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# EFFECTS OF CRUDE OIL CONTAMINATION ON ATTERBERG LIMITS OF SELECTED SOIL ON THE SOUTH WEST KIRKUK-NE IRAQ

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## Abstract

The aim of this study is search the effects of adding crude oil on the atterberg limits of fine grain soil samples selected on the south west Kirkuk –NE Iraq. Due to the lack of information about this crucial topic in Iraq and in particular in Kirkuk city which is one of the richest oil cities in the world, this topic has been selected. The engineering properties of the study samples included (water content, grain size distribution, specific gravity and Atterberg limits). According to USCS the sample is (ML). The study sample was divided into two parts. The first part is uncontaminated soil (0%) which carried out for Atterberg limits tests, the second part is sub-divided into (four portions) crude oil was added to the four portions as (2%, 4%, 6%, 8%) after placing the contaminated samples in sealed containers for a period of two weeks (to gain sufficient homogeneity) then the Atterberg limits tests were carried out for those contaminated samples. The results indicated that increasing the percentage of crude oil from (0% to 4%) due to an increase in the Atterberg limits, and this may be attributed to the fact that the increase in the addition of crude oil to fine soil may lead to a distortion of the internal structure of clay minerals, after an increase in the percentage of crude oil (6% and 8%), a decrease in the values of (Atterberg limits) occurred as the doubled increase in crude oil leads to the replacement of a layer of non-polarized crude oil for liquids instead of a layer of water that surrounds the clay granules, which constrains the access of water to the fine particles.

**Keywords:** Atterberg limits, Kirkuk city, crude oil, engineering properties of soil, oil contaminate .

## Introduction

Oil leaks usually occur during transportation, which leads to the difficulty of removing contaminated areas. There are several sources of oil pollution, such as the breakdown of transportation pipelines, accidents of oil tankers, marine oil

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products [1]. The impact of oil spills is no longer only a adverse impact on the earth's ecosystem, while its impact has exceeded the safety of engineering projects as well as the leakage of hydrocarbon fluids occurs through the movement of these fluids to the bottom of the earth, due to the gravitational effect of semi-saturated soils, access to the groundwater levels [2]. After 2003 war, Iraq, especially the oil-producing areas, witnessed many environmental accidents related to oil leakage from tanker pipelines or oil tanks, as a result of terrorist operations that led to the leakage of huge quantities of oil into the soil, surface water and groundwater (Figure. 1). These oil leaks are certainly it negatively affected on the environment, including changing the engineering properties of the soil, and that was a justification for this study.


Figure (1): forms of oil pollution in iraq (1) and (2) oil pollution in the study area (new oil procecces plant- SW of Kirkuk) (3) oil pipeline explosion in southern qayyarah/mosul 2016https://www.unep.org/ar/alakhbar-walqs) (4) pipeline explosion in Kirkuk (bay hassan field) https://www.aljazeera.net/news/politics 2021.

There are many among the researchers who studied the effect of adding crude oil on the engineering properties of the soil, such as [3], who studied the effect of crude oil pollution on the index properties, strength and permeability of clay loam soil, where it was found that the Atterberg limits of the soil increased with the increase in the addition of crude oil, while there was a decrease in the values of specific gravity, permeability and upper dry density. [4] observed that the destruction of the fine atomic structure of the clay after adding diesel oil to it

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under the scanning electron microscope (SEM), while investigate the effect of the leakage of diesel oil to the soil in the city of Mashhad (western Iran) noted by [5]. decrease in the ability of the soil to bear the loads with oil pollution of the soil. In addition above many searches were working out in this topic like [6] [7]. due to the fact that the city of kirkuk is an oil city, and there have been many crude oil leaks in all its forms as a result of sabotage operations that led to the pollution of large areas of the soil in addition to its contamination of surface water, and because not touched for this type of topic among researchers and academics in the city of kirkuk was all justification for choice this search.
Our study aims to investigate the effect of adding crude oil to the soil taken from (a site close to the north oil company in kirkuk) on the properties of the atterberg limits different percentage of additions of crude oil.

## The Location of the Study Area

The study area is located near the (new oil processes plant that is part of the north oil company (NOC)), which is about (17 km) southwest of the city center of kirkuk - NE iraq and within the coordinates of (N35º24`10``- E44º12`53`` ) Figure () (2). The study area is covered with modern sediments represented by varying amounts of clay, sand, silt and gravel, in addition to the presence of a seasonal river stream (chai su) that is exploited as a gravel quarry in the region. at the same time, there was a clear soil contamination of the site through the crude oil coming out of the new oil processes plant. The area is part of an unstable within the foothill zone according to [8].

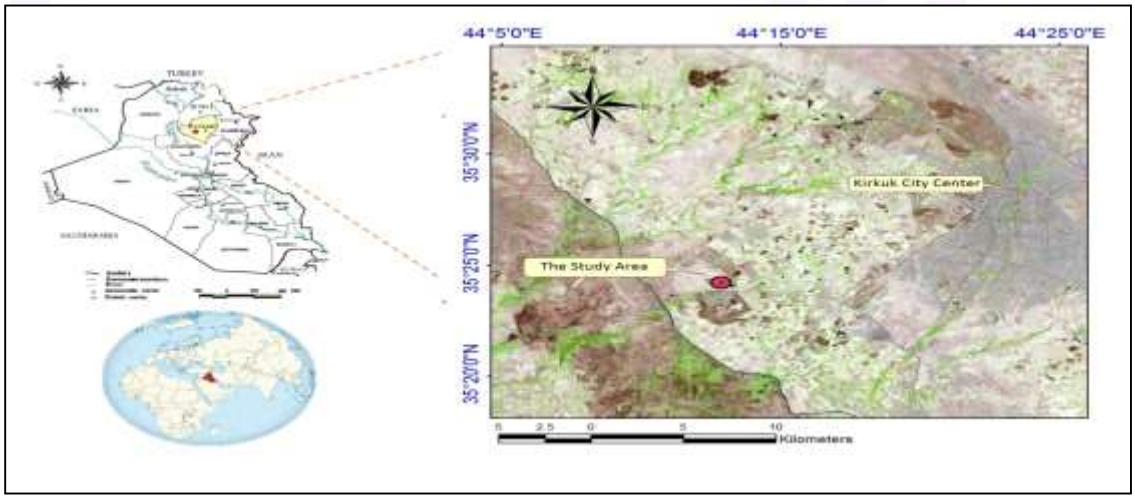


Figure (2) : location of study area

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## Materials and Methodolgy

About (30 kg) Undisturbed soil sample was taken from the study area at depth about (20 cm) below the surface of the earth to avoid the surface layer. A small amount of soil was placed in an airtight container to measure its moisture in the laboratory, while the rest was transferred to the laboratory after being placed in storage bags. Before the samples were dried at room temperature, water content measured based on [9] and then specific gravity measured according to [10] in the engineering geology laboratory at the college of science/university of kirkuk. While the test of grain size distribution of the soil, it was conducted in the laboratories of the (Kirkuk construction lab.) by dry and wet methods, according to [11].

Soil sample divided into two parts, first part a (non-contaminated) samples with crude oil (0%) which tested for Atterberg limits , the (second part) was subdivided into (four parts), crude oil has been added to the four parts as (2 %, 4%, 6%, 8%). After placing the contaminated samples in airtight containers for a period of two weeks (to gain sufficient homogeneity) (Figure () 3)

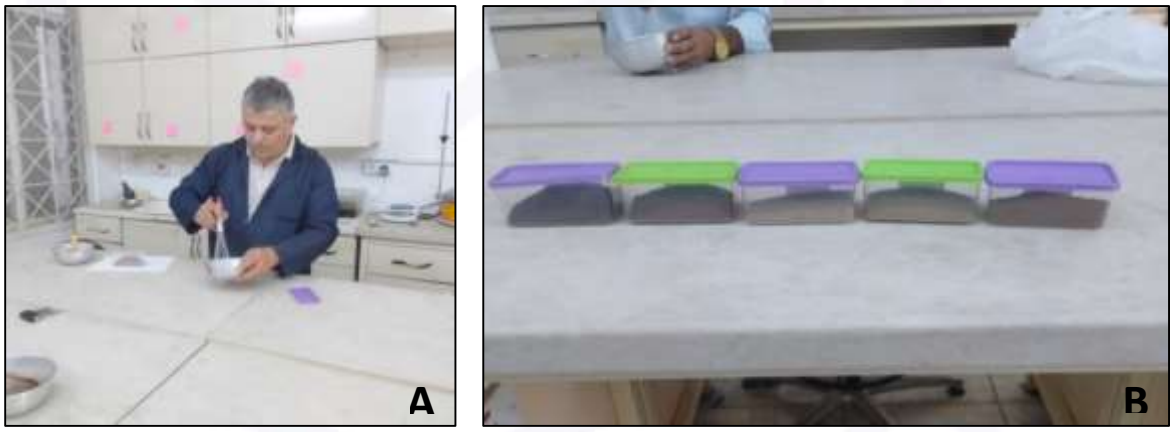


Figure (3) : (A,B) stages of preparing contaminated samples.

After obtaining homogeneous soil with crude oil at percentages (2%,4%,6%,8%), all samples were subjected to (Atterberg limit test) in the (Kirkuk construction lab) according to American standards (AASTHO T89 and T90)

After obtaining the liquidity limit values, plasticity limit and the plastic index for contaminated samples the results were compared and discussed.

## Results and Discussion

**Uncontaminated Sample** : Table (1) and Figure () (4) showed that the soil sample in this study includes ( gravel 1%, sand 32%, silt 50% and clay 17%) , while the values of the Atterberg limits of fluidity, plasticity and plasticity index are (24.55%, 10,05% , 50,14%) respectively and according to the standard soil classification USCS the soil sample can be classified as silty sandy soil (ML) reflects an environment with polygenetic source [8]. it is noted from the table that the water content value is 6.5% and the specific density is 2.65.

Table 1: physical properties of uncontaminated sample

| Soil properties | values |
|---|---|
| Grain size distribution | |
| gravel | % 1 |
| sand | % 32 |
| silt | % 50 |
| clay | % 17 |
| Specific gravity | 2.65 |
| Water content | % 6.5 |
| Liquid limit, $w_L$ | 24.55 |
| plastic limit, $w_P$ | 10.05 |
| Plasticity index, $I_P$ | 14.50 |

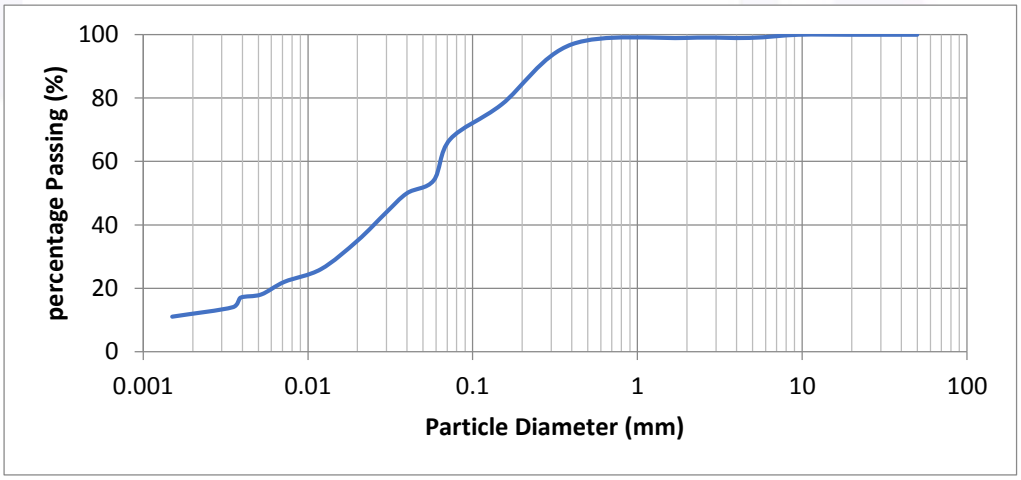


Figure () 4: Grain size distribution of sample

## Contaminated Soil Analysis Results

when observing the results of the Atterberg limits analysis by adding different percentages of crude oil, there are changes in the engineering properties of the soil that occurred with the increase in the addition of crude oil table (2 ) Figure ()s (5 ) the increase in the proportion of crude oil from (0% to 4%) leads to a clear increase in the (liquid limit LL, plasticity limit PL and plasticity index PI) this may be attributed to the fact that the increased addition of crude oil to the fine soil may lead to a distortion of the internal structure of the clay minerals, which leads to the

Table 2:Results of Atterberg limits value of contaminated soil sample.

| Atterberg limits | 0% | 2% | 4% | 6% | 8% |
|---|---|---|---|---|---|
| Liquid limit | 24.55 | 26.11 | 26.37 | 26.83 | 24.53 |
| Plastic limit | 10.05 | 18.74 | 22.94 | 19.74 | 21.34 |
| Plastic index | 14.50 | 7.37 | 3.43 | 7.08 | 3.19 |

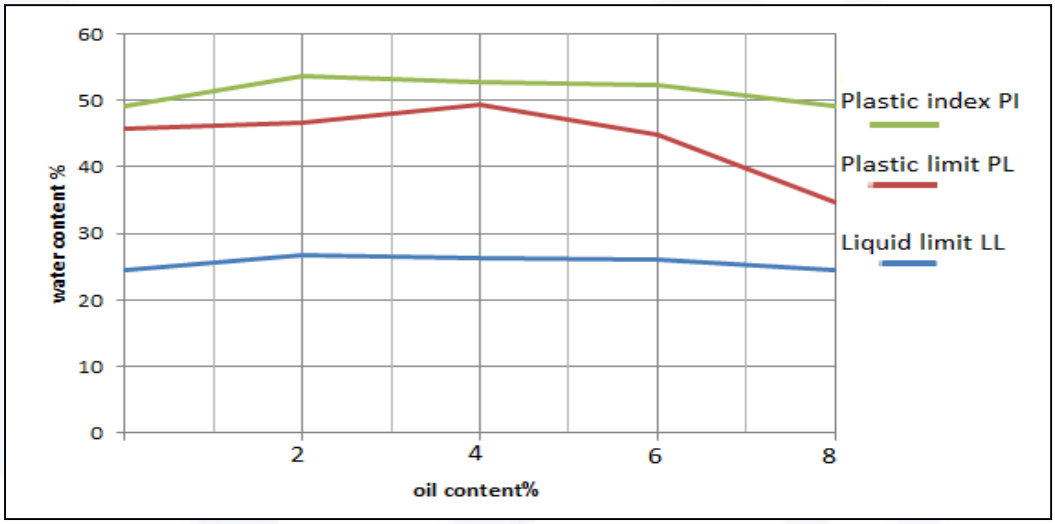


Figure (5) : Atterberg limits results of contaminated soil sample.

Expansion of the inner layers of those minerals and thus to the difficulty of working and forming those clays [3] . After that, an increase in the percentage of crude oil (6% and 8%) will result in a decrease in the values of (LL,PL,PI) these results were similar to the results of [6] and [7], as the doubled increase in crude oil leads to the replacement of a layer of non-polarized crude oil for liquids instead of a layer of water that surrounds the clay granules, which hinders the access of water to the fine granules.

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## Conclusions

In this study, the soil sample can be classified as silty sandy, low-plastic soil that reflects a sedimentary environment of multiple origins. The addition of crude oil to the soil at rates of (2,4,6,8%) affects the properties of the Atterberg limits , as there is a clear that increase in the values of the liquid limit and the plasticity limit when adding crude oil at rates of (2%,4) due to the change in the fine internal structure of the clays, which lead to the expansion of the inner layers of these minerals, and thus to the difficulty of working and forming those clays, while for percentages (6% and 8%), there is a decrease in the values of the liquid limit and the plasticity limit, due to replacing a layer of non-polarized crude oil for liquids instead of the water layer that surrounds the clay granules, which impedes the water's access to the fine granules.

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