Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 2458-9403
Vol. 6 Issue 11, November - 2019

Removal of Nickel Ions from Aqueous Solution by Adsorption Using Powdered Fishbone

***Oguntade, B.K.**
Department of Science Laboratory Technology,
Federal Polytechnic Ilaro, Nigeria
bukunola.oguntade@federalpolyilaro.edu.ng

Babatola, O.M.
Department of Science Laboratory Technology,
Federal Polytechnic Ilaro
Nigeria

Abstract*— This study investigated the adsorption of Ni(II) ions on powdered fishbone as a low-cost adsorbent from aqueous solution. The powdered material was characterized using Fourier Transform Infrared (FT-IR) spectrophotometer) and Scanning Electron Microscope. The determination of Nickel ions was performed on Perkin Elmer model Atomic Absorption Spectrometry (AAS). The effects of hydrogen ion concentration (pH), initial metal concentration and contact time of the adsorption were studied. The adsorption experiments were carried keeping the adsorbent weight (2g) constant. The powdered fish bone recorded 98 % of Ni(II)adsorption under conditions of pH 7, adsorbent and initial metal concentration 20ppm at a contact time of 30 minutes.

Keywords*— Adsorption; aqueous solution; Nickel (II); fishbone

I. INTRODUCTION

An indispensable part of industrial, agricultural and technological advancement of any nation is metal and their compounds. The number of their applications for commercial uses continues to grow with development in modern science and technology [1, 2].
Mercury, cadmium, Chromium, Nickel among others are examples of heavy metals that accumulate in living organisms depending on its exposure rate and dosage [3]. Nickel comes just after iron, oxygen, silicon and, magnesium making it the fifth most common element on the Earth [4]. Nickel is a toxic metal found in the environment as a result of various forms of activities [5].
Effluent water from electroplating, electronics and metal cleaning industries usually contain high concentration of nickel ions and the cause diverse types of diseases [6] such as liver, kidney, spleen cancer, brain and tissue damage among others [7].
According to the guidelines given by the World Health Organization, the maximum permissible concentration of nickel in the electroplating process wastewater and drinking water should be less than 4.1 and 0.1 mg/l, respectively [8].
Nickel is toxic even at low concentrations [9] and is an important source of contamination in industrial societies [10].
Generally, several methods have been used for the removal of Ni(II) from wastewaters, they include chemical precipitation, chemical reduction, flocculation, filtration, evaporation, solvent extraction, biosorption, activated carbon adsorption, ion-exchange, reverse osmosis, electrodialysis, membrane separation processes, etc.[11]. Among these methods, adsorption which has proved to be very efficient and eco-friendly has been used by most of the researchers within the last few decades [12].
The method is considered attractive, low-cost, simple in design and ease of operation [13], while the other methods are non-economical with disadvantages such as incomplete metal removal, high energy requirement, high reagent cost, and generation of toxic sludge [14].
Many investigations on the adsorptive removal of heavy metals from solution using natural adsorbent derived from agricultural wastes such as Potato peels [15], waste eggshell [16] have been reported.
A common type of waste generated from fish is its bone. As bio-waste fishbones are treated as a source of organic matter for the by-production [17]. Fishbone is an enriched natural source of hydroxyapatite(HAP) which has been reported to possess the ability to stabilize heavy metals[18]
In recent decades, fish waste is used as a supplier of raw material for biodiesel [19]. Several compounds have been successfully isolated from fish waste including fish proteinhydrolase (fPH) for cryoprotectant [20], collagen [21] and enzymes [22].
The present study is therefore carried out to investigate the effectiveness of fishbone, for the removal of nickel ions from aqueous media.

II. MATERIALS AND METHODS

A. Chemicals

All the chemicals used in this study were of analytical grade and were used with no further purification. The metallic solution of $Ni^{2+}$was obtained from a stock standard (1000 mg/L) of Ni(II) by Sigma Aldrich. Working solutions of the desired Ni^{2+} (10, 20 and 30) mg/L were prepared from the 1000 mg/L stock into a 100ml of distilled water and then 2 g of the adsorbent was added to it with contact time (30, 60, 90 and 120 minutes) and pH (2, 4, 7 and 9).

B. Preparation of Fishbones Sorbent

The catfish was collected from the Ebute River along Oja Odan road, Yewa south Local Government, Ogun State, Nigeria. The method as described by Kizilkaya *et al* [23] was adopted. The catfish was washed and dissected in a dissecting tray to remove the bones. The collected bones

were washed several times with hot distilled water to remove residue and soluble impurities. Then, it was dried in an oven at 105˚C for 48 hours and ground into a fine powder using mortar and pestle.

C. Biosorption studies

The adsorption capacity of the fishbones was carried according to the method described by Olayinka *et al* [24]. At room temperature, 2.0g to 25mL of metal solutions in the aqueous solution and concentration range of 10-30 mg/L was carried out on a mechanical shaker. The initial pH of the aqueous was adjusted to the desired pH by adding 0.1M HCl or NaOH. The flasks were shaken for a predetermined period at room temperature. After the agitation periods, the nickel loaded adsorbents were centrifuged at 1200rpm for 5mins and the supernatant was analyzed for Ni(II) by Atomic Absorption Spectrophotometer analysis (Analyst 200 AA, Perkin Elmer, USA). Analysis of the blank experiments without adsorbent for each concentration was also analyzed. Triplicate analysis was performed for each solution.
The percentage of metal adsorption by the adsorbents was calculated using equation 1:

$$Q_e\ (\%) = \frac{C_o - C_e}{C_o} \qquad (1)$$

Where C_o= initial concentration in mg/L
C_e= final concentration in mg/L

D. Scanning electron microscopy (SEM)

The surface morphologies of fishbones were studied using SEM (JEOL JSM- 7600F). Samples were coated with a platinum coating of electrically conducting material, deposited on the sample either by low-vacuum sputter coating or by high-vacuum evaporation.

E. FT-IR spectroscopy

The Fourier transform infrared (FT-IR) spectra of the fishbones were obtained using a PerkinElmer (Waltham, MA, USA) Spectrum.

III. RESULTS AND DISCUSSION

A. Characterization of fishbones

The surface morphology of the fishbones before adsorption is presented in Fig. 1. The observation of its surface revealed that there are pore spaces within its biomass. This confirmed that fish bone has several numbers of heterogeneous porous layers which may provide a good possibility of Ni^{2+} to be adsorbed on its surface. Similar observations were reported by the previous researchers for the adsorption and removal of zinc (II) from aqueous solution using powdered fish bones [25]

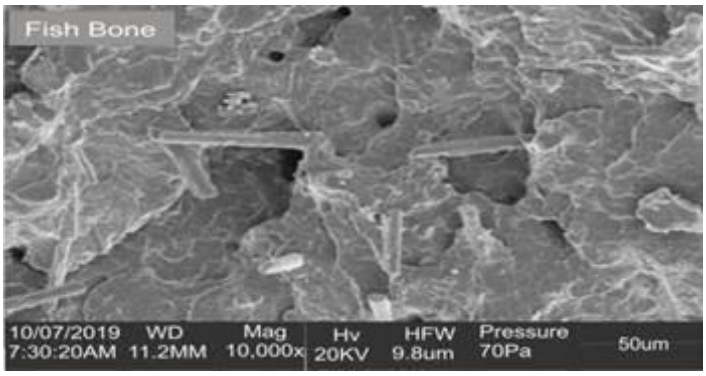

Fig1: SEM image of fishbone

Fig. 2 and 3 show the Fourier Transform Infrared (FTIR) results of the fishbone before and after adsorption respectively. These were carried out to understand better the functional groups available on the surface of the studied adsorbent as this is important in understanding the adsorption process.
From the FTIR spectrum, it was observed that for the metal fishbone after adsorption, some peaks were altered in terms of wavenumber which could indicate that these functional groups were involved in metal binding. The adsorption band around 3430.17cm^{-1}in the raw fishbone which corresponds to OH stretching [26] frequency shifted to 3436.33cm^{-1} after nickel adsorption. The shift in this band could be attributed to the presence of water adsorbed in the samples [27]. The band at 1751.57 cm^{-1} which corresponds to carbonyl stretching mode [28] observed in the raw adsorbent shifted to 1694.21 $cm^{-1}$and is attributed to the presence of carbonyl groups. Some functional groups, such as hydroxyl and carbonyl groups on the surface, could be responsible for the removal of nickel ions by fish bone adsorbent[28]. The band at 2966.00 cm^{-1} which was observed before adsorption corresponds to C-H bonding which shifted to 2929.50 cm^{-1} after adsorption of nickel ions [25,29]. This is attributed to stretching and bending modes of alkane and alkene groups after nickel exposure. The intensities of C-H and C=C bands at 1417 and 870 cm^{-1} in (Fig.2), were reduced which could indicate adsorption of Ni metal ions on the adsorbent [29] after nickel adsorption in (Fig.3).

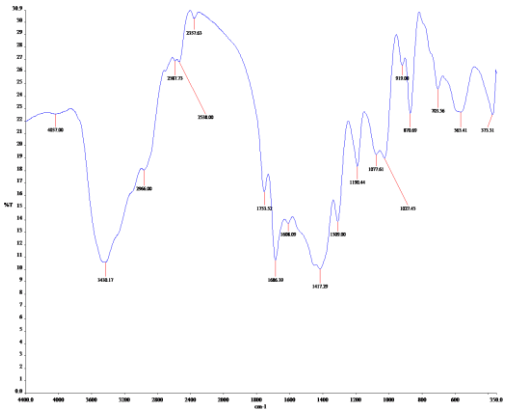

Fig.2: FTIR spectra of fish bone before adsorption

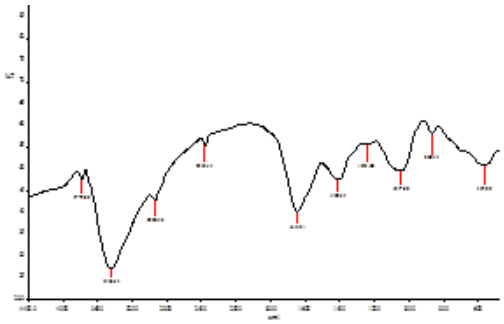

Fig. 3: FTIR of the fishbone after the adsorption process.

B. Effect of contact time

The effect of contact time on the adsorption efficiency of Ni using powdered fishbones at pH 2, 7 and 9 with metal ion concentration of 20ppm is shown in figure 4. It was observed that the maximum adsorption for Ni metal was achieved within 30 minutes at pH 7 with its adsorption efficiency being 98.08 %.Adewoye, et a*l*, [29]**,** suggested that the adsorption process was rapid at 30 minutes due to the availability of active adsorption sites. It was observed that at pH 9, there is a decrease in the adsorption efficiency as the contact time increases. This could be attributed to the slow rate at which the diffusion occurs between the particles of the metal ion and the adsorbent and electrostatic hindrances [30].

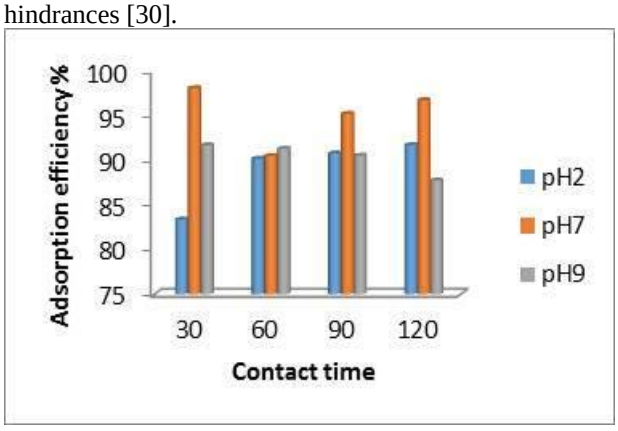

Fig. 4: Effect of contact time of the adsorption of Ni(II) ions.

C. Effect of pH

The adsorption capacity of the adsorbents as a function of hydrogen ion concentration (pH) at a contact time of 30, 60 and 90 minutes was determined. The pH value of the solution range from pH 2 to 9 was used and the results for the adsorption of Ni are shown in Figure 5.

The effect of pH is a controlling factor for any kind of metal adsorption process from aqueous solution [31]. This result showed that the optimal pH for adsorption was found to be 7.0, which indicates that the maximum percentage of removal occurred in a neutral medium.

At low pH values the decreased adsorption of the metal may be as a result of competition for binding sites between the cations and anions. Nevertheless, at high pH values, the positively charged nickel ions are expected to be attracted by the negatively charged nickel ions [32].

The optimum pH values obtained in this study were similar to the values reported by Adewole *et al* for the adsorption of Ni(II) ions from contaminated water using sorghum bicolor [29].

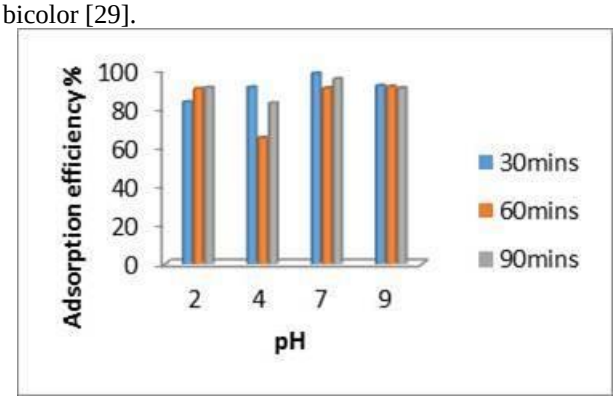

Fig. 5: Effect of pH on the adsorption of Ni(II) ions

D. Effect of initial concentration

The results for the effects of concentration on the adsorption of Ni are shown in figure 6. The results show that the removal efficiency increased from 87-94 % at pH 2, 78-95 % at pH7 and reduced to 91-89 % at pH 9.

This indicates that at higher concentrations, more molecules of the nickel ions competed for available binding sites of the adsorbent than at lower concentrations. Similar trends were reported in the literature [32, 28].

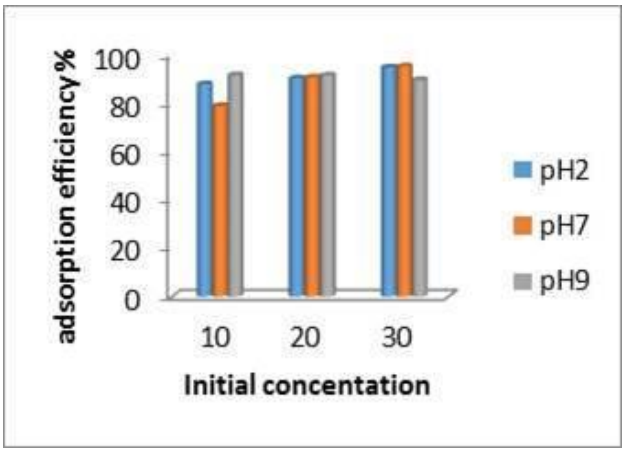

Fig.6: Effect of initial concentration on the adsorption of Ni(II) ions

IV. CONCLUSION

This work indicates the potential of using Fishbone as an effective adsorbent for the removal of Ni(II) ions from aqueous solutions. Two grams of powdered fishbone is found enough to remove 98.08 % of Ni(II). The best adsorption conditions was at pH 7.0, initial metal concentration of 20ppm and 30 minutes reaction time.

REFERENCES

[1] M.A.O. Badmus, T.O.K. Audu, and B.U. Anyata, "Removal of Lead Ion from Industrial Wastewaters by Activated Carbon Prepared from Periwinkle Shells (Typanotonusfuscatus), " Turkish J Eng. Env.Sci, vol. 31 (4), pp. 251-263, 2007.

[2] B. Sushil, S. Sarita, S. Ashok, and V. Sanjay, "Removal of lead (II) from aqueous solution using low cost

adsorbent: A review, " International Journal of Applied Research, vol. 2(7), pp. 523-527, 2016.

[3] Z.N. Garba, I. Bello, A. Galadima, and A.Y. Lawal, "Optimization of adsorption conditions using central composite design for the removal of copper (II) and lead(II) by defatted papaya seed," International Journal of Modern Science, vol. 2(1) , pp. 20-28, 2016.

[4] M. Cempel, and G. Nikel, "Nickel: A review of its sources and environmental toxicology," Pol. J. Environ. Stud, vol. 15(3), pp. 375-382, 2006.

[5] R. Krishnasamy, and D.B. Wilson, "Construction and characterization of an Escherichia coli strain genetically engineered for Ni(II) bioaccumulation," Appl. Environ. Microbiol, vol. 66, pp. 5383-5386, 2000.

[6] N. Akhtar, J. Iqbal, and M. Iqbal, "Removal and recovery of nickel (II) from aqueous solution by loofa sponge – immobilized biomass of Chlorella sorokiniana: Characterization studies," J. Haz. Mat. vol. 108, pp. 85-94, 2004.

[7] International Programme on Chemical Safety (IPCS), Environmental Health Criteria 108; Nickel," World Health Organization, Geneva, 1991.

[8] M.I. Kandaha and J.L. Meunier, "Removal of nickel ions from water by multi-walled carbon nanotubes," J. Hazard. Mater, vol. 146(1-2), pp. 283-288. 2007

[9] M.B. Kadiiska, R.P. Mason, K.L. Dreher, D.L. Costa, and A. J. Ghio, "*In vivo* evidence of free radical formation in the rat lung after exposure to an emission source air pollution particle," Chem. Res. Toxicol, vol. 10, pp. 1104-1108.1997

[10] J.D. Niriagu, and J. M. Palyna, "Quantitative assessment of worldwide contamination of air, water and soils by trace metals," Nature, vol. 333, pp. 134-139, 1988.

[11] O. Gyliene, J. Aikaite, and O. Nivinskiene, "Recycling of Ni(II)– citrate complexes using precipitation in alkaline solutions," Journal of Hazardous Materials, vol. 109(1-3), pp. 105-111, 2004.

[12] H.J. Rao, P. King, and Y.P. Kumar, "Experimental investigation and statistical modeling of the cadmium adsorption in aqueous solution using activated carbon from waste rubber tire". Indian Journal of Science and Technology. 9(45), pp. 1-13, 2016.

[13] W. Peng, H. Li, Y. Liu, and S. Song, "A review on heavy metal ions adsorption from water by graphene oxide and its composites," Journal of Molecular Liquids, vol.230 pp. 496-504, 2017.

[14] Q. Li, J. Zhai, W. Zhang, M. Wang, and J. Zhou, "Kinetic studies of adsorption of Pb(II), Cr(III) and Cu(II) from aqueous solution by sawdust and modified peanut husk," J Hazard Mater, vol. 144 pp. 163-167, 2007.

[15] T. Aman, A. Amad, M. Usman, U. Bano, "Potato peels as solid waste for the removal of heavy metal copper(II) from waste water/industrial effluent" Colloids and Surfaces B: Biointerfaces vol. 63, pp. 116–121, 2008.

[16] H. J. Park, S.W. Jeong, J. K. Yang, B. G. Kim, and S.M Lee, "Removal of heavy metals using waste eggshell," Journal of Environmental Sciences, vol. 19 pp. 1436–1441, 2007.

[17] Mu, Y. Saffarzadeh, A. and Shimaoka, T. (2016), "Feasibility of using natural fishbone apatite on removal of Pb frommunicipal solid waste incineration (MSWI) fly ash," Procedia Environmental Sciencesvol. 31pp. 345-350, 2016.

[18] A. Nzihou, and P. Sharrock, "Role of Phosphate in the Remediation and Reuse of Heavy Metal Polluted Wastes and Sites," Waste and Biomass Valorization, vol 1(1), 30, pp. 163-174, 2010.

[19] R. Alcantara, J. Amores, L. Canoira, E. Fidalgo, M.J. Franco, and A. Navarro, "Catalyticproduction of biodiesel from soy-bean oil, used frying oil and tallow," Biomass and Bioenergy vol. 18, pp. 515–527 2000.

[20] M.A.A. Khan, M.A. Hossain, K. Hara, K. Osatomi, T. Ishihara, and Y. Nozaki, "Effect ofenzymatic fish-scrap protein hydrolysate on gel-forming ability and denaturation of lizard fish Sauridawaniesosurimi during frozen storage.Fish. Sci. vol. 69, pp. 1271–1280 2003.

[21] S. Morimura, H. Nagata, Y. Uemura, A. Fahmi, T. Shigematsu, K. Kida, "Developmentof an effective process for the utilization of collagen from livestock and fish waste," Process Biochem, vol. 37, pp. 1403–1412, 2002.

[22] J.F. Tavares, J.A. Baptista, and M.F. Marcone, "Milk-coagulating enzymes of tuna fish waste as a rennet substitute," Int. J. Food Sci. Nutr, vol. 48, pp. 169–76. 1997.

[23] B. Kizilkaya, A. A. Tekinay, and Y. Dilgin, "Adsorption and removal of Cu(II) ions from aqueous solution using pretreated fish bones," Desalination, vol. 264(1-2), pp. 37–47, 2010.

[24] O. K. Olayinka, O.K. Oyedeji, and O.A. Oyeyiola, "Removal of chromium and nickel ions from aqueous solution by adsorption on modified coconut husk". African Journal of Environmental Science and Technology vol. 3 (10), pp. 286-293, 2009.

[25] H.K Lim, T.T. Teng, M.H Ibrahim, A. Ahmad, H.T. Chee, H.T "Adsorption and Removal of Zinc (II) from Aqueous Solution Using Powdered Fish Bones," APCBEE Procedia vol. 1, pp. 96 – 102, 2012.

[26] M. Nurhadi, R. Kusumawardani, I. Widiyowati, I.I. Wirhanuddin and H. Nur, "Utilization of fish bone as adsorbent of Fe3+ ion by controllable removal of its

carbonaceous component" J. Phys.: Conf. Ser, vol. 1022(1),pp. 012031, 2018.

[27] M. Nurhadi, "Modification of Coal Char-loaded TiO2 by Sulfonation and Alkylsilylation to Enhance Catalytic Activity in Styrene Oxidation with Hydrogen Peroxide as Oxidant," Bull. Chem. React. Eng. Catal., vol. 12(1) pp. 55-61, 2017.

[28] E. Alireza, A. Mokhtar, B. Hajir, P. Elmira, "Fish Bone as a Low-Cost Adsorbent for Dye Removal from Wastewater: Response Surface Methodology and Classical Method, Environmental Modeling and Assessment," vol. 18(3) 2013.

[29] L.T. Adewoye, S.I. Mustapha, A.GAdeniyi, J.O. Tijani, M.A. Amoloye and L.J. Ayinde , "Optimization of nickel (ii) and chromium (iii) removal from ontaminated water using sorghum bicolor," Nigerian Journal of Technology, vol. 36(3) pp. 960 – 972, 2017

[30] S. Qaiser, A.R. Saleemi, and M. Umar, "Biosorption of lead(II) and chromium(VI) on groundnut hull: Equilibrium, kinetics and thermodynamics study," Electronic Journal of Biotechnology, Vol. 12(4), pp 3-4, 2009.

[31] K.S. Low, C.K. Lee, and A.C. Leo, "Removal of metals from electroplating wastes using banana" J Biores Technol, vol. 51, pp. 227-231, 1995.

[32] P.J. Sarma, R. Kumar, and K. Pakshirajan, "Batch and Continuous Removal of Copper and Lead from Aqueous Solution using Cheaply Available Agricultural Waste Materials," Int. J. Environ. Res., Vol. 9,(2), pp. 635-648. 2015.

[33] C.N. Deepa, and S. Suresha, "Biosorption of lead (II) from aqueous solution and industrial effluent by using leaves of Araucaria cookii: Application of response surface methodology," IOSR Journal of Environmental Science, Toxicology and Food Technology, Vol. 8(7), pp. 67-79, 2014.