نشریه مهندسی عمران امیرکبیر

Amirkabir Journal of Civil Engineering

Amirkabir J. Civil. Eng., 51(2) (2019) 103-105
DOI: 10.22060/ceej.2018.13499.5425

Evaluation the effect of Lead and Zinc heavy metals contaminants on settlement characteristics of sandy clay

A. Negahdarr[1]*, M. Nikghalbpour [2], M. R. Shabanian [3], N. Ghadimi Ardebili[4]

,University of Mohagheghe Ardabili, Technical faculty, Ardabil, Iran

ABSTRACT: Preventing leaks of leachate from landfills that generally contain heavy metals to the under layers of soil is one of the most common issues in geo-environmental engineering in the world. Clay minerals are able to exchange cation interlayer with other positive metal cations so they are considered as natural absorbent. Previous studies have shown that the interaction between clay minerals and heavy metals cause the changes in microstructure and surface characteristics of clay minerals which lead to changing in geotechnical properties of clay. Thus, the aim of this paper is to study the effects of heavy metals on compressibility process in sandy clay. For this purpose after preparation of samples some laboratory tests including X- Ray Diffraction (XRD), sedimentation test, 1-D consolidation, absorption and liquid limits were carried out. The results of XRD and sedimentation tests showed that the clay microstructure would change from disperse to flocculate in the presence of Pb and Zn heavy metals in which the intense of this change depends on heavy metal concentration in pore fluid. As a result of change in microstructure of clay minerals, the initial void ratio and settlement characteristics of samples decrease. In the other words by increasing the concentration of heavy metal of Pb from 0 to 25 cmol/kg.soil the initial void ratio of kaolinite samples with 10, 25 and 40 percent of dry weight sands decreased to 0.17, 0.20 and 0.25 respectively. In addition the decrease in same samples in the presence of Zn is 0.13, 0.16 and 0.18 respectively.

Review History:

Received: 5 October 2017
Revised: 28 November 2018
Accepted: 20 January 2018
Available Online: 28 February 2018

Keywords:
Sandy clay
Heavy metal contaminants
Consolidation parameters
Liquid limit
XRD

1-Introduction

Preventing the leaking of leachate of waste into the under layer soil is one of the most common issues in geo-environmental engineering. Heavy metals in leachate have harmful impact on environment and human. Study the abundance of heavy metals shows that Pb, Cu, Cg, Cr, Cd, Zn have high concentrations. Clay soils are used as Liner in landfills exposed to physiochemical attacks by the leachates generated from waste. The presence of heavy metal contamination in heavy metal leachate affects the pore fluid chemistry and controls the diffuse double layer (DDL) thickness of clay particles [1].

According to Guy-Chapman's double layer theory, the thickness of the double layer is only dependent on the salts dissolved and the liquid phase; accordingly, changes in the properties of the liquid phase resulting from entrance of contaminants into the soil environment cause variations in the thickness of the layer and thus the behavioral characteristics of soil. On the other hand, the higher the thickness of the double layer, the less the particles tend to flocculate [2]. Some researchers investigate the geotechnical properties of different kinds of clay in the presence of different contaminations [3-11]. But the effects of heavy metal contaminants on kaolinite clay minerals in the combination of sands less discussed.

2- Materials and methods

The Kaolinite used in this research was in the form of a white powder which was supplied by Iran's porcelain soil industries and is known as super kaolinite. Table 1 indicates some environmental and geotechnical properties of the utilized kaolinite, which have been determined based on ASTM 2007 standard method.

Table 1. The primary physical and chemical characteristics of kaolinite soil

Property evaluated	The measured values
Liquid limit, %	46
P.I. ٪	20
Soil Classification	CL
pH (1:50, Soil-Water)	8.9
Carbonate, %	4

The sand used in this research belongs to ASTM-C778 classification, and is SiO_2 (Otawa) silica sand. In the pure state, the percentage of silica in it is around 8.99. Its particles are round shaped and diameter of the particles varies between 0.595 and 1.18 mm.

Fabrication of the kaolinite-sand mixture samples was performed by a mixture of kaolinite with weight percentages of 10, 25 and 40% sand. The reason of selection of these percentages can be related to the fact that soil nomenclature, according to unified naming system (CL), would remain constant in a relatively wide range of changes in the sand ratio. Following preparation of the soil samples, in order to examine

Corresponding Author, Email: negahdar@uma.ac.ir

the effect of heavy metal contaminants on compressibility process, the experiments of liquid limit determination and consolidation tests were done on the samples according to ASTM D4318 and ASTM D 3080-90 standards, respectively. Further, analysis of the pore water characteristics was done by ICP device provided by Tarbiat Modares University in order to determine the extent of adsorbed cations.

3- Results and Discussion

The results of XRD on the samples in the presence of Zn is shown in Figure 1.

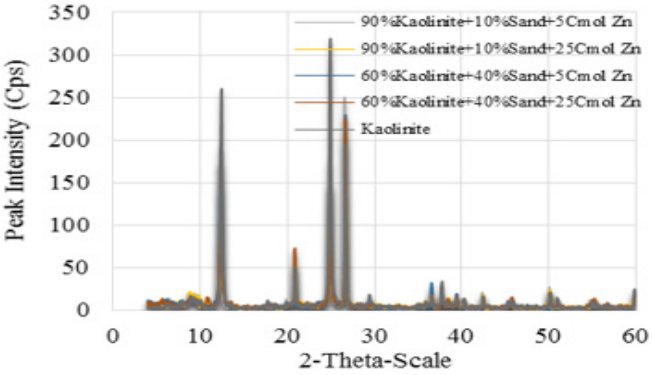

Figure 1. XRD results for samples in the presence of zinc

According to Figure 1, the more intense peak in kaolinite sample is detected than other peaks in 7.13 Å and 3.56Å which indicates the presence of significant amount of Kaolinite mineral in sample. Main peak of kaolinite in pure sample and sandy clay sample in presence of Zn and Pb is shown in Figure 2.

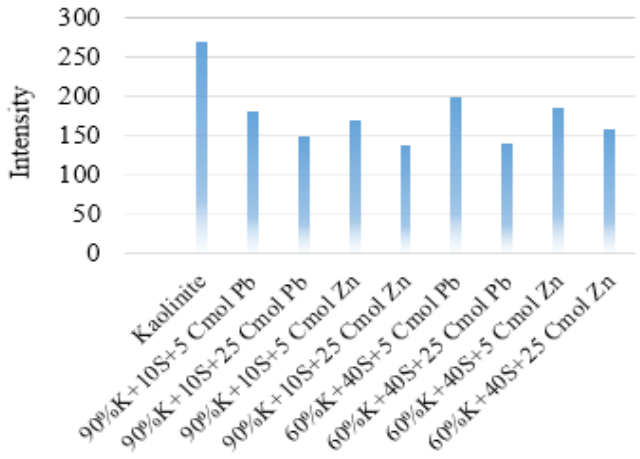

Figure 2. Main peak of samples, contamination Zn and Pb

According to Figure 2, decrease in main peak of kaolinite in samples with 90% of kaolinite in the presence of 5 and 25 cmol/kg.soil of Pb were 33 and 45 respectively. Generally, with the increase in concentration of Zn and Pb heavy metals, the intense main peaks decreased.

Figure 3 shows that in the specified concentration of contamination Pb heavy metal has more effective influence on samples than Zn. The reason of this phenomena is the selective absorbent of kaolinite in absorbing Pb more than Zn. In addition, the results of absorbent tests also confirm this reason.

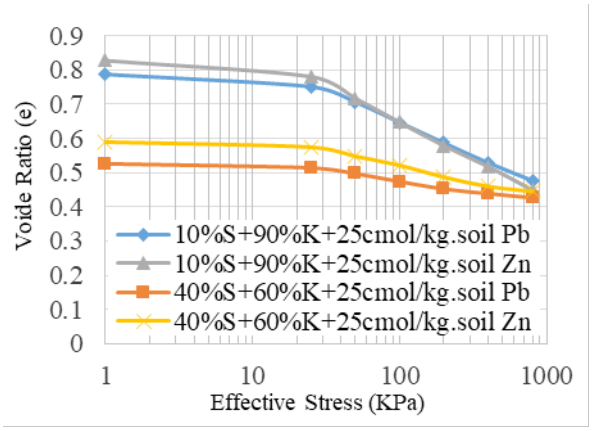

Figure 3. Comparison the effects of Pb and Zn on compressibility of clay-kaolinite samples

4- Conclusions

The results of this research can be summarized as follows:

The results of XRD and sedimentation tests express that the presence of Pb and Zn contaminants cause the reduction in double layer thickness and overcome attraction force to repulsion forces. Therefore, the microstructure changes from diffused to flocculated, in which flocculation intensified by increasing Pb and Zn concentration.

The results of investigating retention of Pb and Zn heavy metals show that in all samples and both heavy metals, the increase in the concentration of heavy metal lead to increasing the retention of samples which is related to the moderate cation exchange capacity of kaolinite and carbonate content.

Liquid limit of all sand-kaolinite samples in the presence of Pb and Zn deceased. The reduction in liquid limit of samples have direct relation with heavy metal concentrations. In addition, the rate of reduction liquid limit of samples with further sand content decreased with increasing heavy metal concentration.

Consolidation curves (changing void ratio to logarithm of pressure) of sand-kaolinite samples in the presence of different concentration of heavy metal show that the increase of concentration of heavy metal initial void ratio and compressibility of samples decreased. In a way that with the increase of Pb contaminant from 0 to 25 cmol/kg.soil the initial void ratio of 10, 25 and 40 percent of sand-kaolinite clay decreased 0.17, 0.20 and 0.25 respectively. Also the reduction in the samples was 0.13, 0.16 and 0.18 respectively in the presence of Zn. Finally, the result of experiments showed that Pb has more influence on samples that Zn. The main reason is the more tendency of kaolinite in absorbing Pb than Zn.

References

[1] P.S. Yarlagadda, M.R. Matsumoto, J.E. VanBenschoten, A. Kathuria, Characteristics of heavy metals in contaminated soils, Journal of environmental engineering, 121(4) (1995) 276-286.

[2] J.K. Mitchell, K. Soga, Fundamentals of soil behavior, (2005).

[3] J.C. Miranda-Trevino, C.A. Coles, Kaolinite properties, structure and influence of metal retention on pH, Applied Clay Science, 23(1) (2003) 133-139.

[4] Y.-J. Du, R.-D. Fan, K.R. Reddy, S.-Y. Liu, Y.-L. Yang, Impacts of presence of lead contamination in clayey soil–calcium bentonite cutoff wall backfills, Applied Clay Science, 108 (2015) 111-122.

[5] H.-Y. Fang, J.L. Daniels, Introductory geotechnical engineering: an environmental perspective, CRC Press, 2006.
[6] I.M. Lo, A.F. Luk, X. Yang, Migration of heavy metals in saturated sand and bentonite/soil admixture, Journal of Environmental Engineering, 130(8) (2004) 906-909.
[7] A. Nakano, L. Li, M. Ohtsubo, A. Mishra, T. Higashi, Lead retention mechanisms and hydraulic conductivity studies of various bentonites for geoenvironment applications, Environmental technology, 29(5) (2008) 505-514.
[8] J. Dutta, A.K. Mishra, Consolidation Behavior of Compacted Bentonites in the Presence of Heavy Metals, Journal of Hazardous, Toxic, and Radioactive Waste, 21(3) (2017) 04017003.
[9] V.R. Ouhadi, Haghayegh, A., Bayeste, H., The effect of heavy metal contamination on performance of sand- bentonit mixture (SEB) in landfill, Modares Technical and engineering Journal, 33 (2008).
[10] V.R. Ouhadi, M. Amiri, Geo-environmental behaviour of nanoclays in interaction with heavy metals contaminant, Amirkabir J, Civil, 42 (2011) 29-36.
[11] V. Ouhadi, R. Yong, M. Sedighi, Influence of heavy metal contaminants at variable pH regimes on rheological behaviour of bentonite, Applied Clay Science, 32(3) (2006) 217-231.

Please cite this article using:
A.R.Negahdar,M.Nikghalbpour,M.R.Shabanian,N.GhadimiArdebili,Evaluation the effect of Lead and Zinc heavy metals contaminants on settlement characteristics of sandy clay ,*Amirkabir J. Civil Eng*., 51(2) (2019)341-350.
DOI: 10.22060/ceej.2018.13499.5425