Using Montmorillonite Mineral Clay to Remove Lead Ions from Wastewater

Najah M. Al-Shuwaiki
Dijlah University College
Najah.shawki@duc.edu.iq

Abstract
In this work many experiments were done to remove lead metal ions from contaminated water. Iraqi mineral clay, montmorillonite is used to adsorb lead ions from contaminated water using continuous adsorption process. The experiments indicated that 1.0 gram of the montmorillonite clay can adsorb 22.08, 21.04 and 20.16 mg of lead from their solutions of 10 ppm at the flow rates of 0.03, 0.05 and 0.08 L/min respectively at duration periods were 2, 3.5 and 6.1 hours. Five grams of montmorillonite clay can adsorb 11.04 liters, 10.5 liters, and 10.08 liters of lead contaminated solution at flow rates of 0.03 L/min, 0.05 L/min, and 0.08 L/min respectively

Keywords
contaminated water, montmorillonite clay, lead, adsorption

1-Introduction
Industrialization in all sectors is at peak throughout the world. Industries use different types of chemicals as a part of their manufacturing process. The effluents released from these industries contain chemical pollutants, as lead, zinc, cadmium, chromium, arsenic, copper, etc. Other sources of water and soil contamination are effluents discharged from different industries like dying textile, leather, plastic, painting, printing, fertilizer and pesticide, mining and smelting ferrous ores, energy and fuel production and food [1]. Textile finishing industries are considered the main contributors to environmental pollution by way of releasing waste water which contains the heavy metals and dyes. Heavy metals are considered harmful due to their features of high toxicity, persistence, and accumulation .[[2] and [3
For these reasons, it is important to remove heavy metals ions from water and other environmental sources. Miretzky et al. [4] used dead large plant leaves to remove heavy metal ions as cadmium, nickel, copper, zinc and lead from water. The results showed lead has the most removable efficiency from solutions. Barbooti et al. [5] could obtain the highest efficiency to remove heavy metals more than 99 % by precipitating magnetic ion by treat-

ing drained water with bivalent iron sulfate (ii) for two hours in 50 oC and pH=10 with a .percent of bivalent iron/total metal = 15

They also removed lead and chrome ions from water by efficiency more than 94 %. He used adsorption onto Iraqi montmorillonite and did experiments design of data analyzing in order to reach the perfect experimental condition. He assumed that lead adsorption did .not affected by pH of the solution, and the neutral solution gives a good adsorption

There results indicated that adsorption process is pH dependent with chromium and pH independent with lead and the best results obtained were 86 % and 100 % removal efficiency for chromium and lead respectively at the conditions of 12.5 g/L of wastewater .amd pH 7.5 within 30 minutes

Barbooti [6] used this clay mineral also to remove the antibiotic oxytetracycline from .water

Industries are a major source of many pollutants such as heavy metals like lead, chromium, copper, and nickel. These heavy metals are toxic and non-degradable in nature, so they released all such pollutants into environment which possess serious risks to human .[and other organism's life [3] and [7

Khan et al. [3] used unmodified bentonite as an adsorbent for lead removal from water. The analytical results at XRD characterization showed that montmorillonite is the main .clay mineral and can be used to release lead from water efficiently

In less developed countries pollution is particularly worse as a consequence of the high cost of the treatment technologies and the lack of proper regulations. The residues derived from industrial activities, which contain heavy metals and other hazardous elements, are often released directly into the environment without a proper treatment. These residues .are dispersed through air, soils and surface water

The presence of heavy metals in air, water, soil and plants is becoming an increasing health and environmental concern because of the wide range of anthropogenic sources of heavy metals that pollute the environment with growing industrialization and extensive use of chemicals [8] and [9]. Wastewater effluent streams from many industries display wide range of heavy metals in varying concentrations [10]. Heavy metals can directly enter the human body through the food chain, causing serious health danger if present in .[excess concentration beyond permissible limits [11

Activated carbon as adsorbent is widely used for removal of various pollutants from water but it is very expensive so it is necessary to find out an adsorbent of low cost, available and have good adsorption capacity [8,12,13] Clay can be used because it offers high adsorption capacity as well as it is low cost and available [8]. Clay minerals are alumino sillicates groups with sizes falling in the colloid fraction of soils. Their particle sizes are smaller than 0.002 mm [14]. Clays are classified into: montmorillonite, smectite, illite, kaolinite, and chlorite. Montmorillonite, kaolinite, and illite are commonly used adsor-.[bents because of their greater surface area and structural rigidity [15] and [16

Arsenic removal has been studied with membranes formed from montmorillonite, kaolinite, and illite operated through pumping. Fang et al. [17] reported that removal by .rejection was as high as 90% of arsenic in the feed stream

Several physical-chemical technologies such as ion exchange, chemical precipitation, membrane filtration, solvent extraction, and adsorption, have been developed for the removal of heavy metals from contaminated water prior to discharge into the ecosystem [12] and [18]. Among the existing technologies, adsorption becomes an attractive alternative technique in treatment heavy metals wastewater contaminated due to its documented cost effectiveness. Recently, different adsorbents such as activated carbon, sand, eggshell, waste tea leaves, wood sawdust, zeolites, olive stones, clay, chitosan, fly ash, coal and peat moss were used to remove heavy metals from aqueous solution, due to their excellent properties such as high surface area, ion exchange capability, present of negative surface charge and their universal abundant in nature. Natural clay minerals are considered as cost-effective alternative to the widely used expensive activated carbon which are used to .[remove heavy metal ions from wastewater [12

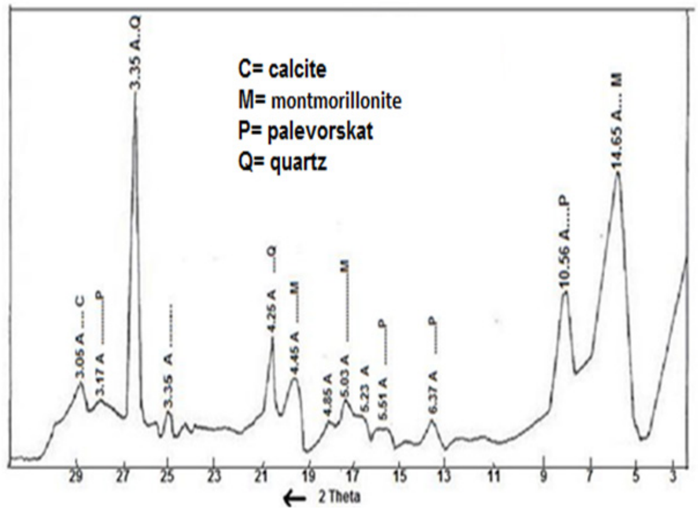
The effect of the montmorillonite content on adsorptive performance of natural Saudi Arabian clay was investigated under kinetic and equilibrium batch studies for aqueous uptake of Cu (II) and Ni (II). The montmorillonite and bentonite used were characterized using scanning electron microscopy (SEM), Brunauer-Emmet-Teller (BET), cationic exchange capacity (CE), energy dispersive X-ray (EDX) and X-ray diffraction (XRD) .[techniques [19

This work depends on using Iraqi clay mineral of known composition, as montmorillonite to remove lead from water and make experimental method for work and analyze results to achieve the best conditions. The montmorillonite clay was analysed in General Company of Geological Survey and Mining in Iraq

2-Methods

Materials which used in the experiment were lead powder of purity 98 % from Merek company and Iraqi montmorillonite clay. The clay was obtained from the general company of geological survey and mining related to ministry of industry and minerals. Figure 1 shows the X-ray diffraction analysis of the montmorillonite clay metals. The analyzing .results indicate a high content of montmorillonite with other elements

Counted amounts of montmorillonite mineral clay were put in several cloth bags to guarantee wide use of clay and consequently a larger surface area. These bags were put inside a vertical container. Many small glass pipe pieces were used to increase the volume and surface area. This container was put inside another container. The contaminated water passed throw a pipe to the internal container which contains the clay from down direction to upper direction of the container to fill it and flood to the outer container, where the pure water will exit. Ten ppm of lead contaminated water was taken from a storage tank through a pump and flow meter to inter the purifying container. Atomic absorption device was used to analyze the outlet purified water



Fiqure 1 X-ray analysis of Iraqi montmorillonite metal of General Company of Geological .Survey and Mining in Iraq

3-Apparatus description

Schematic representation of the apparatus is shown in figure 2

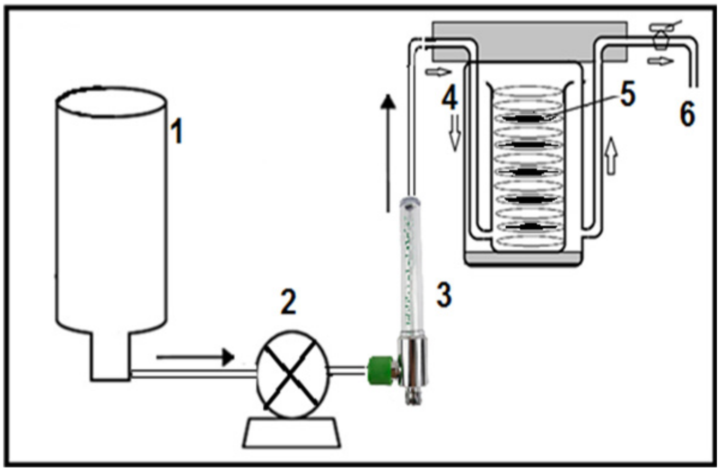


Figure 2 A schematic diagram of the apparatus: (1) water tank, (2) pump, (3) flowmeter, (4) purifying container, (5) mineral clay bags, (6) water tap

Lead solution was prepared by dissolving lead powder by concentrated nitric acid and .diluting by distilled water to get 20 liters solution of concentration equal to 10 ppm

The contaminated water by lead is placed in plastic water tank of 20 liters capacity. The opening of the tank is in the bottom and joined with a pump to control the flow velocity throw a flowmeter connected to the inlet of the purifying container. The adsorption vessel was put in a vertical position. The contaminated water was pumped form down to top to insure complete filling of water. The water passed inside the vessel through cloth bags which filled with clay. These bags were surrounded by many small glass tubes pieces to fill the container. The flow velocity was controlled to permit the inlet water drop to remain about 60 minutes with contact by adsorption materials in the cloth bags, to insure good .exchange of ions as shown in figure 3

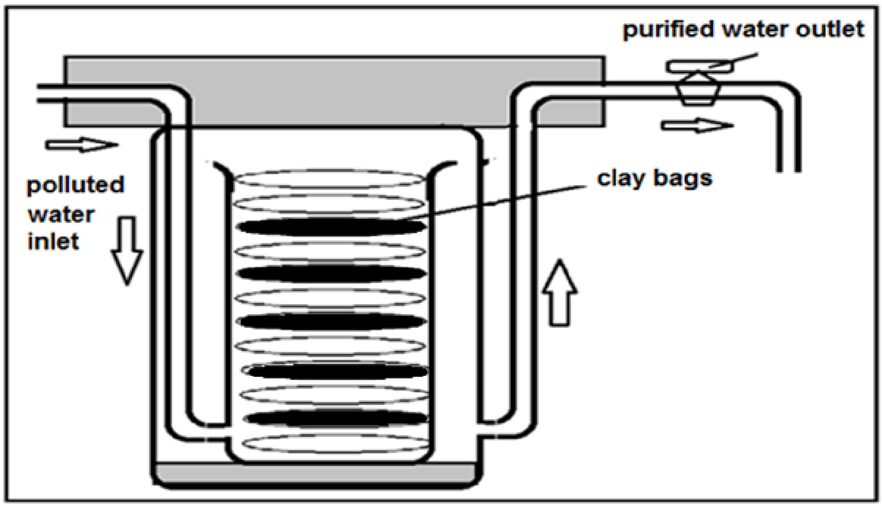


Figure 3 purifying container

In this experiment, 50 liters of lead solution of 10 ppm concentration and 5 cloth bags were filled by 1 gram montmorillonite clay for each were used

4-Results

The lead adsorption capacities of the clay were calculated by many experiments. Five clay bags were put inside the purifying container. Distilled water flowed across the clay particles to soak and improve the process of adsorption before the start of the experiment. Many small plastic containers of 50 ml volume were prepared to take samples. The breakthrough point which indicates the first sample having lead was determined. Many samples of exit water (40 ml) were collected, numbered, and then were taken for analyzing by .atomic adsorption techniques

Figure 4 represents measured lead concentration against outlet water at flow rates of 0.03 L/min, 0.05 L/min and 0.08 L/min. At the flow rate 0.03 L/min the outlet lead concentration became 10 ppm as the initial concentration in the sample of number 276 (11040 ml). This means that 1.0 gm of clay can adsorb 2.208 liters of the 10 ppm solution. Five grams of clay adsorb 11.04 liters of solution which takes time of 368 minutes which equal to 6.1 hours. Initially the lead disappears in the outlet water then gradually it appears in the samples until the number 276 the exit lead concentration was equal the initial lead concentration in the solution which means the pass of 276 *40= 11040 ml of solution which .purified completely from lead

ml solution * 10 (µg/ml)) / 5 g clay = 22080 µg Pb/g clay =22.08 mg Pb/g clay 11040)

.This result of adsorption capacity of clay gives the same beginning estimation

Lead concentrations for the samples form number 1 to 235 at a flowrate 0.05 L/min are shown in figure 4. The lead initially disappears and then gradually appears in the samples until the number 263 where the exit lead concentration was equal to the initial lead concentration of 10 ppm in the solution which means the pass of 263 *40 = 10520 ml of .solution which purified completely from lead

ml solution * 10/5 g clay = 21.040 mg Pb/g clay 10520

This result of adsorption capacity of clay indicates that 2.1 liters of the lead contaminated solution can be purified by 1 gram of clay at a flow rate of 0.05 L/min and 10.5 liters can .be purified by 5 gram of clay at the same flow rate

Figure 4 also represents the measured lead concentration at a flow rate 0.08 L/min. Samples number 252 indicated the initial concentration which was 10 ppm .This number means that 10080 ml of solution and 20.160 mg of lead were adsorbed by 1 gram of clay. As a result 5 grams of clay can adsorb 10.08 liters of the lead contaminated solution with .duration period of 125 min which equals 2.08 hours

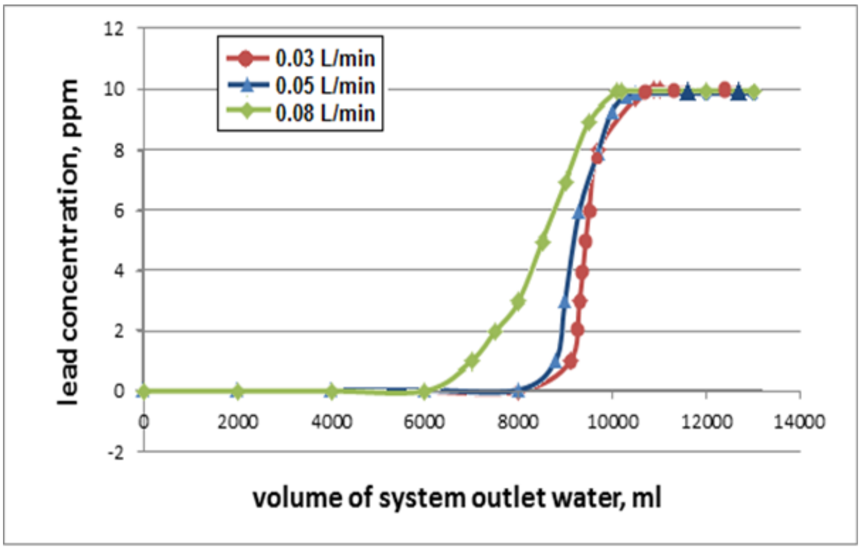


Figure 4 The calculated lead concentration against volume of outlet water at 0.03 L/min, 0.05 L/ .min and 0.08 L/min

5-Conclusions

It is noticed that 5 grams of montmorillonite clay adsorb 11.04 liters of lead contaminated .solution at a flow rate of 0.03 L/min

.It is concluded that 10.5 liters can be purified by 5 gram of clay at 0.05 L/min flowrate

From the experiment it is seen that 5 grams of clay can adsorb 10.08 liters of the lead .contaminated solution at 0.08 L/min flowrate

It was noticed that as the flow rate increased the duration time decreased but the efficiency .of adsorption of contaminated solution was also decreased

For the same parameters of the lead concentration in the contaminated solution and the same flow rate 0.05 L/min it was noticed that 1.0 gram of montmorillonite clay can adsorb 21.04 mg of lead comparing with kaolinite clay in the same conditions where 1.0 gram kaolinite adsorb 20 mg of lead as reported in the experiment before

Bibliography

1-K. Kadirvelu, Kavipriya M., Karthika C., Radhika M., Vennilamani N., Pattabhi S. "Utilizationof various agricultural wastes for activated carbon preparation and application for the removal of dyes and metal ions from aqueous solutions". (2003). BioresourceTechnology,87 129–132

2-M. Tangsathitkulchai, C., Wongsooksin K., and Chuyingsakuntip S. "Removal of residual aluminium dye complexand aluminium ion from spent natural dye solution using
activated carbons". Engineering Journal, (2012) Vol. 16, Issue 5,pp. 29 –43

3-Khan M. R., Hegde R. A., Shabiimam M. A., Adsorption of Lead by Bentonite Clay, International Journal of Scientific Research & Management Studies 5(7) • January 2017 with 541 Reads DOI: 10.18535/ijsrm/ ,{v5i7.2017

4-P. Miretzky, Saralegui, A. and Fernández Cirelli, A. Simultaneous Heavy Metal Removal Mechanism by .Dead Macrophytes. Chemosphere, (2006) 62, 247-254

5-M. Barbooti, M. Simultaneous removal of chromium and lead from water by sorption on Iraqi montmo- .rillonite, J. Environmental Protection, (2015) 6, 236-247

6-M. Barbooti, M. Su, H. Punamiya, P. and Sarkar, D., Oxytetracycline sorption onto Iraqi montmorillonite, .Int. J. Environ. Sci. Technol., (2014) 11 (1), 69-76

7-A. Baysal, N. Ozbek and S. Akman, "Determination of Trace Metals in Waste Water and Their Removal" Processes January 2013 DOI: 10.5772/52025

8-R. Srinivasan, , Advances in application of natural clay and its composites in removal of biological, organic, and inorganic contaminants from drinking water. Advances in Materials Science and Engineering, 2011, 11, 1-17

Yakun Zhang, Liangguo Yan, Weiying Xua, Xiaoyao Guo, Limei Cui, Liang Gao, Qin Wei and 9-Bin Du., 2014, Adsorption of Pb(II) and Hg(II) from aqueous solution using magnetic CoFe2O4-reduced graphene- .oxide. Journal of Molecular Liquids, 191, 177–182

10-T. Missana, M. and Garcı´a-Gutie´rrez. Adsorption of bivalent ions (Ca (II), Sr (II) and Co (II ((onto FEBEX bentonite. Physics and Chemistry of the Earth, 2007 32, 559–567

11-S. Lin, H., Lai, S.L. and Leu, H.G., Removal of heavy metals from aqueous solution by chelating resin .in a multistage adsorption process. Journal of Hazardous Materials, 2000 76, 139–153

12-S. Babel, and Kurniawan, T.A., Low-cost adsorbents for heavy metals uptake from contaminated water: .a review, Journal of Hazardous Materials, 2003, 97(1-3), 219-243

13-R. Virta, L., U.S. Geological Survey-Minerals Information. 1996, http://minerals.usgs.gov/minerals/ .pubs/commodity/190496.pdf, accessed on May 15, 2018

14-O. Oloafe., lagoboye, S.A., Akanji, P.S., Adamolugbe, O. and Olaniyi, A.A., , Kinetic studies of adsorp- .(tion of heavy metals on clays. International Journal of Chemistry, 2015 7(1

15-S. Lin, H and Juang, R.S, Heavy metal removal from water by sorption using surfactant-modified mont- .morillonite. Journal of Hazardous Materials, 2002 92(3), 315-326

16-B. Krishna, S., Murty, D.S.R. and Jai Prakash, B.S., Thermodynamics of chromium (VI) anionic species sorption onto surfactant-modified montmorillonite clay. Journal of Colloid and Interface Science, 2000 229 .(1), 230-236

17-Fang Luo, Tao Yuan ,Qi- ,Jiang-Yong Hu,Say-Leong Ong &Wun-Jern Ng, A Study on Arsenic Removal from Household Drinking Water, Pages 1731-1744 | Received 08 Jan 2003, Published online: 18 Aug 2006, volume 38, 2003- issue9

18-Lakherwal, 2014 D. Lakherwal Adsorption of heavy metals: a review Int. J. Environ. Res. Dev., 4 (2014), pp. 41-48
19-Nuhu DalhatMu'azua Alaadin Bukharib Khaled Munefb, Effect of montmorillonite content in natural Saudi Arabian clay on its adsorptive performance for single aqueous uptake of Cu (II) and Ni (II), Journal of King Saud University- Science Available online 15 June 2018 Science Direct https://doi.org/10.1016/j. .jksus.2018.06.003