Original Research Article
ISSN: 2583-7419
Journal homepage: biologyforum.actabotanica.org

Heavy metals remediation in wastewater and groundwater by metal oxides, activated charcoal, and EDTA

Kuna Gayathri*[1] and Jayanth Chapla[2]

Department of Environmental Science, University College of Science, Osmania University, India

Citation: Kuna Gayathri and Jayanth Chapla (2024). Heavy metals remediation in wastewater and groundwater by metal oxides, activated charcoal, and EDTA. *Acta Biology Forum*. **DOI: https://doi.org/10.51470/ABF.2024.3.3.30**

Corresponding Author: **Kuna Gayathri** | E-Mail: **(kunagayathri@yahoo.com)**

Received 25 September 2024 |Revised 20 October 2024 |Accepted 22 November 2024 |Available Online 19 December 2024

ABSTRACT

Heavy metal pollution load reduction is achieved by using EDTA, metal oxide and activated charcoal individually in water and wastewater samples. In recent advanced treatment involved using the combination of two or more techniques for remediation. The study focuses on the performance evaluation of treatment by combining metal oxides, EDTA, and activated charcoal. Ethylene diamine tetra acetic acid (EDTA) is an excellent chelating agent, as it contains two amino groups and four carboxyl groups used as the binding sites of metal ions. Activated charcoal possesses a high surface area for adsorption, which removes metal ions by adsorption phenomenon. Evaluation of efficiency for removal of heavy metal by varying the pH concentration, contact time, and temperature in water samples. Batch studies were carried out to assess the suitable conditions required for remediation. Effective Remediation of heavy metals in groundwater is achieved with a high concentration of activated charcoal, EDTA, metal oxides for Zn, B, Cu, Cr and decreasing order as Zn > B > Cu > Mn > Pb > Cr > As > Al. By reducing the concentration of activated charcoal, EDTA, and metal oxides for heavy metals in groundwater the effect of treatment is found more for Pb, As, Mn and the decreasing order of reduction follows as Mn > Zn > B > Cu > Pb > As > Al > Cr. Aluminum concentration is not affected by both high and low concentrations. The Reduction of metal concentration in wastewater is more with a high concentration of activated charcoal, EDTA, and metal oxides. all metals Zn, B, Mn, Cu, Pb, As, Al, except chromium, and order of remediation Zn > B > Mn > Cu > Pb > As > Al > Cr. When compared to a higher concentration of activated charcoal, EDTA, and metal oxides to lower in wastewater, all studied metals are reduced excellently at higher levels only. Reduction of heavy metal load in groundwater and wastewater, high and low concentrations of activated charcoal, EDTA, and metal oxides raised by increasing the contact time and temperature. Based on the present study, the remediation efficiency of heavy metals elevated more at 4 days of contact time, next at 40°C and the same day.

Keywords: *Heavy metal remediation, Activated charcoal, EDTA, Metal oxides, Adsorption*

1. Introduction

Water contamination due to heavy metals is a pressing environmental concern, impacting both groundwater and wastewater systems [1]. Heavy metals such as copper (Cu), chromium (Cr), lead (Pb), arsenic (As), manganese (Mn), zinc (Zn), boron (B), and aluminum (Al) pose significant risks to human health and the ecosystem when present in excess concentrations [2]. These metals originate from various anthropogenic activities, including industrial discharges, agricultural runoff, and improper waste disposal. Given the toxicological effects associated with heavy metal exposure, developing efficient and cost-effective treatment methods remains a key priority in water resource management.

Ethylene diamine tetra acetic acid (EDTA) is an excellent chelating agent [3]. It has 6 lone pairs of electrons (two nitrogen atoms and four oxygen atoms), which can participate in the formation of coordinate bonding with metal ions (hexadentate ligand).

$Mn+ + EDTA \rightarrow Metal - EDTA$

Activated carbon (also called activated charcoal, activated coal, or active carbon) is a very useful adsorbent. Due to their high surface area, pore structure, and high degree of surface reactivity. Activated carbons, possess sorption capacity [4]. Metal oxides are crystalline solids that contain a metal cation and an oxide anion. They typically react with water to form bases or with acids to form salts. Most of Earth's crust contains metal oxides. Calcium oxide, also known as quick is lime, lime water, with the formula CaO. Calcium oxide is composed of one calcium (Ca) atom and one oxygen (O) atom, with a chemical formula of CaO. Magnesium oxide is an inorganic compound with the formula MgO, formed by the reaction of magnesium and oxygen [5]. MgO possesses ionic bonding, where magnesium donates two electrons to oxygen, resulting in a strong electrostatic attraction between the resulting Mg^{+2} and O^{-2} ions. Chromium trioxide is a very strong oxidizing agent, especially for organic matter. Sodium acetate trioxide is used for remediation.

Objectives of the Study

The study aimed to assess metal concentration variations before and after treatment.Metal oxides, activated charcoal, and EDTA are added to samples with heavy metals, and found reduction in heavy metal concentration. Chelation and adsorption processes are combined to achieve a major reduction of heavy metals. The adsorption is affected by various parameters like pH, temperature, time of contact, and concentration. The primary objective of this study is to evaluate and compare the effectiveness of High charcoal- EDTA–Metal oxide (HCEM) concentration and low charcoal- EDTA–Metal oxide concentration (LCEM) treatment methods in the removal of

heavy metals from groundwater and wastewater. The present article focuses on the effectiveness of the remediation process by varying the HCEM and LCEM concentrations, and changing in contact time and temperatures [6].

The study aims to:

1. Assess the reduction efficiency of HCEM and LCEM methods for specific heavy metals.

2. Compare the performance of these treatment methods across different water sources.

3. Provide insights into optimizing these methods for enhanced water purification.

Scope of the Study

Pashamylaram village is located in the Patancheru mandal of Medak district in Telangana, India. The study area lies in latitude 17° 31' to 17° 32' north and longitude 78° 10' to 78° 11' 24" east. This study focuses on groundwater and wastewater samples collected from seven different stations (GW-1 to GW-7 for groundwater and WW-1 to WW-7 for wastewater).

2. Methodology

The study involved sample collection from seven stations (GW-1 to GW-7 and WW-1 to WW-7), analysis, treatment, and data interpretation to evaluate the remediation process. The groundwater and wastewater samples are collected and analyzed as per standard protocol [7].

Remediation Design: Ground water (GW) and wastewater (WW) samples are analyzed for the physicochemical, microbial, heavy me,tals and metal concentration in collected samples.

HCEM: To one-liter sample of both GW and WW add 3g of activated charcoal, 40ml 1M EDTA and 3 g of metal oxide (CaO, MgO, sodium acetate trioxide, and 0.005g chromium oxide). Form 1L, 250 ml kept aside for 5 hr , and 250ml HCEM from above are placed in the oven at 40°C for 23 hr and under UV light for 30 minutes for enhancing the remediation process, and both are filtered with GF/A - Whatman glass fiber filters and analyzed the heavy metal concentration. Left 500 ml of HCEM are placed aside for 4 days, and the treated sample and find the heavy metals concentration [8].

LCEM: To one liter sample of both GW and WW, add 2g of activated charcoal, 20ml 0.5M EDTA, and 1 g of metal oxide (CaO, MgO, sodium acetate trioxide, and 0.005 g of chromium oxide). From this, 250 ml were separated and placed for 5hrs and remaining 250ml LCEM from the above treatment are kept in oven at 40 °C for 23 hr and under UV light for 30 minutes for enhancing the remediation process and both are Filtered with GF/A - Whatman glass fiber filters and analyzed the heavy metal concentration. Left 500 ml of LCEM are placed aside for 4 days, and filtered the treated sample and find the reduction of heavy metals.

The collected samples were subjected to different treatment conditions:

(A) immediate application of HCEM and LCEM, (B) placing the samples to 40°C, and (C) allowing the samples to settle for four days post-treatment to observe long-term effects. The treated samples were then analyzed for heavy metal concentrations to determine removal efficiency [9].

Heavy metal concentrations (copper, chromium, lead, arsenic, manganese, zinc, boron, and aluminum) were determined using Atomic Absorption Spectroscopy (AAS).

The measurements were performed before and after treatment to assess removal efficiency. To ensure the accuracy and reliability of measurements, calibration curves for each metal were prepared, using standard solutions, and blanks and control samples were analyzed to check for contamination. The performance of HCEM and LCEM treatments was compared to identify the most effective method for heavy metal removal. Variations in efficiency across different metals and treatment conditions were evaluated [10].

The experimental analysis is conducted under three distinct conditions: Condition A: Treatment conducted on the same day, Condition B: Treatment after heating to 40 °C.and Condition C: Treatment after four days.

The concentrations of key heavy metals are measured before and after treatment to determine the effectiveness of HCEM and LCEM methodologies. Additionally, the study explores variations in removal efficiency based on initial contamination levels and external treatment conditions.

3. Results and Discussions

The treatment of groundwater across seven stations (GW-1 to GW-7) under different conditions (A: same day, B: after 40°C treatment, and C: after 4 days) highlights the effectiveness of HCEM (High Charcoal, EDTA, Metal Oxide) treatment for various metal contaminants. Copper (Cu) levels showed a significant decline after treatment, with GW-1 initially containing 4.1 mg/L and dropping to 0.06 mg/L after four days. A similar trend was observed in other stations, with GW-7 reducing from 1.9 mg/L to just 0.03 mg/L. Chromium (Cr), however, remained largely unaffected by the treatment, with GW-7 exhibiting the highest concentration at 8.9 mg/L, which did not decrease significantly even after four days [11].

Lead (Pb) levels showed a noticeable decline, particularly in GW-5 and GW-7. For instance, GW-5 started at 3.7 mg/L and dropped to 1.02 mg/L, while GW-7 decreased from 4.3 mg/L to 1.18 mg/L. In contrast, arsenic (As) showed minimal reduction across all stations, with values remaining nearly the same after treatment. GW-1, for example, started at 0.9 mg/L and only slightly decreased to 0.83 mg/L. Manganese (Mn) was effectively reduced through HCEM treatment, with GW-1 decreasing from 2.9 mg/L to just 0.05 mg/L, and GW-2 dropping from 4.8 mg/L to 0.08 mg/L. Zinc (Zn) followed a similar trend, with most stations showing a sharp reduction to undetectable levels after treatment. GW-1, which initially had 5.5 mg/L of zinc, became nearly free of the metal after four days [12].

Boron (B) was also successfully removed in most stations. GW-1, which had an initial concentration of 1.25 mg/L, dropped significantly to 0.029 mg/L, while GW-2 and GW-3 saw boron levels reduced to undetectable amounts. Aluminium (Al), on the other hand, showed minimal changes after treatment, with GW-7 having the highest levels at 4.7 mg/L and only slightly reducing to 4.54 mg/L.

Based on the results obtain the effective reduction of heavy metals like Cu, Cr, Zn and B maximum by HCEM treatment as shown in below Figure. No.1.0

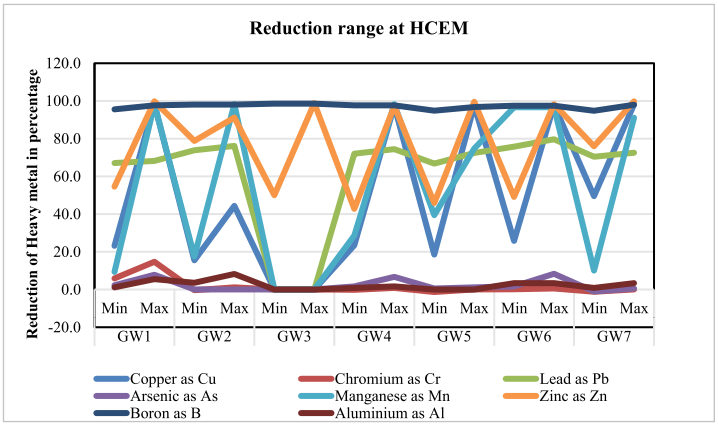

Figure.No.1.0 Reduction range of Each Metal at HCEM for GW1 to GW-7

3.1. Heavy metal removal from Ground water by LCEM method

The heavy metal concentrations in seven groundwater samples (GW-1 to GW-7) were measured in mg/L after LCEM treatment under three similar conditions as done above.

For copper, the LCEM treatment generally results in a reduction, with GW-3 showing no detectable levels across all three conditions, while GW-5 and GW-6 display higher concentrations under certain conditions. Chromium similarly is absent in GW-3, but GW-7 consistently records the highest values, with little variation between conditions A, B, and C. Lead, which is undetectable in GW-3, shows significant reductions post-treatment overall; however, GW-6 still exhibits the highest lead concentration. Arsenic follows a similar pattern with GW-3 again showing no detectable presence and GW-6 reaching up to 1.9 mg/L, despite only modest reductions observed after treatment.

Manganese is nearly completely removed in GW-5 and GW-6 across all conditions, whereas GW-1 and GW-4 exhibit only minimal reductions. Zinc levels are very low in GW- 3, yet remain highest in GW-6 even after treatment under conditions A, B, and C. Boron starts with its highest concentration in GW-1 but is reduced across the conditions, with GW-5 and GW-6 displaying particularly low values. Aluminium shows minimal reduction overall, remaining almost absent in GW-3 while being highest in GW-6, regardless of whether the treatment is conducted immediately, at 40°C, or after 4 days. Based on the results obtain the effective reduction of heavy metals like Pb, As, Mn maximum by LCEM treatment as shown below Figure. No. 1.1

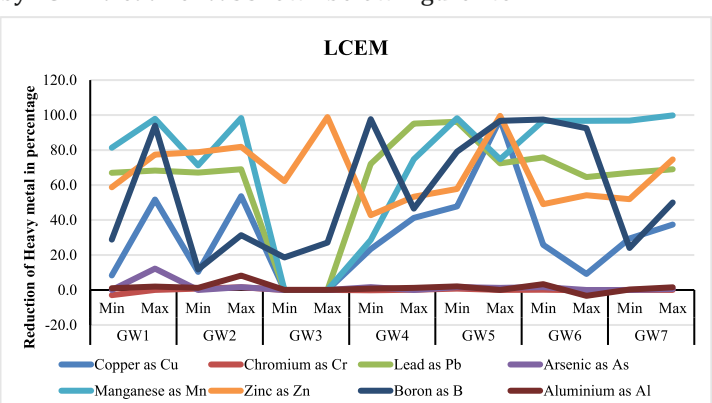

Figure.No.1.1 Reduction range of Each Metal at CEM for GW1 to GW-7

The wastewater quality across seven stations (WW-1 to WW-7), were analysed metal contaminant levels before and after HCEM (High Charcoal, EDTA, Metal Oxide) treatment. The treatment effects were evaluated under similar conditions as above. Copper concentrations decreased significantly after HCEM treatment. WW-1 initially contained 1.5 mg/L, reducing to 1.28 mg/L after four days. The most drastic decline was observed in WW- 5, where copper dropped from 0.9 mg/L to undetectable levels (<0.01 mg/L). Similarly, WW- 6 and WW-7 showed copper levels becoming undetectable after treatment. However, in WW-2, the concentration decreased from 2.4 mg/L to 0.045 mg/L, indicating that HCEM was highly effective in most cases.

Unlike copper, chromium levels remained largely unchanged. WW-1 started at 2.0 mg/L and slightly decreased to 1.97 mg/L after four days. WW-2, which had the highest initial chromium concentration (4.8 mg/L), showed a minor decline to 4.58 mg/L. WW-3 and WW-5 also displayed minimal reduction. These results indicate that HCEM treatment was ineffective in significantly reducing chromium contamination. Lead levels were significantly reduced across all stations. WW-1 decreased from 3.8 mg/L to 0.15 mg/L, while WW-2 dropped from 2.5 mg/L to 0.82 mg/L. WW-3, WW-4, and WW-5 also exhibited sharp reductions, with final lead concentrations reaching minimal levels. WW-7, however, retained 0.2 mg/L of lead even after four days, suggesting incomplete removal. Arsenic levels remained nearly constant across all stations. WW-1 had 0.5 mg/L, and after treatment, the concentration stayed at 0.5 mg/L. Similarly, WW-2 started at 1.3 mg/L and was only slightly reduced to 1.04 mg/L. WW-6 and WW-7 also showed negligible changes.

These findings indicate that HCEM does not effectively remove arsenic. HCEM treatment was highly effective in removing manganese. WW-1 saw a significant reduction from 1.7 mg/L to 1.08 mg/L. WW-2, which initially contained 4.9 mg/L, dropped drastically to 0.08 mg/L. The most notable reduction was observed in WW-6, where manganese decreased from 1.9 mg/L to just 0.03 mg/L. This suggests that HCEM is highly efficient in manganese removal.

Zinc levels decreased significantly after treatment. WW-1 started at 4.3 mg/L and was reduced to 3.32 mg/L after four days. WW-2, which initially contained 3.3 mg/L, showed a sharp decline to 0.02 mg/L. Similarly, WW-6 dropped from 5.3 mg/L to 0.04 mg/L. These results confirm that HCEM treatment is highly effective in removing zinc from wastewater. Boron concentrations were almost eliminated after treatment. WW-1 had an initial concentration of 1.5 mg/L, which became undetectable after treatment. WW-3, WW-4, and WW-5 also showed similar trends, with boron dropping to nearly 0.01 mg/L or less.

These results indicate HCEM is very effective in boron removal. Aluminum levels remained relatively stable, with minimal reductions. WW-1 started at 0.5 mg/L and slightly changed to 0.45 mg/L. WW-5 had the highest aluminum concentration (4.2 mg/L), which decreased to 3.5 mg/L after treatment. The negligible reduction suggests that HCEM is not highly effective in aluminum removal. Except chromium major reduction occurs at HCEM waste water samples as below Figure.No.1.2

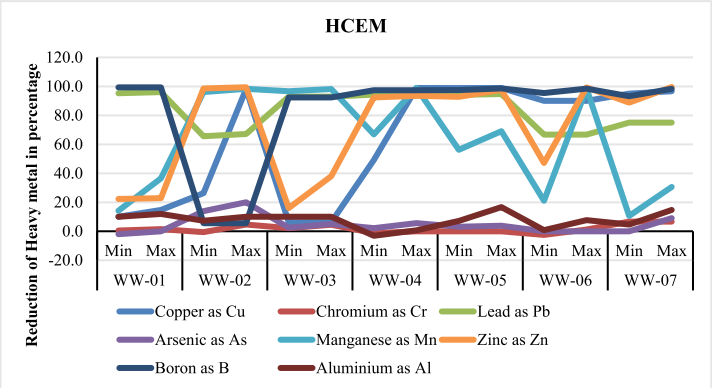

Figure.No.1.2 Reduction range of Each Metal at LCEM for WW1 to WW-7

Heavy metal removal from wastewater by LCEM method

The wastewater quality across seven stations (WW-1 to WW-7), was evaluated metal contaminant levels before and after LCEM (Low Charcoal, EDTA, Metal Oxide) treatment. The treatment impact is analyzed. Copper concentrations showed a moderate reduction after LCEM treatment. WW-1 started at 1.5 mg/L, decreasing to 1.33 mg/L after four days. WW-2 had 2.4 mg/L, which slightly declined to 2.15 mg/L. The most significant drop was observed in WW-6, where copper levels went from 0.1 mg/L to undetectable (<0.01 mg/L) after four days. Overall, while LCEM helped in reducing copper levels, it did not achieve complete removal in most stations.

Chromium levels remained largely unchanged across all stations. WW-1 had an initial concentration of 2.0 mg/L, which only dropped marginally to 1.99 mg/L after four days. Similarly, WW-2 started at 4.8 mg/L and showed minimal reduction, ending at 4.79 mg/L. The persistence of chromium suggests that LCEM is not highly effective in removing chromium. Lead levels saw a substantial decrease in most stations. WW-1, for example, had 3.8 mg/L initially but dropped significantly to 0.54 mg/L after four days. WW-2 also experienced a significant reduction from 2.5 mg/L to 0.31 mg/L. WW-5 and WW-6 showed the most drastic decline, with lead levels reaching 0.07 mg/L after treatment. However, trace amounts remained in some stations, indicating that LCEM is effective but does not completely remove lead.

Arsenic concentrations showed negligible changes, indicating that LCEM had little effect on its removal.

WW-1 initially had 0.5 mg/L and actually increased slightly to 0.52 mg/L after same-day treatment before stabilizing at 0.51 mg/L. WW-2, which started at 1.3 mg/L, only dropped slightly to 1.22 mg/L after four days. Most stations displayed little to no reduction, confirming that LCEM is ineffective in arsenic removal

LCEM treatment had minimal impact on manganese concentrations. WW-1 started at 1.7 mg/L and showed only a slight decrease to 1.43 mg/L after four days. WW-3, which had the highest manganese level at 6.2 mg/L, was only reduced to 6.04 mg/L. These results suggest that LCEM is not effective in significantly lowering manganese levels.

Unlike other metals, zinc levels remained almost unchanged after treatment. WW-1 initially contained 4.3 mg/L, but even after four days, the level was still 4.27 mg/L. WW-2 showed a similar trend, decreasing only slightly from 3.3 mg/L to 3.28 mg/L. The minimal reduction suggests that LCEM does not effectively remove zinc from wastewater. Boron concentrations saw some reduction but remained measurable. WW-1 started at 1.5 mg/L and slightly dropped to 1.49 mg/L after four days. WW-3, which initially contained 0.13 mg/L, was reduced to 0.11 mg/L. While a small decrease was observed, LCEM treatment did not eliminate boron effectively. Aluminum concentrations showed minor fluctuations, but overall, there was no significant reduction. WW-1 had 0.5 mg/L, which remained at 0.48 mg/L after four days. WW-5, which contained 4.2 mg/L initially, slightly dropped to 4.19 mg/L. The lack of major reduction indicates that LCEM is not suitable for aluminum removal.. Except Lead no major reduction occurs at HCEM waste water samples as below Figure.No.1.2

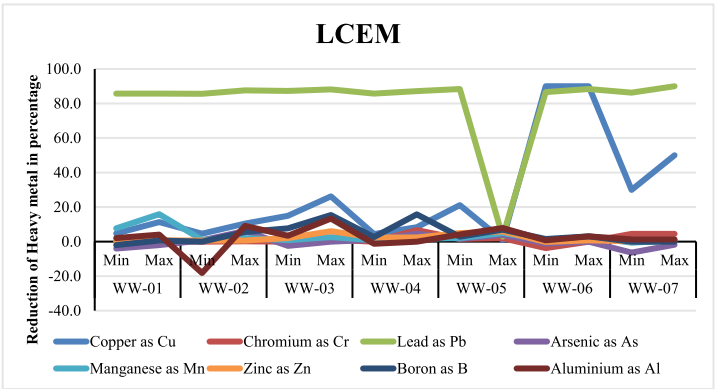

Figure.No.1.3 Reduction range of Each Metal at LCEM for WW1 to WW-7

Table:3.1.Heavy metal removal from Groundwater by HCEM method

S. No	Parameters	Units	GW-1	A	B	C	GW-2	A	B	C	GW-3	A	B	C	GW-4	A	B	C	GW-5	A	B	C	GW-6	A	B	C	GW-7	A	B	C
1	CopperasCu	mg/L	4.1	3.15	0.06	0.06	5.3	4.48	3.88	2.95	0	0	0	0	3.2	2.45	0.08	0.08	5.5	4.48	0.13	0.13	2.4	1.78	0.05	0.05	1.9	0.96	0.03	0.03
2	ChromiumasCr	mg/L	3.4	3.1	3.2	2.9	2.6	2.61	2.59	2.57	0	0	0	0	6.2	6.21	6.15	6.15	5.3	5.37	5.3	5.3	7.4	7.39	7.36	7.36	8.9	9	8.9	8.9
3	LeadasPb	mg/L	1.7	0.56	0.54	0.54	2.1	0.55	0.5	0.5	0	0	0	0	2.9	0.81	0.74	0.74	3.7	1.23	1.05	1.02	3.1	0.75	.0.63	.0.63	4.3	1.27	1.2	1.18
4	ArsenicasAs	mg/L	0.9	0.88	0.83	0.83	0.6	0.6	0.6	0.6	0	0	0	0	1.2	1.18	1.12	1.12	1.7	1.69	1.68	1.68	0.6	0.55	0.59	0.59	1.9	1.92	1.89	1.89
5	ManganeseasMn	mg/L	2.9	2.63	0.05	0.05	4.8	3.96	1.38	0.08	0	0	0	0	6.5	4.64	0.11	0.11	4.8	2.91	1.33	1.21	0.3	<0.01	<0.01	<0.01	5.3	4.77	0.47	0.47
6	ZincasZn	mg/L	5.5	2.5	<0.01	<0.01	4.2	0.89	0.37	0.42	0.9	0.45	<0.01	<0.02	1.8	1.03	0.09	0.05	2.2	1.19	<0.01	<0.01	6.5	3.31	0.16	0,11	4.7	1.13	<0.01	<0.01
7	BoronasB	mg/L	1.25	0.056	0.056	0.029	0.51	<0.01	<0.01	<0.01	0. 7	<0.01	<0.01	<0.01	0.43	<0.01	<0.01	<0.01	1.04	0.05	0.03	0.04	0.4	<0.01	<0.01	<0.01	0.5	0.03	<0.01	<0.01
8	AluminiumasAl	mg/L	4.2	4.15	3.97	3.97	1.7	1.64	1.59	1.56	0	0.01	0.01	0.01	2.4	2.38	2.36	2.36	1.1	1.1	1.1	1.1	0.3	0.29	0.29	0.29	4.7	4.66	4.54	4.54

Table:3.2.Heavy metal removal from Groundwater by LCEM method

S.No	Parameters	Units	GW-1	A	B	C	GW-2	A	B	C	GW-3	A	B	C	GW-4	A	B	C	GW-5	A	B	C	GW-6	A	B	C	GW-7	A	B	C
1	CopperasCu	mg/L	4.1	3.76	2.74	1.98	5.3	4.75	4.19	2.46	0	0	0	0	3.2	1.88	1.67	1.67	5.5	4.98	4.67	2.65	2.4	2.18	2.04	2.04	1.9	1.34	1.19	1.19
2	Chromium as Cr	mg/L	3.4	3.5	3.41	3.4	2.6	2.58	2.56	2.56	0	0	0	0	6.2	6.19	6.15	6.15	5.3	5.28	5.26	5.3	7.4	7.41	7.38	7.38	8.9	8.9	8.9	8.9
3	LeadasPb	mg/L	1.7	0.56	0.54	0.54	2.1	0.69	0.65	0.65	0	0	0	0	2.9	0.14	0.11	0.11	3.7	1.17	0.98	0.98	3.1	1.1	0.87	0.87	4.3	1.42	1.33	1.33
4	ArsenicasAs	mg/L	0.9	0.9	0.8	0.79	0.6	0.6	0.59	0.59	0	0	0	0	1.2	1.2	1.18	1.18	1.7	1.69	1.68	1.68	0.6	0.6	0.59	0.59	1.9	1.9	1.89	1.89
5	ManganeseasMn	mg/L	2.9	0.54	0.34	0.06	4.8	0.82	1.38	0.08	0	0	0	0	6.5	1.64	0.12	0.12	4.8	0.82	0.09	0.09	0.3	<0.01	<0.01	<0.01	5.3	0.17	<0.01	<0.01
6	ZincasZn	mg/L	5.5	2.27	1.24	1.24	4.2	0.89	0.76	0.76	0.9	0.34	<0.01	<0.02	1.8	0.84	0.76	0.76	2.2	1.19	<0.01	<0.01	6.5	2.98	0.13	0.1	4.7	2.26	1.19	1.19
7	BoronasB	mg/L	1.25	0.89	0.75	0.075	0.51	0.45	0.35	0.35	0. 7	0,57	0.51	0.51	0.43	0.23	0.12	0.09	1.04	0.83	0.56	0.56	0.4	<0.01	<0.02	<0.03	0.5	0.38	0.25	0.25
8	AluminiumasAl	mg/L	4.2	4.16	4.12	4.12	1.7	1.68	1.65	1.56	0	0.01	0.01	0.01	2.4	2.37	2.35	2.35	1.1	1.05	1	1	0.3	0.31	0.29	0.29	4.7	4.69	4.63	4.63

Table:3.3.Heavy metal removal from Wastewater by HCEM method

S. No	Parameters	Units	WW-1	A	B	C	WW-2	A	B	C	WW-3	A	B	C	WW-4	A	B	C	WW-5	A	B	C	WW-6	A	B	C	WW-7	A	B	C
1	Copper asCu	mg/L	1.5	1.35	1.28	1.28	2.4	1.77	1.23	0.045	0.8	0.75	0.75	0.75	3.7	1.88	0.04	0.04	0.9	<0.01	<0.01	<0.01	0.1	<0.01	<0.01	<0.01	0.3	0.015	<0.01	<0.01
2	ChromiumasCr	mg/L	2	1.99	1.97	1.97	4.8	4.83	4.74	4.58	0.9	0.86	0.88	0.88	1.5	1.5	1.52	1.5	1.6	1.6	1.6	1.6	0.8	0.79	0.82	0.82	0.9	0.84	0.84	0.84
3	LeadasPb	mg/L	3.8	0.18	0.15	0.15	2.5	0.86	0.85	0.82	1.1	0.078	0.078	0.078	0.7	0.04	0.03	0.03	1.9	0.11	0.1	0.1	0.6	0.2	0.2	0.2	0.8	0.2	0.2	0.2
4	ArsenicasAs	mg/L	0.5	0.51	0.5	0.5	1.3	1.12	1.06	1.04	0.4	0.38	0.39	0.39	0.9	0.85	0.88	0.88	1.6	1.55	1.54	1.54	0.9	0.9	0.9	0.9	1.1	1	1.1	1
5	ManganeseasMn	mg/L	1.7	1.46	1.21	1.08	4.9	0.19	0.08	0.08	6.2	0.21	0.18	0.11	3.8	0.05	0.04	1.26	2.1	0.92	0.78	0.65	1.9	1.5	0.03	0.03	1.7	1.52	1.18	1.18
6	ZincasZn	mg/L	4.3	3.34	3.32	3.32	3.3	0.045	0.02	0.02	0.5	0.42	0.37	0.31	4.1	0.27	0.31	0.31	4.9	0.35	0.12	0.17	5.3	2.8	0.82	0.04	4.8	0.54	0.02	0.02
7	BoronasB	mg/L	1.5	<0.01	<0.01	<0.01	0.18	0.17	0.17	0.17	0.13	<0.01	<0.01	<0.01	0.38	<0.01	<0.01	<0.01	0.72	0.018	<0.01	<0.01	0.65	0.03	0.02	<0.01	0.59	0.04	<0.01	<0.01
8	AluminiumasAl	mg/L	0.5	0.44	0.45	0.45	1.1	1.02	0.99	0.99	0.3	0.27	0.27	0.27	1.6	1.65	1.64	1,59	4.2	3.9	3.5	3.5	1.3	1.29	1.2	1.2	1.5	1.43	1.28	1.32

Table:3.4.Heavy metal removal from Wastewater by LCEM method

S.No	Parameters	Units	WW-1	A	B	C	WW-2	A	B	C	WW-3	A	B	C	WW-4	A	B	C	WW-5	A	B	C	WW-6	A	B	C	WW-7	A	B	C
1	Copper asCu	1.5	1.43	1.33	1.33	2.4	2.29	2.15	2.15	0.8	0.68	0.59	0.59	3.7	3.54	3.39	3.39	0.9	0.77	0.71	0.71	0.1	<0.01	<0.01	<0.01	0.3	0.21	0.15	0.15	1.5
2	Chromiumas Cr	2	2	1.99	1.99	4.8	4.8	4.79	4.79	0.9	0.89	0.9	0.9	1.5	1.4	1.5	1.5	1.6	1.61	1.63	1.63	0.8	0.83	0.8	0.8	0.9	0.86	0.86	0.86	2
3	LeadasPb	3.8	0.54	0.54	0.54	2.5	0.36	0.31	0.31	1.1	0.14	0.13	0.13	0.7	0.1	0.09	0.09	1.9	0.27	0.22	0.22	0.6	0.08	0.07	0.07	0.8	0.11	0.09	0.08	3.8
4	ArsenicasAs	0.5	0.52	0.51	0.51	1.3	1.29	1.22	1.22	0.4	0.41	0.4	0.4	0.9	0.89	0.86	0.86	1.6	1.64	1.61	1.61	0.9	0.91	0.9	0.9	1.1	1.17	1.12	1.12	0.5
5	Manganeseas Mn	1.7	1.57	1.43	1.43	4.9	4.85	4.8	4.8	6.2	6.15	6.04	6.04	3.8	3.77	3.74	3.74	2.1	2.08	2.1	2.1	1.9	1.88	1.85	1.85	1.7	1.71	1.69	1.69	1.7
6	ZincasZn	4.3	4.29	4.27	4.27	3.3	3,28	3,28	3,28	0.5	0.49	0.47	0.47	4.1	4	4	4	4.9	4.85	4.85	4.85	5.3	5.31	5.26	5.26	4.8	4.79	4.75	4.75	4.3
7	BoronasB	1.5	1.53	1.49	1.49	0.18	0.18	0.17	0.17	0.13	0.12	0.11	0.11	0.38	0.37	0.35	0.32	0.72	0.71	0.7	0.7	0.65	0.64	0.63	0.63	0.59	0.59	0.59	0.59	1.5
8	Aluminumas Al	0.5	0.49	0.48	0.48	1.1	1.3	1	1	0.3	0.29	0.26	0.26	1.6	1.62	1.6	1.6	4.2	4.17	4.19	4.19	1.3	1.29	1.26	1.26	1.5	1.48	1.48	1.48	0.5

**A(sameday),B(after40°C),andC(after4days)*
**HCEM= HighCharcoal,EDTA,MetalOxide*
**LCEM=LowCharcoal,EDTA,MetalOxide*
**WW=Wastewater,GW=Groundwater*

4. Conclusions

The study evaluated the effectiveness of HCEM and LCEM treatments for groundwater and wastewater quality improvement. In groundwater treatment, HCEM was highly effective in reducing copper, manganese, zinc, and boron, while lead showed moderate improvement. However, it was less effective in removing chromium, arsenic, and aluminum, which remained largely unchanged. GW-7 exhibited the highest contamination levels, indicating the need for further treatment to bring its quality within acceptable limits. Similarly, LCEM treatment significantly reduced lead, manganese, and zinc concentrations but was less effective for chromium and aluminum. Interestingly, GW-3 consistently showed low metal levels, suggesting that inherent groundwater characteristics might contribute to the reduced presence of these contaminants.

For wastewater treatment, HCEM proved highly effective in removing manganese, zinc, and boron, leading to a notable improvement in water quality. However, itseffectiveness in reducing copper and lead was moderate, and trace amounts remained in certain stations. It was largely ineffective against chromium, arsenic, and aluminum, indicating the need for supplementary treatment methods. WW-2 exhibited consistently higher metal concentrations compared to other stations, emphasizing the necessity for further treatment or alternative solutions at that site. On the other hand, LCEM treatment provided only a moderate reduction in copper and lead levels while having minimal to no effect on chromium, arsenic, manganese, zinc, boron, and aluminum.WW-3 was identified as the most contaminated station, requiring additional or alternative treatment approaches.

Both HCEM and LCEM treatments significantly improve water quality by targeting specific metals, their inefficacy in removing chromium, arsenic, and aluminum suggests that supplementary or alternative treatment methods are necessary for complete purification.

References

1. Zhang, K., Dai, Z., Zhang, W., Gao, Q., Dai, Y., Xia, F. and Zhang, X., 2021. EDTA- based adsorbents for the removal of metal ions in wastewater. *Coordination Chemistry Reviews*, *434*, p.213809.

2. Deliyanni, E.A., Kyzas, G.Z., Triantafyllidis, K.S. and Matis, K.A., 2015. Activated carbons for the removal of heavy metal ions: A systematic review of recent literature focused on lead and arsenic ions. *Open Chemistry*, *13*(1), p.000010151520150087.

3. Al-Qahtani, K.M.A., 2017. Extraction heavy metals from contaminated water using chelating agents. *Oriental journal of Chemistry*, *33*(4), pp.1698-1704.

4. Taman R1, Ossman ME2,3, Mansour MS1 and Farag HA1 (2015). Metal Oxide Nano-particles as an Adsorbent for Removal of Heavy Metals Journal of Advanced Chemical Engineering.

5. Hashim, M. A., Mukhopadhyay, S., Sahu, J. N., & Sengupta, B. (2011). Remediation technologies for heavy metal contaminated groundwater. Journal of environmental management, 92(10), 2355-2388.

6. Mulligan, C. N., Yong, R. N., & Gibbs, B. F. (2001). Remediation technologies for metal-contaminated soils and groundwater: an evaluation. Engineering geology, 60(1-4), 193-207.

7. Madadrang, C. J., Kim, H. Y., Gao, G., Wang, N., Zhu, J., Feng, H., ... & Hou, S. (2012). Adsorption behavior of EDTA-graphene oxide for Pb (II) removal. ACS applied materials & interfaces, 4(3), 1186-1193.

8. Cui, L., Wang, Y., Gao, L., Hu, L., Yan, L., Wei, Q., & Du, B. (2015). EDTA functionalized magnetic graphene oxide for removal of Pb (II), Hg (II) and Cu (II) in water treatment: adsorption mechanism and separation property. Chemical engineering journal, 281, 1-10.

9. Verma, M., Kumar, A., Lee, I., Kumar, V., Park, J. H., & Kim, H. (2022). Simultaneous capturing of mixed contaminants from wastewater using novel one-pot chitosan functionalized with EDTA and graphene oxide adsorbent. Environmental Pollution, 304, 119130.

10. Yadav, S., Yadav, A., Bagotia, N., Sharma, A. K., & Kumar, S. (2021). Adsorptive potential of modified plant-based adsorbents for sequestration of dyes and heavy metals from wastewater-A review. Journal of Water Process Engineering, 42, 102148.

11. Sable, H., Kumar, V., Singh, V., Rustagi, S., Chahal, S., & Chaudhary, V. (2024). Strategically engineering advanced nanomaterials for heavy-metal remediation from wastewater. Coordination Chemistry Reviews, 518, 216079.

12. Khan, F. S. A., Mubarak, N. M., Khalid, M., Walvekar, R., Abdullah, E. C., Mazari, S. A., ... & Karri, R. R. (2020). Magnetic nanoadsorbents' potential route for heavy metals removal—a review. Environmental Science and Pollution Research, 27, 24342-24356.