Sorption of copper, lead and zinc on bentonite sediment material

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Abstract: *The retention studies of Cu, Pb and Zn on bentonite materials samples, in the laboratory to understanding metal adsorption between solution phase and solid phase of the suspended materials. The metals adsorption shows different adsorption responses between these materials. In the bentonite case the most of heavy metal Cu, Pb and Zn concentration was measured in the solid phase, which consequence a high K_d value.*

I.   Introduction

In the water, system the suspended sediment is contains of sand, clay and other silicate minerals and hydrous metal oxides, as well as organic particle such as microorganisms, diatoms and plant detritus (Hart et al, 1982). A mixture of factors such as natural efficiency, soil, flora, water cycle, and element controls the availability of metals in the fluvial system (Jain and Sharma 2001; Zhang and Huang 1993; Aurada et al.,1983; Warren et al.,1981). The most of the metals load is held and distributed by suspended particulate matter in river system environments (Covelli et al., 2007). Several earlier studies suggest that suspended particles can play an important role in carrying metals in the river system (Giesy and Briese 1977; Reuter and Perdue 1977; Hoffmann et al.,1981; Salbu et al., 1985; Tanizaki et al.,1992; Dai and Martin 1995; Ross and Sherrell 1999, Hill et al 2001).

The heavy metal transported in fluvial system in the both dissolved form, and adsorbed to the surface coating of the suspended particulate matter (Gallo et al 2006). In addition, there is some important as carrier particles for oxides and organic matter coating and hydrous Fe and Mn oxides. Moreover, organic matter influences heavy metal partitioning onto suspended particle like Mineral surfaces such as clays and alumino silicates (Horowitz, et al 1991). The exchange of metal ions between water and sediment is an important process to study the metals transport in the water system (Singh, et al 2005).

Suspended materials nature can control metals absorption rate and the availability of dissolved metals. Metal is linked easily to clay materials that may be because the chemical and physical properties of the clay materials such as a high ion exchange capacity (Boenigk et al., 2005). The correlation between the concentrations of trace metal and sediment are important, which may be due to the change in total surface area of the sediment in suspension (Bradley et al., 1982). The surface area of a sediment particle controls the surface chemistry and its ability to adsorb sediment-associated contaminants (Gibbs et al., 1977, Horowitz and Elrick 1987). The fine particle size is increasing the surface area of the clay, which may be resulting increase the ability to absorption metal per unit mass (Lead et al., 1999).

Bentonite has one octahedral sheet: two tetrahedral sheets. The bentonite has largely negative charges within the crystal, because of the extensive isomorphous substitution. The interlayer bonding is weak, which results in high cation exchange capacity (CEC) (800-1200 mmol Kg^{1-}) and high surface area (800×10^3 m^2 Kg^{-1}) of the bentonite (Bohn, 2001). The amount of the surface layer charge plays an important role in determining the strength and type of bonding layers. If the layer charge is zero, very weak Van der Waals forces bond the layer together. On the other hand, the bonding is strong when the layer charge is negative, because cations go between the unit layers.

The distribution coefficient (K_d = [metal] $_{solid}$/ [metal] $_{solution}$) was determined for each system as a function of adsorbent concentration. K_d values have frequently been used to assess the relative concentration of metals in solution associated with suspended materials (Yin et al 2002). The higher the K_d value, the more metal is associated in the solid materials. Materials representative of components of suspended particles was bentonite. This study will evaluate the ability of different components of suspended material to take up heavy metals. Experiments were carried out to measure the distribution of copper, lead and zinc between an aqueous phase and solid phase sediment material. This study tries to simulate the natural system, exploring the effects of trace metals on important materials, which are commonly found in the soil.

II.   Methods

Four representatives of bentonite sample were investigated. The samples were analysed by Atomic absorption Spectrometry a Perkin Elmer 400 B model. The experiment was performed by adding different masses (0.3 g, 0.5 g, 0.8 g and 1 g) of the bentonite to one litre of distilled water containing trace metal at a1mg/l concentration of metal in a clean, dry glass beaker.

Approximately e.g. 0.3 g of dry material was weighed in a beaker.1 ml of 1 mg/l concentration of metal was added to one litre of distilled water. The 0.3 g of the material was added to the 1 mg/l concentration solution. A stirrer bar was added and the beaker placed on a magnetic stirrer for mixing the sample. The sample was mixed for times ranging between 15 and 30 minutes. The nylon membrane filter paper with 0.2 □ m pore size was weighed. The sample material was filtered through 0.2 □ m pore size filters, and the filter paper was reweighed to determine the mass of material recovered. The filter paper was digested in 3:1 hydrochloric acid /nitric acid solution, an aqua regia digest.

III. Results and discussion

The recovery of bentonite and distribution of Cu, Pb, and Zn metals between solid and solution phase are shown in table (1). The results show most of the mass was recovered. The majority of the metals were measured in the solid phase and measuring low concentrations in solution phase tend to increase K_d values, which result Kd values are > 1. The K_d of metal ions increase with increasing mass of bentonite, except with 0.8 g mass with Cu and Pb. The K_d values for Cu and Pb were higher than for Zn. Metals can adsorb onto bentonite in the two distinct processes, in the permanent negatively charged sites, and a smaller variable charge occurs on the edges of bentonite.

The affinity order of metal K_d for bentonite are shown in table (2), were quite similar with the different masses, were Pb > Cu > Zn for 0.3 g, 0.5 g and 0.8 g of bentonite mass, this was in agreement with the findings of previous research (Gu et al 2010,Yun et al 2006, and Farrah, et al 1976, 1978,1980). On the other hand, different metals K_d order with 1g of bentonite were Pb ≈ Cu > Zn. In general the lowest K_d value was found for Zn.

were Cu > Zn > Pb for 0.3 g and 0.5 g of bentonite mass, this was in disagreement with the findings of previous research Gu et al., 2010,Yun et al., 2006, and Farrah, 1976, 1978,1980. That may be because the concentration of Cu and Pb in 1 L of filtered water was lower than the detection limit, for this reason, use the detection limit amount for this metal to determine the Kd value. On the other hand, different metals K_d order with 0.8 g and 1g of bentonite were Zn > Cu > Pb. In general the lowest K_d value was found for Pb. The K_d order may be different on the surface layer for the bentonite because of the role of so many variables (nature of sites available, nature of counter ion, etc (Farrah et al., 1980). In the current studies the difference of the K_d results may come from the effects of increasing the amount of the sorbent with fixed metal concentration.

Table (1) Recovery of bentonite and distribution of Cu, Pb, and Zn metals between solid and solution phase

A	B	*C	D	E	F	**G	***H	#I
Sample weight (g)	Weight of bentonite recovered in filter	Recovery of bentonite	Concentration of metal in digest of recovered bentonite	Weight of metal in recovered bentonite	Weight of metal in 1 L of filtered water	Total weight of metal recovered	Total weight of metal adjusted for recovery of bentonite	Kd
	(g)	(%)	(mg/l)	(mg)	(mg)	(mg)	(mg)	
0.3	0.2845	94	9.7	0.97	0.21	1.2	1.2	4.6
0.5	0.4615	92	9.9	0.99	0.21	1.2	1.3	4.7
0.8	0.6082	76	5.8	0.58	0.21	0.79	0.97	2.8
1	0.9233	92	7.5	0.75	0.21	0.96	1.03	3.6
1 mg/l Pb								
0.3	0.2767	92	5.85	0.585	0.5	1.085	1.14	1.2
0.5	0.4481	90	7.59	0.75	0.5	1.25	1.33	1.5
0.8	0.7447	93	6.82	0.68	0.5	1.18	1.23	1.4
1	0.977	92	7.47	0.74	0.5	1.24	1.30	1.5
1 mg/l Zn								
0.3	0.277	92	5.78	0.578	0.25	0.828	0.88	2.3
0.5	0.4754	95	6.48	0.648	0.23	0.878	0.91	2.8
0.8	0.7925	99	7.77	0.77	0.27	1.04	1.05	2.9
1	0.9283	93	8.01	0.8	0.12	0.92	0.98	6.7

*C= (B/A)*100, **G= (E+F), ***H= (E*100/C) +F, #I= (E/F)

IV. Conclusion

The results show most of the bentonite was recovered in the filter paper. The majority of the metal was measured in the solid phase, with only a small amount measured in the aqueous phase. That may be cause an increase in K_d values. The high in metal K_d may be because bentonite is swelling clay, with a high surface area and a high cation exchange capacity. In the current studies the difference of the K_d results may come from the effects of increasing the amount of the sorbent with fixed metal concentration. The K_d order may be different on the surface layer for the bentonite because of the role of so many variables (nature of sites available, nature of counter ion, etc (Farrah,et al 1980). That may be because of an increase in surface negative charge with increasing bentonite mass, and fixed metal concentration.

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