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Effect of oil leaching on the soil, coastal, marine and groundwater in Kuwait

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ABSTRACT

The leachability of oil from un-stabilized layer of soilallows the oil toeasily pass through the soil strata. This may have an impact on the physical properties of soil either in coastal or land zone, such as the shear strength parameters and the compressibility parameters.Also, chemical properties (adsorption and retention of heavy metals). Column test was used with uncontaminated soil and statured with five different types of oil (A, B, C, D and E)to mimicsitu condition. The direct shear test results show reduction in the angle of friction on oil types due to lubrication, and no significant change in the cohesion and consolidation parameters. Finally, the retention profile for all samples shows that type C has most retention in soil layers for As, Cd, Ni, Pb and Zn. All metals with different oil type have high concentration on the top layer of soil and up to 50 mm depth. These results will cause highimpact on the coastal environment and will increase the ecological risk.

Keywords: Coastal environmental; column test; crude oil; heavy metals; Kuwait soil

INTRODUCTION

Kuwait is one of the main countries that produce and export crude oil and oil is the main sourceof income for the country. In 2016, over 92.2 million barrels of oil are produced every day all over the world. Most of Kuwait's landis considered as oily field and this oil is located under the soil layers.This oil requires special processes such as drilling, transportingand exporting to the world. These processes could affect the surrounding environment in general, specifically the soil layers in the coastal, land and groundwater (Ajagbeet al., 2012). Also, the oil spills could be premeditated by man such as during the gulf war in 1991 where the oil was disposed into the Gulf Sea which caused damage to theliving organismsand the soil surrounding the coastal (Tajik, 2004). The marine ecosystem and coastal environment could be destroyedbecause of the oil leaching (Mohebbi-Nozaret al., 2015).Also, surficial coastal sediments could be polluted through oil spills (Amid et al., 2014). Moreover, the soil structure and groundwater could be contaminated and damaged due to oil spills (Khosraviet al., 2013; Gong et al., 2014). The oil spills have a negative effect on the strength and compressively of the soilcausing pollution to the groundwater and ocean environment (Veil et al., 2004; Yu et al., 2013).

Kuwait lies on the upper northwestern part of the Arabian Gulf and isconsidered as a small country in land compared to the other oil exporting countries therefore causing a conflict between the shortage of land and increase in population. In thelong term,running out of oil from the well will force the government to reuse these lands for residential, commercial, construction or agricultural needs. Also, the infiltration of heavy metals through soil layers will cause damage to the soil structure, toxicity to the groundwater, and coastal zones(Xiao-Wen et al., 2014; Yu et al., 2013).

The heavy crude oil is considered as a main impact on land and coastal environmental issues compared to different oil types. The heavy oil has high concentration of heavy metals and asphaltene. Most of the Kuwaiti soil is considered as a high preamble soil which allows the oil to easily pass through the soil layers. This investigation is carried out to determine the effectiveness of heavy crude oil on the geotechnical and geoenvironmental properties of soil. The main important geotechnical parameters that control the quality of soil structure are strength and compressibility. Strength can be described by the internal angle of friction and cohesion, while compressibility can be measured by compression and swelling indices. In other hand, crude oil carried out many hazards metal to soil and organism such as As, Cd, Ni, Pb and Zn which cause a health risk (Chen et al., 2015).

Earlier study by Puri (2000) measured the strength of soil – oil interaction. The laboratory experiment was conducted by preparing SP (Poorly graded sand) soil samples with various type of crude oil percentages. The direct sheartest was used in this study to determine the angle of internal friction. The results show the angle of friction of sand affected by oil contamination. It concluded that there was a decrease of 20 to 25 % in the amount of the angle of friction of the contaminated sand compared to the clean sand samples.Two studies done by Abousninaet al., (2015) were conducted to test the effect of the cohesion and angle of friction of fine sand with different percentage of light crude oil (0 to 20%). The results show a marginal decrease in the friction angle for fine sand, mixed with light crude oil.

It was also found that the cohesion increases for fine sand up to 1% of oil, and decreased as the percentage of light crude oil increased. On the other hand, Khamehchiyanet al., (2007) conducted laboratory experiments for different clay and sand soil samples. The soils were mixed with various amount of crude oil to observe the shear strength parameters. The results show a high reduction in the cohesion for the clay soil, while no significant change in the sand soil. An interesting study by Kermani&Ebadi (2012) used uncontaminated and contaminated soil with different amount of crude oil. They observed an increase in the angle of friction and cohesion as oil content increases which is contrary of all previous studies.

In the earlier studies, heavy metals were focused to investigate the metal pollution to the environment (Aloulouet al., 2011). Zhang et al., (2015) found that the Zn, Cd, Co, Cu, Ni, Be, and Pb were the most available metals in the soil and caused toxicity to the environment. Moreover, a study had been made by Armidet al.,(2014) which measures the effect of the three-heavy metal of oil (Pb, Cd and Cr) on the surficial coastal sediments in Kendari Bay. The results show an increase in the contamination of the coastal area.

In this study,a series of tests were conducted to examine the quality of soil contaminated with crude oil. The strength parameters such as the angle of friction and cohesionwill be used to determine the bearing capacity of soil. The compressibility parameters such as compression and swelling indiceswereconducted to examine the settlement of the soil.The heavy metal analysis such as breakthrough curves and retention profile carried out to determine the penetration and migration of oil through soil strata. The mass balance test was calculated to measure the accuracy of test results.

BASIC PROPERTIES OF SOIL SAMPLES AND CRUDE OIL

Soil samples were taken from test pits with 0.5 to 2 m depth fromAl-Rawdatainarea in Kuwait. Al-RawadationAreais located in the north of Kuwait. This area is rich in crude and groundwater which makes it a critical site for investigation. The basic soil properties measured in this study are field density, natural moisture content, sieve analysis and specific gravity. The field density (gd) and moisture content (w) tests were conducted for these samples using ASTM D1556 (2015) and ASTM D2216 (2010) respectively.The samples were air dried, pulverised to pass through 4.75 mm sievein the laboratory and carried out following ASTM D422 (2007) sieve analysis test.Figure1 shows the grain size distribution of the collected sample in this study. The sample wasclassified by using the unified soil classification system (USCS) and found to be as silty sand soil by following ASTM D2487 (2011). The specific gravity (Gs) was tested in laboratory by using ASTM D128 (2015). Table 1 summarized the basic soil properties for the sample used in this study.

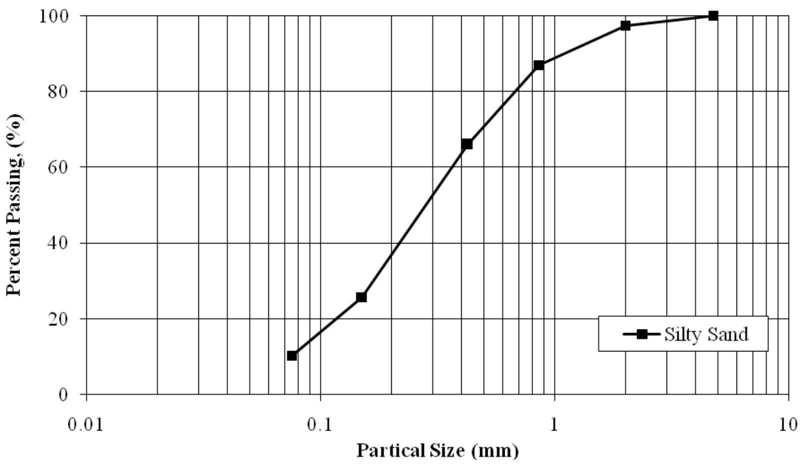

Fig. 1. Grain size distribution of the collected sample in this study

Table 1. Basic soil properties for the sample used in this study.

Soil Type	Specific Gravity, Gs	Atterberg limits LL (%)	Atterberg limits PL (%)	Atterberg limits PI (%)	Grain Size Distribution Gravel (%)	Grain Size Distribution Sand (%)	Grain Size Distribution Silt and Clay (%)	Compaction Characteristics $w_{opt.}$ (%)	Compaction Characteristics γ_{dmax} (g/cm^3)	Compaction Characteristics w_{field} (%)	Compaction Characteristics γ_{dfield} (g/cm^3)
Silty Sand	2.65	Non - Plastic			0	85.2	14.8	8.50	2.03	2.90	1.80

Five crude oil samples were provided from petroleum fluid research center (PFRC) (Kuwait university) and have been used in this paper. Table 2 concluded the basic crude oil properties for the five samples including viscosity, specific gravity, American petroleum institute (API) gravity and Saturate, Aromatic, Resin and Asphaltene (SARA) test.

Table 2. Basic crude oil properties for the five samples.

Oil Type	Viscosity @ 20 °C cP	Specific gravity mg/ cm³	API	SARA Analysis Test Asphaltene	Resin	Aromatic	Saturate
Type A	53.43	0.896	26.42	10.2	17.9	51.4	20.5
Type B	367.8	0.9818	12.6215	4.5	19.1	59.2	12.4
Type C	451.6	0.9545	16.683	4.2	21.1	61.2	13.5
Type D	395.6	0.956	16.4429	4	18.7	63.7	13.6
Type E	402.2	0.959	16.05	2.5	25	58.6	13.9

SAMPLE PREPARATION

After the sample was air dried, pulverised and classified, the soil is prepared by using leaching column test ASTM D4874 (2014). Five column tests with two trials for each were examined. To match filed condition, each soil was remoulded to the natural moisture content (2.9%) and field density (1.8Mg/m3). The column cell was divided into four layers equally; each soil layer is compacted and the top of each layer was scratched with a knife to insure homogeneity of layers. The column cell was placed in the column test apparatus and screwed tightly to avoid the liquid leakage. The column test was connected withlow constant air pressure (7.5 kPa) to allow the crude oil to flow smoothly through the tested soil as recommended by ASTM D4874 (2014). Figure 2 shows the schematic two column tests that was used to test the soil – oil interaction.

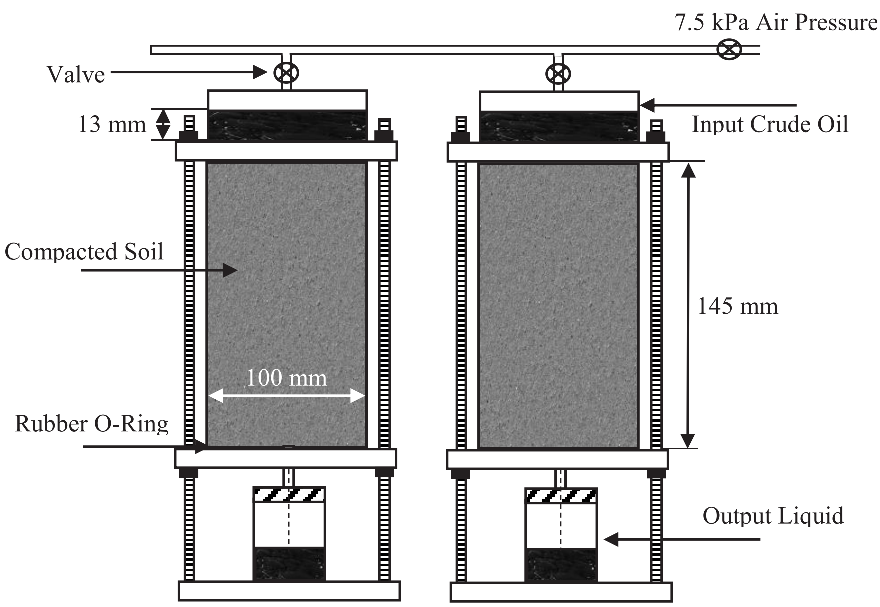

Fig. 2. Schematic two column tests that been used to test soil – oil interaction

PROGRAM OF LABORATORY TESTING

The tested soil samples were examined in this study by using direct shear test, consolidation test, and heavy metals analysis. The compacted soils in the column test were saturated with distilled water up to 2 pore volume (PV). Next, the crude oil was added to the saturated compacted soil up to 5PV and each 1PV should have accomplished 24 hours. The discharge liquid was collected each 0.5PV in Environmental sampling supply containers that meets the united stated environmental protection agency (USEPA) standards to be tested.

When the test was completed, the sampleswere extracted from the column cell gently to avoid any disturbers in the remoulded soil specimen by using the extracted tools. The samples were used to examine the direct shear and consolidation tests. To achieve the undisturbed soil sample, the specimen cutter ring (dia. 63 mm for direct shear test and dia. 75 mm for consolidation test) was inserted manually into the column cell. The soil around the cutting ring was loosened by using a sharp knife to remove the specimen easily. Then, the surfaces of the specimen were levelled and been pushed carefully into the direct shear box and consolidation cell.

Direct Shear Test

The direct shear tests were conducted to measure soil – oil interaction strength parameter (the internal angle of friction and cohesion) following the ASTM D3080 (2011). The direct shear test was performed using shear box (dia.63 mm and height 20.6 mm) with normal stress 31.5, 63, and 125 kPa and under strain rate 0.35mm/min. The sample was installed and run in the direct shear apparatus by using ELE D7 software to calculate the deformations and shear strength parameters (ϕ and c).

The theory used to determine the strength of soil – oil is Mohr – Coulomb failure criteria, which is defined ascombination of normal stress (σ) and shearing stress (τ_f) and expressed as:

$$\tau_f = c + \sigma \tan \phi \quad (1)$$

where c is cohesion and f is angle of friction on linear function.

Consolidation Test

The consolidation test was used to measure settlement parameters such as compressibility and swelling of the soil – oil interaction that has been taken from the column using ASTM D2435 (2011). The consolidation test was conducted using consolidation ring (dia. 75mm and height 18mm) and five vertical pressure were applied and loaded at 25, 50, 100, 200, 400 kPa. The unloading stage was measured after the end of the maximum load stage. The samples were assembled and performed in the consolidation test apparatus by using ELE D7 software to determine the compression and swelling index. The test was analysed based on time square root method as per ASTM D2435 clause 12.3.2.

Heavy Metals Analysis

The heavy metals caused toxicity either on the surface of soil, layers of soil or ground water. As a result, five main elements of heavy metals were tested [such as Arsenic (Ar), Cadmium (Cd), Nickel (Ni), Lead (Pb), and Zinc (Zn)]in this study to examine itseffect on the surrounding environment. These toxic heavy metals were chosen as the top 10 chemicals that caused a major public concern in the world health organisations.

Three tests for the heavy metals were carried out in this study. The first test was the analysis of the initial concentration and final concentration for each 0.5PV output liquid by using inductively coupled plasma optical emission spectrometry (ICP-OES) by using ASTM UOP38915-.These analyses were examined at National Unit for Environmental Research and Services (NUERS) in Faculty of Science, Kuwait University. At the beginning of the test, the sample was filtered by using 0.2µm pore size filter paper and placed in the ICP-OES apparatus. The concentration of the heavy metals (Ar, Cd, Ni, Pb and Zn) were recorded to study the effect of soil – oil interaction. The second test was conduct on the heavy metals to study the absorption of the soil layer to these metals. Acid digestion method was used to determine the amount of absorption following USEPA (1996). The soil – oil samples were collected at depth 25mm, 50mm, 75mm, 100mm, 125mm, and 145 mm to be refluxed and heated at 95^{o}C following heavy metals determination by ICP-OES.

The final test was performed to verify the balance between the mass of initial (C_i), retained (C_r) and final (C_f) heavy metals concentration in the crude oil. The summation of the retained and final concentration (C_T) was compared to the initial concentration to measure the quality of the tests data. The difference percentage (Δ) of the total concentration and initial concentration could be measured from the following equation:

$$\Delta = 100 \text{ x } (C_T/C_i) \quad (2)$$

RESULTS AND DISCUSSION

Direct shear test

The shear stress vs the horizontal displacement figures for five different oil under three load pressures. The load pressures used in this test are 32, 64 and 125 kPa and each test was performed twice for accuracy reason. The maximum of the shear stress and the relationship between shear stress vs normal stress was obtained. Also, the amount of cohesion for each soil – oil interacted samples were measured for the intersection between the Mohr – Coulomb envelop line and the shear stress axis. The internal angle of friction of the samples were determined for the slop of the Mohr – Coulomb envelop.

Shear Stress vs Shear Displacement

Figure 3 shows the vertical stress at 32 kPa for the clean soil and five oil – soil interaction types. The figure shows the clean soil having the maximum shear stress as compared to others. This was due to increase of the friction between the particles because of the absence of cohesion at low moisture content (Kemper and Rosenau 1984). Moreover, the oil type B and C decreased by 26% compared to clean soil. The reduction friction is caused by the increase in the lubrication between soil particles due to present oil. Although the oil type, A and D, have different oil properties; effect on the soil is almost the same with a slight difference of about 4%. Oil Type E shows no significant change compared to the clean soil.

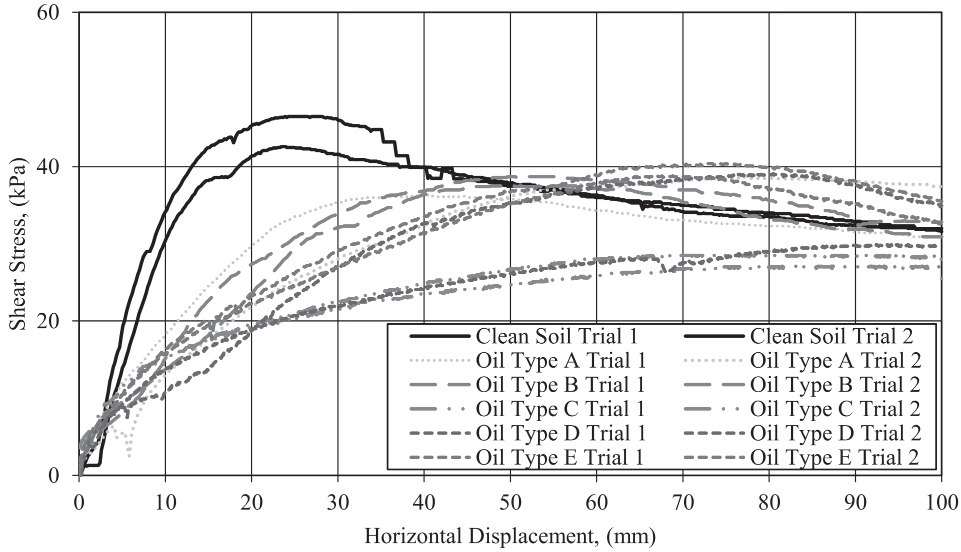

Fig. 3. The different types of oil with the vertical stress 32 kPa

Figure 4 presents the different types of oil with the vertical stress 63 kPa. The figure shows the clean soil having a maximum shear stress of 79.5 kPa. Oil types A, D and E is showing A decreased vertical stress by 22%, compared to the clean soil due to existence of the oil while the oil type B and C have negligible changes.

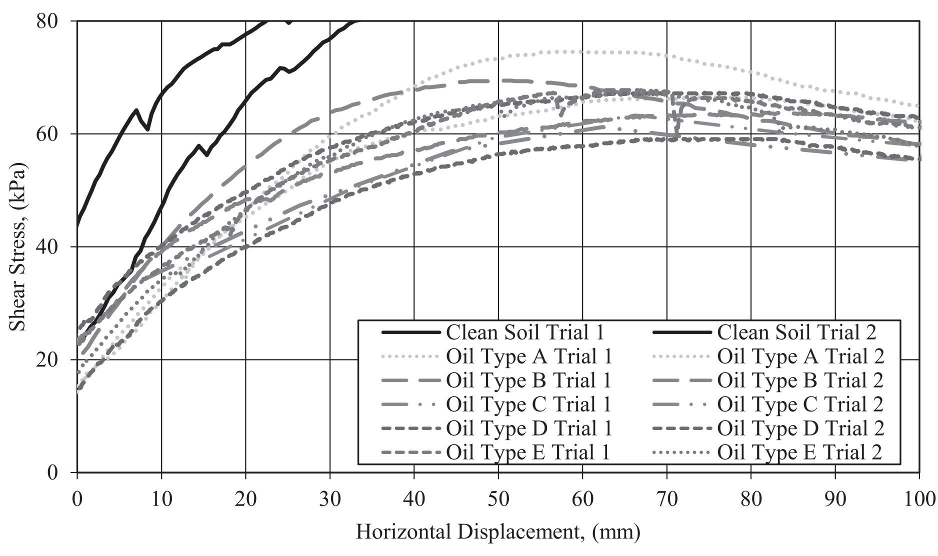

Fig. 4. The different types of oil with the vertical stress 63 kPa

At vertical pressure 125 kPa, Figure 5 shows the clean soil having the maximum shear stress. The oil type B, C and D represent a decrease by 22% while type A and E decreased by 19 % compared to the clean soil.

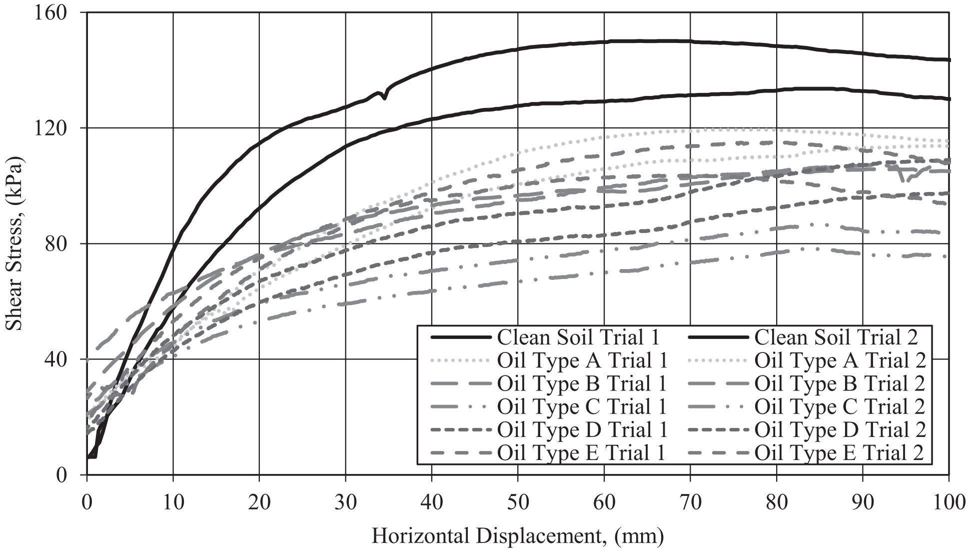

Fig. 5. The different types of oil with the vertical stress 125 kPa

In conclusion, the three Figures 3,4 and 5 shows that clean soil has the maximum shear stress and the increased vertical stress. Also, oil type A and D have the most effectiveness on the shear stress. If we increase the vertical stress, the shear stress will decrease.

Shear Stress vs Normal Stress

Figure 6 shows failure envelope which is the relationship between the maximum shear stress and normal stress for the clean soil, and five different oil types. The results show a constant decrease in the angle of friction and cohesion for all types of oil compared to clean soil. The angle of friction decreased by 18% compared to clean soil due to presence of oil which lead to the lubrication between soil particles. For the cohesion, type A shows decreased by 15%, while type D shows no significant change. Type B, C and E show an increase in cohesion by 17%. These results are appearing due to the variation of oil properties.

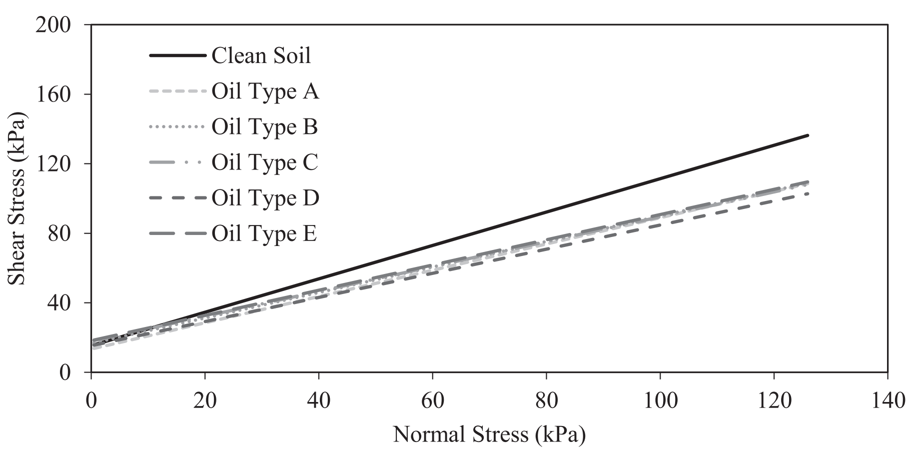

Fig. 6. Failure envelope for the clean soil and five different oil types

Table 3 summarized the angle friction and cohesion for clean soil and five types of oil – soil interaction.

Table 3 Angle friction and cohesion for clean soil and five types of oil – soil interaction.

Soil Type	**Silty Sand**			
Oil Type	**Ø** (Degree)	Standard Deviation	**c** (kPa)	Standard Deviation
Clean Soil	43.8	1.683	15.4	0.325
Oil Type A	37.1	0.608	13.4	1.648
Oil Type B	36.3	2.319	16.6	1.407
Oil Type C	35.6	1.881	17.9	1.344
Oil Type D	34.8	1.831	15.3	0.707
Oil Type E	35.9	0.127	18.2	2.362

Consolidation Test

When crude oil interacts with the soil, it can cause an increase in the settlement of the soil. This can lead to serious damage to the surrounding areas. The settlement can be tested by using consolidation test. The most important parameter for the consolidation test that measures the soil settlement are compression index (Cc) and swelling index (Cs). Five different oil types were used in this test to investigate these parameters and their effect on the soil.

Effective Stress vs Void Ratio

The void ratio (e) and log of effective stress (σ)curves of the five oil samples were examined under five different vertical load pressure such as 25, 50, 100, 200 and 400 kPa. Each test was done twice for accuracy purpose. Figure 7 shows the e – log σ curves of the clean soil and the five oil – soil interaction specimens. The results show that the initial void ratio for the clean soil is higher than the other samples. Moreover, the void ratio shows it is decreasing with increasing pressure and this is due to decrease in suction.

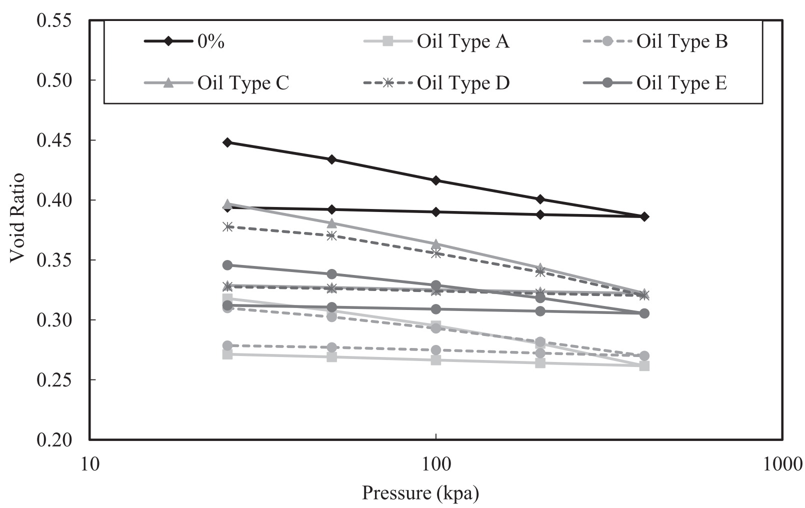

Fig. 7. The e – log σ curves of the clean soil and the five oil – soil interaction specimens

Table 4 summarized the compression index and swelling index of the soil – oil interaction. The results show no significant change in the compression and swelling index for the five oil types.

Table 4 Compression index and swelling index of the soil – oil interaction.

Soil Type	**Silty Sand**			
Oil Type	**Cc**	Standard Deviation	**Cs**	Standard Deviation
Clean Soil	0.058	0.006	0.007	0.001
Oil Type A	0.062	0.001	0.009	0.001
Oil Type B	0.038	0.001	0.008	0.001
Oil Type C	0.059	0.000	0.006	0.000
Oil Type D	0.065	0.004	0.007	0.000
Oil Type E	0.041	0.005	0.006	0.000

Heavy Metals Analysis

In this section the heavy metals tests were conducted to study the effect of the toxicity on soil layers. Breakthrough curves were measured from discharge liquid of the column test. The behaviour of heavy metals flowing through the soil from column test can be explained by acid digestion test.

Breakthrough Curves

The breakthrough curves are the test that studies the relationship of the final liquid discharge concertation and the initial crude oil concentration. This relationship was expressed as Cf/Ci and drawn in Figure 8.

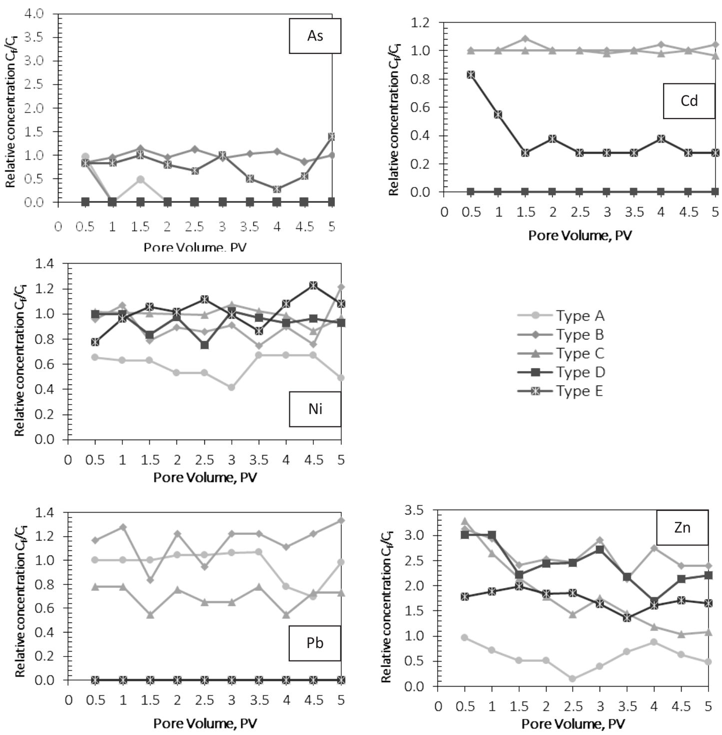

Fig. 8 Breakthrough curves

The results show that type A and B doesn't contain any of As and Cd metals, while type C doesn't contain As. On the other hand type E doesn't include any Pb metal. We can also observe that there are some metals that doesn't show any changes in the initial and final concentration. For instance, metal Cd for type B and C, metal As for type B and E, and metal Pb for type A. in type E, Cd was highly absorbed up to 1.5PV and behaves constant up to 5PV. The metal Ni shows no significant change is retained for the type B, C, D and E, while type A shows a constant retention rate. However, type c shows a constant change on C_f/C_i values for Pb metal. The C_f/C_i values for Zn metal show absorption for type A which can effect soil structure.

In conclusion, Figure 8 shows silty sand has low ability to retain the heavy metals as there is no ion – exchange in this type of soil.

Retention Profile

Figure 9 shows the retention profile for the chosen heavy metals on soil – oil interaction layers. These tests have been done for five different types of oil and performed twice. It can be observed from Figure 9 that type C has most retention in soil layers for As, Cd, Ni, Pb and Zn. This type oil indicates that it is the most effective on soil structure, which need special treatment. Moreover, it shows from figure 9 that all metals with different oil type have high concentration on the top layer of soil and up to 50 mm depth. This means that the top layer of the soil is most effected layer and requires further research. In conclusion, the retention of the heavy metals seems to be limited and this result is due to the absence of ion exchange on the silty sand soil.

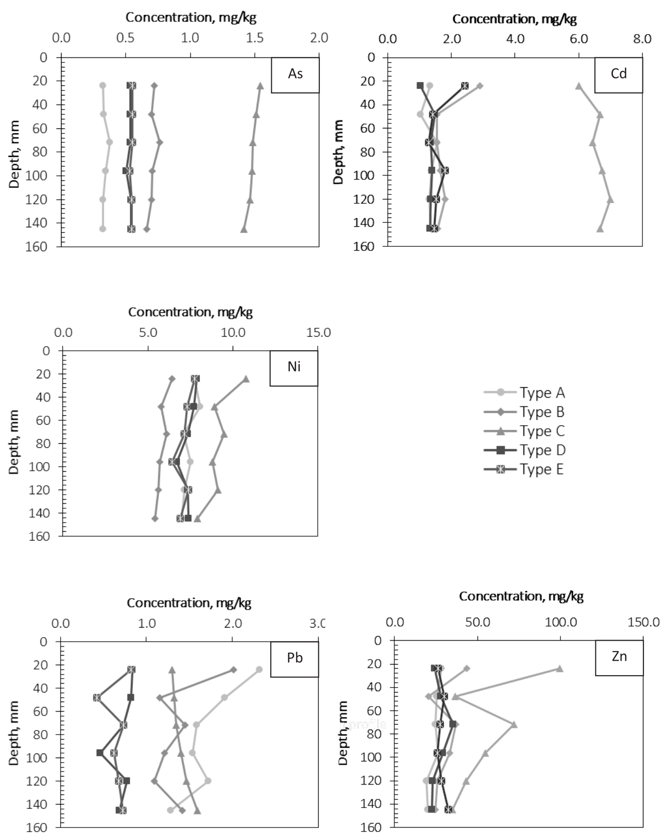

Fig. 9. Retention profile

Mass balance calculation

The mass balances for all specimens were calculated and has been described in section 4.3. Table 5 summarised the difference percentage (Δ) of the total concentration and initial concentration. The table shows a good quality of the tests result.

Table 5 Mass balance calculation.

Results		**Column Test**		**Acid Digestion**	$C_T = C_r + C_f$	**Δ**
Sample	**HM**	**Input (C_i) (mg)**	**Output (C_f) (mg)**	**Retained (C_r) (mg)**	**(mg)**	**C_T/C_i (%)**
Type A	As	0.218	0.172	0.008	0.179	82.18
	Cd	0.000	0.000	0.000	0.000	0.00
	Ni	0.395	0.005	0.445	0.450	113.80
	Pb	0.218	0.100	0.109	0.209	95.71
	Zn	0.461	0.300	0.143	0.443	96.08
Type B	As	0.759	0.719	0.011	0.730	96.22
	Cd	0.364	0.361	0.004	0.365	100.22
	Ni	21.140	18.502	0.035	18.537	87.69
	Pb	0.273	0.260	0.008	0.268	98.31
	Zn	1.647	1.400	0.184	1.584	96.19
Type C	As	0.036	0.001	0.040	0.041	111.28
	Cd	0.910	0.867	0.009	0.876	96.23
	Ni	49.825	47.498	0.055	47.553	95.44
	Pb	0.582	0.522	0.008	0.530	91.09
	Zn	5.434	5.000	0.341	5.341	98.28
Type D	As	0.018	0.010	0.008	0.018	98.64
	Cd	0.018	0.014	0.003	0.017	94.46
	Ni	52.536	47.316	0.044	47.361	90.15
	Pb	0.018	0.013	0.004	0.017	95.18
	Zn	6.075	5.500	0.162	5.662	93.21
Type E	As	0.055	0.040	0.010	0.050	91.40
	Cd	0.055	0.049	0.003	0.052	95.75
	Ni	42.819	41.384	0.043	41.427	96.75
	Pb	0.855	0.800	0.004	0.804	94.01
	Zn	4.702	4.400	0.170	4.570	97.19

The results of this study were compared with a previous study done in Iran (Khamehchiyanet al., 2007).The laboratory experiment was carried out by mixing three different types of soil (silty sand, poorly graded sand and lean clay) with different percentage of cured oil (2%, 4%, 8%, 12%, and 16% by dry weight). This study examined the strength and compressibility of the soil – oil interaction samples such as direct shear test. The results show a decrease in the shear strength (angle of frication and cohesion) on the silty sand samples by 23%. While in our study the results were decreased by 18%. This slight difference may be caused due to the soil curing and preparation.

SUMMARY AND CONCLUSION

Laboratory experiments were conducted in soil labs, petroleum fluid research centre and National Unit for Environmental Research and Services at Kuwait University to investigate the relationship between five types of crude oils and soil. Five types of oil were provided from PFRC and been tested on silty sand soil in Kuwait. The column tests were used to mimic field condition and perfume geotechnical and geoenvironmental characteristic. Direct shear, consolidation and heavy metals tests were applied to measure the strength, compressibility and retention of crude oil on soil respectively.

The direct shear results show a constant decrease of the angle of friction and cohesion for all types of oil compared to clean soil. The angle of friction decreased by 18% compared to clean soil due to presence of oil which lead to the lubrication between soil particles. For the cohesion, type A shows decreased by 15%, while type D shows no significant change. Type B, C and E shows an increase in cohesion by 17%. These results are appearing due to the variation of oil properties.

The compression index and swelling index of the soil – oil interaction were tested using consolidation test. The results show no significant change in the compression and swelling index for the five oil types.

To study toxicity of soil – oil interaction, heavy metals analysis was conducted in this paper. The breakthrough curves show that type A and B doesn't contain any of As and Cd metals, while type C doesn't contain As. In other hand type E doesn't include any Pb metal. The metal Ni shows no significant change is retained for the type B, C, D and E, while type A shows a constant retention rate. In addition, the retention profile for all samples shows that the type C has most retention in soil layers for As, Cd, Ni, Pb and Zn. All metals with different oil type have high concentration on the top layer of soil and up to 50 mm depth. This means that the top layer of the soil is most effected layer and required further research. In conclusion the retention of the heavy metals seems to be limited and this result is due to the absence of ion exchange on the silty sand soil.

The quality of the test resultswas measured by using mass balance calculation and show good agreement.For future investigations, testing can be done in these areas such as changing soil type, different oil type, effect of temperature on soil. Finally, work should be considered in assessment with fate and impacts of oil in the marine environment. Also, the soil that contaminated with crude oil especially type C has harmful negative effect on natural habitats. Plants will be contaminated with oil and may cause damage to the internal organs of the animals. In addition, the bearing capacity of the soil will be weak due to contamination. As a result, the soil will not be suitable for constructing any future structure.

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تأثير التسريب النفطي على التربة ، الساحل ، المارينا والمياه الجوفية في الكويت

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الخلاصة

تُعتبر معالجة وتصميم التربة المحطيه بالمناطق النفطيه قُبيل بدء اي مشروع نفطي لتعود بالأثر الايجابي على بُنية وتركيب التربة والبيئه المحطيه بها سواء كانت بريه او ساحليه، بحيث يشكل تسريب النفط في التربه الغير معالجة أسهل واسرع باختراق طبقات التربة ما يترتب عليه تاثيراً سلبياً على البيئة البريه والساحلية والايكولوجية. لذا يُقدم هذا البحث دراسة وافيه وشامله لتقييم تأثير تسريب النفط على بنية وتركيب التربة من الناحيه الفيزيائية كقياس عوامل إجهاد القص (زاوية الاحتكاك، التماسك) وعوامل الانضغاط (مؤشر الانضغاط ، مؤشر الانتفاخ) ، ومن الناحيه الكيميائية كقياس إمتزاز وحفاظ التربة للمعادن الثقيلة الاكثر سُميه الموجوه بالنفط ، بإستخدام اختبار العمود (فحص مخبري) باعداد تربه غير ملوثه بناءاً على الكثافه الجافه الموقعية ومحتوي الرطوبه الموقعية ، وإشباعها بخمس انواع مختلفة من النفط A، B، C، D and E لمحاكاة وتمثيل بُنية وتركيب التربة في الموقع .

وطبقاً لنتائج فحص القص المباشر للتربة فقد لوحظ إنخفاض في معامل زاوية الاحتكاك لجميع انواع النفط ويرجع ذلك للزوجة النفط والتي تعمل على انزلاق وتقليل الاحتكاك بين جزيئات التربة ، علاوة على ذلك لم يُلاحظ اي تغير في معامل التماسك والانضغاط للتربة. واخيراً أظهر مؤشر الاحتفاظ ان نوع النفط (C) يُعتبر أكثر الانواع النفط التي تخزنت معادنها الثقيلة (الزرنيخ ، الكاديوم ، النيكل ، الرصاص ، الزنك) في التربة مقارنة بالانواع الاخرى. علاوة على ذلك لوحظ إرتفاع تركيز المعادن الثقيلة في الطبقات العلويه للتربة وحتى عمق 50 مليميتر .