University of Tabriz

Journal of Civil and Environmental Engineering
Volume 53 (2024), Issue 4 (Winter), 1-12

EXTENDED ABSTRACT

Impact of Temperature and Type of Clay Double Layer Cation on Adsorption of Copper Heavy Metal Contaminant

Vahid Reza Ouhadi [a]*, Ali Reza Vejdani Vahid [b]

[a] *Faculty of Civil Engineering, Bu-Ali Sina University, Iran; Adjunct Prof, School of Civil Engineering, University of Tehran*
[b] *Faculty of Civil Engineering, Bu-Ali Sina University, Iran, Hamedan, Iran*

Received: 23 April 2022**; Review:** 16 December 2022**; Accepted:** 24 December 2022

Keywords:
Clay, Temperature, Heavy Metal Contaminant, Double Layer Cation, De-hydroxylation.

1. Introduction

Bentonite is commonly used as a liner in landfills to prevent the leaching of the waste leachate to the groundwater (Yong et al., 1992; Abollino et al., 2003; Zhan et al., 2022). Sodium-bentonite and calcium-bentonite are among the useful materials for this purpose. On the other hand, in several cases clayey soils are exposed to high temperature in engineering and geo-environmental engineering projects (Tan et al., 2004). Dehydration and de-hydroxylation are the two major phenomena during heating process of clayey soils (El Warid et al., 2022). In spite of several researches on the interaction of heavy metals and clayey soils, there are lack of research on the subject of mutual effect of temperature and double layer cation type on the adsorption of heavy metals in clayey soil. Therefore, the main objective of this paper is to investigate on the impact of temperature and type of double layer cation on adsorption of copper heavy metal by the clayey soils with high plasticity index. To achieve the above mentioned objective, calcium chloride salt was used to make homo-ionic bentonite. Several types of geo-environmental engineering experiments were performed to address and to achieve the above mentioned objective.

2. Methodology

To make homo-ionic bentonite, calcium chloride salt from Merck Company, was used, for which the calcium chloride with four times of bentonite cation exchange capacity was added to the soil. To prepare the heat treated soil samples, sodium-bentonite samples were heated at 50, 100, 200, 400, 600, 700, 800, 850, 900, 950, and 1000 degrees centigrade. In addition calcium-bentonite samples were heated at 200, 400, 600, and 800 degrees centigrade. Then, samples were exposed to different concentration of copper nitrate. After achieving equilibrium, samples were dried. Finally, a series of geo-environmental engineering experiments were performed on soil samples.

3. Results and discussion

The results of heavy metal retention by sodium bentonite samples which already were treated at 25 to 1000 degrees of centigrade and then were exposed to different concentration of copper nitrate are plotted and presented in Fig. 1.

---

* Corresponding Author
E-mail addresses: vahidouhadi@yahoo.ca (Vahid Reza Ouhadi), alireza.vejdanivahid@gmail.com (Ali Reza Vejdani Vahid).

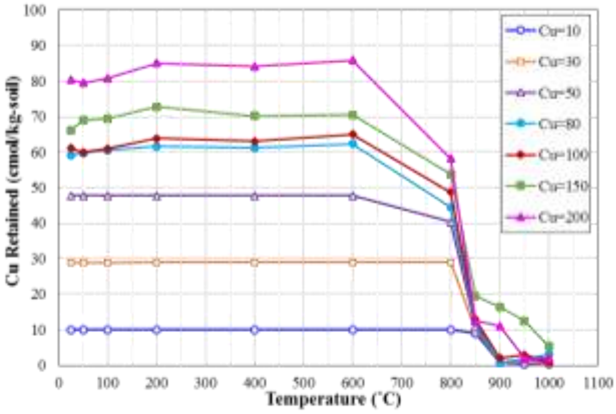

Fig. 1. The contaminant retention by pre-heated sodium-bentonite at different Cu-concentrations

As the results of Fig. 1 show, with increasing the temperature up to 600 degrees, the contaminant retention of samples at any specific initial heavy metal concentration are relatively similar. The dehydration temperature of clay minerals is reported to be around 350 degrees (Zivica and Palou, 2015). Therefore, based on the results of Fig. 1, it can be concluded that an increase in initial temperature around dehydration temperature, has low impact upon contaminant retention in soils with high plasticity index. In addition, for samples initially treated at 600 to 800 degrees centigrade, the de-hydroxylation and initial concentration of heavy metals were two major controlling factors.

4. Conclusions

According to the results of this paper the following conclusions can be addressed:

- In sodium-bentonite samples, due to the presence of sodium ions in clay double-layer, the soil behaviour is noticeably function of de-hydroxylation at temperatures above 600 degrees centigrade.

- At 400 to 600 degrees centigrade and above, the major mechanism for contaminant retention is the existence of carbonate in soil. This emphasizes on the importance of presence of carbonate in clayey soils to have a stable buffering capacity at high temperature.

- The change in the intensity of major peak of montmorillonite at 600 degrees centigrade and above is independent of type of double layer cations.

5. References

Abollino O, Aceto M, Malandrino M, Sarzanini C, Mentasti E, “Adsorption of heavy metals on Na-montmorillonite”, Effect of pH and organic substances, Water research, 2003, 37 (7), 1619-1627. https://doi.org/10.1016/S0043-1354(02)00524-9

El Wardi FZ, Ladouy S, Atbir A, Khabbazi A, “Study of the thermal and mechanical properties of local clay materials activated with quicklime”, Sefrou (Morocco), Materials Today: Proceedings, 2022. https://doi.org/10.1016/j.matpr.2022.02.348

Tan Ö, Yılmaz L, Zaimoğlu AS, “Variation of some engineering properties of clays with heat treatment”, Materials Letters, 2004, 58 (7-8), 1176-1179. https://doi.org/10.1016/j.matlet.2003.08.030

Yong RN, Mohamed AMO, Warketin BP, “Principles of contaminant transport in soils”, Elsevier, Holland, 1992.

Zhan LT, Ni JQ, Feng S, Kong LG, Feng T, “Saturated hydraulic conductivity of compacted steel slag-bentonite mixtures A potential hydraulic barrier material of landfill cover”, Waste Management, 2022, 144, 349-35. https://doi.org/10.1016/j.wasman.2022.04.004

Zivica V, Palou MT, “Physico-chemical characterization of thermally treated bentonite”, Composites Part B: Engineering, 2015, 68, 436-445. https://doi.org/10.1016/j.compositesb.2014.07.019