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Adsorption of Water Heavy Metals onto Natural Clay

KEYWORDS: Heavy metals, natural clay, adsorption capacity, pH effect.

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ABSTRACT *Extensive endeavors are mandatory to economically remove the heavy metals from contaminated water, among viable options the natural clay. Adsorption capacity of clay materials towards adsorption of heavy metals sequences are greatly influenced by operating conditions. In these study competitive adsorptions of heavy metals ions (Zn and Pb) on natural clay was investigated in order to understand the influence of initial pH on the clay adsorption capacity of heavy metals. Batch adsorption experiments were performed at six different pH values (4, 5, 6, 7, 8, and 9) with 10g of clay for each value. The results indicate that the best removal was obtained at pH 5. In another experiments the clay weight was changed to six values (4, 6, 8, 10, 12 and 14) in each value the pH adjusted to 5 . The best removal obtained at clay weight 8g and stayed equal for (10,12 and 14)g had the lowest concentration of Zn, but in Pb all clays treatments was free from Pb.*

1. Introduction:

As a result of agricultural, commercial and industrial activities conducted in the absence of environmental regulations and enforcement in the past, sediments contaminated by organic compounds, heavy metals, and other potentially toxic chemicals have accumulated in many of the world's deepwater and wetland environments. These sediment-borne contaminants can eventually become incorporated into aquatic food webs and adversely affect ecological receptors like benthic organisms and fish, and ultimately pose a risk to human health. The adsorption by different silicate minerals of some heavy metals, present in industrial waste water, has been studied. These adsorbents (mainly clay minerals) are readily available, inexpensive materials and offer a cost-effective alternative to conventional treatment of wastes from the metal finishing industry. The results show that some mineral species are suitable for the purification of such residual waters down to the limits prescribed by current legislation concerning industrial wastes. The Langmuir model was found to describe such adsorption processes best. Sepiolite (Orera, Spain) has an adsorption capacity of 8.26 mg g (super -1) Cd (super 2+), the capacities depending on the metal adsorbed in the order: Cd (super 2+) >Cu (super 2+) >Zn (super 2+) >Ni (super 2+). This mineral shows the highest sorption capacity relative to the other minerals studied. Factors in the reaction medium such as pH and ionic strength influenced the adsorption process (Sanchez *et al*. 1999). The interaction between minerals and heavy metals has been a hot object of study in environmental science, mineralogy and soil science. Through the selective adsorption experiment of Ca-montmorillonite, illite and kaolinite to Cu^{2+}, Pb^{2+}, Zn^{2+}, Cd^{2+} and Cr^{3+} ions at certain conditions, it could be concluded that Cr^{3+} is most effectively sorbed by all the three minerals. Also, it can be found that Pb^{2+} shows a strong affinity for illite and kaolinite while Cu^{2+} for montmorillonite. Based on the adsorption experiment at varying pH of solution, it can be found that the amount of heavy metals sorbed by minerals increases with increasing pH of the solution (Hongping *et al*. 2000). The sorption of seven metals (Cd, Cr, Cu, Mn, Ni, Pb and Zn) on Na-montmorillonite was studied as a function of pH and in the presence of ligands, forming complexes of different stabilities with the metals of interest. The continuous column method was used as it better simulates natural conditions. The total capacity of Na-montmorillonite towards these metals was determined. The pH variations influence to a higher extent the concentrations of Cu, Pb and Cd in the effluent (Abollino *et al*. 2003). Clay minerals have high sorption, ion exchange and expansion properties. Al-Degs *et al*. 2006 found that natural Jordanian clay containing silicate and carbonate minerals is an effective adsorbent for the removal of Zn (II), Pb (II), and Co (II) ions from aqueous solutions. Unuabonah *et al*. 2008 studied sorption of Pb(II) and Cd(II) from aqueous solutions onto sodium tetraboratemodified kaolinite clay, and an observed increase in the sorption capacity of the kaolinite after modification with sodium tetraborate corresponded to its increase in cation exchange capacity.

In this paper, the Zn and Pb adsorption on to natural clay was studied in different pH and in the best pH studied at different amount of clay weight.

The rest of the paper is organized as follows: Section 2 presents Materials and methods, Section 3 Results and Dissections, and Section 4 Conclusion the paper.

2. Materials and methods:

Reagents: 2 ppm of Zn and Pb were prepared from the standard solution from their respective nitrate salts at concentration of 1000 mg L -1 using the equation No.1 (APHA, 2009).

$$M_1 \times V_1 = M_2 \times V_2 \quad (1)$$

Where:

M= Mass,

V= Volume

Natural clay characterization: Clay powder used from the Malaysian clay collected from (Penang). From the chemical analysis the conducted by acid digestion of 10 g of clay sample using 50 ml of concentrated HNO3 for heavy metals analysis. Respectively, the clay pH, electrical conductivity, Moisture content, soil organic matter (ASTM, 2004).

Experiments: Clay was crashed and sieved in 2mm mash sieve, then mixed with deionized water companied 2 ppm of Pb and Zn respectively.

After adjusted the pH values with (1M H_2SO_4) and (0.1M NaOH) on pH meter (HACH session 3 additional) , 10 g of the clay powder was added to each container mixed it for 3 min. in mixer on 120 rpm leave it to settle down for 20 min then filtered two time with Watt man filter paper No. 4 the solution stored in 4^0C for 24 hr then analysis the concentration of heavy metals on AAS Perkin Elmer 100 & 200 to obtained the best pH value which had the lowest concentrations of Zn and Pb.

The next experiment was done at the best pH value from the first experiment beakers with different weights of clay (4g,6g,8g,10g,12g and 14g) respectively, mixed with 2ppm of Pb and Zn on a shaker at 120 rpm for 3 min., then left to settle down for 20 min., filtered two time with Watt man filter paper No. 4 the solution stored in 4^0C for 24 hr., the concentrations of heavy metals analyzed on Atomic Absobtion Spectro photometer (Perkin Elmer 100 & 200). The removal % for Zn and Pb determent used the equation No. 2, (APHA, 2009).

$$\frac{A-B}{A}\times 100 \qquad (2)$$

Where:

A= Initial concentration

B= Final concentration

3. Results and Dissections:
The clay characteristics for this study were summarized in table 1.

Table 1: Clay characteristics

Characteristics of the clay	
pH	9
Moisture content (%)	2.95
Soil organic matter (%)	3.90
Electrical conductivity (mS cm-1)	50

The results showed, the best adsorption of Zn & Pb on clay it was at pH 5, shown the concentrations of Zn & Pb more decreased at this pH in the polluted water after mixed with 10g of clay, see **Figures 1&2.**

That means the pH value had effect on the concentrations of heavy metals in the effluent, the acidity helps the heavy metals ions to accumulate on to natural clay, that is agreement with (Abollino *et al.* 2003) and (Lukman *et al.* 2013) the pH most import ant factors affecting metal availability and for clays adsorption for heavy metals.(Hongping, *et al.* 2000) explained that the amount of heavy metals sorbed by minerals increases with increasing pH of the solution.

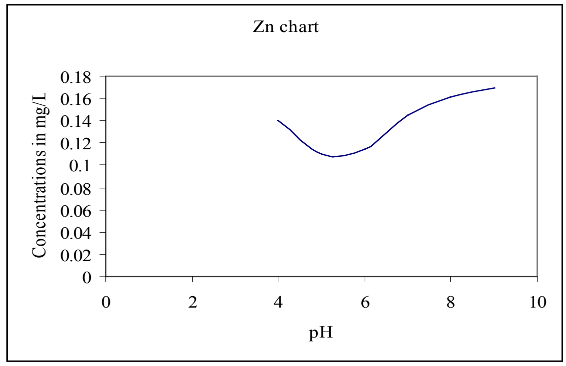

Figure 1: The lowest Zn concentration at pH 5.

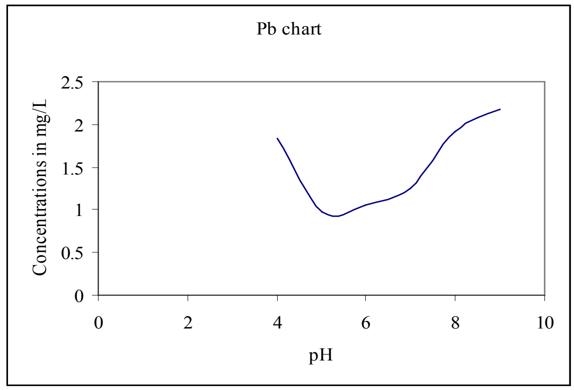

Figure 2: The lowest Pb concentration at pH 5.

From the experiment before, pH5 was the best for adsorption of Zn and Pb on clay, at this pH, different amounts of clay was added to the solution (4,6,8,10,12,14)g. The best adsorption was at 8g of clay, and still same amount of adsorption at 10, 12 and 14g these weights had the lowest concentrations of Zn (0.03) ppm, in the other hand the polluted water was free from Pb in all different treated of clay, that means the clay completely adsorbed of pb with different weights, clays have received attention as excellent adsorbents of Zn and Pb in their ionic forms from aqueous medium. The adsorption capacities differ from metal to metal and also depend on the type of clay used (Bhattacharyya and Gupta, 2008). Table 2 explained the summary of results, and Figure 3 showed Zn concentrations at different weights of clay.

Table 2: Summary of results

Weighting	Zn concentrations in ppm	Pb concentrations in ppm	pH
4	0.05	0	5
6	0.04	0	5
8	0.03	0	5
10	0.03	0	5
12	0.03	0	5
14	0.03	0	5

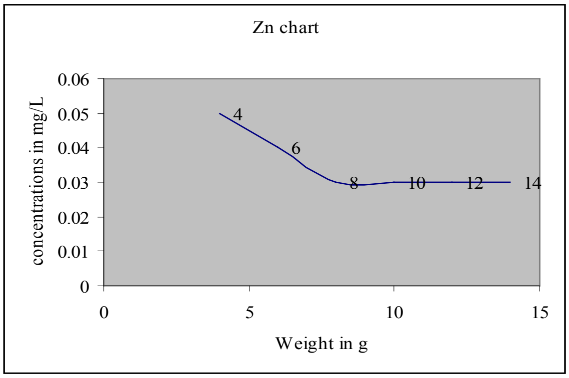

Figure 3: Zn chart with weight

The removal percentage was obtained for Zn & Pb to explain the capacity of clay weight to removing the metals, it was 98.5% and 100% respectively, (Peak et al. 2006) and (Zhang et al. 2008) found the removal percentage of Zn2+ at pH above 7 was 92%. **Figure 4** showed the removal percentage increased with increased the clay weight at pH 5 and stabled from 8g and above of clay.

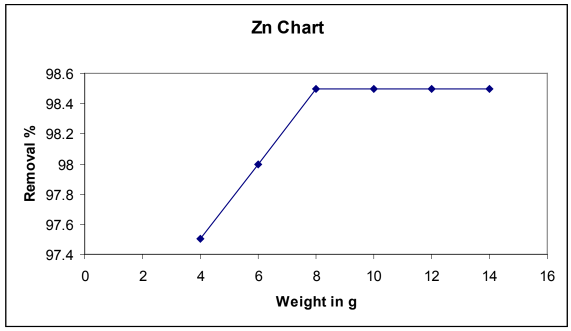

Figure 4: Zn chart with weight and removal %

4. Conclusion:
This study found the pH factor affected on clay adsorption of Zn and Pb, and the amount of clay in the solution affected also. The best removal for Zn and Pb they were at pH 5 and 8g of clay. The adsorption capacities differ from metal to metal; it was 98.5% for Zn, whereas for Pb it was 100% completely absorbed from the contaminated water.

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