 10 and 12 minutes respectively.

pH: For each adsorbate, 20 ml solution of 1600 ppm were introduced into the system containing a constant mass of activated carbon, and pH varying from 2 to 6 adjusted by using solutions of *NaOH* or *HCl*. Each sample was stirred during the time balance.

Concentration of the adsorbate: the experiments were carried out with solutions of Ni^{2+} and Cu^{2+} of concentration varying from 500 to 2000 ppm in the fixed experimental conditions according to the previous analyzed parameters.

NaCl electrolyte: the effect of the sodium chloride electrolyte (*NaCl*) *was studied.* 5 mL of the electrolyte of concentration varying between 100 to 500 ppm of the electrolyte were mixed with 20 mL of a solution of adsorbate of concentration 2000 ppm, and stirred for a given time interval.

2.4 Experimental Analysis

Adsorption capacity: the adsorbed quantities for each adsorbate were determined by the relation,

$$Q_t = (C_0 - C_t). \ v/m \qquad (1)$$

Where Q_t *(mg/g) = quantity of aqueous solution adsorbed at the moment t; V = volume of solution (mL);* C_0 *and* C_t *are the initial and the concentration at time t respectively and m = mass of adsorbent used.*

2.4.1 Adsorption isotherms

2.4.1.1 Langmuir isotherm

This model rest on a kinetic vision of the adsorption of gas molecules on a plane surface [6]. The adsorption sites on solid surface are homogeneous from an energy point of view: "homogeneous surface of adsorption". Each site can adsorb only one molecule, and only one layer of molecule can be formed [7].

The Langmuir equation:

$$Q_e = Q_m \frac{bC_e}{1 + bC_e} \qquad (2)$$

Where Q_e *= quantity adsorbed per unit mass of the adsorbent (mg/g);* C_e *= equilibrium concentration (mg/L);* Q_m *= maximum quantity adsorbed per unit mass of the adsorbent (mg/g) and b = constant of Langmuir.*

The linear form of this equation is given by: (See Fig. 8.)

$$\frac{C_e}{Q_e} = \frac{C_e}{Q_m} + \frac{1}{bQ_m} \qquad (3)$$

The shape of the curve obtained predicts if adsorption is "favorable" or unfavorable. This is possible; thanks to the knowledge of the value of the constant of separation R_L whose expression is [7]:

$$R_L = \frac{1}{1 + bC_0} \qquad (4)$$

The value of R_L indicates if adsorption is unfavorable ($R_L > 1$), favorable ($0 < R_L < 1$) or irreversible ($R_L = 0$) [6-7].

2.4.1.2 Freundlich isotherm

The Freundlich isotherm represents adsorption on heterogeneous surfaces whose expression is as follows [8]:

$$Q_e = K_f C_e^{1/n} \qquad (5)$$

Its linear form is given by the relation: (Fig. 9.)

$$LogQ_e = LogK_f + \frac{1}{n}LogC_e \qquad (6)$$

Where K_F *= Freundlich constant (mg/g);* 1/n *inform about the intensity of adsorption.*

Dubinin - Kaganer - Radushkevich (D-K-R) isotherm

D-K-R isotherm is generally used to describe the nonhomogeneous sites of adsorption, and provides information making it possible to know the nature of the interactions brought into play between the adsorbent and adsorbed it. [9-10]

Its equation is as follows,

$$Q_e = Q_m \exp\left[\frac{RT(l_n(1 + \frac{1}{C_e}))^2}{-2E_a^2}\right] \qquad (7)$$

Where Q_m *= is the maximum quantity to fill full-course (mg/g);* E_a *= energy of adsorption which should be provided to move adsorbed it of the surface of the adsorbent in the solution (Kj.mol^{-1}); Qe = quantity adsorbed with balance in the solid phase (mg/g) and R = constant of perfect gas (J.K^{-1} mol^{-1}).*

Its linear form is as follows, (See Fig. 10)

$$\ln Q_e = \ln Q_m - \beta \mathcal{E}^2 \qquad (8)$$

Where ε is the Polanyi potential given by,

$$\varepsilon = RT\ln(1 + \frac{1}{C_e}) \qquad (9)$$

2.4.2 Kinetics of adsorption experiments

2.4.2.1 Pseudo-first order model

It describes adsorption in the solid systems. This model was proposed by Lagergren in 1898 [11].

$$\frac{dQ_t}{dt} = K_1(Q_e - Q_t) \qquad (10)$$

After integration at the moments t=0 and t, and for the quantities qt= 0 at t=0 the preceding equation become, (See Fig. 11.)

$$\log(Q_e - Q_t) = \log Q_e - \frac{K_1}{2,303}t \qquad (11)$$

Where Q_t *et* Q_e *the adsorption capacities at times t and at equilibrium balance and* K_1 *is the rate constant of adsorption of the pseudo-first order model (min^{-1}).*

2.4.2.2 Pseudo-second order model

The equation speed of the kinetics of second-order adsorption is given by the relation [12-13],

$$\frac{dQ_t}{dt} = K_2(Q_e - Q_t)^2 \qquad (12)$$

Its linear form is given, (See Fig. 12.)

$$\frac{t}{Q_t} = \frac{1}{K_2 Q_e^2} + \frac{t}{Q_e} \qquad (13)$$

Where K_1= constant speed of the process of adsorption pseudo second order (mg.g^{-1}.min^{-1}).

2.4.2.3 Elovich kinetic Model

The equation of the Elovich kinetic model is described by the equation [14], (See Fig. 13.)

$$\frac{dQ_t}{dt} = \alpha e^{\beta Q_t} \qquad (14)$$

Its linear form is given by the relation, (See Fig. 14.)

$$Q_t = \frac{1}{\beta}\ln(\alpha\beta) + \frac{1}{\beta}lnt \qquad (15)$$

2.4.2.4 The intraparticle diffusion model

The intraparticle diffusion equation is given by the following expression [15],

$$Q_t = k_{id}\sqrt{t} + C \qquad (16)$$

Where Q_t, quantity relating of the molecule adsorbed to time t; k_{int} the constant of diffusion will intra particulate and C the value thickness of boundary layer.

3. RESULTS AND DISCUSSION

3.1 Characterization of the Activated Carbon

FTIR Spectroscopy was used to determine the nature of the functions on the surface of the activated carbon (Fig. 1). We observe peaks of absorption with 3362cm^{-1}, 1594 cm^{-1}, 1597 cm^{-1}, and 1506 cm^{-1} which are respectively characteristic of the vibrations phenolic -OH, -NH- and aromatic -COOH, and -C=C- aromatic and/or of the functions -NO.

Table 1 gives results on the values of the "Burn-off" and of the iodine index. The analysis of the results reveals that the chemical activation of the hulls of *Balanites aegyptiaca* was very significant with a loss in mass moreover 50% [3]. The value of the iodine index obtained reveals the microporous adsorbing material.

Table 1. values of some parameters of the characterization of the activated carbon

parameters	Burn-off (%)	Iodine index (mg/g)
values	51,42	550,11
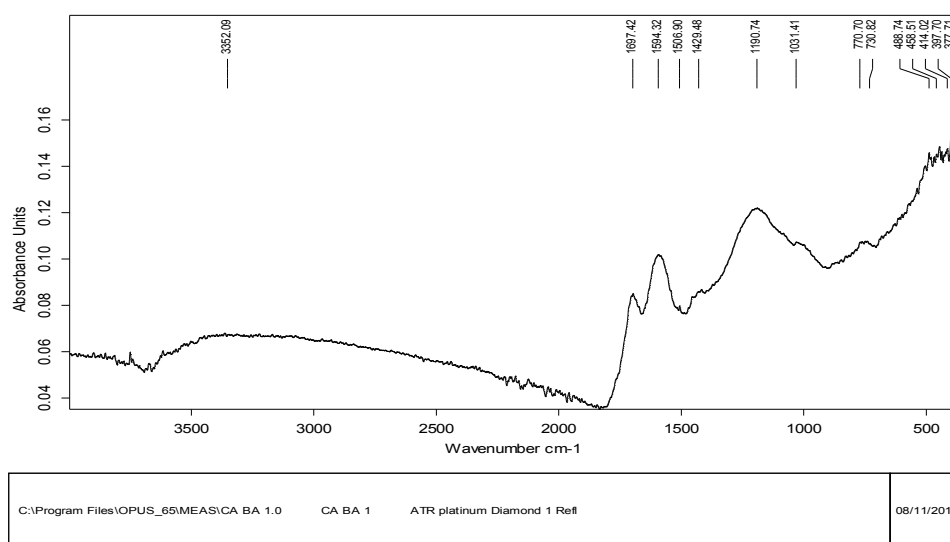
Fig. 1. FTIR Spectrum of CA before adsorption

3.2 Effect of Agitation Time

We observe on Fig. 2 that the kinetics of adsorption results in a growth followed by a stabilization of the adsorbed quantities for the Ni^{2+} and Cu^{2+} ions. The first stage corresponds to strong and fast adsorption, because a maximum sites is still unoccupied, which facilitates the fixing of the Ni^{2+} and Cu^{2+} ions. One second stage slower shows a progressive reduction in the adsorption free sites, which at the end of 10 and of 12 minutes respectively for the Ni^{2+} and Cu^{2+} ions, reached the balance of adsorption [16,17]. This figure represents the evolution of the quantities adsorbed on the activated carbon according to time. The adsorbed quantities obtained are high for lowest times of balance of

adsorption. We had electrostatique interaction between the Nickel (Ni^{2+}) and Copper (Cu^{2+}) with the adsorbent surface.

3.3 Effect of the amount of adsorbent

The study reveals that the adsorption capacities decrease gradually with the increase in the mass of the adsorbent (Fig. 3).This is valid at the same time for the Ni^{2+} and Cu^{2+} ions. This reduction could be related to the agglomeration of the activated carbon particles caused by the agitation of the medium. This agglomeration involves consequently a reduction in the distance inter particulate between the particles of adsorbent, thus reducing the diffusion of the Ni^{2+} and Cu^{2+} ions towards the adsorption sites [18].

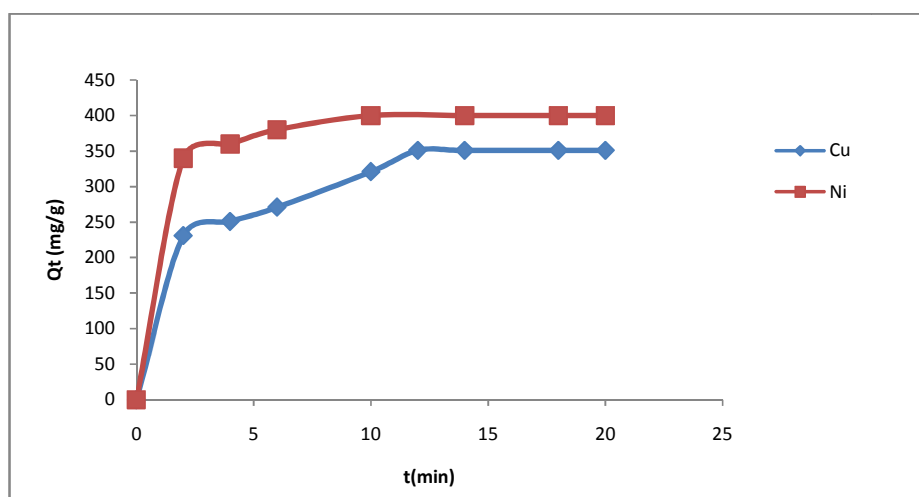**Fig. 2. Effect of agitation time on adsorption of the Ni^{2+} (V=20ml, pH=4 and m=0.01g) and Cu^{2+} (V=20ml, pH=5 and m=0.01g) ions**
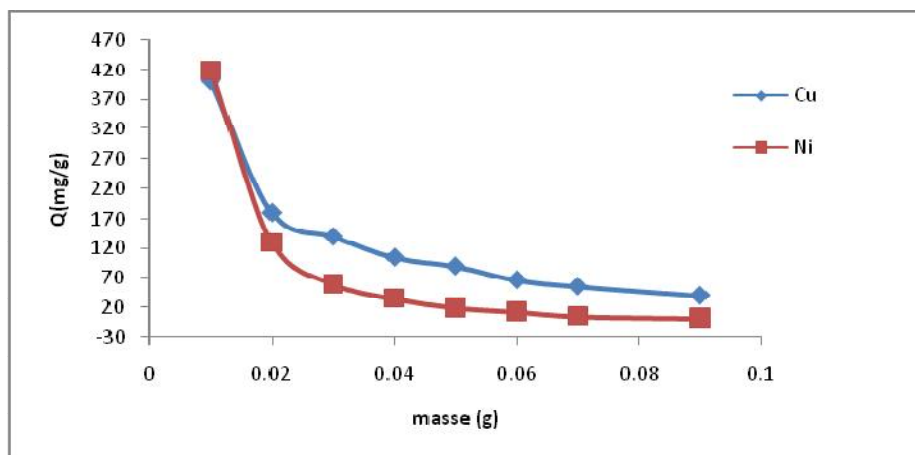
Fig. 3. Effect of adsorbent mass on the adsorption of the Ni^{2+} (V=20ml, pH=4 and t=10 min) and Cu^{2+} (V=20ml, pH=5 and t=12 min) ions

3.4 Effect of pH of Solution

The effect of the pH (Fig. 4) was studied for a variation of pH from 2 to 6, at room temperature. We observe a significant improvement on the adsorbed quantities, and consequently an increase in the percentage of adsorption of the Ni^{2+} and Cu^{2+} ions eliminated.

Indeed, the behavior of adsorbent material with respect to the metal cations shows that with the studied values pH (acid pH), only the functions -NH- and -NO on the external surface of the activated carbon would be likely by acido-basic reaction or electrostatic attraction to fix Ni^{2+} and Cu^{2+} ions. Moreover optimum pH of adsorption are 4 and 5 respectively for the Ni^{2+} and Cu^{2+} ions [19-20]. The pH value keeps constant during the adsorption process. These values are: pH=4 during the adsorption of Nickel (Ni^{2+}) and pH= 5 during the adsorption of Copper (Cu^{2+}).

3.5 Effect of NaCl Electrolyte

Fig. 5 shows the evolution of the adsorbed quantities of the Ni^{2+} and Cu^{2+} ions according to the concentration of added electrolyte. The study shows as the addition of *the NaCl electrolyte*, makes grow to a significant degree the quantities adsorbed as well for the Ni^{2+} ions as for the Cu^{2+} ions. This growth is also a function of the concentration of the electrolyte. This by the fact
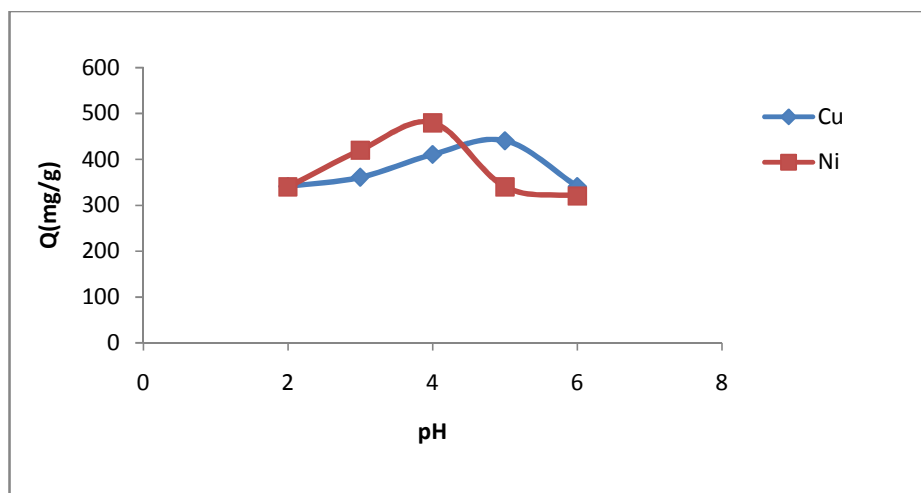

Fig. 4. Effect of pH on the adsorption Ni^{2+} (V=20ml, t=10 min and m=0.01g) and Cu^{2+} (V=20ml, t=12 min and m=0.01g) ions
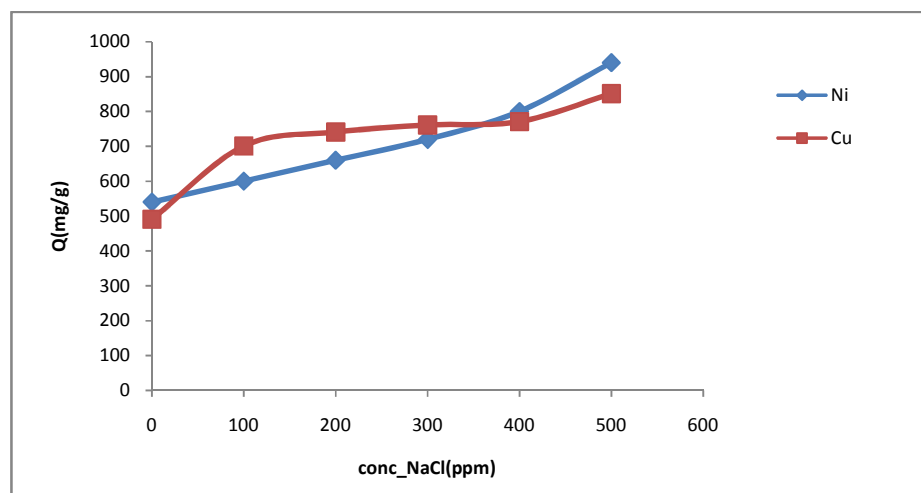
Fig. 5. Effect of NaCl electrolyte on the adsorption of the Ni^{2+} (V=20ml, pH=4, m=0.01g and t=10 min) and Cu^{2+} (V=20ml, pH=5, m=0.01g and t=12 min) ions

that, the addition of the solution *NaCl* would lead to an increase in the ionic force, which would contribute to the aggregation of the adsorbates supporting the bringing together between the adsorbent and the adsorbate [21-22].

3.6 Effect of Initial Concentration

The study shows that effect of the initial concentration of the adsorbate on the adsorbed quantities is very significant. We also observe that the adsorption isotherm of the Ni^{2+} ions obtained (Fig. 6), indicates a multi-layer adsorption, with continuous increase in the ions adsorbed according to the increase in the concentration. The adsorption isotherm of the Cu^{2+} ions obtained (Fig. 7), shows a full-course adsorption, which is also accompanied by a continuous increase in the ions adsorbed according to the increase in the concentration.

3.7 Adsorption Isotherms

In comparison with the results presented in table 2, we can draw the analyses according to which the adsorption of the Ni^{2+} and Cu^{2+} ions would present for all the isotherms models studied a good correlation.

Indeed, D-K-R model would indicate a good affinity between the adsorbate and the adsorbent, with a good uniform distribution of the adsorption sites in the case of the Ni^{2+}ions. As for the Cu^{2+} ions, this last does not seem to corroborate a uniformity of the adsorption sites.

However Langmuir model presents a better correlation for the adsorption of the Ni^{2+} and Cu^{2+} ions, with respective correlation coefficients of 0.982 and 0.929 and separate factors (0< R_L< 1) indicating a favorable adsorption. The quantities adsorbed for Langmuir model are 500 and 454.5 mg/g respectively for the Ni^{2+} and Cu^{2+} ions. These values are close to the experimental values obtained which are of 540 mg/g for the Ni^{2+} ions and 491 mg/g for the Cu^{2+} ions.

Freundlich model revealed that the constant 1/n >1 for the Ni^{2+} ions, which would mean low adsorption intensity of on the activated carbon. As for Cu^{2+} ions, Freundlich model indicated a constant 1/n = 0.2 revealing strong adsorption intensity on the activated carbon of the ions [23].

3.8 Adsorption Kinetics

The adsorption kinetics of the Ni^{2+} and Cu^{2+} ions was studied while following the effect of the agitation time on the balance of adsorption. The values presented in table 3 are obtained starting from the kinetic models described previously.

The analysis of the results reveals that the adsorption of the Ni^{2+} ions would be controlled by kinetics of pseudo-first order model because of the high value of the correlation coefficient (R^2=0.993), and that of the Cu^{2+} ions would be controlled by the kinetics of pseudo-second order model, because also of high correlation coefficient (R^2=0.998).

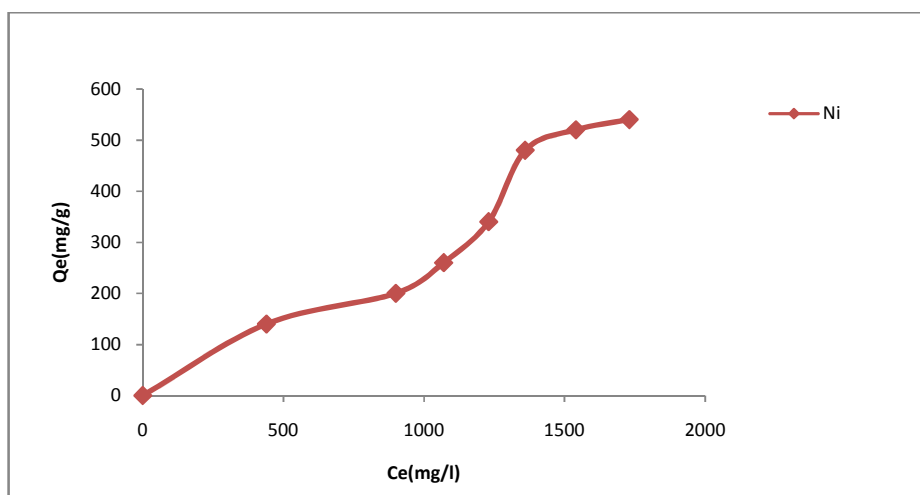**Fig. 6. Adsorption isotherm of the Ni^{2+} ions for V=20ml, pH=4, m=0.01g and t=10 min**
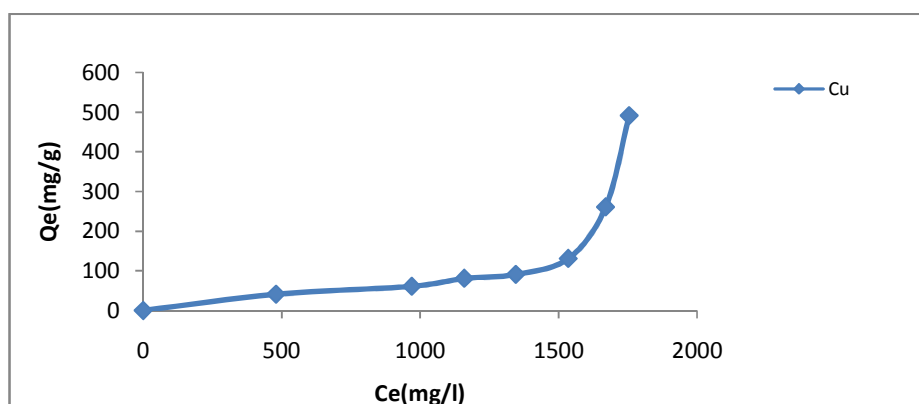
Fig. 7. Adsorption isotherm of the Cu^{2+} ions for V=20ml, pH=5, m=0.01g and t=12 min

Table. 2. values of the various parameters of the isotherms models studied

Models	Langmuir				Freundlich				D-K-R	
Parameters	K_L*10^{-7}	Q_m (mg/g)	R_L	R^2	K_F	$1/n$	R^2	$K'*10^6$	Q_m (mg/g)	R^2
Ni^{2+}	2.00	500	0.87	0.982	3.476	1.014	0.973	1	789.18	0.968
Cu^{2+}	2.33	454.5	0.96	0.929	531.126	0.2	0.816	2	603.36	0.759

Table 3. values of the various parameters of the kinetic models studied

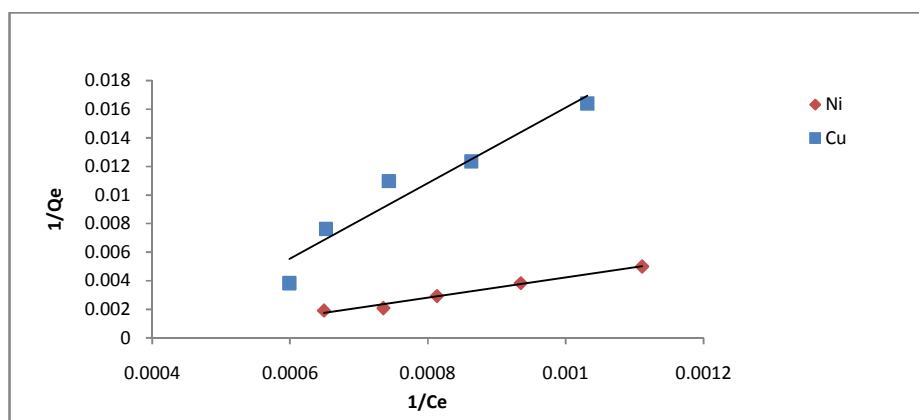| Modele*s	Parameters	Ni^{2+}	Cu^{2+}
Pseudo-1er order	K_1 (min^{-1})	526.46	420.6
	Q_e (mg/g)	0	0
	R^2	0.993	0.970
Pseudo-2nd order	K_2 (mg/g.min)	$1.38*10^{-7}$	$2.17*10^{-6}$
	Q_e (mg/g)	$5*10^4$	10^4
	R^2	0.895	0.998
Intra Particule diffusion	C (m^2.s^{-1})	323.07	170.5
	K_{id} (mg.L/min)	18.154	41.24
	R^2	0.908	0.996
Elovich	A	$3.57*10^6$	$1.48*10^3$
	B	0.036	0.018
	R^2	0.984	0.980

Fig. 8. Linear plot of the model of Langmuir, for V=20ml, pH=4 and m = 0.01g
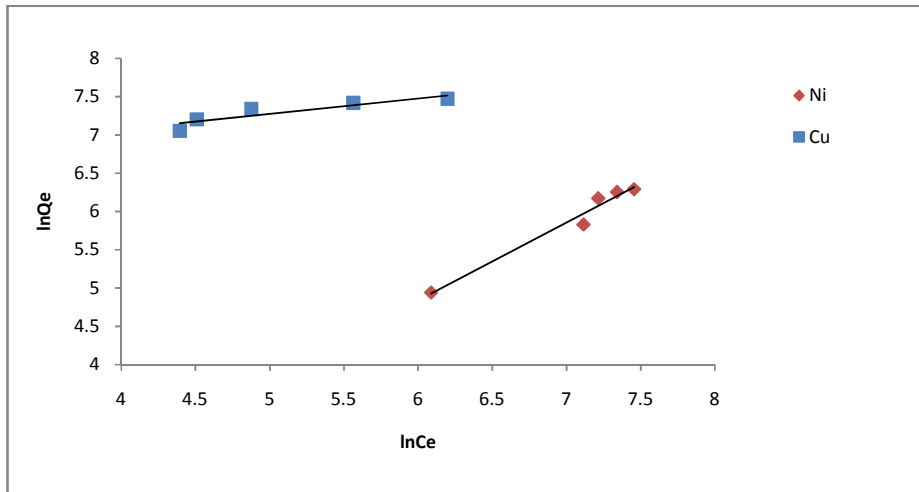
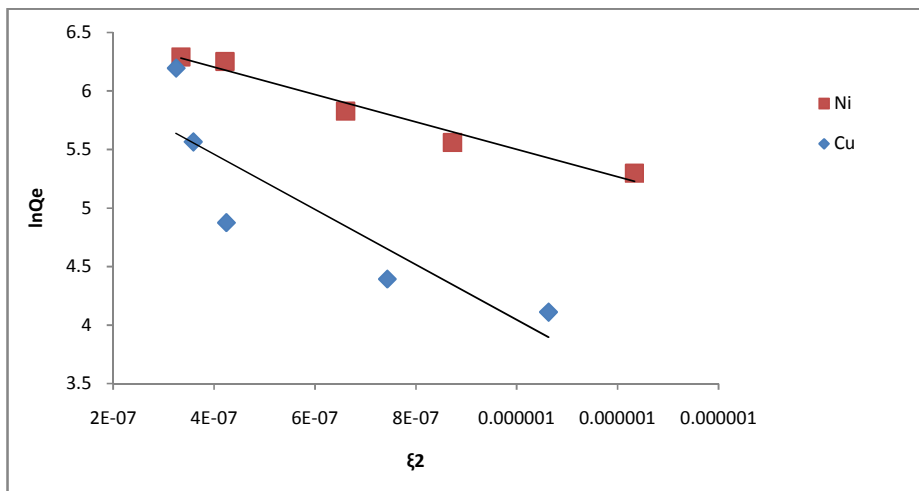**Fig. 9. Linear plot of the Freundlich model, for V=20ml, pH=4 and m=0.01g**

Fig. 10. Linear plot of the Dubinin-Kaganer-Radushkevich model, for V=20ml, pH=4 and m=0.01g
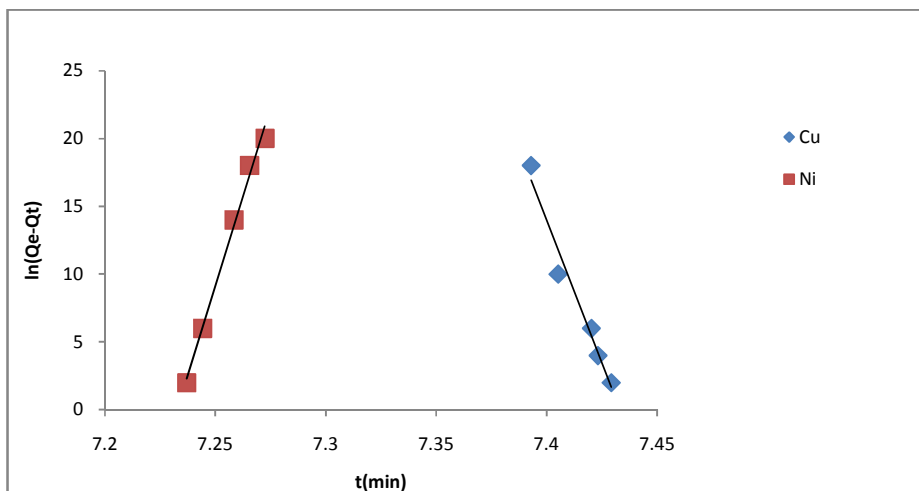

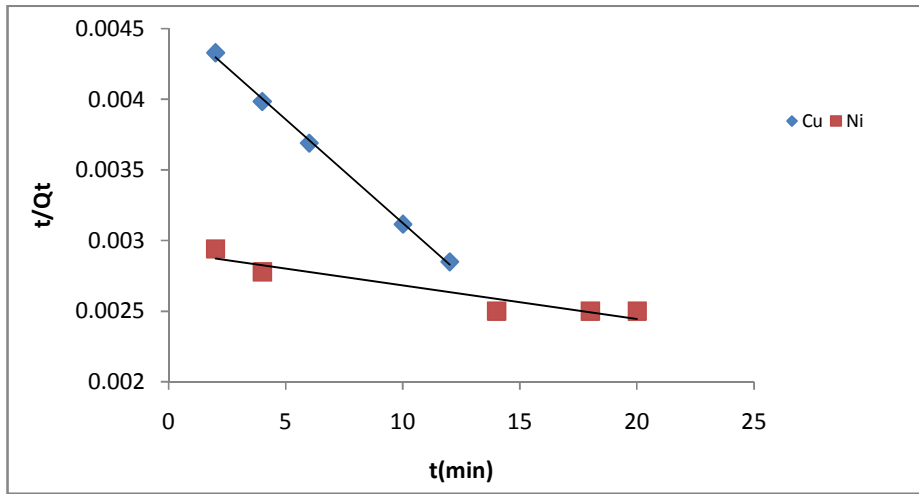**Fig. 11. Linearized pseudo-first order plots for, V=20ml, pH=4 (Ni^{2+}) and pH=5 (Cu^{2+}), m=0.01g**

Fig. 12. Linearized pseudo-second order plots for, V=20ml, pH=4 (Ni^{2+}) and 5 (Cu^{2+}), m=0.01g
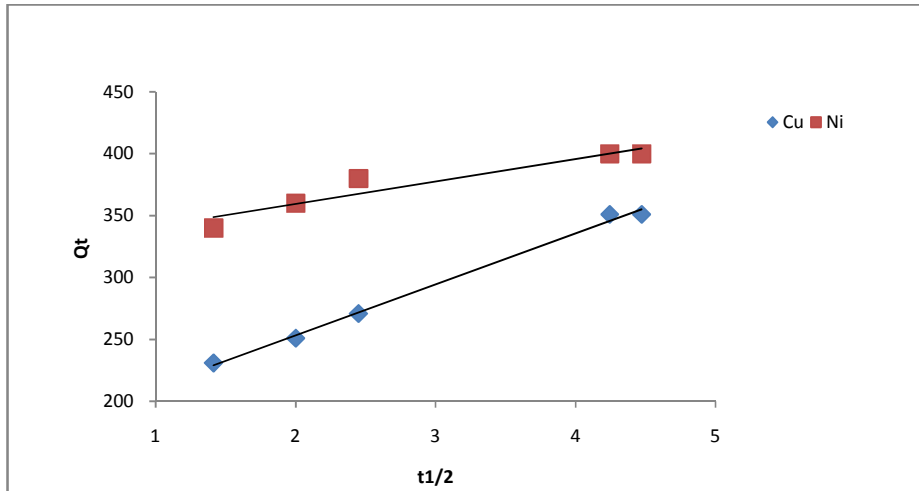

Fig. 13. Linearized intraparticle diffusion plots for, V=20ml, pH=4 (Ni^{2+}) and 5 (Cu^{2+}), m=0.01g
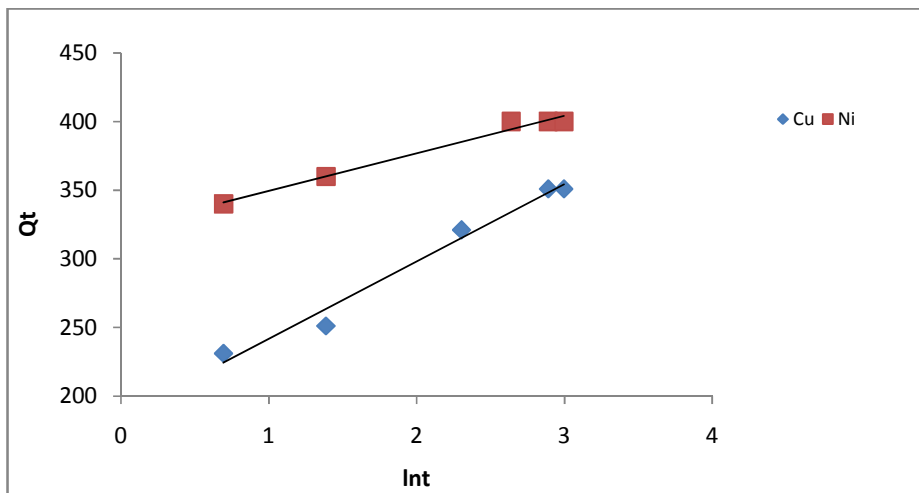

Fig.14. Linearized Elovich plots for, V=20ml, pH=4 (Ni^{2+}) and 5 (Cu^{2+}), m=0.01g

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The high values of R^2 and the constants of Elovich and intraparticle diffusion models as much for the Ni^{2+}ions that for the Cu^{2+}ions would indicate that rate of adsorption are very high. This promotes the fast attack of the balance of adsorption supports on our adsorbent material. Moreover the kinetic model of intraparticle diffusion would indicate that the diffusion of the adsorbates is the essential mode of transport between the adsorbates and the adsorbent. But this phenomenon would not constitute the stage kinetically limiting. Because the R^2 of this model are lower than those of the of the pseudo-first order model for the Ni^{2+} ions and of the pseudo-second order model for the Cu^{2+} ions.

4. CONCLUSION

The objective of this work was the study of the Ni^{2+} and Cu^{2+} ions adsorption fro, aqueous solution on the activated carbon of the hulls of *Balanites aegyptiaca.* The prepared activated carbon was characterized by FTIR spectroscopy, the index of iodine and the Burn-off. The analysis of the parameters such as the agitation time, mass adsorbent, pH of the solution, initial concentration of the adsorbate and the effect of the *NaCl* electrolyte made it possible to determine the optimum conditions for adsorption. The study of the adsorption isotherms and the kinetic models made it possible to describe the mechanism of adsorption brought into play. The best conditions were established, with respect to pH and contact time, to saturate the available sites located on the activated carbon. This work revealed a fast attack of the balance of adsorption at the end of 10 min for the Ni^{2+} ions and of 12 min for the Cu^{2+} ions. The mechanism of adsorption brought into play showed the adsorption of the Ni^{2+} and Cu^{2+} ions follows the Langmuir isotherm. The kinetics adsorption revealed that pseudo-first order and pseudo-second order models better describe the adsorption of the Ni^{2+} and Cu^{2+} ions. This study showed maximum adsorbed quantities of 540 mg/g for the Ni^{2+} ions and of 491 mg/g for the Cu^{2+}ions which are comparable with the values of for the commercial activated carbon reported in earlier studies.

Balanites aegyptiaca is a multipurpose plant with many attributes and considerable potential, functional groups that are considerably different to those of activated materials, which may lead to greater adsorption potential of activated samples. From this study, it is clear that the hulls of *Balanites aegyptiaca* can be used in manufacturing of activated carbon which is used in the process of water treatment, oil bleaching and filtration of food products.

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