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# The Effect of Waste Leachate on the Strength Parameters of Clay with High and Low Plasticity

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**ABSTRACT:** The leachate may cause negative effects on the mechanical behavior of contaminated soil. The objective of this research was to study this effect through performing consolidation and shearing experiments. The samples with different pollution contents underwent direct shear and consolidation tests in bot long-term short-term conditions. The shear strength and oedometric behavior of contaminated specimens was compared with non-contaminated specimens. In order to study the effect of pollution duration, and the length of soil exposure to leachate, the experiments were conducted at certain time intervals after contaminations of specimens. The samples were kept at barred packages and then tested at the required time. The result show that permeation of leachate into the soil pores leads to decrease in shear strength and increase in settlement. The result also shows that long term exposure of specimens by leachate with low concentration shows the same results observed for specimens exposed to high concentrated leachate in a short period of time. In other words, leachate even in small concentrations have major long-term drawbacks on shear strength and compressibility of soil. Therefore, the leachate will affect the performance of structures relied on such soils.

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## 1- Introduction

Pollutions resulted from human activities not only contaminate the air and water, but also contaminate the soil. Several factors may result in soil contamination. Chemical contamination of soils would change their mechanical behavior [1]. Landfills are widely used in disposal of municipal solid wastes as an economical and viable method [2, 3]. In this method, municipal wastes are buried in landfills compacted and covered by soil layers. Water passed through buried wastes in landfills produces leachate permeating in the surrounding soil layers and resulting serious environmental problems [4-6]. Chemicals dissolved in leachate absorbed by soil particles changes the soil matrix influences the engineering properties of the soil mass [7, 8]. Fine soils with low permeability were used as a barrier to insulate the landfills to prevent the dispersion of contaminants found in leachate. Therefore, the effect of the leachate contaminated fine soils is the subject of this study. In this research, the effect of the leachate on the shear strength and compressibility parameters of two clays with low and high plasticity was investigated in the laboratory. The leachate contaminated soil specimens were prepared in the laboratory replacing their natural pore water by leachate. Direct shear and consolidation tests conducted on specimens contaminated by leachate with different concentrations after two different periods of exposure to leachate to study the short-term and long-term effect of contamination on the mechanical parameters of the clay.

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## 2- Materials

The basic parameters of clays used in this research were according to Table 1. It should be noted that the soils used in this study was not collected from landfill location.

**Table 1. Basic parameters of clays**

| Parameter | Clay1 | Clay2 |
|---|---|---|
| USCS name | CH | CL |
| Opt. water content | 18% | 17% |
| Max. dry density | 1.45 g/cm$^3$ | 1.52 g/cm$^3$ |
| LL | 59% | 40% |
| PL | 27.5% | 24% |
| PI | 31.5% | 16% |
| Gs | 2.87 | 2.78 |

The leachate used in this study was collected from a landfill in Rasht city located in the north of Iran. The major composition of the leachate was according to Table 2.

**Table 2. Composition of the leachate with PH=5.9-7.7**

| Parameter | Unit (mg/l) |
|---|---|
| $NH_3$-N | 1140-2591 |
| $Cl^-$ | 5630-6340 |
| $SO_4^{4-}$ | 142-352 |
| Mg | 8-363 |
| Ca | 97.5-787 |
| Mn | 0.5-11.6 |
| Fe | 2-14.44 |
| Cr | 0.0-2.78 |
| Ni | 0.0-32.45 |
| Cu | 0.0-2.13 |
| Zn | 0.1-38.06 |
| Cd | 0.01 |
| Pb | 0.04 |

## 3- Experimental Program

In order to prepare laboratory specimens, soil samples were completely dried in the oven with 104 C° for 24 hours. Then dried soil mixed with different leachate contents including 5%, 10% and 20% of dry soil mass. Then the contaminated specimens exposed to air for 48 hours to reduce their liquid content to less or equal to optimum water content. Some water added to specimens with leachate content less than their optimum water content to reach their liquid content to the optimum water content. Compaction, consolidation and direct shear tests conducted on contaminated specimens after 48 hours to investigate the short-term effect of contamination on their mechanical properties. Also, these tests conducted after 180 days to evaluate the long-term effects of leachate contamination. The time period (180 days) required to reach a steady-state condition was determined based on several tests conducted in intervals. The Atterberg limits of contaminated CH and CL clays are tabulated in Table 2 and 4 respectively.

**Table 3. Atterberg limits of contaminated Clay1 (CH)**

| Samples | Leachate content (%) | | | |
|---|---|---|---|---|
| | 0 | 5 | 10 | 20 |
| LL | 59 | 54 | 51 | 47 |
| PL | 27.5 | 25 | 23 | 20 |
| PI | 31.5 | 29 | 28 | 27 |

Based on the laboratory tests, it can be concluded that increasing the leachate content in CH soil reduced both liquid and plastic limits of the soil while the liquid limit of CH soil increased and its plastic limit was not affected by leachate.

**Table 4. Atterberg limits of contaminated Clay2 (CL)**

| Samples | Leachate content (%) | | | |
|---|---|---|---|---|
| | 0 | 5 | 10 | 20 |
| LL | 40 | 44 | 47 | 54 |
| PL | 24 | 25 | 24 | 24 |
| PI | 16 | 19 | 23 | 30 |

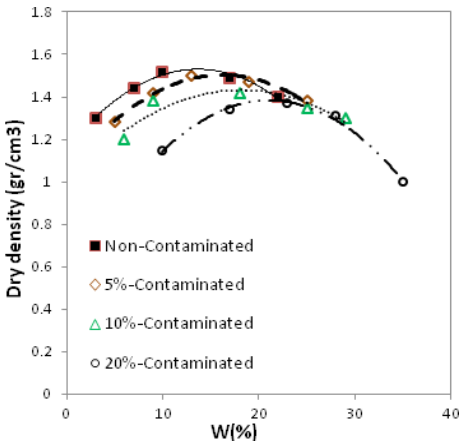


**Figure 1. The results of Proctor tests on CL soil**

The results of standard Proctor tests on CL soils are illustrated in Figure 1. It can be seen that increasing the leachate content reduced the maximum dry density and increased the optimum water content for CL soils. Similar results observed for CH soil. Figure 2 shows the results of short-term consolidation tests on leachate contaminated CH soil. It can be seen that higher leachate contents reduced the initial void ratio and the slope of NCL lines of the soil. Similar results observed for all leachate contaminated CH and CL soils. It means that leachate contamination reduces the void ratio of the soil that may cause settlements.

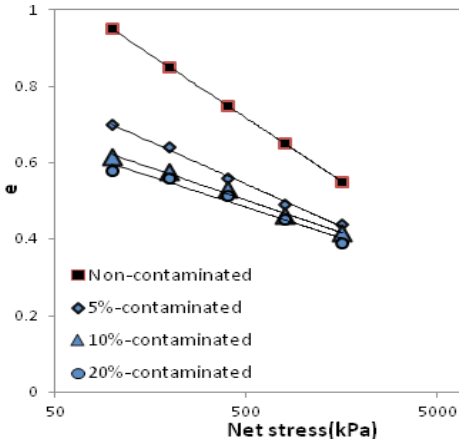


**Figure 2. NCL lines for CH soil after 180 days**

The results of direct shear tests on contaminated specimens are shown in Table 5 for CH and CL soils.

**Table 5. Results of direct shear test on CH and CL soils**

| Soil | Leachate | Time (Day) | C (kPa) | φ° |
|---|---|---|---|---|
| CH | 0 | 2 | 60 | 29 |
| CH | 5 | 2 | 66 | 26 |
| CH | 10 | 2 | 72 | 20 |
| CH | 20 | 2 | 80 | 16 |
| CH | 5 | 180 | 65 | 24 |
| CH | 10 | 180 | 72 | 17 |
| CH | 20 | 180 | 81 | 13 |
| CL | 0 | 2 | 36 | 33 |
| CL | 5 | 2 | 40 | 27 |
| CL | 10 | 2 | 45 | 20 |
| CL | 20 | 2 | 51 | 16 |
| CL | 0 | 180 | 40 | 22 |
| CL | 10 | 180 | 45 | 16 |
| CL | 20 | 180 | 51 | 14 |

It can be seen in Table 5 that the internal friction angle of contaminated soils has reduced for both soils both in short-term and long-term tests while the cohesion of these soils was not affected by leachate seriously.

## 4- Conclusion

Results of this study showed that the leachate contamination increase the optimum water content of fine soils while reduced their maximum dry density and internal friction angle. The leachate content is an important factor affecting the mechanical properties of fine soils. The most important finding of this study reveals that the effect of contamination could be a time dependent phenomenon. Long-term effects of low content contamination would be greater than their short-term effects.

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