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Removal of Pb & Ni from industrial wastewater by using brass industry waste (Slag) as an adsorbent

Animesh Agarwal[1], Nitin Kr Agrawal[2], Vikas Gupta[3], Sunit Giri[4]

[1&2]Moradabad Institute of Technology, Ram Ganga Vihar Phase – 2, Moradabad, India
[3]IFTM University, Moradabad, India
[4]Hindu Inter College, Moradabad, India

ABSTRACT

The removals of Pb and Ni from their aqueous solution, using Brass industry slag as an adsorbent studied as slag consist of calcium oxide, aluminum oxide, magnesium oxide etc. The research is a bench scale experimental type and analysis have performed by using different amount of adsorbent in solution with five different concentration of both metals and also in mixed combination. About 90% and 100% Pb removal achieved by using 0.5 and 1.5 g adsorbent for solution having concentration of 5 and 10 mg/L Pb. It was also found that adsorption efficiency depend on the amount of adsorbent as adsorption efficiency of Ni was increased from 75% to 100% in the same solution(5 mg/L).It was also observed that adsorption efficiency was decreased about 4% and 8% of Pb and Ni in Mixed metal solution.

Key words: Brass industry slag, Adsorption, Heavy metals, Ram Ganga River.

INTRODUCTION

Water is essential to all forms of life and makes up 50-96 % of the weight of all plants and animals. It is also a vital resource for agriculture, manufacturing and other human activities. In urban areas, the careless disposal of industrial effluents and other wastes in rivers & lacks may contribute greatly to the poor quality of river water [1-4]. Most of the rivers in the urban areas of the developing countries are the ends of effluents discharged from the industries. African countries and Asian countries experiencing rapid industrial growth and this are making environmental conservation a difficult task [5].

Toxic heavy metals constantly released into the environment. They are dangerous environmental pollutants due to their toxicity and strong tendency to concentrate in environment and in food chains [6-7].The source of environmental pollution with heavy metals is mainly industry, i.e. metallurgical, electroplating, metal finishing industries, tanneries, chemical manufacturing, mine drainage and battery manufacturing [8].

Considerable research been carried out over the last decade on the protection against plant and animal life degradation. Several big cities contribute to increase this problem, as they are sources of industrial effluents. In order to reduce the environmental pollution, a number of studies been considered to minimize the problems caused by the commonly employed treatment of metal bearing effluents [9-10].

Removal of metals from wastewater achieved principally by the application of several processes such as adsorption

[6], sedimentation [11], electrochemical processes [12], ion exchange [13], cementation14], coagulation/flocculation[15], filtration and membrane processes[16], Chemical precipitation and solvent extraction[17-18]. Adsorption is the one of the important procedure for the removal of heavy metals from the environment because of strong affinity and high loading capacity.

Moradabad a metro city of Uttar Pradesh, India, having urban population more than 3.7 million and has seen rapid industrialization during last few decades. The city is full of brass, steel & glass cottage industries. The annual turn over of the city is nearly rupees 10,000 million. All these industries are in unorganized sector and thus have unplanned growth leaving to high degree of air, water and soil pollution [19-20]. The most of the industries are dumping their effluents in Ram Ganga River pass from the heart of the city. A large number of small-scale manufacturing units of brass been also situated in the heart of the city. During manufacturing process, high temperature coal based furnaces used to melt the metal. After the completion of the process, large amount of slag produced as a waste. This Slag consists of calcium oxide, magnesium oxide, and other metal oxides and can used as adsorbent for the removal of heavy metals in the environmental field. Oxides containing in the slag are similar to those of Portland cement concrete, and the slag used such as raw material in road construction. For sorption properties of slag, several researchers reported the river water pollution through heavy metals and removal of heavy metals from wastewaters using slag [21-30] but no one uses Brass industry slag as an adsorbent. In the present study Brass industry slag is used as an adsorbent for the removal of Pb and Ni from industrial wastewater.

MATERIALS AND METHODS

Adsorbent

The steel industry waste (Slag) collected from the bank of river Ram Ganga where local small industries generally dump their waste and sieved to less than 2mm size and its composition was as follows:

CaO – 68.5%
SiO_2 – 15.3%
Al_2O_3 – 7%
MgO – 5%

Adsorbate Solution

Analytical grades of $Pb(NO_3)_2$, HCl and NaOH were purchased from Merck, India. Lead ions were prepared by dissolving its corresponding Nitrate salt in distilled water. Stock solution of Nickel was prepared using Nickel sulphate.

Adsorption Studies

Individual and mixed solutions of Pb and Ni with different concentrations of 5, 10, 20, 40, 100 mg/L were prepared , the experiment were performed using three different amount of adsorbent 0.5, 1, 1.5, in single solution. 0.5 gm adsorbent was placed in a conical flask in which 100 ml of solution with known concentration of Pb was added and the mixture was shaken in shaker. The mixture was than filtered after 24 hours contact time and final concentration of metal ion was determined in filtrate by atomic adsorption spectrophotometer (GBC 902). All the Experiments carried out in triplet and mean concentration calculated by averaging them. The procedure repeated by varying the adsorbent dose and concentration of Pb and Ni solution both individual and in mixed solution and the results summarized in Tables (1-3). Based on residual concentrations, the adsorption efficiency of slag is calculated and summarized in Table (4-6).

Table-1: Mean concentration of Residual Lead after Adsorption by Slag (24 hour contact time)

SNo.	Quantity of Slag(gm)	Initial Concentration of Pb (mg/L)				
		5	10	20	40	100
1.	0.5	0.5	1.0	3.3	7.6	25.0
2.	1	0.07	0.2	1.1	2.4	5.4
3.	1.5	0	0	0.7	1.1	4.3

Table-2: Mean concentration of Residual Nickel after Adsorption by Slag (24 hour contact time)

SNo.	Quantity of Slag(gm)	Initial Concentration of Ni (mg/L)				
		5	10	20	40	100
1.	0.5	1.2	2.5	5.2	10.1	40.1
2.	1	0.2	0.9	2.2	4.3	20.1
3.	1.5	0	0.5	1.9	2.6	12.2

Table-3: Mean concentration of Residual Metal in mixed metal solution using 0.5 g Slag after adsorption (24 hour contact time)

SNo.	Metal Solution	Initial Concentration (mg/L)				
		5	10	20	40	100
1.	Pb	0.6	2.3	5.1	8.2	30
2.	Ni	1.5	3.0	6.2	13.4	45.2

Table-4: Slag Adsorption Efficiency for Lead at various Concentrations (24 hour contact time)

SNo.	Quantity of Slag(gm)	Initial Concentration of Pb (mg/L)				
		5	10	20	40	100
		Adsorption Efficiency (%)				
1.	0.5	90	90	83.5	81	75
2.	1	98.6	98	94	94	94.6
3.	1.5	100	100	96.5	97	95.7

Table-5: Slag Adsorption Efficiency for Nickel at various Concentrations (24 hour contact time)

SNo.	Quantity of Slag(gm)	Initial Concentration of Ni (mg/L)				
		5	10	20	40	100
		Adsorption Efficiency (%)				
1.	0.5	75	75	74	73.7	59.9
2.	1	94	91	89	89	79.8
3.	1.5	100	95	90.5	93	87.8

Table-6: Slag Adsorption Efficiency for Nickel and Lead in Mixed Metal solution using 0.5g Slag (24 hour contact time)

SNo.	Metal Solution	Initial Concentration (mg/L)				
		5	10	20	40	100
		Adsorption Efficiency (%)				
1.	Pb	88	77	74.5	79.5	70
2.	Ni	70	70	69	66.5	54.8

RESULTS AND DISCUSSION

The data obtain from above analysis indicate that the adsorption efficiency is maximum for Pb (Table- 1and 2). Table-1 shows the residual concentration of Pb in solution after 24 hours contact time and Fig -1 shows the adsorption efficiency for various concentrations of Pb and Ni by 0.5 g slag. It is clear that slag is a good adsorbent for removal of Pb from wastewater. The adsorption rate is dependent on adsorbent amount and initial concentration of metal in synthetic solution. 90% removal of Pb from a 5 mg/L solution was possible by applying 0.5 g slag where as the similar amount of adsorbent was not enough to treat 100mg/L. Pb solution to above 75% but by increasing the amount of slag to 1.5 g it was possible to increase the efficiency of adsorption to about 95.7% for the same solution (100mg/L Pb). It shows that we would have better treatment by using excess slag. As this adsorbent is cheap and available in brass industry waste, there would be no problem to increase its consumption.

Table- 4 & 5 indicate that adsorption efficiency is dependent on the type of metal too , as for Ni we have not more than 75% removal in same condition (0.5 gm adsorbent in solutions 5,10,20,40,100, mg/L) but for Pb the efficiency is reported to be 90%.. Table-3 represent the results of adsorption experiments conducted on the mixture of metal solution as mentioned before , the maximum and minimum removal efficiency in the first stage experiments with 0.5 g of adsorbent was 90% and 75% for Pb and Ni . However, for the mixture of these metals a decrease of 4% has observed for Pb whereas Ni adsorption has decreased about 8%. The efficiency of Pb and Ni adsorption by various amounts of slag shown in fig-1 to 3 for individual solution and for mixed solution of Pb and Ni (fig-4) and in comparison to individual solution in fig-5.

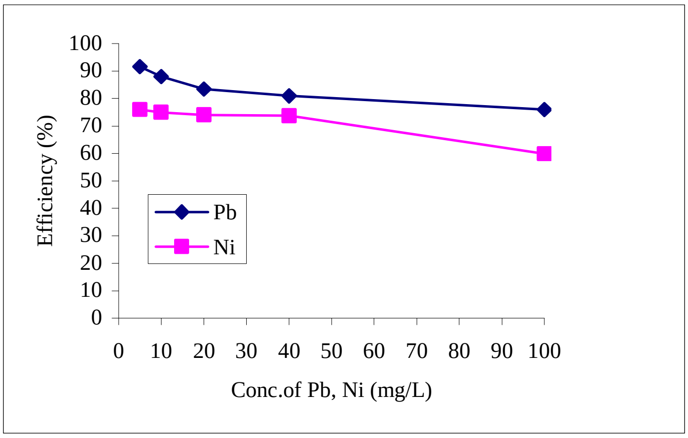

Fig. 1: % Adsorption of Lead and Nickel by 0.5 g Slag

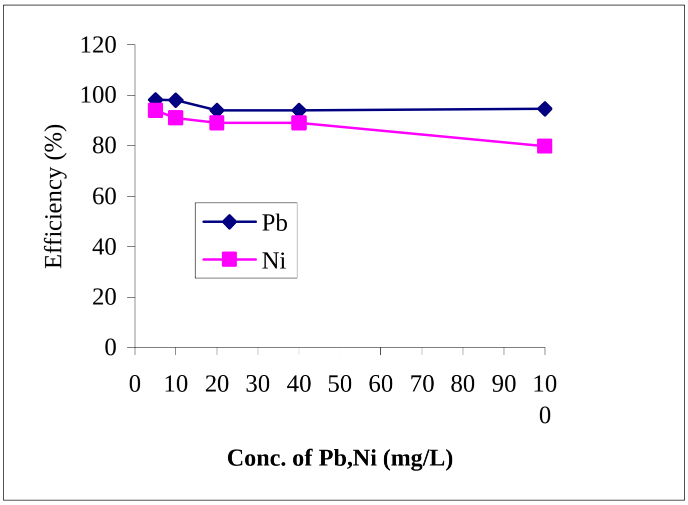

Fig. 2: % Adsorption of Lead and Nickel by 1 g Slag

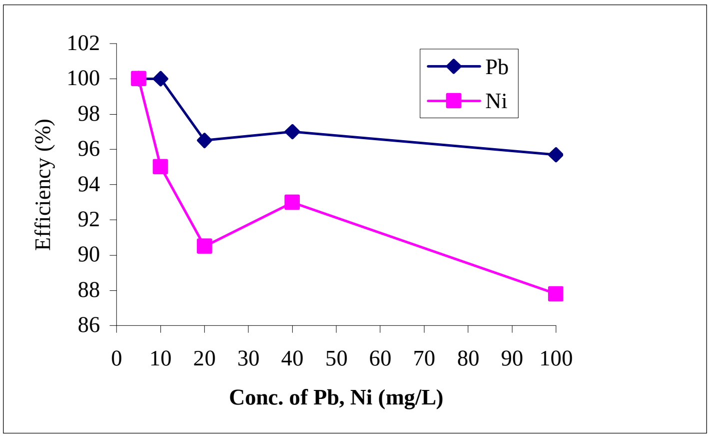

Fig. 3: % Adsorption of Lead and Nickel by 1.5 g Slag

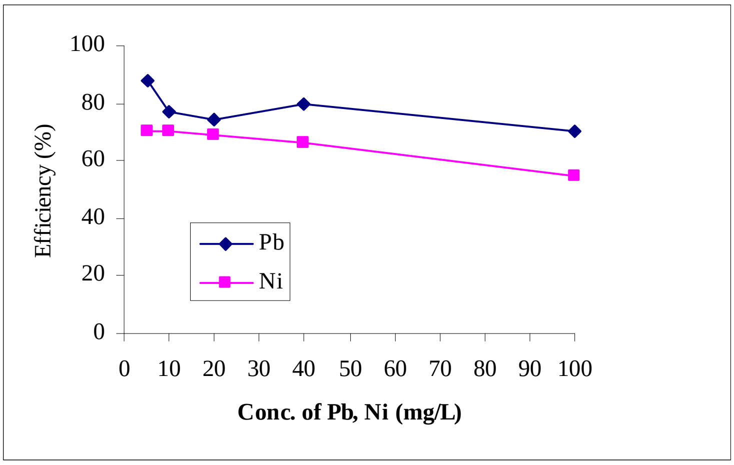

Fig. 4: % Adsorption of Lead and Nickel in Mixed Metal Solution by using 0.5 Slag

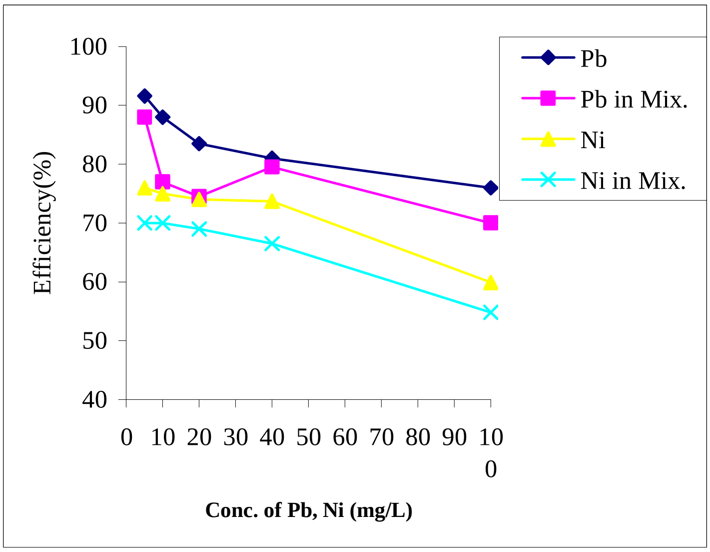

Fig.5: A Comparison Between % Adsorption of Lead and Nickel in individual and Mixed Metal Solution by 0.5 g Slag

CONCLUSION

The above results shows that Brass industry slag like the most other natural adsorbents can be used in the treatment process of heavy metals and the treatment efficiency may be as high as 100% by precise choosing of adsorbent amount. It was also observed that the concentration of heavy metals has an important effect on the result of this treatment. Slag is a waste material and conveniently used for the treatment of industrial wastewater, it is as the industrial waste is utilizing for the treatment of industrial wastewater.

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