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Short Communication

Biosorption Characteristics of Water Hyacinth (*Eichhornia crassipes*) in the Removal of Nickel (II) Ion under Isothermal Condition

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Abstract. This study was taken to investigate the potentiality of water hyacinth (*Eichhornia crassipes*) as an alternative biosorbent for the removal of Ni (II) ion from aqueous solution. The optimum pH, contact time and concentration were found to be 6.0, 40 min and 1.0 mg/L under isothermal condition. The biosorption of Ni (II) ion was found to decrease with increasing pH, initial concentration and contact time. Results obtained were analysed with Langmuir and Freundlich biosorption models. The equilibrium data fitted well to the Langmuir biosorption model with correlation coefficient (R^2) value of 0.98. The monolayer adsorption capacity was 0.29 mg/g. The removal of Ni (II) ion from aqueous solution using water hyacinth biomass followed a monolayer biosorption.

Keywords: monolayer biosorption, water hyacinth, nickel removal

Contamination of toxic metals such as copper, lead, zinc, nickel and chromium in the aquatic environment is a matter of attention as studied by Kaewsarn and Yu (2001). Heavy metal contamination may cause serious health problems such as cancer and brain damage (Mukhopadhyay, 2008).

The presence of nickel ions in surface water is a problem of increasing importance in Nigeria.

The permissible limit of nickel according to World Health Organization (WHO) in drinking water is 1 mg/L as reported by Nemerow (1963). Current developed methods for solving water contaminated related problems include filtration, ion exchange, membrane separation, nutrient stripping and adsorption. The adsorption technology (biosorption) which utilizes natural biomass materials is very effective for the detoxification of metal-bearing industrial effluents.

Water hyacinth (*Eichhornia crassipes*) is known as one of the 'world's worst aquatic weeds' (Malik, 2007). On the other hand, it appears to be a valuable material with a remediation property. Therefore, *E. crassipes* biomass was used in this study to remove Ni (II) ion from aqueous solution under isothermal condition and isotherm model equations were used to analyse the equilibrium data.

The leaves of water hyacinth were collected from Choba River, Choba community in Obio-Akpor local government area of Rivers state, Nigeria. The water hyacinth biomass was sun-dried for two days. The biosorbent was prepared by washing it with 0.1M HCl (to convert alignates to alignic acid) and then rinsed with deionized water. The leaves were then dried further in an oven for 24 h until the leaves became crisp. After drying, the leaves were ground by a manual grinder, to a constant size of 150 μm.

The nickel stock solution (1000 mg/L) was prepared using analytical grade of $CH_3COOONi.4H_2O$ and test solution was prepared by dilution to the desired concentrations. The biosorption study was carried out by adopting a column reactor system under isothermal condition. The column experiment was performed in a packed bed consisting of a cotton wool and the biomass with inner diameter of 30 mm and length of 500 mm. The water hyacinth leaves powder (1 g) was used to study the effect of pH, contact time and concentration at 298 K. The supernatant obtained was analysed using atomic absorption spectrophotometer (AAS). The amount of metal ion biosorbed per gram of the biomass q_e was calculated using the equation below.

$$q_e = \frac{C_i - C_e}{M} \times \frac{50}{1000}$$

where:

q_e = the amount of metal ion biosorbed per gram of the biomass in mg/g

C_i = the initial concentration of the metal ion in mg/L,

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C_e = the equilibrium concentration of the metal ion in mg/L

M = the mass of the biomass in g; 50 = the volume of the metal ion in milliliters; 1000 = the conversion factor to liters. The experiment was performed in triplicate and the mean values taken for each parameter.

The effect of pH on the biosorption capacity is shown in Fig. 1. The biosorption capacity of Ni (II) ion increased initially and then became constant with increasing pH. A pronounced dependence of Ni (II) ion biosorption on the solution pH was observed (Abdullah and Devi Prasad, 2010). This biosorption behaviuor at low pH showed competition between Ni (II) ion and the net positive charge on the biosorbent surface thereby lowering the rate of uptake. However, as the pH increased, the rate of biosorption increased and optimum biosorption was achieved at pH6. This could be as a result of the unsaturation of the metal binding sites on the surface of the biomass indicating weak chemical interaction between Ni (II) ion and the biomass surface charges. At pH above 6, the biosorption of Ni (II) ion decreased. At this point, precipitation of nickel (II) hydroxide set in leading to a decrease in the rate of Ni (II) ion uptake (Wang and Xing, 2002).

The effect of contact time on the biosorption of Ni (II) ion using water hyacinth biomass is shown in Fig. 2. The result obtained showed that there was an initial fast uptake of Ni (II) ion followed by a slow and constant biosorption. The increase in the rate of biosorption within 10 - 40 min could be due to unsaturation of the active sites of the biomass and at higher time, precipitation of the nickel (II) hydroxide took place thereby reducing the rate of Ni (II) ion uptake (Turp *et al.,* 2011). Therefore, the optimum biosorption time of 40 min was obtained.

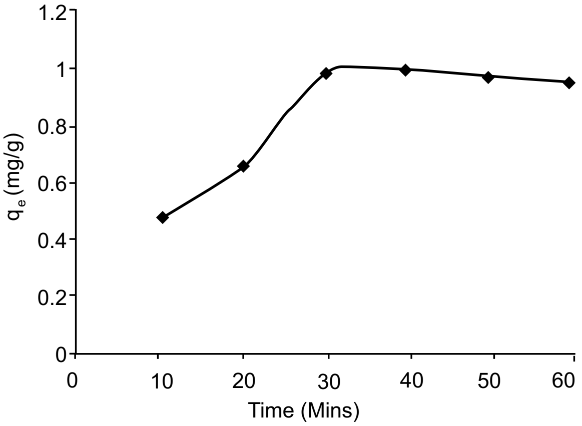

Fig. 2. Effect of contact time on Ni (II) ion biosorption using water hyacinth biomass at 298 K.

The initial ion concentration serves as an important driving force for overcoming mass transfer resistance of Ni (II) ion between the aqueous and solid phases (Pandey *et al.,* 2007). The effect of different initial Ni (II) concentrations on the water hyacinth biosorption capacity is shown in Fig. 3. The biosorption of Ni (II) ion showed a concentration dependency. The rate of biosorption increased as the concentration of Ni (II) ion increased from 20 - 60 mg/L. It was observed that Ni (II) ion uptake decreased above 60 mg/L. This could be as a result of the concentration gradient established between Ni (II) ion and the biomass surface charges due to precipitation. This observation is similar to the research of Tsai and Chen (2010).

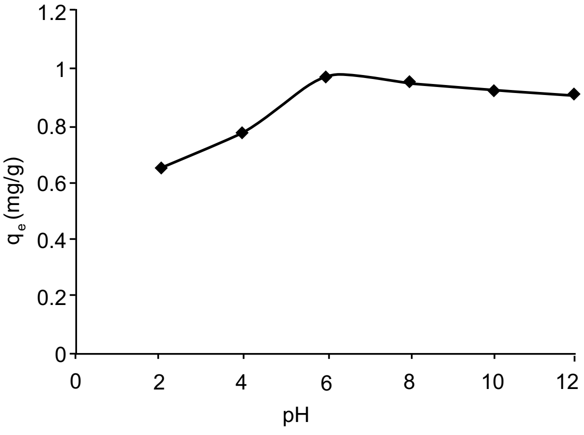

Fig. 1. Effect of pH on the biosorption of Ni (II) ion using water hyacinth biomass at 298 K.

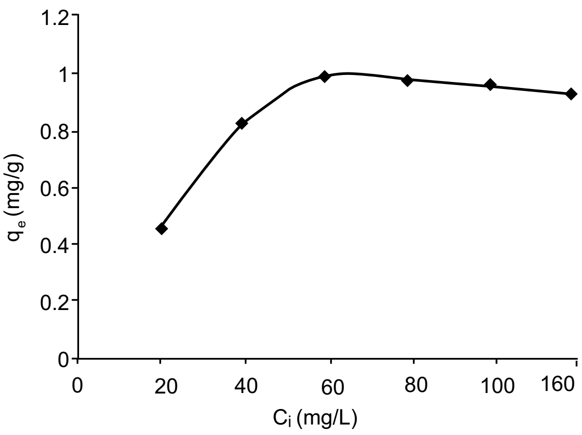

Fig. 3. Effect of concentration on Ni (II) ion biosorption using water hyacinth biomass at 298 K.

The plot of Langmuir as the best model equation is represented in Fig. 4. However, Langmuir isotherm constants were determined from a plot of C_e/q_e against C_e as shown in Table 1 (Akbal and Camci, 2011). The isotherm correlation coefficient (R^2) of Langmuir was 0.98 indicating a physical type of biosorption with monolayer capacity of 0.29 mg/g. The result of the biosorpion capacity obtained was greater than the work done by Hassan *et al.* (2010).

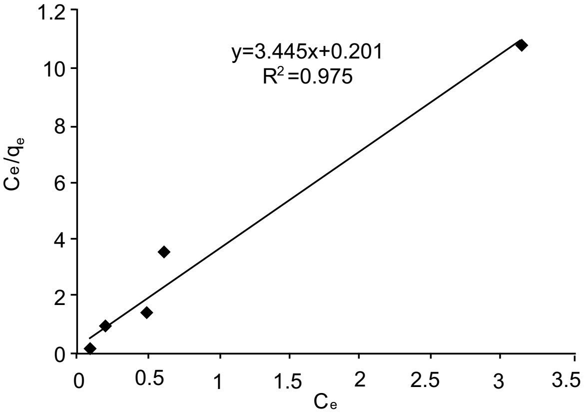

Fig. 4. A plot showing Langmuir adsorption model of Ni (II) ion using water hyacinth biomass.

Table 1. The Langmuir parameters

Model equation	Parameters	water hyacinth
Langmuir	K_L	0.06
	Q_{max} (mg/g)	0.29
	R^2	0.98

The biosorption process was dependent on the pH of the aqueous solution, contact time and concentration of Ni (II) ion in the solution. The optimum contact time and pH of 40 min and 6 were obtained for the biosorption process. The equilibrium data obtained fitted well to Langmuir adsorption model equation with a linear correlation coefficient (R^2) of 0.98 indicating a monolayer type of adsorption.

However, the results obtained from the column reactor system under isothermal condition have shown that water hyacinth leaves which is termed as nuisance to water ways and aquatic lives can be transformed into a useful source for pollution control.

References

Abdullah, M.A., Devi Prasad, A.G. 2010. Biosorption of nickel (II) from aqueous solutions and electroplating wastewater using tamarind (*Tamarindus indica L.*) bark. *Australian Journal of Basic and Applied Sciences,* **4**: 3591-3601.

Akbal, F., Camci, S. 2011. Copper, chromium and nickel removal from metal plating wastewater by electrocoagulation. *Desalination*, **269:** 214-222.

Hasan, S.H., Ranjan, D., Talat, M. 2010. Water hyacinth biomass (WHB) for the biosorption of hexavalent chromium: Optimization of process parameters. *Bio Resources*, **5:** 563-575.

Kaewsarn, P., Yu, Q. 2001. Cadmium (II) removal from aqueous solutions by pre-treated biomass of marine alga *Padina* Sp. *Environmental Pollution*, **112 :** 209-213.

Malik, A. 2007. Environmental challenge *vis a vis* opportunity: The case of water hyacinth. *Environment International,* **33:** 122-138.

Mukhopadhyay, M. 2008. Role of surface properties during biosorption of copper by pretreated *Aspergillus niger* biomass. *Colloids and Surfaces A*: *Physicochemical and Engineering Aspects,* **329:** 95-99.

Nemerow, N.L. 1963. *Theories and Practices of Industrial Waste Treatment.* 557 pp., Addison-Wesley Pub. Co. Inc., Reading, Massachusettes, USA.

Pandey, P.K., Choubey, S., Verma, Y., Pandey, M., Kamal, S.S.K., Chandrashekhar, K. 2007. Biosorptive removal of Ni (II) from wastewater and industrial effluent. *International Journal of Environmental Research and Public Health,* **4:** 332-339.

Tsai, W.T., Chen, H.R. 2010. Removal of malachite green from aqueous solution using low-cost *Chlorella* based biomass. *Journal of Hazardous Materials*, **175:** 844-849.

Turp, S.M., Eren, B., Ates, A. 2011. Prediction of adsorption efficiency for the removal of nickel (II) ions by zeolite using artificial neural network (ANN) approach. *Fresenius Environmental Bulletin*, **20:** 3158-3165.

Wang, K., Xing, B. 2002. Adsorption and desorption of cadmium by goethite pretreated with phosphate. *Chemosphere*, **48:** 665-670.