

# Heavy Metal Removal From Automobile Industrial Effluent Using Neem Sawdust Biosorbent

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**Abstract:** The presence of heavy metals in industrial effluent poses a serious environmental threat, particularly due to swift in economic and urban development. This study evaluates the efficiency of Neem sawdust as a sustainable, low-cost adsorbent for the removal of heavy metals from automobile industrial effluent. Batch experiments were conducted as per Standard Methods, resulting in a considerable improvement in water quality. Significant reductions in heavy metal concentrations were observed; Chromium (Cr) decreased by 55%, Iron (Fe) by 87.77%, Nickel (Ni) by 30%, Copper (Cu) by 63.15%, Zinc (Zn) by 88.6%, and Manganese (Mn) by 48.62%, while Cadmium (Cd) was completely removed (100%). These findings demonstrate the potential of Neem sawdust as an effective and environmentally friendly adsorbent for heavy metal removal in wastewater treatment applications.

**Keywords:** Heavy metals; Effluent; Neem sawdust; Eco-friendly adsorbent

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## 1. INTRODUCTION

Water is essential for life on Earth, yet we still lack a clear understanding of how it changes over time and across different regions, particularly in terms of its flow and storage. Water pollution, a critical global issue, stems from both point and non-point sources. Point sources, like effluents from factories and wastewater discharge, are identifiable and localized. Non-point sources, such as agricultural runoff and urban waste, are diffuse and difficult to trace out (Singh et al. 2024; Kaushik and Kaushik, 2022). The industrial sector accounts for approximately one-third of the total energy consumption among the four main sectors of residential, industry, transportation and commercial (Feng and Mears, 2016; Babel et al. 2020). The automobile industry is an important driver of the economic growth in India and one of the successful sectors in which the country has high participation in global value chains (Migliani, 2019). Heavy metals are naturally present in the environment; however, human activities have significantly contributed to their increased contamination. Industries such as textiles, ore processing and refining, mining, paint and alloy manufacturing, metal plating, battery production, electrical equipment manufacturing, pesticide production, and sludge disposal releases the substantial amounts of heavy metal loaded waste into the environment (Zeb et al. 2022).

The conventional methods used to remove heavy metals from aqueous solutions include chemical precipitation, coagulation, solvent extraction, reverse osmosis, electro chemical reduction, evaporation, electrolysis and electroplating, ion floatation, membrane separation, ion exchange and adsorption. Most of these methods suffer with high capital and regeneration costs of the materials. These are not suitable for the small-scale industries (Sathya et al. 2022). Adsorption is widely regarded as one of the most effective methods for removing pollutants from wastewater, due to its versatility, simple design, cost-effectiveness, potential for adsorbent reuse, and environmental friendliness. As a result, it has been extensively researched and broadly implemented in practical applications. (Ighalo et al. 2022; Aibinu et al. 2022). Adsorption is referred to as the physical adhesion or bonding of ions and molecules to the surfaces of other molecular substances (Chen et al. 2019). The present study aims to determine the efficacy of Neem saw dust in removal of certain heavy metals from automobile industrial effluent.

## 2. MATERIALS AND METHODS

In this study, effluent was collected from an automobile industry in Malur Industrial area of Malur, Kolar Karnataka State, India. Collected effluent was brought to the laboratory of Department of Environmental Science, Bangalore University for further analysis as per the Standard Methods. ‘

### 2.1 Analysis of Heavy metals

Heavy metal concentrations in the industrial effluent samples were determined using the wet-dry ashing method prior to analysis by Atomic Absorption Spectroscopy (AAS). Initially, the effluent samples were allowed to settle undisturbed for a minimum of 18 hours to facilitate separation of the solid and liquid phases. The supernatant liquid was carefully decanted and filtered using Whatman No. 42 filter paper to isolate the environment-available fraction of heavy metals.

For digestion, 50 mL of each industrial wastewater sample was treated with 2 g of air-dried sawdust in a 100 mL conical flask, followed by the addition of 0.1 N ortho-phosphoric acid. The mixture was subjected to digestion until white fumes were observed, indicating completion of the acid reaction. Subsequently, the digested samples were diluted with deionized water to ensure the leaching of all metal ions and were rinsed three times with distilled water. The resulting solutions were filtered again through Whatman No. 42 filter paper and transferred to a 50 mL volumetric flask, with the final volume adjusted to 50 mL. The prepared samples were analyzed for heavy metal content using Atomic Absorption Spectroscopy (AAS), following standard analytical protocols. (Baker and Suhr, 1982).

### 2.1 Application of Treated Sawdust for Heavy Metal Removal

Raw sawdust of *Azadirachta indica* (Neem sawdust) was thoroughly washed with distilled water to remove impurities. The washed sawdust was then air-dried at room temperature. Once dried, the sawdust was treated with 0.1 N ortho-phosphoric acid to enhance its adsorption properties. After acid treatment, the sawdust was washed repeatedly with distilled water until the pH of the wash water reached neutral, ensuring the removal of any residual acid.

The neutralized sawdust was then dried in a hot air oven at 150°C to obtain the final activated adsorbent. A series of batch experiments were conducted to evaluate the effectiveness of the treated sawdust in removing heavy metals from effluent. These experiments tested various dosages of the adsorbent, and the optimum dosage was determined to be 2 g for 100ml effluent.

Subsequently, the performance of the 2 g dosage was assessed for its ability to adsorb heavy metals from the effluent. The efficiency of heavy metal removal was evaluated to determine the adsorption potential of the treated sawdust.

**2.2 Data analysis:** Statistical analysis was carried out using Paired t-test. The difference in mean values at  $p < 0.05$  or  $p < 0.01$  was considered as statistically significant. Statistical analysis was performed using Graph Pad Prism version 5.01.

## 3. RESULTS

Neem sawdust was used to remove heavy metals in automobile industry effluent. The heavy metals like Chromium, Iron, Nickel, Copper, Zinc, Manganese and Cadmium were recorded and tabulated for control and after treatment using Neem saw dust

Heavy metals in effluent wastewater represent a significant environmental concern, particularly due to the rapid industrialization and urbanization that have occurred over recent decades. The heavy metals levels of Chromium, Iron, Nickel, Copper, Zinc, Manganese and Cadmium were recorded and tabulated (Table 1). From the series of experiment it is found that the optimum removal of heavy metal was found in 2g saw dust for 100 ml of effluent.

**Table 1.** Concentrations of heavy metals before and after treatment

Sl.No	Parameters (ppm)	Control	After treatment	P value	% Reduction
1	Cr	0.02±0	0.009±0**	0.0099	55
2	Fe	14.8±2.3	1.91±0.96**	0.0075	87.77
3	Ni	4.6±0.46	3.22±0.24**	0.0077	30
4	Cu	0.019±0	0.007±0**	0.0028	63.15
5	Zn	9.04±0.03	1.29±0.09**	0.0013	88.6
6	Mn	5.45±0.35	2.8±0.1**	0.0031	48.62
7	Cd	0.001±0	0±0		100

Values are expressed as mean  $\pm$  SD (n=3). \* $p < 0.05$ ; \*\* $p < 0.01$  denotes significance with respect to before treatment using Paired t-test

### 3.1 Heavy metal removal using Neem saw dust

The total concentration of Chromium (Cr) decreased from 0.025 ppm to 0.009 ppm, indicating a 55% reduction. Iron (Fe) levels dropped substantially from 14.8 ppm to 1.81 ppm, achieving an 87.77% decrease. Nickel (Ni) concentrations were reduced from 4.6 ppm to 3.22 ppm, marking a 30% decline. Copper (Cu) levels fell from 0.019 ppm to 0.007 ppm, showing a 63.15% reduction. Zinc (Zn) also saw a major decrease, from 9.04 ppm to 1.03 ppm, amounting to an 88.6% reduction.

Manganese (Mn) levels dropped from 5.45 ppm to 2.8 ppm, resulting in a 48.62% decrease, although the final concentration remained slightly above the permissible limits set by the Central Pollution Control Board (CPCB). Cadmium (Cd) was completely eliminated, with levels dropping from 0.001 ppm to 0 ppm, representing a 100% removal. The findings highlight the strong potential of neem sawdust in effectively reducing heavy metal concentrations (Figure 1).

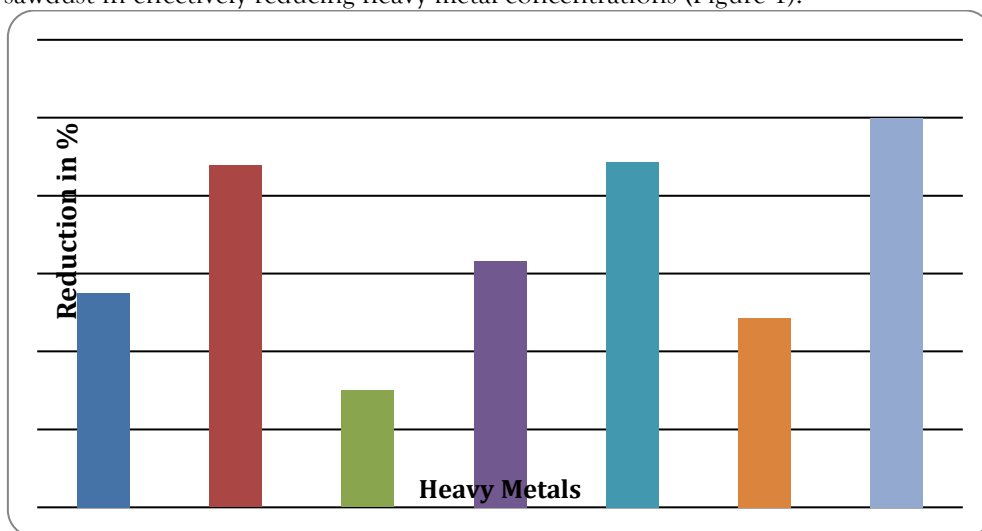


Fig1: Percentage removal of heavy metals after treatment with neem saw dust

## 4. DISCUSSION

Neem sawdust has shown significant potential in removing heavy metals such as Chromium, Iron, Nickel, Copper, Zinc, Manganese, and Cadmium from contaminated water.

In the present study initial pH of the effluent was 4.13. After treatment with neem sawdust, the pH increased to 6.2 for 2g, adsorbent dosage, suggesting effective neutralization which is similar with the findings of Khatmode & Thakare (2015), who also observed that neem sawdust could neutralize the pH of textile effluents. Cadmium was completely removed (100%) after treatment, which supports the findings of Rahman (2024), who reported a 91.35% reduction in cadmium using Chitosan. Copper levels were reduced by 63.15% following treatment with neem sawdust, which is notably higher than the 42.7% reduction reported by Deng (2024) using biochar.

Zinc concentrations were reduced by 88.6%, aligning with the results of Pragati (2015), who observed a 90% removal rate using sawdust. Chromium levels decreased by 55%, although Garg (2023) reported a higher efficiency (73.4%) using walnut shell adsorbents. Nickel concentrations were reduced by 30%, demonstrating neem sawdust's relative effectiveness. In comparison, Bhagat (2023) reported lower reductions with rice husk (17%) and soybean husk (33%), while wheat husk showed a higher reduction of 50%.

Zinc and iron showed the highest removal efficiencies by treated sawdust, with reductions of 88.6% and 87%, respectively. In contrast, nickel removal was significantly lower, around 30%. The sawdust contains lignin and cellulose which offer functional groups like hydroxyl (-OH) and carboxyl (-COOH) that help bind metal ions through processes such as complexation and ion exchange (Saravanane et al. 2002)

In the presence of multiple metals, competition for binding sites occurs. Metals with stronger affinity or higher concentrations are more likely to be adsorbed. Ions like  $\text{Cu}^{2+}$ ,  $\text{Zn}^{2+}$ ,  $\text{Fe}^{2+}$ , and  $\text{Cr}^{3+}$  generally bind more easily to sawdust than  $\text{Ni}^{2+}$ . This is due to differences in their size, charge, hydration energy,

and how strongly they interact with the sawdust surface (Macena et al. 2025). As a result, nickel is less effectively adsorbed compared to metals like iron and zinc.

## 5. CONCLUSIONS

This study examines the application of neem sawdust as an effective adsorbent for treating heavy metals in effluent generated from the automobile industry. The results showed that the pH of the wastewater improved, shifting from acidic to more neutral values after treatment. Heavy metals such as zinc, iron, and chromium exhibited notable reductions, with the effluent becoming completely free of cadmium after treatment. Copper and nickel concentrations were also significantly reduced.

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