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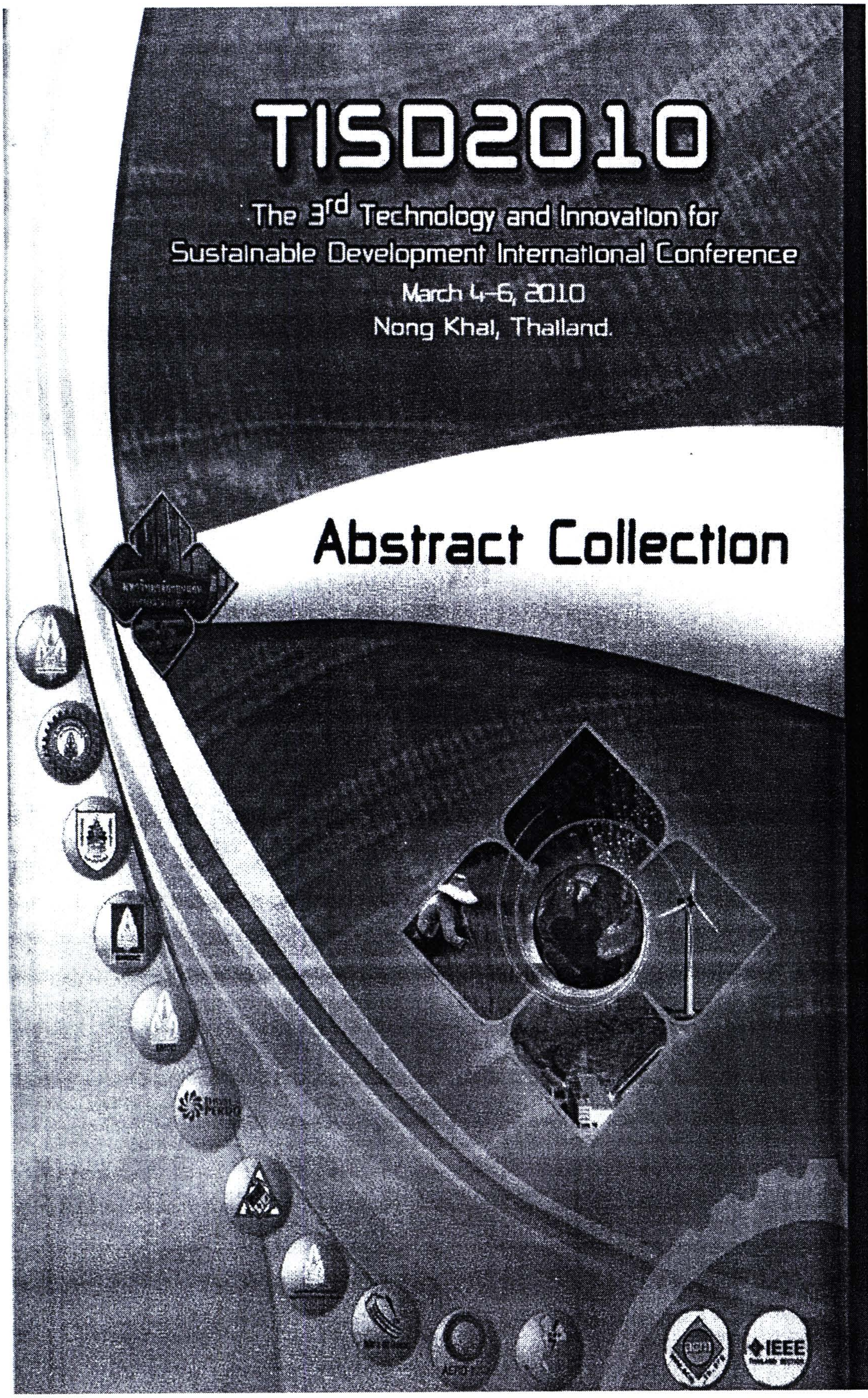
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The

Measurement of Contaminated Sorption in Khon Kaen Soils from Laboratory

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Abstract

This research was purposed to study the sorption capacity of heavy metal by the loess and clay in Khon Kaen region. Geographically, the general composition of the soils in Khon Kaen was 65% of sand, 30% of alluvial soils, and 5% of clay. According to the research, it revealed that the loess had very low percent of plasticity index and had poor capacity of being ion exchange. When clay and loess was tested by batch equilibrium, the result was as Langumuir sorption. When tested with heavy metal solution, the loess had the poor performance of sorption heavy metal solutions to copper (Cu), nickel (Ni) and zinc (Zn) respectively. As for the clay, it showed that clay had good performance in sorption Cu, Zn and Ni consecutively. From the study, sorption capacity could be applied to develop the land where is the main factor of any construction and also improve wastewater treatment system in order to reducing the contamination on soils and water.

Keywords: Loess, Clay, Sorption, Contaminations

1. Introduction

Due to economics growth during many decades, industrial structure has been increased. As a result of this, we have seen the infrastructure around every part of Thailand including the Northeast. Obviously, when economics grows, foundation structure will increase as well. From many cases we have seen on news, it cannot be denied that still there are some of the plant operators neglect social environmental responsibility and this leads to pollution problems. This is the main objective that brought about the research to be a choice of improving pollution problem by focusing on the sorption capacity of heavy metal by the soils in the Northeast region. The research was studied and tested in order to find out the suitable and unhazardous chemicals with the cheap price to reduce the sorption of land contamination as well as studying for better ways of preventing hazardous waste from any possible sources to communities, most of top soil layer in the Northeast of Thailand is loess. Loess covers the wide range of this region and the thickness of loess is approximately 5-6 meters from surface (Fig.1). Loess found in this region is typically red especially in Khon Kaen and neighboring provinces (Fig. 2). It is considered from engineering geophysics as silty sand due to its bare bonding. From the experiment, it showed that soil was able to absorb hazardous chemicals and toxic metals such as Zn, Cu and Ni that found in community wastes, industrial waste or even in abandoned hazardous sites. The factors affecting toxic sorption were kinds of toxics and different qualifications of soils. Due to this, this research was specifically studied on sorption's qualifications of loess and clay in Khon Kaen in order to find out its heavy metal sorption's capacity.

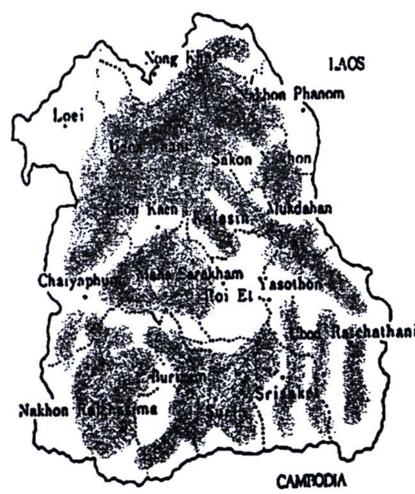

Figure 1 Areas of loess (stippled area) in the Northeast of Thailand.

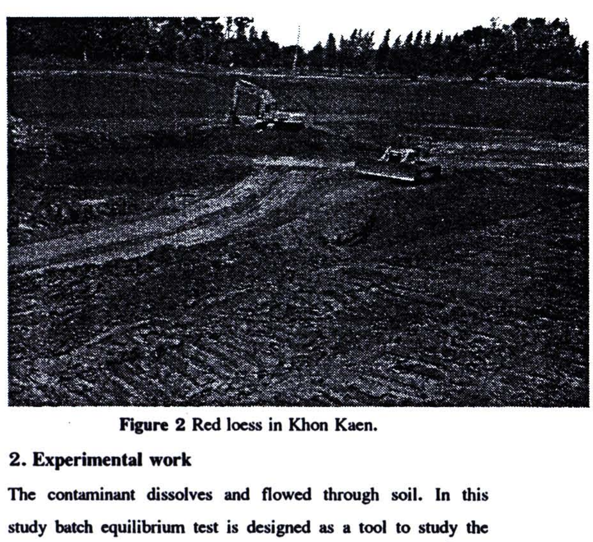

Figure 2 Red loess in Khon Kaen.

2. Experimental work

The contaminant dissolves and flowed through soil. In this study batch equilibrium test is designed as a tool to study the equilibrium sorbtion of soil suspensions with contaminants. In batch test, chemical solution and disaggregated state are brought into contact. After period of time that normally ranges from hours to days, the degree of portioning of the chemical between the solution and the soil is determined. The equilibrium contact time was firstly determined and investigated by kinetic batch sorption tests. As explained in details by Tanchuling (2005). Batch absorption test was also taken to find the metal's sorption qualification to these heavy metal solution which were zinc, copper and nickel by dissolving nitrate from $Zn(NO_3)_2$, $Cu(NO_3)_2$ and $Ni(NO_3)_2$. The test processes are as follows;

1) Soil samples were loess and clay. These two samples was washed to clear as much as contaminant away first after that, sized it by taking through by the sieve No.200 (Fig.4).
2) Heavy metal used in the experiment were Copper Sulfate, Nickel Sulfate, and Zinc Sulfate with the composition of 5, 25, 50 and 100 ml/L concentration respectively (Fig.5).
3) Constant mass of oven soil powder of 2.5g and 50 ml of metal solution were added into a set of 120 ml. plastic bottle (Fig.6).
4) The soil solutions were shaked for 6, 12, 24 and 48 hours (Fig.7) and then filtrated through 0.2 micrometer filter to separate the solid and liquid solution.
5) Liquid solution was then analyzed concentration by using Atomic adsorption spectrophotometer (Fig.8)

3. Material description

The basic, index and engineering properties of Khon Kaen loess and clay are tabulated in Tables 1 and 2.

Table 1 Khon Kaen loess properties.

Properties	Loess
Soil Classification (USCS)	SM
Specific gravity	2.60
Natural water content (%)	5 - 12
Liquid limit (%)	16.0
Plastic limit (%)	13.0
Plasticity index (%)	3.0

Table 2 Khon Kaen clay properties.

Properties	Clay
Soil Classification (USCS)	CM
Specific Gravity	2.69
Natural water content (%)	76.32
Liquid limit (%)	55.18
Plastic limit (%)	27.36
Plasticity index (%)	27.82

Heavy metal chosen in this study was zinc (Zn), copper (Cu) and nickel (Ni) which was obtained by dissolving nitrate. In Tables 3, 4 and 5 shown Properties of zinc nitrate, copper nitrate and nickel nitrate, respectively.

Table 3 Properties of zinc nitrate.

Compound used	Zinc nitrate
Formula	$Zn(NO3)_2$
Molecular weight (g/mol)	297.49
Density (g/cm^3)	2.065
Solubility (g/100 ml)	184.3

Table 4. Properties of copper nitrate.

Compound used	Copper nitrate
Formula	$Cu(NO_3)_2$
Molecular weight (g/mol)	295.65
Density (g/cm^3)	2.07
Solubility (g/100 ml)	137.8

Table 5 Properties of nickel nitrate.

Compound used	Nickel nitrate
Formula	$Ni(NO_3)_2$
Molecular weight (g/mol)	290.79
Density (g/cm^3)	2.05
Solubility (g/100 ml)	94.2

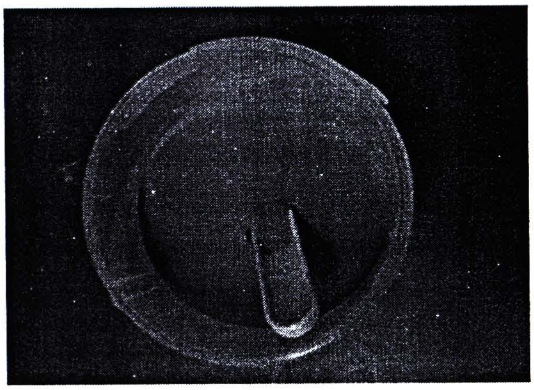

Figure 4 Soils passed sieve No. 200.

Figure 5 Initial concentration of solution.

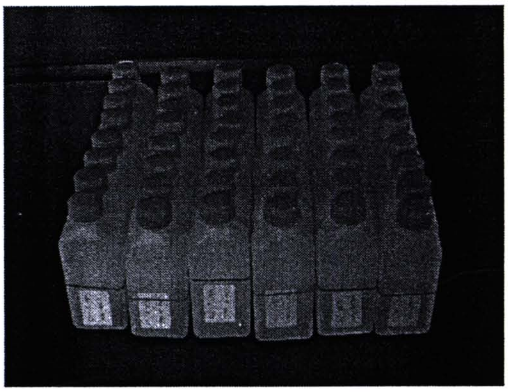

Figure 6 Soil and solution.

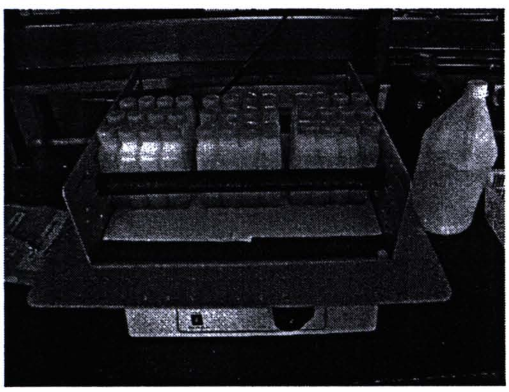

Figure 7 Shaking soil and solution.

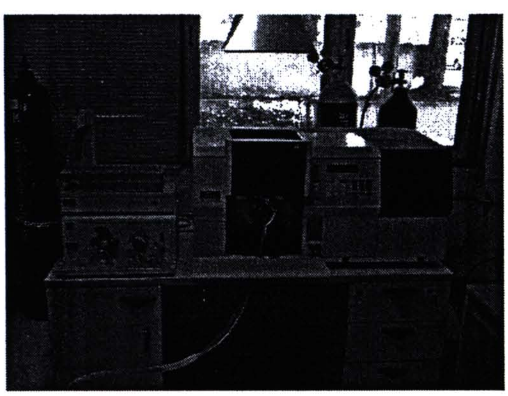

Figure 8 The analysis of concentration by Atomic adsorption spectrophotometer (AAS).

4. Experimental result

From the experiment, it can be carried out the results are as the follows;

1) For the loess, its equilibrium of sorption copper and nickel could be found since the first hour of experiment and the equilibrium sorption of zinc was found in the 48 hours of the test (Tables 6, 7 and 8).

Table 6 Contact time of zinc by loess (100 mg/L).

Mixing time	$C_{initial}$ (mg/L)	C or $C_{equilibrium}$ (mg/L)	C_{solid} (mg/g)
6	100	205.80	-26.513
12	100	115.00	-3.758
24	100	104.80	-1.202
48	100	93.40	1.651

Table 7 Contact time of copper by loess (100 mg/L).

Mixing time	$C_{initial}$ (mg/L)	C or $C_{equilibrium}$ (mg/L)	C_{solid} (mg/g)
6	100	75.400	6.170
12	100	74.800	6.315
24	100	72.400	6.928
48	100	69.800	7.562

Table 8 Contact time of nickel by loess (100 mg/L).

Mixing time	$C_{initial}$ (mg/L)	C or $C_{equilibrium}$ (mg/L)	C_{solid} (mg/g)
6	100	85.90	3.525
12	100	87.20	3.213
24	100	86.40	3.414
48	100	84.70	3.843

2) For the clay, all of the equilibrium sorption of copper, nickel and zinc occurred in the 48 hours of experiment (Tables 9, 10 and 11).

Table 9 Contact time of zinc by clay (100 mg/L).

Mixing time	$C_{initial}$ (mg/L)	C or $C_{equilibrium}$ (mg/L)	C_{solid} (mg/g)
6	100	-3.80	26.002
12	100	11.40	22.203
24	100	21.60	19.608
48	100	50.80	12.325

Table 10 Contact time of copper by clay (100 mg/L).

Mixing time	$C_{initial}$ (mg/L)	C or $C_{equilibrium}$ (mg/L)	C_{solid} (mg/g)
6	100	-6.60	26.714
12	100	16.40	20.967
24	100	45.10	13.747
48	100	44.30	13.981

Table 11 Contact time of nickel by clay (100 mg/L).

Mixing time	$C_{initial}$ (mg/L)	C or $C_{equilibrium}$ (mg/L)	C_{solid} (mg/g)
6	100	41.20	14.759
12	100	49.90	12.525
24	100	58.70	10.375
48	100	59.20	10.241

After that plot the Equilibrium results on the graph between the concentrations of solid (C_{solid}) and the concentration of liquid (C) in order to see the highest tendency that soils can absorb (Figs.8 and 9).

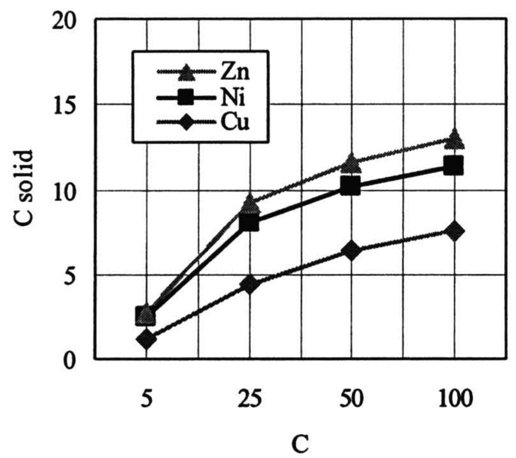

Figure 8 The sorption of zinc, copper and nickel by loess.

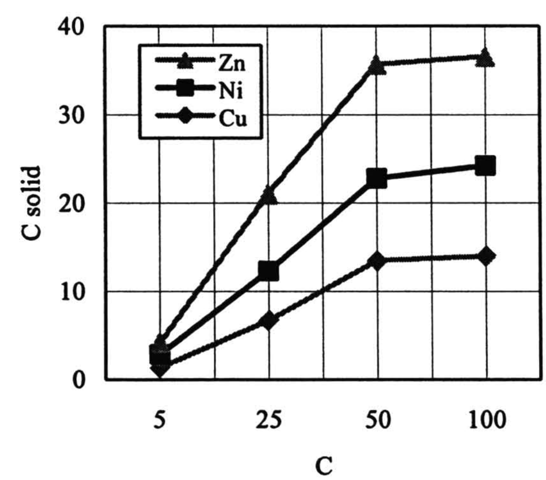

Figure 9 The sorption of zinc, copper and nickel by clay.

For sorption by loess and clay, the curves are in Figs.10 and 11. It can be found from the results that the lowest sorption of copper can be occurred with loess soil and the lowest sorption of zinc can be occurred with clay soil. This is implied that once loess has been contaminated, precipitation or flow of water to soil will cause all contaminations to flow directly into an aquifer below the loess layer or to flow mainly into the river nearby the loess deposits. The results in Figs.10 and 11 also show that the highest sorption in loess is occurred with zinc and the highest sorption in clay is occurred with nickel that is a very low permeability media.

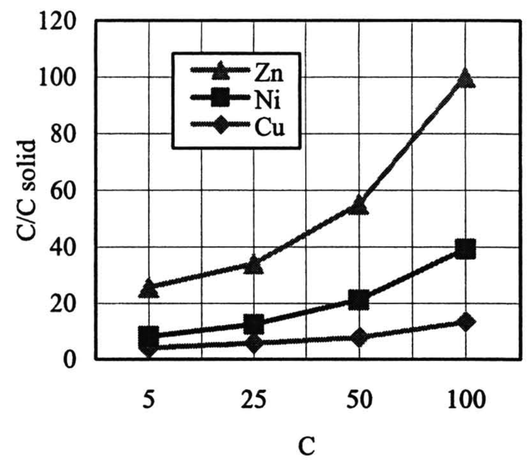

Figure 10 Batch sorption of the toxic metals by loess.

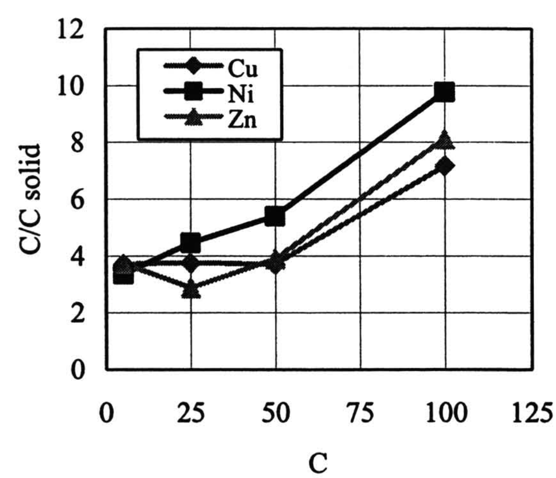

Figure 11 Batch sorption of the toxic metals by clay.

It has been observed in Figs. 12 and 13 that the Langmuir sorption isotherms fit quite satisfactorily

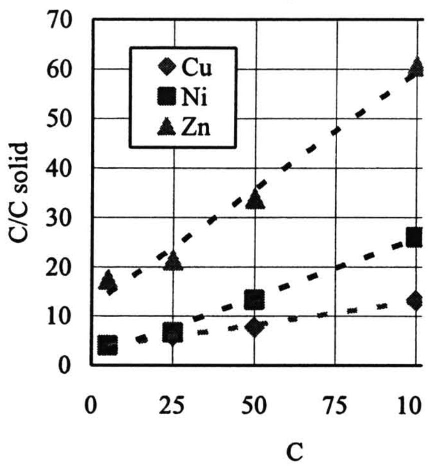

Figure 12 Langmuir isothermsof toxic metalsby loess.

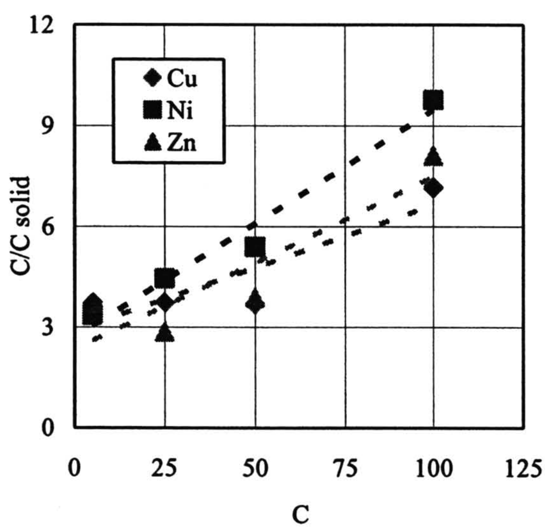

Figure 13 Langmuir isotherms of toxic metals by clay.

The result will be plotted at the graph for find the slope and the intercept form to compare with Langmuir. The slope is the maximum amount of contaminant that can be adsorbed by the solid (mg/g) and y intercept is the adsorption constant related to the binding energy (L/mg). Langmuir sorption isotherm has been developed on the concept that a solid surface possesses a finite number of sorption sites and mathematically expressed as

$$C_{solid} = \frac{\alpha \beta C}{1 + \alpha C}$$

where α = the adsorption constant related to the binding energy (L/mg) and β = the maximum amount of contaminant that can be adsorbed by the solid (mg/g). To determine the values of α and β, a relationship of C versus C/C_{Solid} is plotted. The determined values of α and β based on the calculation from Fig.14 for different isotherms are shown in Table 11.

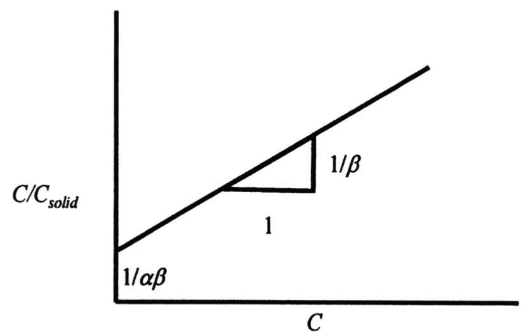

Figure 14 Langmuir isotherm's parameters.

Table 11 Langmuir isotherm parameters.

Soils	solution	α (L/mg)	β (mg/g)
loess	zinc	0.2	0.47
	copper	3.1	0.0961
	nickel	2.3	0.2382
clay	zinc	8.3	0.0513
	copper	9.2	0.0373
	nickel	5.5	0.0674

5. Conclusion

With the amount of hazardous waste in Khon Kaen Province increasing continuously, soil which is the main substance to keep the waste is ineffective enough to absorb all wastes and when compare the sorption concentration, loess has the very low equilibrium; therefore, when the solutions' concentration increases, loess do not have good performance of absorbing. As a result, the waste or chemicals will eventually contaminate on soils or even run to water. For clay, it is more efficient in absorption solutions than loess and it can be concluded that the similarities and differences between clay and loess' equilibrium are as follows;

1) Equilibrium of both clay and loess to the metal solutions is not over 48 hours. If more than 48 hours, both of clay and loess will not absorb any solution until it was evaporate.
2) Loess has lower equilibrium than clay.
3) Both clay and loess have sorption value according to Langmuir.
4) Though clay and loess have sorption value according to Langmuir, it isn't allowed to directly let hazardous waste on soils by law as it's still dangerous. Then, to fix the problem hazardous waste should be treated properly before being abandoned.

6. Acknowledgement

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ประวัติผู้เขียน

นายณรงค์เดช มหาศิริกุล เกิดเมื่อวันที่ 17 มิถุนายน พ.ศ. 2527 ณ อำเภอเมือง จังหวัดขอนแก่น สำเร็จการศึกษาระดับมัธยมศึกษา เมื่อปีการศึกษา 2545 โรงเรียนสาธิตมหาวิทยาลัยขอนแก่น (ศึกษาศาสตร์) จังหวัดขอนแก่น และสำเร็จการศึกษา วิศวกรรมศาสตรบัณฑิต สาขาวิชาวิศวกรรมโยธา คณะวิศวกรรมศาสตร์ มหาวิทยาลัยขอนแก่น เมื่อปีการศึกษา 2550 เข้าศึกษาในระดับปริญญาโท สาขาวิชาวิศวกรรมสิ่งแวดล้อม คณะวิศวกรรมศาสตร์ มหาวิทยาลัยขอนแก่น เมื่อปีการศึกษา 2551