Removal of Heavy Metals from Wastewater by Using Carbon Nanotube

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ABSTRACT

Research has led to researches on how wastewater is treated. Heavy metals in wastewater, on the other hand, are a rising issue since they are difficult to remove and remain in the environment for an extended period of time. Heavy metals are harmful, so it is critical to remove them from wastewater. Many alternative methods for removing heavy metals from wastewater have been discovered in previous investigations. This paper discusses recent developments and various methods for removing heavy metals from wastewater. It also examines the benefits and drawbacks of using these strategies, as well as how they might be applied. Adsorption on non-biological adsorbents, biosorption, and photocatalysis are all being studied as new removal processes. Because of how successful, diverse, and simple these approaches are for removing heavy metals from wastewater, they have created new trends and attracted an increasing number of researchers. In general, the best solution for polluted wastewater relies on how it may be used, the type of wastewater, how much it costs, and how simple it is to set up.

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1. INTRODUCTION

Water is one of the most vital natural resources on the planet because all living creatures require it to survive, and people require it to develop and learn. People are utilizing more and more water as industrialization and urbanization accelerate, and a lack of water has become a severe concern for economic progress. At the same time, pollution of water, especially from heavy metals, has become a worldwide environmental problem. Heavy metals can get into waterways through a variety of different ways, such as mining, electroplating, metallurgy, chemical plants, farming, and garbage. Heavy metals like Pb, Zn, Cu, Hg, and others can build up in the food chain, which could be bad for human health.Heavy metals, for example, can harm the kidneys, brain, central nervous system, lungs, and other organs. Heavy metals can also harm the ecosystem and other organisms that rely on it because microorganisms cannot eliminate them once they are there. They instead accumulate their way up the food chain. Heavy metals are extremely hazardous, and it is believed that the majority of them cause cancer. As a result, removing heavy metals from water is a great idea that has received a lot of attention. Also, to get rid of something more effectively, people frequently utilize more than one way at the same time. Adsorption is one of the most prevalent methods we've discussed so far because it's inexpensive and simple to implement. Porous metal-organic framework (MOF) materials have also demonstrated in recent years that they are far superior to other materials at removing hazardous pollutants from the environment.

This is due to the fact that they have a large number of pores, and those pores may perform great things and come in a lot of shapes. Ricco et al. created a magnetic nanocomposite (MIL-53) out of aluminum MOF and discovered that it was particularly effective in removing Pb(II), with a value of 492.4 mg g1. Nanomaterials are also an effective approach to remove heavy metals from wastewater today. Nanomaterials have received a lot of interest in recent decades. Nanomaterials have been employed in a variety of fields, including electronics, health, and energy. Nanomaterials have also been increasingly popular in the realm of environmental protection during the last few decades. In general, nanomaterial's are items with nanoscale outer dimensions (often between 1 and 100 nm) or with nanoscale interior structure or surface. Because of these properties, they have a high ability to absorb and react, which is beneficial for removing heavy metal ions. Nanomaterials have been the subject of much study to see how they may be used to treat water containing heavy metals, and they have demonstrated great potential as an alternative to absorbing heavy metals from sewage.

People are becoming increasingly concerned about the environment as a result of globalization and rapid industrialization. So, especially in the chemical industry, we require solutions that are effective and efficient. Heavy metals contained in wastewater and industrial effluent are the primary cause of environmental pollution. Heavy metals are typically reported to have a density more than 5 g/cm3. The majority of these elements dissolve easily in water and are known to be toxic or carcinogenic. Both people and the animals and plants that dwell in the bodies of water into which they flow are endangered. They can enter the body and accumulate, causing cancer, organ damage, nervous system difficulties, and, in the worst cases, death. There is also less room for development and progress. Several businesses' waste water streams have been found to contain heavy metals. The electroplating, electrolysis depositions, conversion-coating, anodizing-cleaning, milling, and etching industries generate heavy metals like cadmium, zinc, lead, chromium, nickel, copper, vanadium, platinum, silver, and titanium. Tin, lead, and nickel are just a few of the heavy metals that are wasted while making printed circuit boards (PCBs).

2. METHODOLOGY

Carbon-Based Nanomaterials - Carbon-Based Because of their exceptional thermal and electrical properties, nanomaterials were originally exploited in the electronics industry. Nonetheless, carbon-based nanomaterials offer some distinguishing properties, including a huge surface area, the ability to be altered chemically or physically, and the ability to remove both organic and inorganic contaminants. As a result, they could be used to treat wastewater. The emphasis here is on carbon-based nanomaterials such as carbon nanotubes and graphene.

Carbon Nanotubes

Carbon nanotubes (CNTs) have been the subject of much investigation in recent decades, and it has been claimed that they possess a range of remarkable features, including optical, electrical, vibrational, mechanical, and thermal capabilities. 3800
According to several research, they can be utilized to remove heavy metals from wastewater. Carbon nanotubes are classified into two types: single-walled CNTs (SWCNTs) and multi-walled CNTs (MWCNTs) (MWCNTs). Their widths range between one and three nanometers, while their lengths range from a few hundred to thousands of nanometers. Carbon nanotubes outperform standard methods for removing heavy metals from wastewater due to their vast specific surface area, high adsorption capacity, and rapid rate of adsorption. Some claimed that carbon nanotubes were particularly attractive to Mn(VII), Tl(I), Cu(II), Pb(II), Cr(VI), and other elements. Types may adhere to carbon nanotubes primarily at the exterior surface, internal sites, interstitial channels, and external groove sites.

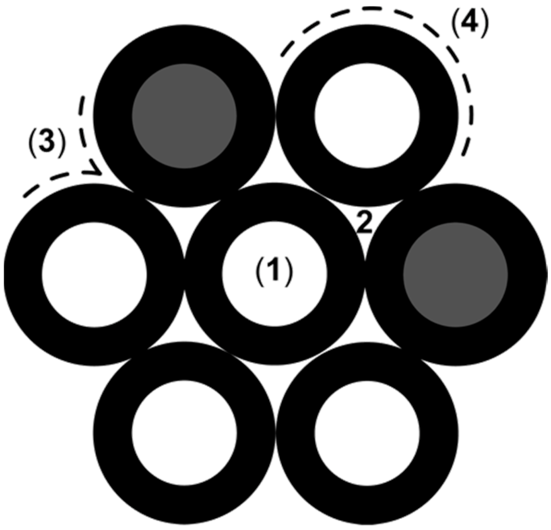

Figure 1"Different adsorption sites on a homogeneous bundle of partially open-ended single-walledcarbon nanotubes (SWNTs)"

"Functional groups such as -COOH, -NH2, -OH, and others are frequently added to the surface of CNTs via chemical modification, heat treatment, or endohedral filling to improve their ability to attract heavy metals. For example, oxidants such as KMnO4, HNO3, H2SO4, and NaOCl were believed to modify the surface of CNTs, making them considerably better at absorbing things". Mohamed et al. reported that they were able to get rid of Hg(II) by employing a functionalized-CNTs absorbent. To create the novel functionalized CNTs, deep eutectic solvent (DET) and allyltriphenylphosphonium bromide were sonicated with pre-oxidized CNTs. The batch adsorption test findings revealed that the optimal conditions were pH = 5.5 and a contact period of 28 minutes.

3. Results and Discussion

Table 1 Characteristics of the different sludge based activated carbons and commercial activated carbon

Sl. No	Control Tests	SAC	PAC	SSAC	FAC	CAC
1.	Apparent Density (g/cm³)	0.309	0.212	0.610	0.510	0.680
5.	Moisture content (%)	1.50	2.73	6.40	5.60	7.23
3.	Matter soluble in water (%)	3.6	4.2	4.2	4.7	1.5
4.	Matter soluble in Acid (%)	8.6	7.1	5.9	6.6	4.7
5.	Decolorizing power (mg/g)	67.0	74.5	52.5	49.5	73.5
6.	Ash content (%)	2.07	2.41	1.41	1.92	2.60
7.	Carbon content (%)	51.00	48.00	31.50	36.82	62.00
8.	Surface area (m²/g)	417	402	398	362	491
9.	Particle size (μm)	355-710	355-710	355-710	355-710	355-710

BATCH ADSORPTION EXPERIMENTS

In the present study of Batch mode adsorption, experiments were carried out by agitating 150 mL of sample synthetically prepared solutions of Cd(II), Pb(II), Ni(II) with known initial concentration and known quantity of activated carbon in a 300 mL BOD bottle. The samples were shaken in a wrist action shaker and were drawn at an interval of 5 min. The samples were filtered through Whatman filter paper. Absorption of Atoms The amount of metal remaining in the filtrate was determined using a spectrophotometer (AAS) Batch adsorption experiments were carried out using activated carbon based from sewage sludge and commercial carbon to remove Cadmium (II), Lead (II), and Nickel (II). Experiments were repeated with varying carbon doses, contact periods, pH levels, and initial sample concentrations for the various Sludge-based Activated Carbons and Commercial Activated Carbons (CAC). To determine how well the Carbons operated, Langmuir and Freundlich isotherms were calculated. The parameters involved in the experiment are shown in the Figure 2

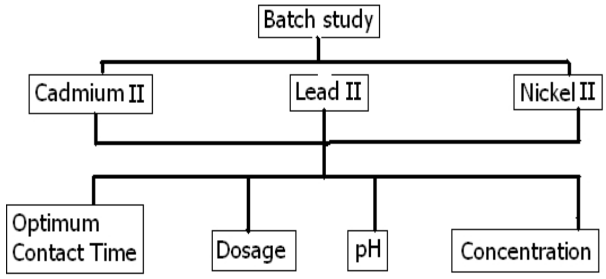

Figure 2 Sketch of parameters involved in the experiment

REMOVAL OF CADMIUM

Removal of Cadmium (II) using activated carbon prepared from Sugar mill sludge

Cadmium (II) sample of 150 mL with an initial concentration of 500 ppm was treated with varying doses of 0.25 g to 2.0 g carbon prepared from the various sludge based activated carbons. Samples were shaken using the wrist action shaker continuously for 5 min, 10 min, 15 min, 20 min, 25 min

and 30 min.

Constants arrived for various carbons on Cadmium (II) removal

Type of Sludge based Activated Carbon	Langmuir Constants			Freundlich Constants	
	Ka	q_m	R_L	K_F	n
Sugar mill sludge	0.0012	0.7165	0.623	0.0015	1.175
Paper mill sludge	0.0042	0.1171	0.322	0.0005	1.0867
Sewage sludge	0.0045	0.0562	0.308	0.0009	1.567
Fertilizer sludge	0.0004	0.2781	0.839	0.00005	0.878
Commercial Carbon	0.0006	2.6399	0.759	0.0027	1.159

Table 2 Results of various carbons on Cadmium (II) removal

Sl. No	Type of Carbon	Optimum Dose (g)	Optimum Contact Time (min)	pH	Initial Concentration (ppm)	% Removal
1.	PAC	1.5	20	5.8	500	78.8
2.	SSAC	1.5	15	5.8	500	66.4
3.	FAC	1.0	25	5.8	500	51.6

Optimum contact time and dose

To find the optimum contact time the dose of the carbon was varied. A plot of percentage of Cadmium (II) removal against time in minutes is shown in the Figure 3.

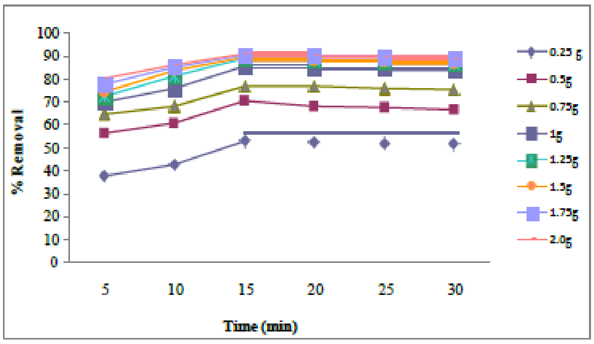

Figure 3 Adsorption curve showing Cadmium (II) adsorption for different contact time and dose using SAC

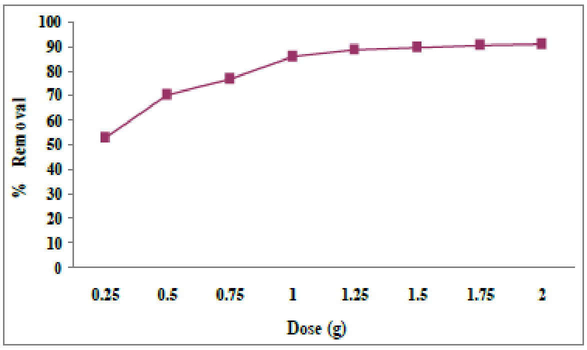

Figure 4 Effect of dose at optimum contact time of 15 min

Effect of pH

The effect of pH on the adsorption of Cadmium (II) by Sugar Mill Sludge Carbon at equilibrium conditions is presented in Figure 5

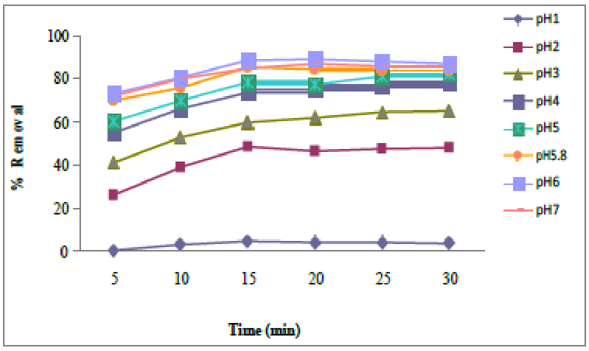

Figure 5 Adsorption curve showing Cadmium (II) adsorption for different contact time and pH using SAC

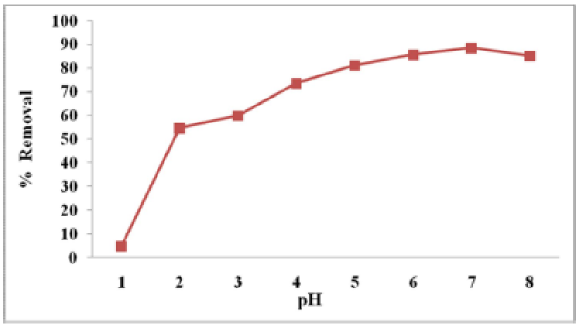

Figure 6 Effect of pH at optimum contact time of 15 min

Effect of initial concentration of Cadmium (II)

The effect of initial concentration on the adsorption of cadmium (II) by Sugar Mill Sludge carbon at equilibrium condition is presented in Figure 7.

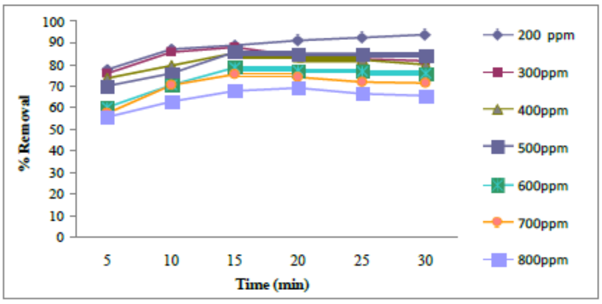

Figure 7 Adsorption curve for different initial concentration with time using SAC

4. CONCLUSION

Several industries generate waste water containing copper and cadmium. Heavy metals in wastewater must be handled according to environmental regulations so that their quantities remain safe. The findings of this study indicate that membrane processes are particularly successful at removing heavy metals such as Cu" and Cd2+ from wastewater streams. They can reduce the concentration of heavy metals in the effluent stream to levels acceptable and suggested by Jordanian guidelines for industrial wastewater discharge. Heavy metal-containing industrial effluent can be reused after RO and NF treatment. This can alleviate the strain on traditional water resources. This is especially crucial in a country like Jordan, where water is always scarce. Heavy metals could be recovered using a membrane technique, which should be investigated further.

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