

# Advancements in Heavy Metal Removal from Industrial Wastewater: Exploring Low - Cost Adsorption Techniques and Chemically Enhanced Adsorbents

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**Abstract:** *The present study reviews, various heavy metals, their sources and need for heavy metals removal from the polluted and industrial wastewater. Various ill effects of heavy metals. Different techniques to remove heavy metals from the polluted and industrial wastewater. Adsorption as a more convenient, economical technique for the removal of heavy metals for the small - scale industries. Low - cost adsorbents. Chemically treated adsorbents with their effect on adsorption rate.*

**Keywords:** Heavy metals, low - cost adsorbents, adsorption, industrial wastewater

## 1. Introduction

Water is very essential for industries, microorganisms, plants and human being for drinking, cleaning and washing. Industries utilize water for different operations like cleaning, dilution, cooling, steam generation, washing, curing etc. Agriculture field also consume a large quantity of water for irrigation. The water may be utilized from its various sources like lakes, rivers, streams, ponds, groundwater, rain etc. The largest and major source of water is rain. This is purest water source but it becomes impure and inconvenient for industrial applications, irrigation, domestic use and for various living thing on this universe. The contamination of colloidal matter, dissolved gases, suspended matter, dissolved salts, biological matter, microorganisms, chemicals etc. makes rainwater unsuitable for above said purposes. This rainwater due to contact with various rocks and polluted and non - treated discharge from various chemical, pharmaceutical, food, mechanical, paint, fabrics, processing, electronic etc. industries contain various heavy metals. Such heavy metals contain water is not suitable for different applications and it may causes some ill effects also. So such metals needs to remove from this polluted water by any suitable and economical technique.

### Heavy Metals and Their Sources

Mn, Zn, Ni, Cu, <sup>1</sup> Cd, Hg, Cr, Pb, As, Fe, Ti etc. heavy metals are found in polluted and industrial wastewater. Each heavy metal has its own tolerance limit beyond this limit they cause different ill effects. Their sources are also different. Tolerance limit, sources and some ill effects of some heavy metals are.

#### 1) Pb:

MPL: 0.05 mg L<sup>-12</sup>

Sources: Lead, batteries, paint, printing, glass industries etc.  
Ill effects: Anemia, central nervous system, headache, <sup>3</sup>liver, reproductive system, destruction in kidney, brain etc.

#### 2) Ni:

MPL: 0.1 mg L<sup>-1</sup>

Sources: Electroplating, batteries manufacturing, mining, Metal finishing and Forging industries etc.

Ill effects: Diarrhoea, damage to lungs, kidneys, vomiting, Skin dermatitis, Anemia<sup>4</sup> etc.

#### 3) As:

MPL: 0.06mg L<sup>-1</sup>

Sources: Fertilizers industries. Ceramic, pesticides, dyes, metallurgical, detergents, glasswares industries etc.

Ill effects: Black foot disease, diarrhea, vomiting, cancer etc.

#### 4) Hg:

MPL: 0.1mg L<sup>-1</sup>

Sources: Cosmetics, paints, fertilizers, batteries, pulp and paper, oil refining industries, pesticides, pharmaceuticals industries etc.

Ill effects: Cerebral palsy and convulsions, mental retardation, genetic defects, chest pain etc.

#### 5) Cr:

MPL: 0.05 mg L<sup>-12</sup>

Sources: Electroplating, tanning, Leather, textile, dyeing industries etc.

Ill effects: Ulcer, Edema, Carcinogenic, skin irritation, liver damage etc.

#### 6) Cu:

MPL: 2 mg L<sup>-15</sup>

Sources: Electroplating and PCB industries etc.

Ill effects: Skin, brain, heart, carcinogenic, accumulation in the kidneys, hemochromatosis, gastrointestinal problems etc. (MPL: Maximum Permissible Limit)

## 2. Techniques

There are various techniques to remove heavy metals from polluted and industrial wastewater. Ion exchange,<sup>6</sup> membrane separation, solvent extraction, chemical

precipitation, coagulation, adsorption etc. are few of them. Adsorption, reverse osmosis and ion exchange methods can be used for dilute concentrations of the metals.<sup>7</sup> Among this adsorption technique is more convenient and economical.

#### Adsorption Technique and Low - Cost Adsorbents:

Most of the above said techniques have some merits and demerits like some are generate sludge, some are expensive, initial investment is very high, running cost is very high etc. Few techniques are simple and in which there is possibility of metal recovery also. In comparison to above techniques adsorption technique is more convenient and economical. This technique is ecofriendly because generally natural adsorbents are used which are available free of cost or very cheap. It is low - cost technique. Its efficiency is very high. Quality of treated water is very high. For it space required is less. It needs simple equipment. It is very easy to operate. Noanytype of sludge is formed. It is suitable for toxic pollutants also.

Any easily available and low - cost adsorbent is used in this technique. Few such adsorbents are, Tea waste, Prosopis spicegera, Jute stick, by - products from different industries, Jambhool, wool, green tea, Potato husk, activated red mud, Apple Pomace, waste building materials, Coffee,<sup>8</sup> Hydroxides of aluminium and iron, Ratrani leaf, Almond husk, feathers, Ashoka leaf, hairs, Coconut husk, Cassia Siamea, Date tree leaves, activated carbon, Algae, ores, Cashew nut shells, bagasse, Syzygium cumini, Sunnhemp, albumin, waste rubber, Jute<sup>9</sup>etc.

#### Chemically Treated Adsorbents:

To increase the adsorption efficiency alkali and acid treated adsorbents can be used.  $\text{HNO}_3$ ,  $\text{HCl}$ ,  $\text{H}_3\text{PO}_4$ ,  $\text{H}_2\text{SO}_4$  as acids and  $\text{Ca}(\text{OH})_2$ ,  $\text{KOH}$ ,  $\text{NaOH}$  as alkali can be used for this purpose.

#### Applications of Adsorption Technique:

- 1) Purification of enzymes<sup>10</sup>
- 2) Decolourisation and purification<sup>11</sup>
- 3) Recovery of dyes from dilute solution<sup>12</sup>
- 4) Removal of dyes from industrial wastewater
- 5) Separation of gas mixture
- 6) Heavy metals removal from industrial wastewater and polluted water.

### 3. Conclusion

In all methods adsorption is effective, easy, low - cost technique for the removal of heavy metals from any polluted water.

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