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REMOVAL OF HEAVY METALS FROM SYNTHETIC WASTE WATER USING IRON OXIDE

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ABSTRACT: Now a days, heavy metals is a major issue. Various chemical industries release heavy metals into the water bodies. They are toxic to living creatures, thus they must be removed to reduce the risk of uptake by plants, animals, and humans. Over the previous few decades, various heavy metals removal technologies have been developed and intensively research. In this study, Iron oxide was well synthesized by simple co- precipitation method. Heavy metal ions such as Pb(II), Ni(II), As(III), and Cd(II) can be removed from water, using Iron oxide as adsorbent.

Keywords : Adsorption, Heavy metal, Co- precipitation, waste water, iron oxide.

1. INTRODUCTION

Water contamination has a strong link to population growth and industrialization, as well as to environmental and health concerns. The effluent has a unique chemical composition, because of several factors, a significant threat to our environment pollutants in soil, air and water, such as heavy metals Lead, arsenic, nickel, and cadmium are all considered hazardous substances.

Arsenic in the Environment, Industrial Production, and Use: Arsenic is a common element that can be found in low concentrations in almost any environment. matrices of the environment [1]. The trivalent arsenite is one of the most common inorganic forms of arsenic. As well as pentavalent arsenate methylated metabolites are the organic forms – MMA stands for monomethylarsonic acid, DMA is fordimethylarsinic acid, and TMO stands for trimethylarsine oxide. Arsenic pollution happens as a result of natural events such as volcanic eruptions, anthropogenic activity, such as eruptions and soil erosion [1]. There are a number of arsenic- containing Compounds are manufactured in industrial settings and have been used to make things like insecticides, herbicides, fungicides, algicides, sheep dips, and other agricultural applications, dyestuffs and wood preservatives. They've also been utilised in veterinary medicine to treat a variety of elements. For at least a century, arsenic compounds have been utilised in the medical field to treat syphilis, yaws, amoebic dysentery, and trypanosomiasis [2,3]. Certain tropical diseases are still treated with arsenic-based medicines. In human medicine, diseases such as African sleeping sickness and amoebic dysentery, and in veterinary medicine, parasitic diseases in dogs, such as filariasis, and black head in turkeys and chickens [3]. The Food and Drug Administration(USFDA) recently approved arsenic trioxide as an antimicrobial. Treatment of acute promeylocyticleukaemia with an anticancer drug [4] Its therapeutic properties. The induction of programmed cell death (apoptosis) in leukaemia cells has been blamed.

Cadmium in the environment, in Industrial Production, and in use : Cadmium isa toxic heavy metal that can harm both the environment and living organism. It is widelydistributed throughout the earth's crust, with an average concentration of roughly 0.1 mg/kg. The sedimentary rocks have the highest quantities of cadmium compounds in the environment. cadmium concentrations in marine phosphates are estimated to be around 15 mg/kg [5]. cadmium is used in a wide range of industrial operations.

The most significant industrial sector cadmium is a metal that is used in the production of pigments, batteries, and metals [6]. Despite the fact that the usage of cadmium inbatteries has expanded dramatically in recent years, commercial use has reduced in industrialized countries due to environmental concerns. For example, daily cadmium intake in the united states is roughly 0.4g/kg per day, which is less than half of what it is in Europe. This drop has been related to the implementation of strict effluent limitations for plating operations and, more recently, the implementation of general effluent limits. In several nations, cadmium use is restricted.

Lead in the environment, industrial production, and use: lead is a bluish-gray metal that is found in trace levels in the earth's crust. Although lead occurs naturally in the environment, anthropogenic actions such as the use of fossil fuels increase the amount of lead in the environment. High concentrations are released as a result of burning, mining, and manufacturing. lead is a poisonous substance. There are several industrial, agricultural, and domestic uses for this product. it's currently in use in leadacid batteries, ammunition, metal items (solder and pipes), and electronics are all manufactured. To protect against x - rays a total of 1.52 million metric tonnes of leadwas used in various industrial applications, in 2004, applications were filed in the united states lead-acid battery production accounts for a significant portion of that total accounted for 83 percent of total usage, with the remainder covering a wide range of products like as 3.5% for ammunition, 2.6% for paint, glass, pigments, and chemicals, and 1.7% for sheet lead [7,8]. lead in paints has been dramatically reduced in recent years in the industrial sector. caulk, pipe solder, and ceramic goods [9]. Despite this, there has been some setbacks. According to the research, 16.4 million US households with child under the age of 6 years, 25% of dwellings had large levels of leadcontaminated soil. damaged paint, dust, or bare earth near to the structure [10]. Dust and soil contaminated with lead frequently re-contaminate the environment, cleansed dwellings [11] and helps to raise blood lead levels in youngsters who are exposed to it,[12] playing on bare, contaminated ground. The most common cause of lead poisoningin children is made up of dust and chips that have accumulated as a result of the deterioration of the material. Dust and chips from decaying lead paint on interior surfaces are the most common source of lead poisoning in children [13]. children who live in homes with deteriorating lead paint can have blood lead concentrations of up to ten times the national average at least 20 g/dL [14].

Nickel, in the environment, industrial production, and use: a well-known heavy metal, is prevalent in the environment at extremely low amounts. Nickel may be foundin many types of soils and meteorites, as well as erupting from volcanic eruptions. Nickel is primarily bound with oxygen or sulphur in the environment, forming oxides or sulphides in the earth crust. Nickel's ubiquitous industrial use, recycling, and disposal has resulted in significant environmental damage. Nickel is released into the atmosphere by nickel mining or other industrial activities such as power plants or incinerators, rubber and plastic industries, nickel-cadmium battery industries, and industries, among others. Nickel's widespread use in numerous industries, as well as occupational exposure, has a significant negative influence on human health.

2 Experimental :

2.1 Synthesis of Adsorbent by Co-precipitation method:

Take a 20g of ferric chloride salt(Finar:anhydrous extrapure) dissolve it in distilled waterand make up to the mark in 250 ml volumetric flask, to make homogenous solutionstirr it on magnetic stirrer for the 60 min. After making homogenous solution adjusted ph of the solution by using NaOH(strong base),As a precipitating agent. set the ph at 7 or 7.2. After the ph adjustment filter the whole material. After filtration give wash with milli - Q water to the material and dry at 80°temprature for 12 hours in tray dryer.

2.2 Preparation of stock solutions of heavy metal:

Stock solution of pb^{2+} was prepared by using lead nitrate Dissolved it in distilled water. prepared standard solution of lead(II) 100 ppm (100mg/L). solution of different concentration was prepared by diluting the stock solution. Stock solution of cd^{2+} was prepared using cadmium chloride Dissolved it in distilled water. Prepared standard solution of cadmium(II)100 ppm (100mg/L). solution of different concentration was prepared by diluting the stock solution. Stock solution of Ni^{2+} was prepared by using nickel chloride Hexahydrate. Dissolved it in distilled water. Prepared standard solution of nickel(II) 100ppm (100mg/L).solution of different concentration was prepared by diluting the stock solution. Stock solution of As^{3+} was prepared by sodium arsenate.

Dissolved it in distilled water. Prepared standard solution of arsenic(III)100ppm (100mg/L). solution of different concentration was prepared by diluting the stock solution.

2.3 Adsorption Analysis:

0.5g of - Iron oxide were added in all 4 stock solutions of heavy metals and it takes 1 hour to make a homogeneous mixture using a magnetic stirrer. After following ,separation of the adsorbent by filtration of the solution and filtrate was analyzed. Initial and final metal ions concentrations were analyzed by an inductively coupled plasma-

optical emission spectrometer (ICP-OES).The adsorption efficiency(AE) was calculated by analyzing initial and residual heavy metal ions concentrations in solution before and after contact with adsorbent through the following equation.

$$AE\% = \frac{(C_0 - C_e)}{C_0} \times 100 \qquad (1)$$

where C0 and Ce (mg/ L) are the initial and final residual concentrations of heavy metal ions in aqueous solutions. The equilibrium adsorption capacity of heavy metalions was calculated using the following equation:

$$q_e = \frac{(C_0 - C_e)\, v}{M} \qquad (2)$$

where C0 and Ce (mg/ L) are initial concentration and equilibrium concentration of heavy metal ions, respectively;V (L) is the sample volume and m (g) is the mass of iron oxide.

Study of the effect of adsorbent dose on Iron oxide [15] was carried out at a controlled temperature in alaboratory setting. Temperature of Iron oxide & concentration of stock solutions are changed and again applied the same procedureon all4 stock solutions of heavy metals.

3. Result and discussion:

3.1 Adsorption study: By ICP - OES

Model: Optima 7300DV Range: Above 0.21 mg/kgMake:
Perkin Elmer

The effect of adsorbent amount, on heavy metals adsorption by Iron oxide was studied in the 100ml solution was mixed with different doses of adsorbent. while keeping other parameters constant. Initial concentration of heavy metals was kept at 100 mg/L with the contact time of 60 min.

It was shown that the removal efficiency of metal ions generally increased with an decrease in the dosage of Iron oxide. An Decrease in the adsorbent dosage from 0.5, 0.4, 0.3 g led to an increase in the removal efficiency of cd^{2+} from 24.67 to 88.76 to 91 respectively. The removal efficiency of As^{3+} from 88.90 to 99.37 to 99.59 respectively. The removal efficiency of Ni^{2+} from 90.47 to 91.34 to 92.61 respectively. The removal efficiency of pb^{2+} from 99.47 to 99.96 to 99.98 respectively. Adsorbent mass decrease with the increase in removal efficiency.

It was found that adsorption order of heavy metals ion on Iron oxide was: As3+> Pb2+> Cd2+>Ni2+ The trend was proportional to increasing size of the metal ions as well as p-block elements were found to show good Adsorption on Iron oxide than the transition metal ions.

Heavy metal	**Initial metal conc.**	**Final metal conc.**	**Doseof Adsorbent**	**Removal efficiency**	**dsorption capacity**
Cd2+	100 mg/L	54.95	0.5 g	24.67 %	3.6
As3+	100 mg/L	12.11	0.5 g	88.90 %	19.398
Ni2+	100 mg/L	9.069	0.5 g	90.47 %	17.23
Pb2+	100 mg/L	0.489	0.5 g	99.47 %	18.24

Native Conc. 100 ppm (100 mg/l) Dose of Adsorbent 0.5 g

Table:1

Heavy metal	Initial metal conc.	Final metal conc.	Doseof Adsorbent	Removal efficiency	dsorption capacity
Cd2+	100 mg/L	8.199	0.4 g	88.76 %	16.18
As3+	100 mg/L	0.6858	0.4 g	99.37%	27.10
Ni2+	100 mg/L	8.245	0.4 g	91.34 %	21.74
Pb2+	100 mg/L	0.034	0.4 g	99.96%	18.10

Native Conc. 100 ppm (100 mg/l) Dose of Adsorbent 0.4 g

Table :2

Heavy metal	Initial metal conc.	Final metal conc.	Doseof Adsorbent	Removal efficiency	dsorption capacity
Cd2+	100 mg/L	6.200	0.3 g	91.00 %	22.25
As3+	100 mg/L	0.4424	0.3 g	99.59 %	36.21
Ni2+	100 mg/L	7.033	0.3 g	92.61 %	29.39
Pb2+	100 mg/L	0.02	0.3 g	99.98%	24.14

Native Conc. 100 ppm (100 mg/l) Dose of Adsorbent 0.3 g

Table :3

Heavy metal	Initial metal conc.	Final metal conc.	Doseof Adsorbent	Removal efficiency	dsorption capacity
Cd2+	50 mg/L	28.859	0.5 g	33.14 %	2.8614
As3+	50 mg/L	0.058	0.5 g	99.89 %	10.800
Ni2+	50 mg/L	24.58	0.5 g	26.42 %	1.766
Pb2+	50 mg/L	0.003	0.5 g	99.98 %	5.7574

Native Conc. 50 ppm (50 mg/l) Dose of Adsorbent 0.5 g

Table:4

4. REUSE OF WASTE SILICA AS ADSORBENT FOR HEAVY METALS REMOVALFROM WATER BY IRON OXIDE MODIFICATION.

4.1 Preparation of Iron Oxide-coated waste silica:

The coating process of the adsorbent proposed by Meng and Letterman. Before coating,waste silica from synthetic organic laboratories was collected [16]. Raised and pretreatedat the required temperature. In 200ml water, 9g of waste silica and 3g of FeCl3 salt were mixed and coated. Use the magnetic stirr to make homogenous solution, stirr for 1 hour. NaOH is added as a precipitating agent. Adjust the phof solution at 7 or 7.2. filter the whole solution with what man filter paper. After filtrationwashed the material and dried at 80° temperature for 12 hours.

4.2 preparation of stock solutions of heavy metal:

Stock solution of pb^{2+} was prepared by using lead nitrate. Dissolved it in distilled water. prepared standardsolution of lead(II) 100 ppm (100mg/L). solution of different concentration was prepared by diluting the stock solution. Stock solution of cd^{2+} was prepared using cadmium chloride.

Dissolved it in distilled water. Prepared standard solution of cadmium(II)100 ppm (100mg/L). solution of different concentrationwas prepared by diluting the stock solution. Stock solution of Ni^{2+} was prepared byusing nickel chloride Hexahydrate. Dissolved it in distilled water. Prepared standard solution of nickel(II) 100ppm (100mg/L). solution of different concentration was prepared by diluting the stock solution. Stock solution of As^{3+} was prepared by sodium arsenate. Dissolved it in distilled water. Prepared standard solution of arsenic(III)100ppm (100mg/L). solution of different concentration was prepared by diluting the stock solution.

4.3 Adsorption Analysis:

0.5g of - coated silica were added in all 4 stock solutions of heavy metals andit takes 1 hour to make a homogeneous mixture using a magnetic stirrer. After following separation of the adsorbent by filtration of the solution and filtrate was analyzed. Initial and final metal ions concentrations were analyzed by an inductively coupled plasma- optical emission spectrometer (ICP-OES).The adsorption efficiency(AE) was calculated by analyzing initial and residual heavy metal ions concentrations in solution before and after contact with adsorbent through the following equation.

$$\mathbf{AE\% = \frac{(C_0 - C_e)}{C_0} \times 100} \qquad \mathbf{(1)}$$

where C0 and Ce (mg/ L) are the initial and final residual concentrations of heavy metal ions in aqueous solution.The equilibrium adsorption capacity of heavy metal ions was calculated using the following equation:

$$\mathbf{q_e = \frac{(C_0 - C_e)\,v}{M}} \qquad \mathbf{(2)}$$

where C0 and Ce (mg/ L) are initial concentration and equilibrium concentration of heavy metalions, respectively;V (L) is the sample volume and m (g) is the mass of iron oxide.

5 Result and discussion:

5.1 Adsorption study: By ICP - OES

Model: Optima 7300DV Range: Above
0.21 mg/kgMake: Perkin Elmer

By the use of coated material (Iron oxide adsorbent coated with waste silica) as anadsorbent, we can get better result at minimum use of Iron oxide adsorbent. Theremoval efficiency of cd^{2+}, As^{3+}, Ni^{2}, Pb^{2+} are32.1%, 99.40%, 28.30%, 99.8% respectively.

Heavy metal	Initial metal conc.	Final metal conc.	DoseOf Adsorbent	Removal efficiency	dsorption capacity
Cd2+	100 mg/L	39.80	0.5 g	32.1 %	3.76
As3+	100 mg/L	0.592	0.5 g	99.40 %	19.92
Ni2+	100 mg/L	64.83	0.5 g	28.30 %	5.118
Pb2+	100 mg/L	0.158	0.5 g	99.8 %	15.58

Native Conc. 100 ppm (100 mg/l) Dose of Adsorbent 0.5 g

Table :5

CONCLUSION :

In the present work, we have synthesized iron oxide using the co- precipitation method utilising NaOH as a precipitating agent because the co- precipitation method is simple, cheaper, environment friendly and effective compared to other available methods. The synthesized iron oxide was applied as an adsorbent for the removal of hazardous heavy metals such as Cd2+, As3+, Ni2+, and Pb2+. Effect of Temperature, and adsorbent dose was also studied.in results we shown decreased adsorbent dosage increase the removal percentage of heavy metals because Adsorptivecapacity of adsorbent available was not fully utilized at a higher adsorbent dosage in comparison to lower adsorbent dosage. The plausible reason could be the variation in the pH of the solution which may influence the binding sites of the heavy metal ions on the surface of the iron oxide, which causes the variation in the adsorption with adsorbent dose. It was found that adsorption order of heavy metal ion on iron oxide was: As3+> Pb2+> Cd2+>Ni2+ The trend was proportional to increasing size of the metal ions as well as p-block elements were found to show good Adsorption on iron oxide than the transition metal ions.

Further study shows how to wrap waste silica in Iron oxide to prepare it for heavy metals removal from water. adsorption takes place only on the surface of Iron oxide.As a result,we used a larger amount of Iron oxide adsorbent. We use less of our Iron oxide adsorbent as a result of this alteration, resulting in a good removal percentage of heavy metals removal from water. By this method we can reduse the useof actual adsorbent hence we can reduse the cost of wastewater treatment.

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