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Effect of Leachate pH on the Collapse Potential and Shear Strength Parameters of Collapsible Soils

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ABSTRACT: Collapse soils have a stable loose honeycomb-type structure in a low degree of saturation which is susceptible to a large reduction in total volume or collapse upon wetting. The aim of this study is to evaluate the collapse potential and shear strength parameters due to saturation of soil caused by the infiltration of contaminants including leachate wastewater and chemicals into the soil. Since the separation of leachate components is difficult, especially with change of ingredients and pH in long time, the two factors sulfuric acid and sodium hydroxide were used as representatives of the leachate in the pH of 1 to 14. Furthermore, collapse tests and direct shear tests were performed on soil samples which were saturated by leachate. Experimental results show that leachate with a low pH or acidic solutions increase the soil collapse potential; on the other hand, leachate with a high pH or alkaline solutions cause less soil collapse. Variation range of soil collapse in acidic solution was much more than alkaline solution. Direct shear test results demonstrate that acidic leachate increase the soil cohesion and reduce the internal friction angle of soils; however, alkaline leachate reduce the soil cohesion and increase the friction angle of soils.

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1- Introduction

The effects of acid and alkali on soil properties have been studied in the past decades. Soil type, plastic index, stress, hydraulic conductivity and acid-alkali solution properties, are the topics that have been investigated in this area. Huang and Keller studied dissolution of clay minerals in organic acids at room temperature and concluded that the dissolution of clay minerals depends on the type of clay mineral and used acid [1]. Mahdavi studied the effect of pH changes on some mechanical parameters of clay and concluded that pH reduction and acidification of the soil caused soil agglomeration and increased soil permeability to 87% compared to non-contaminated sample, while increasing soil pH caused to decrease in permeability to 47% compared to the initial state [2]. Benson and Huaming studied hydraulic conductivity of compacted clay liners and concluded that according to the effect of chemicals on soil structure and void areas, they have an effect on hydraulic conductivity [3]. Farster and Heick attributed changes in the structure of soil in the vicinity of chemicals to changes in ion concentration, ion exchange, adsorption, or dissolution of anions [4]. Ramakrishnegowda et al. studied geotechnical properties of shed soil affected by alkali contamination and concluded that the shear strength of soil decreases essentially due to the decrease in the cohesion of the soil particles. The hydraulic conductivity of the soil increases with higher concentrations of alkali solution. These changes in geotechnical properties of soil are attributed to change in the structure of soil particles in interaction with alkali materials [5]. In this study, the effect of pH of leachate on the rate of collapse and shear strength parameters of collapsible soils has been investigated.

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2- Methodology

Loess soil was provided from Kalale in Golestan province at the north of Iran. The basic properties of the soil are presented in Table 1.

Table 1. Geotechnical properties of soil sample

USCS	pH	GS	LL	PL	PI
CL	7.9	2.67	25	20	5

In order to simulate the effect of leachate on the potential of collapse and shear strength parameters of soil, sulfuric acid and sodium hydroxide were used with different range of pH, collapse test and direct shear test were performed on soil samples under saturated conditions. Furthermore, the effect of percentage of pollution was evaluated on the rate

of collapse. In this study, collapse and direct shear test were performed according to ASTM D5333 and ASTM D3080 standards, respectively.

3- Results and discussion

Firstly, the collapse tests were conducted on soil samples without contamination and the soil samples were saturated by water. The average rate of collapse was 11.67(%) for soil, which makes the soil to be placed in the category of severely collapse.

Moreover, collapse tests were conducted under saturated conditions with different pH values and the results are shown in Figures 1 and 2. The experimental results showed that the leachate with low pH increased the potential of collapse of soils and leachate with high pH resulted in less collapse. It should be noted that the variation range of soil's collapse in low pH values was much more than in high pH values. In other words, changes in soil collapse caused by one or two units change in pH to acidification side is much more than the same change to alkalizing side.

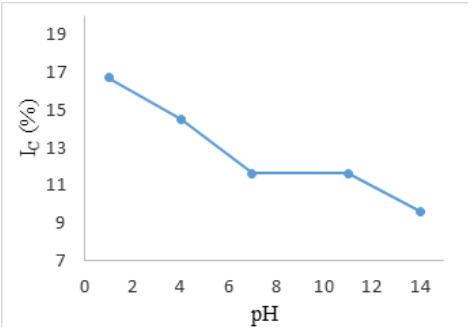

Figure 1. Behavior of soil collapse vs pH

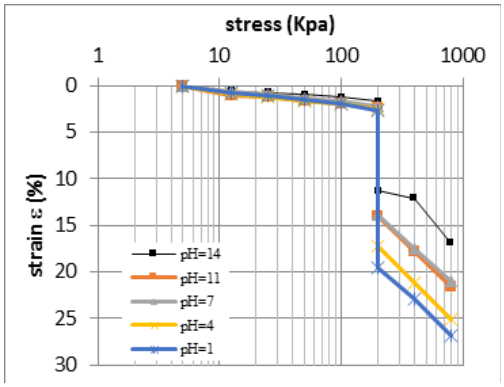

Figure 2. Comparison of soil collapse in saturated conditions with different pH values

The collapse tests results for different percentages of contamination are shown in Figure 3. Since the contaminated soil samples were saturated with water, acid and alkali effect largely disappeared and the final pH of the soil under the influence of acid and alkali has not changed much in this case. As shown in Figure 1, the variation range of soil collapse in high pH or alkaline solutions is low. Due to this fact that the final pH of the soil has not changed much, it can be concluded that increasing the percentage of pH would not create significant changes in the potential collapse. On the other side, the effect of soil saturated with water and acid is largely disappeared by increasing the percentage of acid, and the potential of collapse increased with increasing the percentage of acid due to the high variation range of soil collapse under the low pH condition.

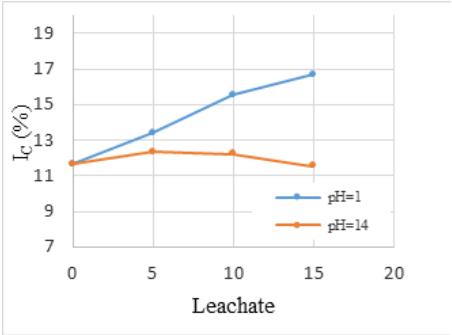

Figure 3. Comparison of soil collapse for different percentages of contamination

Direct shear test results under saturated conditions with different pH values are shown in Table 2. The results showed that acidic leachate increased the soil cohesion and alkaline leachate reduced the soil cohesion. Conversely, internal friction angle of soil was reduced when faced with acidic solution (low pH) and increased in alkaline solution (high pH).

Table 2. Direct shear test results under saturated conditions with different pH values

pH	C (kPa)	Ø (˚)
1	66	7.04
4	60.67	8.25
7	36.12	9.5
11	28.27	11.53
14	20.33	15.89

Figure 4 shows the failure envelope graphs related in this case.

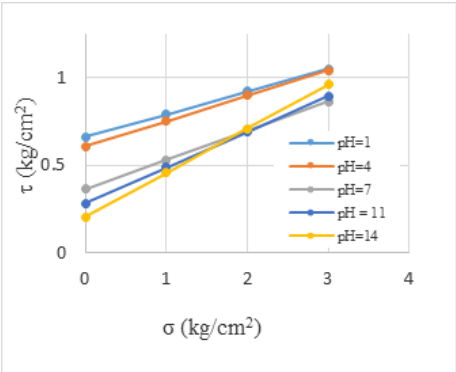

Figure 4. Failure envelope graphs under saturated conditions with different pH values

4- Conclusions

1. Leachate with low pH increased the potential of collapse of soils and leachate with high pH caused less collapse to happen.
2. Variation range of collapse soil in low pH values (acidic leachate) was much more than high pH values (alkaline leachate). In other words, changes in soil collapse caused by one or two units change in pH to acidification side is much more than the same change to alkalizing side.
3. Direct shear test results demonstrated that by decreasing pH of leachate, soil cohesion increased and with the increase of pH, soil cohesion decreased. Conversely, by reducing pH, internal friction angle of soil reduced and with increasing of pH, internal friction angle of soil increased.
4. Variation range of soil cohesion in low pH was much more than in high pH. In other words, Changes in soil cohesion that caused by one or two unit change in pH to acidification side is much. more than the same change to alkalizing side.

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