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Research Article

Adsorption of nickel using low cost materials as adsorbents

K.V. MANJUNATH AND N.T. MANJUNATH

ABSTRACT : Wastewater from industries must ultimately be return to the receiving bodies or to the land. In these wastewaters metals may be present in both soluble and insoluble forms. The concentration of metals must be reduced to acceptable levels before discharging them into environment. Otherwise these could pose threats to public health and may also affect aesthetic quality of receiving bodies. The removal of nickel from aqueous solution by economically feasible adsorbents was investigated, as a part of research work and presented in this paper. The effects of flow rate (contact time) initial concentration of metal ions (Co) for its removal on the adsorbents *viz.,* coconut husk, saw dust and sugar cane leaves have been studied at pH of 4.0. Maximum and minimum removal efficiency under optimum conditions of experimentations were recorded with coconut husk and sugar cane leaves, respectively.

KEY WORDS : Aqueous solution, Nickel, Adsorption, Low cost adsorbents

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INTRODUCTION

Even though the natural sources contributes metal to environment, mobilization of heavy metal in the environment due to industrial activity is of serious concern. In these days, the amount of heavy metal ions released to the environment has been increasing significantly resulting from industrial activities and technology development. Metals may exists in wastewaters of many industries such as metal plating, tannery, radiator manufacturing, smelting alloy industries, storage batteries manufacturing, mining activities etc. Common nickel compound when present in large amount will produce toxic effect in human beings and other animals. The higher concentration of nickel causes poisoning effect like headache, giddiness, nausea, tightness of the chest, dry cough, vomiting, shortness of breath, rapid respiration etc.

The methods existing for the removal of metals from the wastewaters can be grouped into biotic and abiotic. Abiotic methods include physicochemical processes such as precipitation and adsorption. On the other hand, biotic methods are based on accumulation of heavy metals by microorganisms and plants. Further, in advanced countries removal of heavy metals from wastewaters is commonly achieved by advanced technologies such as ion exchange, chemical precipitation, ultra filtration or electrochemical deposition. The disadvantages of these methods like incomplete metal removal, high reagent and energy requirement of long time, regeneration difficulties, generation of toxic sludge or other waste product that require careful disposal as made it imperative to look for cost-effective treatment method *i.e.* capable for removing heavy metals from waste streams. The researchers across the globe have made an attempt to remove metals from wastewaters using various adsorbents. The materials developed for this purpose range from industrial waste to agricultural waste product. These materials tried include Neem leaves (Sharma and Bhattacharya, 2005), teak leaves (Ajmal *et al*., 2001), saw dust (Singh and Lal, 1992, Nigam and Rama, 2003), coconut fibre pith (Manju and Anirudhan, 1997), peanut hull (Brown *et al*., 2010),

MEMBERS OF RESEARCH FORUM

Address for correspondence :
N.T. MANJUNATH, Center for Environmental Science, Engineering & Technology, University B.D.T. College of Engineering, DAVANGERE (KARNATAKA) INDIA
Email: manjunt@yahoo.com

Coopted Authors :
K.V. MANJUNATH, Department of Civil Engineering, Dr. Ambedkar Institute of Technology, BENGALURU (KARNATAKA) INDIA
Email: kvmait@yahoo.com

coconut husk (Oyedeji *et al.,* 2010), rice husk (Dos Santos *et al.,* 2006), Maize leaf (Adesola Babarinde *et al.*,2008).

The objective of the present investigation was to study the effect of initial concentration of nickel, contact time in terms of flow rate, low cost adsorbents at pH 4 on the extent of nickel removal by adsorption on to saw dust, sugar cane leaves and coconut husk.

EXPERIMENTAL PROCEDURE

Preparation of adsorbent :

The procedure adopted by the other researchers for preparation of adsorbents was used to prepare the adsorbent considered in the present research work.

The saw dust collected from nearby saw mill was washed several times with doubly distilled water. Washed saw dust was then treated with 0.2 M aqueous solution of disodium hydrogen phosphate for 24 hours (Siddiqui *et al*.,1999). Further, the treated saw dust was washed several times with doubly distilled water till no phosphate is released in the washing. It was then dried at 40°C in a oven and was used for experimentation.

The procedure proposed by Nigam and Rama (2003) was used for preparation of raw sugar cane leaves as adsorbent. Raw sugar cane leaves were cut to sizes of about 1 cm long and were soaked in doubly distilled water for 24 hours and further washed with distilled water several times and then completely dried under the solar light.

The coconut husk procured from a local coir factory was cut into small pieces and blended, extracted with hot water several times until the supernatant was colourless. It was then dried at 70°C in a oven and was used for experimentation (Oyedeji *et al*., 2010).

Preparation of adsorbate :

Nickel stock solution was prepared by dissolving stachiometrically calculated quantity of analytical grade nickel sulphate in one litre of doubly distilled water. The stock solution was further diluted with doubly distilled water to desired concentration for obtaining the test solution. However, the stock solution which was prepared based on stachiometrical calculation was further rechecked for its absolute concentration by using the procedure as given in APHA (2006).

Variables considered :

Potential of adsorbents *viz.*, saw dust, sugar cane leaves and coconut husk in adsorbing nickel under varied flow rates of 20, 40, 60 and 80 ml/min, initial metal concentrations of 20, 30, 40 and 50 mg/l at solution pH of 4 were studied.

Experimental set-up :

Up flow column (cylindrical jar) was used for experimentation. The hole was drilled at the bottom of the column and it was covered with a fine mesh to take care of adsorbent washout. A small plastic tube was attached to the hole at the bottom. Column was filled with adsorbent upto predetermined depth. The aqueous solution was fed at varied flow rates by adjusting the speed of peristaltic pump. Samples from the over flow pipe fixed to the column at the top were collected and analysed. The average values of samples collected (Triplicate) were tabulated.

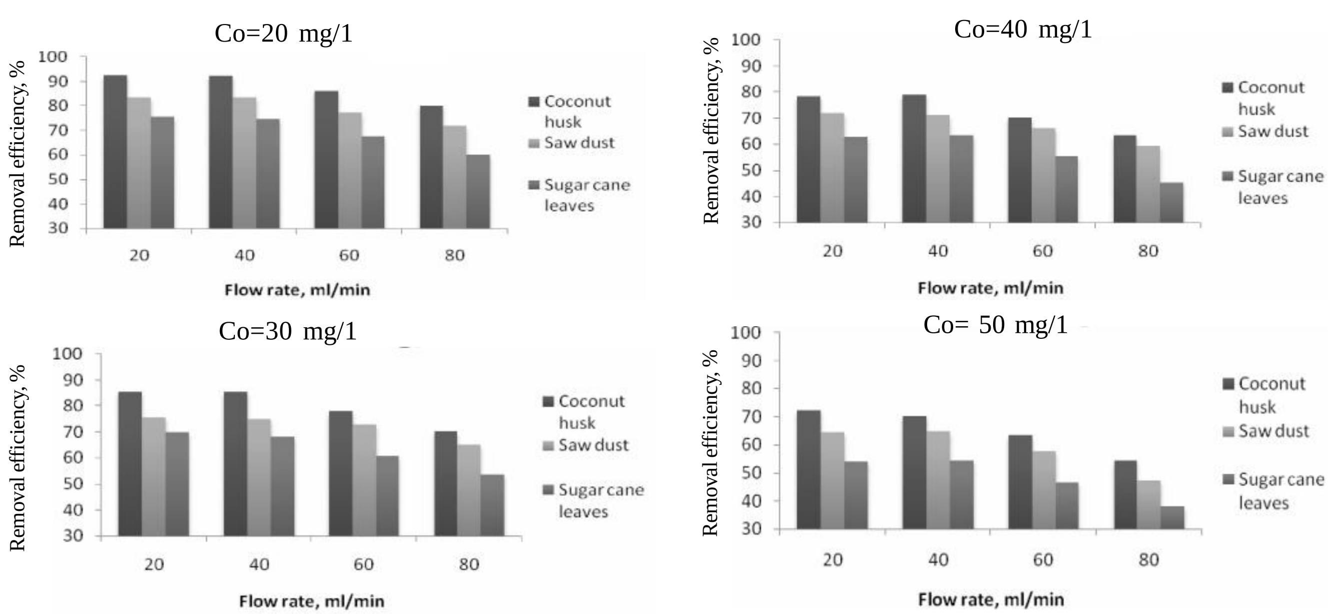

Fig. 1: Effect of flow rate on removal efficiency

EXPERIMENTAL FINDINGS AND ANALYSIS

The findings of experimentation are shown in Fig.1. The inferences drawn based on the results and analysis are documented herewith. For two initial flow rates of 20 and 40 ml/min, the removal efficiency at all varied conditions of experimentation remained unaltered within the statistical limitation. However, the inverse relationship between the removal efficiency and flow rate was documented for flow rates of 40 ml/min and beyond. The decrease in removal efficiency with increase in initial metal concentration was observed. Coconut husk exhibited maximum nickel removal potential followed by saw dust and sugar cane leaves.

Within the statistical limitations, removal efficiencies for flow rates of 20 and 40 ml/min recorded were found to be same. Beyond the flow rate of 40 ml/min decrease in the removal efficiency with increase in flow rate was observed. Similarly with increase in initial concentrations of metal in aqueous solution beyond 20 mg/l decrease in removal efficiency has recorded. Coconut husk (92.6 %) was found to have highest nickel removal efficiency. On the other hand, maximum removal efficiencies of 83.6 and 75.6 per cent were recorded with saw dust and sugar cane leaves. These efficiencies corresponds to flow rate of 20 ml/min and Co of 20 mg/min. For flow rate of 40 ml/min removal efficiencies of 92.6, 85.6, 79.1 and 70.3 per cent on coconut husk were, respectively recorded for initial metal concentrations of 20, 30, 40 and 50 mg/l. Accordingly these conditions remaining same the saw dust was found to have the removal potential of 83.3, 75.1, 71.3 and 64.8 per cent. Similarly these values for sugar cane leaves were 74.5, 68.3, 63.6 and 54.4 per cent, respectively.

For all the adsorbents and initial metal concentrations considered for study at flow rate of 60 ml/min removal efficiency varying from 86.3 to 46.7 per cent was recorded. Accordingly at flow rate of 80 ml/min the removal efficiency observed ranged from 80.1 to 38.1 per cent. Thus, the sequence of nickel removal potential of these adsorbents studied was CH > SD > SCL.

Conclusion :

Investigations were made to evaluate nickel adsorption potential by three low cost adsorbents under varied experimental conditions. On optimizing all experimental variables studied in the present work, it was concluded that at flow rate of 20 ml/min and initial metal concentration of 20 mg/l, the better adsorption of metal by the adsorbents can be achieved. Further, out of three adsorbents tried, coconut husk as highest potential compared to other two adsorbents. At optimum conditions of experimentation, adsorption of 92.6, 83.6 and 75.6 per cent of nickel on coconut husk, saw dust and sugar cane leaves, respectively can be achieved.

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