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Adsorption of Some Heavy Metals from Sewage Water of Internal Departments for Students in Diyala University

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Abstract

This study focuses on treated sewage water in the internal departments of Diyala University, located in the northeastern part of Baghdad City, Iraq, for treatment utilizing indigenous Attapulgite clay, then releasing it into the waterway. Investigating the use of Attapulgite clay to reduce heavy metal ion concentrations (Fe, Ni, Zn, Pb) and suspended solid particles (SS) in effluent water. In addition to reusing treated sewage water to mitigate the environmental hazards associated with polluted water, further industrial applications for Iraqi clays are being explored. Seventy experiments were carried out on effluent water to evaluate the efficacy of Attapulgite clay in filtering wastewater containing high levels of suspended solids (SS) and heavy metal ions. The study revealed a reduction in the concentrations of the selected heavy metal ions from Fe 18, Pb 1.8, Ni 3.6, and Zn 6 ppm to Fe 1.22, Pb 0.36, Ni 0.295, and Zn 0.674 ppm after the implementation of the therapy. Meanwhile, the SS concentration decreased from 0.92 grammes to 0.03 grammes after the aforementioned treatment. The current investigation has produced findings that demonstrate a decrease in clay content and time required for processing.

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1. Introduction

Effective treatment of domestic wastewater is crucial in contemporary urban management [1]. Sewage water refers to the wastewater that includes residual substances generated by home, commercial, industrial, and sanitary facilities, as well as ground, surface, and rainwater. It is defined by its rate of flow, physical environmental conditions, chemical components, and the existence of microorganisms [2]. Wastewater flows, commonly known as sewage, are the wastewater that constitutes the water supply of a residential area. It is composed of more than 98.8% clean water and characterized by its volume or rate of flow, chemical constituents, physical condition, and the bacterial species it supports. Wastewater can be classified into the following categories based on its origin: sanitary, commercial, industrial, agricultural, or surface runoff [3]. Heavy metals are hazardous substances predominantly found in industrial effluent of industrial origin [4]. The ions originate from several industrial processes like dyeing, plating, mining, battery storage, human activities, and electrochemical metal finishing [5]. Discharge of wastewater into streams without effectively removing heavy metals results in the accumulation of these contaminants in groundwater, soil, plants, and sediments [6]. These metals and their ions are non-degradable and hence toxic, making their presence in water potentially hazardous to both public health and the ecosystem [7]. They give rise to several health issues such as pulmonary impairment, Wilson's disease, sleeplessness, dermatitis, renal impairment, nausea, headache, dizziness, chronic asthma, fast respiration, and cancer [8]. Several processing strategies exist for reducing the concentrations of heavy metal ions in sewage water. These procedures include adsorption, precipitation, ion exchange, electrolytic methods, solvent extraction, membrane processing, cementation onto iron, and flotation [9]. Decreased the concentration of heavy metals under study when a low concentration of clays (5gm/L) is used because the adsorption capability of clays increased with decreasing the concentration of sorbent due to the abundance of the effective sites of absorption [10, 11]. Adsorption is the phenomenon in which molecules are adsorbed from a liquid phase in their surroundings and subsequently bound to the surface of a solid object [12, 13]. The adsorption capacities of several inexpensive adsorbents (such as clay, agricultural waste, biomass, sewage sludge, coal fly ash, and inexpensive zeolites) have been assessed for the elimination ions of heavy metals from wastewater [14, 15]. The compound formula of attapulgite is $(OH_2)_4(OH)_2Mg5Si8O_2O \cdot 4H_2O$. An open-channel structure in magnesium aluminum silicates is distinguished by the development of elongated (needle-shaped) crystals. The composition varies directly due to the partial replacement of magnesium and aluminum with iron and other elements [16, 17]. Given their unique properties, palygorskite or attapulgite is used in various industrial applications such as oil-based and water-based foundry sand binder adhesive viscosity control in the oil sector, and oil well drilling muds. Moreover, it is used as a thickening in pharmaceuticals, a gelling agent, a stabilizer for wax emulsions, a filler for liquid suspensions, an oil drying agent, a carrier for catalysts, an agent for petroleum refining, a desulfurization agent, a deodorizing agent, and other similar applications [4]. Attapulgite is structurally classified as a 2:1-layer inverted crystal structure, as shown in Figure 1. Through the repetitive replacement of aluminum with iron, magnesium, calcium, and other metals, an abundance of negative charge is produced, leading to the attainment of a satisfactory cation exchange capacity. Sequential inversions in the silica tetrahedral sheet result in the methodical arrangement of parallel channels or apertures throughout the structure. The aforementioned features, in conjunction with the elongated shape and the small particle size, result in a significant surface area [18][19]. The composition of attapulgite consists of two distinct forms of water: one that is chemically attached to the octahedral cations and the other that is rather loosely bound inside the channels. Zeolitic water is the widely used designation for the latter type of water. Furthermore, the channels may also include interchangeable cations. An important physical characteristic is the elongated shape and the existence of open areas [20, 21].

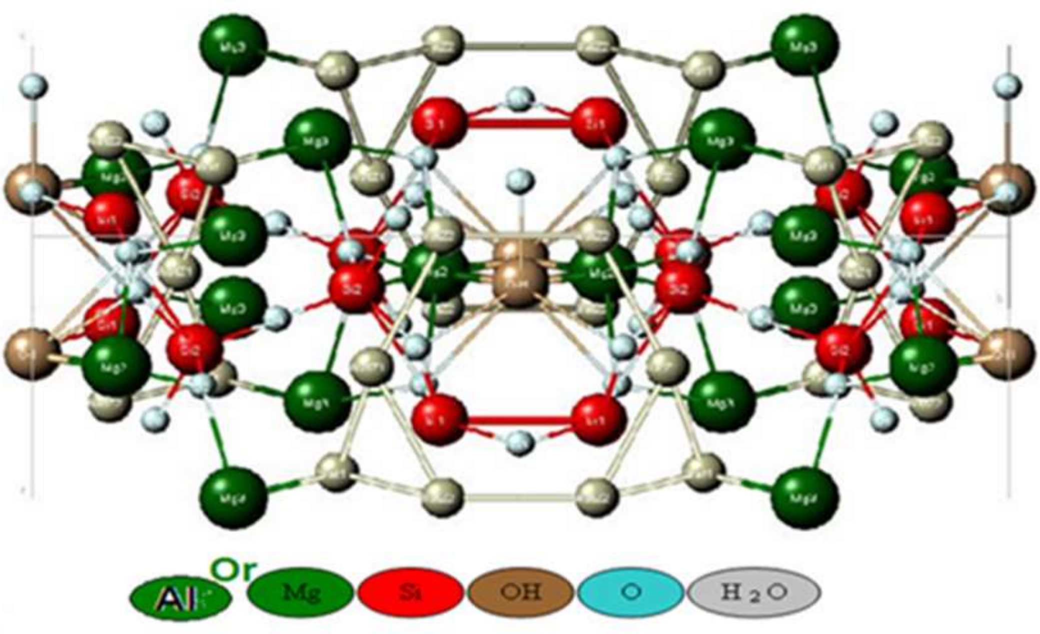

Figure 1. Attapulgite Structure.

The University of Diyala is located in the northeastern suburb of Baghdad, Iraq. The goal of the study is to effectively treat effluent water by using locally accessible attapulgite clays to eliminate heavy metal ions (Fe, Pb, Ni, Zn) and thereafter recycle it. The key goal is to reduce environmental risks linked to polluted water and determine appropriate industrial uses for attapulgite clays. An evaluation of the efficacy of clays in treating sewage water from a station with elevated levels of heavy metal ions and suspended solids (SS) was carried out through a series of 70 trials.

2. Research Materials and Procedures

2.1. Attapulgite clay

The present work used attapulgite clay sourced from the Iraq Geological Survey (GEOSURV) located in the Al-Najaf region to the southwest of Baghdad. It has been accurately measured 75 µm size by Iraq Geological Survey.

2.2. Mineralogical investigation

It was conducted at Iraq Geological Survey (GEOSURV) using X-ray diffraction (XRD) technique. The results of the mineralogical analysis are shown in Figure 2.

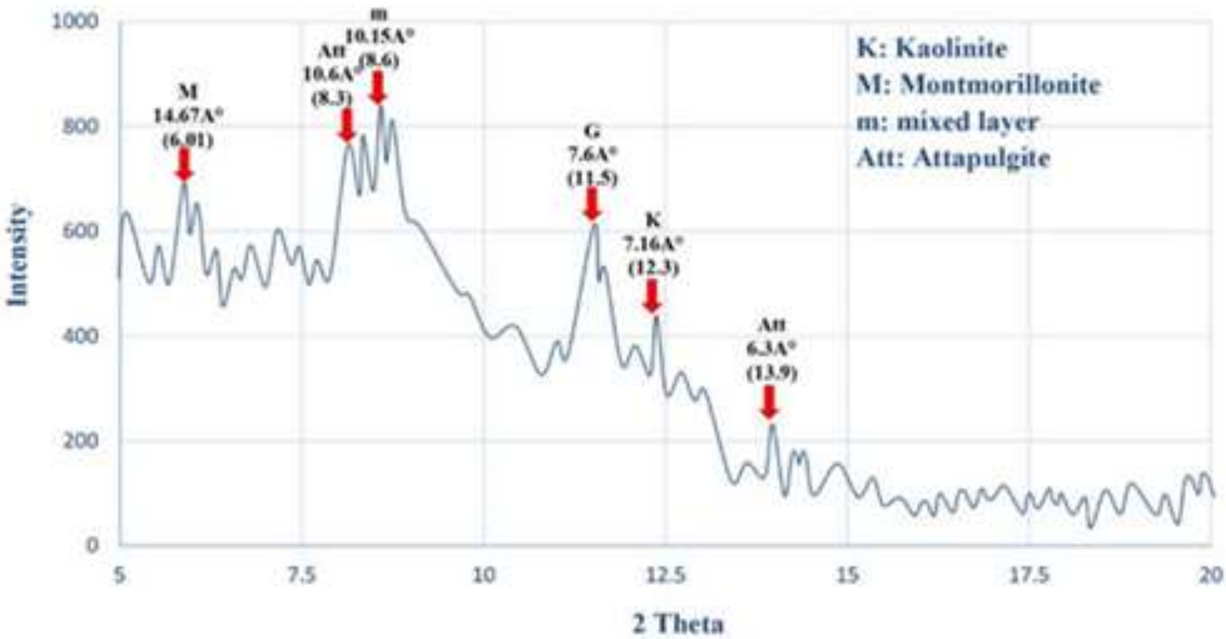

Figure 2. Investigation of the mineral compositions of attapulgite clay.

Chemical composition of Attapulgite clay was assessed using chemical analysis and the methods used by the Iraq Geological Survey (GEOSURV), as presented in Table .1.

Table 1. An analysis of the chemical components of attapulgite clays.

Chemical Components of attapulgite clay	The Percentage of oxides (%)
silicon. dioxide	41.54
Ferric. oxide	5.44
Aluminum. oxide	10.52
Titanium. dioxide	0.49
Calcium Oxide	15.45
Magnesium. oxide	4.06
Sulfur trioxide	0.17
Sodium. oxide	0.93
Potassium. oxide	0.43
Chloride	0.70
Iodide	0.93
Total	99.77

2.3. Heavy metals analysis

In the service laboratory at Baghdad University-Science College-Chemistry Dept., the treated solutions were examined using the Atomic Absorption Spectrophotometer (AAS) technique to quantify the amounts of iron (Fe), lead (Pb), nickel

(Ni), and zinc (Zn) in sewage water both before and after treatment with attapulgite clays. The quantities of heavy metal ions in sewage water were determined using Atomic Absorption Spectroscopy (AAS) prior to the treatment process. The pre-treatment and post-treatment heavy metal concentrations are displayed in Table 4.

3. Results and Discussions

Before treatment, the data revealed a substantial increase in the concentration of heavy metal ions in the sewage water. The analysis indicated that the sewage water included Iron, Lead, Nickel, and Zinc with amounts of 18, 1.8, 3.6, and 6 parts per million (ppm), respectively. An increase in the amount of attapulgite clays used in the treatment process enhances the effectiveness of precipitation and purification of sewage water. Moreover, the rate at which suspended solids (SS) precipitate reduces with an increase in the density of clays, as seen in Figure 4. Under gravitational forces, the attapulgite clays, when mixed with sewage water, clung to pollutants and precipitated at the bottom of the beaker. The objective of this work is to examine the behavior of suspended solids in effluent water when they remain suspended in water for 72 hours without undergoing precipitation, without the presence of volcanic clays. In contrast, sewage water samples were treated with attapulgite clays and took around 24 hours to settle suspended solids at the bottom of the beerwer. Furthermore, the rate of precipitation is affected by the particle size of the raw materials employed in the treatment process. In particular, a reduced size of clay particles leads to a decrease in the precipitation rate. In Table 2, the weight of suspended solids in untreated and treated effluent water was recorded as 0.92 grammes at time zero. After 6 hours, the mass of the solid sigma (SS) dropped to 0.17 grammes in water treated with attapulgite clays, compared to 0.18 grammes in untreated sewage. Following 24 hours of contact with clays, the weight of suspended solids (SS) in treated water reduced steadily from 0.16gm in sewage to 0.15gm.

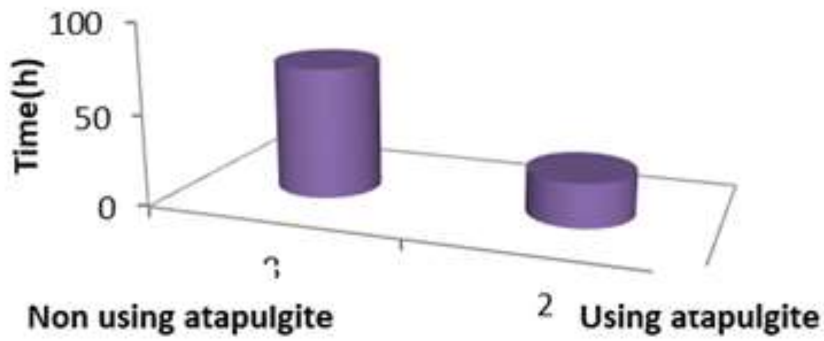

Figure 3. Reduction in the duration of the settlement procedure.

3.1. Evaluation of the impact of. mixing duration on the treatments of sewage water with attapulgite clay

An analysis was conducted to determine the optimal mixing time for treating sewage water with attapulgite clays, as shown in Table 3.To increase the duration of interaction between sewage water and attapulgite clays, a consistent concentration of 5gm/L of attapulgite clays was introduced into the sewage water for various time intervals (1, 3, 6, 9, 12, and 15 hours).The temporal fluctuations in mixing time did not exhibit a consistent decline in heavy metal concentration as the concentration of attapulgite clays rose.

Table 2. Quantification of suspended solids in treated and untreated effluent water at various time intervals.

Time(h)	Quantification of SS in untreated wastewater containing attapulgite clay (grammes)	Total suspended solids in wastewater treated with attapulgite clay (grammes)
Zero	0.92	0.92
6	0.18	0.17
24	0.16	0.15
48	0.13	0.12
72	0.11	0.03

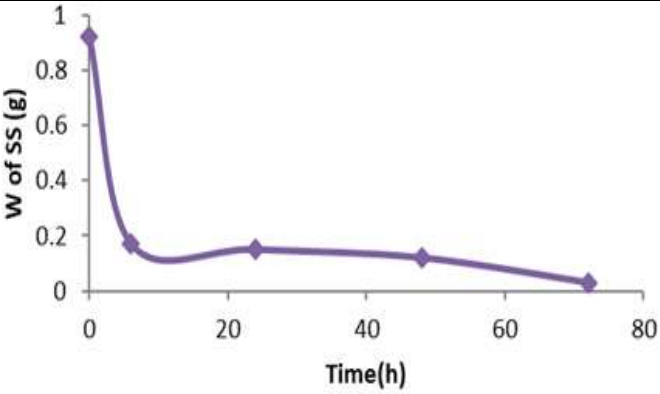

Figure 4. A decrease in the relative weight of suspended solids as time progresses.

Table 3. Quantification of heavy metal content in sewage water treated with attapulgite at various time intervals.

Heavy metals	Quantification of heavy metal content following treatment with attapulgite at various time intervals (ppm)					
	1h	3h	6h	9h	12h	15h
iron	1.24	1.22	1.223	1.224	1.221	1.22
lead	0.38	0.36	0.361	0.352	0.35	0.345
Nickle	0.297	0.295	0.293	0.2921	0.292	0.291
Zinc	0.675	0.674	0.6743	0.6741	0.6742	0.6741

3.2. Assessment of the effectiveness of attapulgite clay in the treatment of wastewater

In this study, the usage of attapulgite clay was found to decrease the concentration of heavy metal ions in sewage as compared to sewage treated with clays. We can demonstrate Table .4 that the levels of Lead and Iron declined from 18 and 1.8 parts per million (ppm), respectively, following their initial values of 1.22 and 0.36 ppm. Moreover, the content of Nickel and Zinc drastically decreased from 3.6 and 6 ppm to 0.295 and 0.674 ppm, respectively, following treatment with clays. The adsorption and reduction ions of heavy metals from treated sewage water by attapulgite clay can be attributed to the crystal's substitutions in the eightfold layer and presence of channels in this ore, which serve as efficient absorption sites [22]. The observed results indicate that attapulgite clays exhibit a high level of effectiveness in scavenging heavy metal ions (Fe, Pb, Ni, and Zn) from wastewater, hence reducing their concentration to levels below the permissible environmental threshold. Furthermore, one can observe the following from the results:

a. Heavy metal concentrations under investigation decreased when a small concentration of clay (5gm.L-1) was utilized. This is because the adsorption capacity of clay rose as the concentration of sorbent decreased, owing to the numerous effective absorption sites present.
b. Results were obtained by combining 5gm.L-1 of clay with effluent water and stirring for 3 hours.

Table 4. Comparative analysis of heavy metal concentration in sewage, water pre and post treatment. with Attapulgite clay

heavy metals	Initial heavy metal concentration prior to clay treatment (ppm)	Quantification of heavy metal content following clay treatment (ppm)
Fe	18	1.22
Pb	1.8	0.36
Ni	3.6	0.295
Zn	6	0.674

Diagrams 5-8 depict the impact of attapulgite clays on the heavy metal ions being investigated.

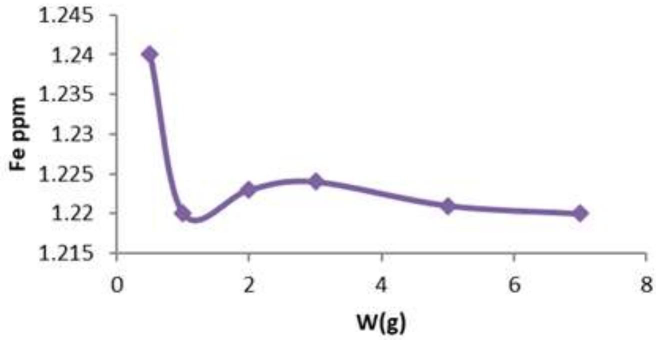

Figure 5. Assessment of iron concentration in treated sewage water.

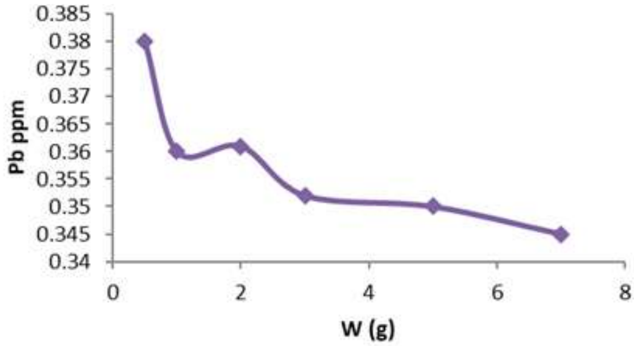

Figure 6. Quantification of lead concentration in treated sewage water.

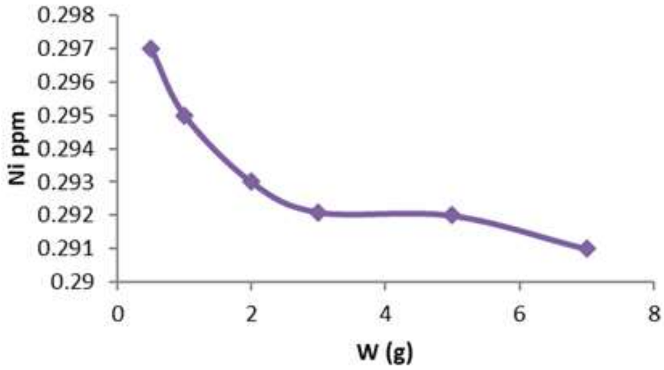

Figure7. Nickel concentration in treated sewage water.

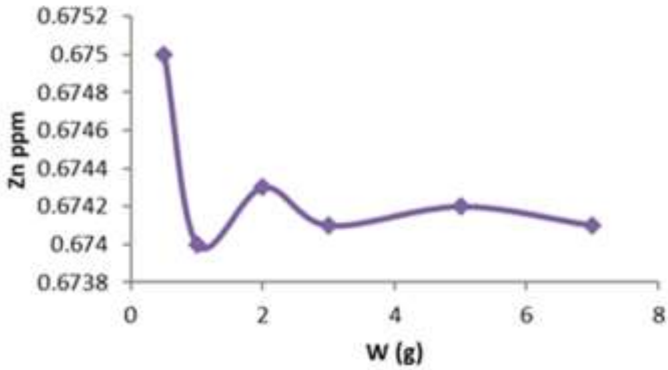

Figure 8. Quantification of zinc concentration in treated sewage water.

4. Conclusions

The ions of heavy metals found in effluent water are derived from industrial waste, drinkable water, and human waste used in laundry appliances. Attapulgite clay, located nearby, accelerates the settling and precipitation of solid plankton when combined with the clay being utilized. Ion's reductions of heavy metal levels in sewage by the application of attapulgite clay products. After undergoing treatment, the levels of heavy metal ions (mostly iron, lead, nickel, zinc) in wastewater decreased from 18 parts per million (ppm), 1.8 ppm, 3.6 ppm, and 6 ppm to 1.22 ppm, 0.36 ppm, 0.295 ppm, and 0.674 ppm, respectively. The ideal parameters for treating wastewater are presented below:

1- Clay particle sizes are 75 micrometers.

2- Clay concentrations are 5 g/l after 3 hours of mixing.

Conflicts of Interest: No conflict of interest.

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