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RESEARCH ARTICLE

Effect of Oily Wastewater Head Spills of the Refineries on the Diffusion Rate and Contamination of Soils – A case Study of Kawergosek (Erbil city) Refinery

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ABSTRACT

Field study works have been carried out to investigate the diffusion rate of oily wastewater on clayey soils and measuring the degree of contamination with chemical components for both horizontal and vertical directions. Three pits have been prepared for this work with 30 cm in diameter and 50 cm in depth, which are lying on a straight line and 100 cm clear distance between them. Three, 30 cm diameter plastic pipes were fixed inside the pits having the length of 50 cm, 150 cm, and 200 cm, respectively, to study the effect of the height of the spilled oily wastewater on the rate of diffusion. The pipes filled with oily wastewater separately, the diffusion rate with time has been recorded. The results showed that the vertical diffusion rate of the oily wastewater was increased with the increase of the height, while the longitudinal diffusion rate recorded lower values. The same observation has been noted for the degree of soil contamination.

Keywords: Clayey soil; Diffusion rate; Oily wastewater; Soil contamination; Soil pits

INTRODUCTION

Oily wastewater spills in the refineries and spilled crude oil in the oil fields during accidents become a large problem nowadays in the oil industry countries. Necessary steps to control these problems become one of the major issues not to produce various environmental problems and risks which will have a many side effects on the life and health of the citizens whom they live on the surrounding areas also, on their agricultural lands (Sprague et al., 2000; Kogbara Ayotamuno, 2007).

The diffusion rate of the oil spills depends on the many factors such as, soil properties, duration, volume of spills, and oil specifications… (Uzoije, 2008). The effect of slow dissolution of spilled oil to the soil medium would appear in a short-term period and its bad effect on the agricultural products appears quickly, while for long-term period would have an adverse effect on the ground water(Shoukr et al., 2016).

Viscosity of oil can be considered as a qualitative property, higher viscosity referee to a thick fluid while the low viscosity referee to a thin fluid. It is obvious that thin fluid oil generally moves faster than a thick one in to the subsurface of the ground due to the less effect of the viscosity (Oghenejoboh et al., 2008). Density of the spill oil also is another factor which effects on the rate of diffusion to the ground sub surfaces ,(Omole et al., 2009).

The effect of the height of the oily wastewater spills in the refineries on the diffusion rate to the ground subsurface is another factor to be studied; this investigation would focus on this important part. Oily wastewater of the refineries, (Kwergosek refinery in particular), has been used, this fluid contains more than 80% water, and named the oily wastewater, this fluid generally left free to the lands in most of the refineries, therefore, its interesting to study its adverse effect on the soil and environment.

MATERIALS AND METHODS

The soil pits and plastic PVC pipes used in this investigation are shown in Plate 1. Three pits were dug of 30 cm in diameter on a straight line, 1 m clear distance between each of them. Three plastic pipes were installed in the pits 30 cm in diameter and 50 cm, 100 cm, and 200 cm in height. Then, the Kawergosek oily wastewater spilled into each pipe separately and the diffusion rate with time were recorded, the total time spent for the diffusion of all three heads of oily wastewater spills was around 10 h. After the completion of the test, the surrounding soils were dug horizontally and vertically till the effect of the fluid

disappeared by sight and smell. Various contaminated soil samples in different intervals in both horizontal and vertical directions were taken to the laboratory for examining the degree of chemical contamination.

RESULTS AND DISCUSSION

The chemical characteristics of oily wastewater used and properties of soil are shown in Tables 1 and 2.

The results of the rate of diffusion of the oily wastewater to the ground surfaces in the pits for the three cases are shown in Figure 1.

From Figure 1, the diffusion rate results of the oily wastewater into the subsurface of the soil increased with increase of the head, this due to the increase of head especially for vertical directions this would leave quick effect on the ground water, while for horizontal direction, the diffusion remains slow and its adverse effect would appear on the soil contamination. Another reason for the quick diffusion rate was due to the properties of the oily wastewater, which contains more water and less oil; therefore, the viscosity and density would have less effect on the movement of the fluid in to the soil. The equations of the three diffusion cases are shown below:

- For 50 cm head of oily wastewater: $Y = 0.0002X^2 - 0.1782 + 50.46$ (1)
- For 100 cm head of oily wastewater: $Y = 0.0004X^2 - 0.3904X + 90.06$ (2)
- For 200 cm head of oily wastewater: $Y = 228.79e^{-0.016x}$ (3)

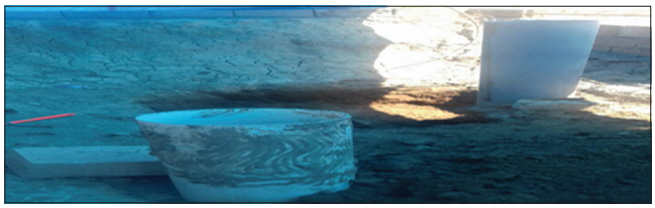

Plate 1: Location of the PVC pipes

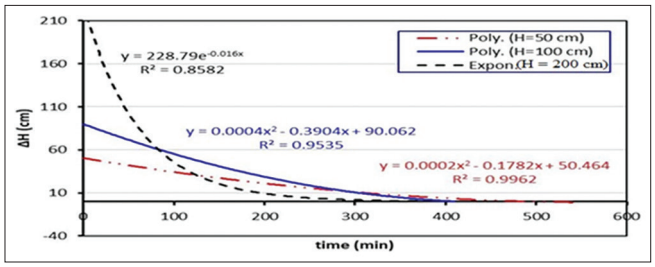

Figure 1: Oily wastewater diffusion rate for 50 cm, 100 cm, and 200 cm spilled heads

Contaminated soil samples were taken at the base of the pits downward vertically and horizontally in various distances until the effect of oily wastewater contamination disappear by vision and smell. Field investigation test regarding the chemical test results inside the pit model, the three tests for examining the soil contamination process are clarified in Figures 2-7, the scientific discussion on the rate of oily wastewater percolation for all three heads is the effect of the head which had a great influence on the rate of diffusion.

The degree of chemical soil contaminations was fluctuated for all chemical parameters; organic, total soluble salt (TSS), PH, carbonates, SO_3, and hydrocarbon. In general, the effect of oily wastewater on the soil contamination appears at the base of the pits and disappeared at nearly 40 cm, 50 cm, and 60 cm far from the pit base for 0.5 m, 1 m, and 2 m, respectively. Details of the contamination process explained as follows:

1- Contamination results of soil chemical pollution with hydrocarbon. [Figure 2] From the results of contaminated soil with hydrocarbon, it can be noted that the percentages of contamination were increased by increasing the oily wastewater head, a higher result was recorded for vertical diffusions than for horizontal for all three heads due to the head pressure effect. Percentage increase was 0.21% for horizontal direction and 0.32% for vertical direction for 0.5 m head of oily

Table 1: Kawergosk oily wastewater sample properties

Test	Unit	In-let	FAO 1992standards for irrigation	Turkish standards for irrigation	WHO 2011, standards for drinking water
ECw	µs/cm	1745	700–3000	700–3000	1000
TDS	ppm	872.5	450–2000	500–2000	500
Calcium (Ca)	ppm	5	20	20	200
Magnesium (Mg)	ppm	3.13	60	30	30
Sodium (Na)	ppm	14.11	900	900	200
Chloride (Cl)	ppm	0.33	4–10	4–10	5
Iron (Fe)	ppm	2.3	5	0.1–1.5	0.3
Nitrate (NO3)	ppm	26	5–30	10–30	50
pH		9.4	6.5–8.4	7–8	6.5–9.5
Oil	%	15			
Water content %	%	85			

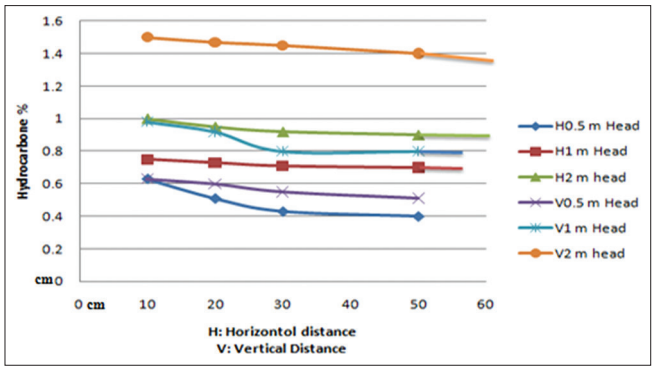

Figure 2: Contaminated results of hydrocarbon content for polluted soil for all heads of oily wastewater

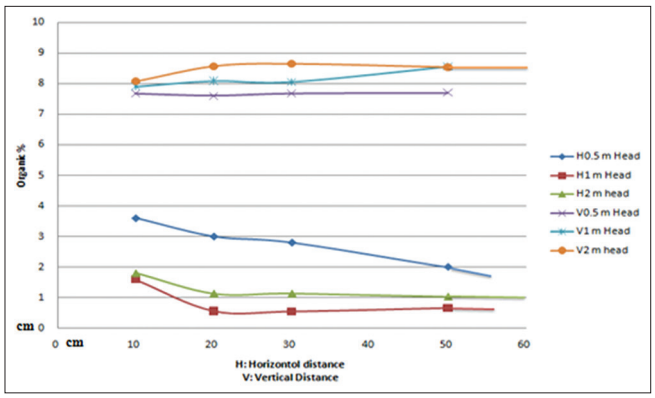

Figure 3: Contaminated results of organic content for polluted soil for all heads of oily wastewater

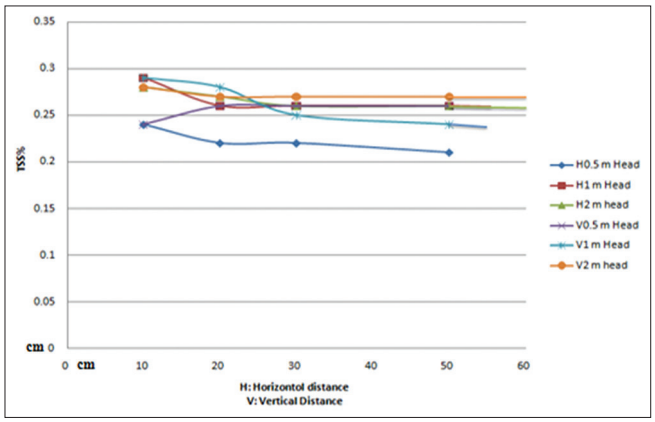

Figure 4: Contaminated results of total soluble salt content for polluted soil for all heads of oily wastewater

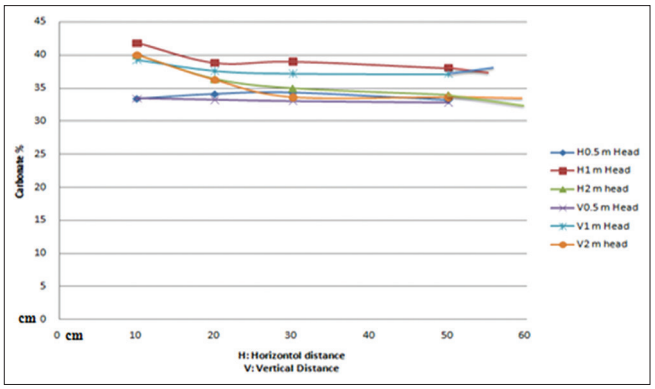

Figure 5: Contaminated results of carbonates content for polluted soil for all heads of oily

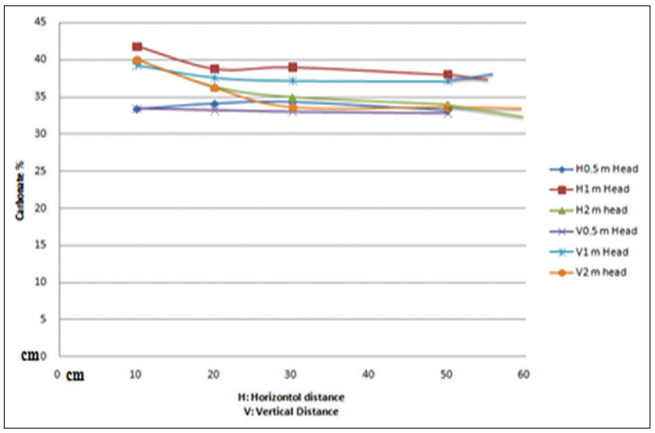

Figure 6: Contaminated results of SO3 content for polluted soil for all heads of oily wastewater

Table 2: Physical properties of examined soil

Soil type	CL-Lean clay
Gs	2.7
γ_d	1.4 g/cm^3
W%	5.6%
LL	37.8%
PL	14.7%
PI	23.1%

wastewater. Percentage increase for 1 m and 2 m head was almost close to each other and was 0.225% for horizontal direction and 0.56% for vertical direction.

2- Contamination results of chemical soil pollution with organic. [Figure 3] Results of organic content in the examined soil for all three heads of added oily wastewater showed a slight decrease comparing with zero contamination soil. For 0.5 m head, the recorded value was 0.9% for horizontal direction and 0.69% for vertical directions. The contamination effect disappeared at 40 cm far from the pit base. For 1 m head, a slight decrease has been observed, 2.56% and 2.77% for horizontal and vertical directions, respectively, and the effect of contamination disappeared on nearly 50 cm from the pit base. For 2 m head, the decreased results were 2.28% and 2.32% in horizontal and vertical directions, respectively, and the effect of contamination disappeared on 60 cm far from the pit base. Therefore, the organic contamination effect of soil with oily wastewater was limited because generally it appears mostly near top soil layers.

3- Contamination results of soil pollution with TSS. [Figure 4] TSS results for all three heads of oily

wastewater for both directions showed a slight increase, the recorded values were 0.065% and 0.055% horizontally and vertically, respectively.

4- Contamination results of soil pollution with carbonate Figure 5. In general, carbonate results were decreased for both directions and for all three heads of added oily wastewater comparing it with zero contaminated soil results. For 0.5 m head, percentage decrease was 7.9% and 6.95% for horizontal and vertical directions, respectively. For 1 m head the results were, 0.6% and 2% horizontally and vertically. For 2 m head, the results were 4.2% and 4.44% horizontally and vertically.

5- Contamination results of soil pollution with SO_3. [Figure 6] Looking at the contamination results of SO_3, it can be noted that the effect of oily wastewater on the soil contamination was limited for both directions, a slight decrease in the results have been recorded for 0.5 m head, 0.0065% and a slight increase recorded for 1 m head 0.002%, for both directions, while a slight increase has been observed, for 2 m head of oily wastewater, 0.002% for both directions.

6- Contamination results of soil pollution with pHs Figure 7. High results were recorded for pH, for 1 m and 2 m, heads of oily wastewater, while for 0.5 m head a few results were recorded. This gives an indication that pH would appears more in high soil depths. For 0.5 m head, the results were decreased by 0.53% and 0.49% horizontally and vertically, respectively, for 1 m head of oily wastewater a slight increase was recorded, 0.42% and 0.33% for horizontal and vertical directions, while for 2 m head, the results increased by 0.35% and 0.37% horizontally and vertically.

7- Overall results of soil contamination for all three heads of oily wastewater are illustrated in Figure 8. From Figure 8 can be noted that high results were recorded for carbonate then pH for all heads of oily wastewater. Organic appears more in zero contamination and for 0.5m head results. Due to the effect of the pressure head, hydrocarbon results recorded high values for 1 m and 2 m heads for both vertical and horizontal directions.

8- The following two comparisons have been made between the obtained results,

   a. Between the above-mentioned results with those obtained in Table 3 and the results are shown in Table 4.

   b. Between the average contamination results of hydrocarbon as main chemical contaminated components for all three heads with the results of direct shear test of laboratory contaminated samples, Table 5 and the results are shown in Table 6.

From Table 4, we can observe that the actual percentages of chemical soil contaminations with oily wastewater have been reported; this would give us an indication that oily wastewater has large effects on soil contamination and would lead to various expected environmental problems.

From Table 6, it can be noted that a slight decrease in the values of Cohesion and slight increase of angle of internal friction has been observed.

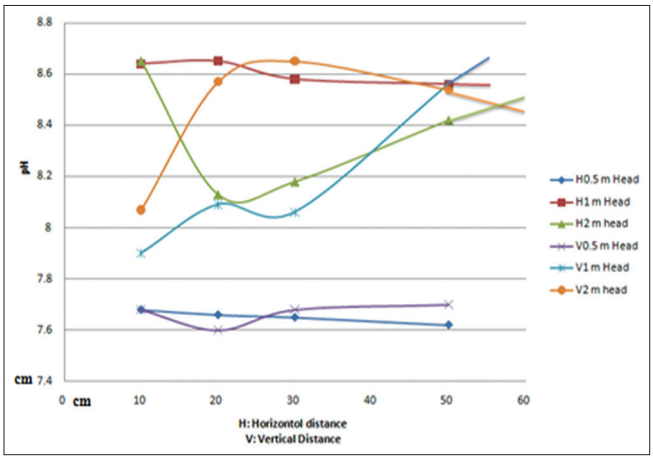

Figure 7: Contaminated results of pH content for polluted soil for all heads of oily wastewater

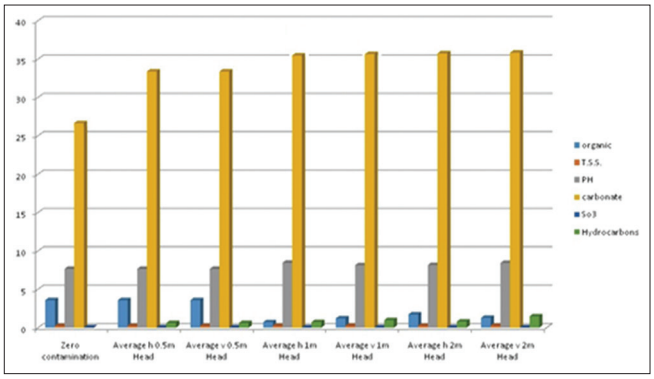

Figure 8: Soil contamination results for all chemical test components and all oily wastewater heads

Table 3: Chemical properties of contaminated soil samples with oily wastewater

Contaminated samples (%)	Organic	TSS	pH	Carbonate	SO_3	Hydrocarbon
0	3.7	0.21	8.18	25.2	0.067	-
5	1.28	0.21	8.4	30.2	0.052	4
10	1.24	0.21	8.01	30.6	0.052	5
15	1.21	0.22	7.93	31.4	0.055	6
20	0.77	0.24	7.86	32	0.062	10

Table 4: Percentages of chemical contamination for all three heads of oily wastewater

Oily wastewater	Organic (%)	TSS (%)	pH (%)	Carbonate (%)	SO_3 (%)	Hydrocarbon (%)
0.5 m Horizontal distance	<5	15–20	More than 20	More than 20	15–20	<5
0.5 m Vertical distance	<5	More than 20	More than 20	More than 20	20	<5
1 m Horizontal distance	15–20	More than 20	<5	More than 20	More than 20	<5
1 m Vertical distance	15–20	More than 20	5–10	More than 20	More than 20	<5
2 m Horizontal distance	<5	More than 20	<5	More than 20	More than 20	<5
2 m Vertical distance	<5	More than 20	5–10	More than 20	More than 20	<5

Table 5: Results of direct shear test for zero and all four percentages of contaminated soils with oily wastewater

% of Contamination	Cohesion (C) kPa	Angle of internal friction Φ (degree)
0	17.2	18
5	17	28
10	16.5	35
15	16.1	36
20	16	36

Table 6: Direct shear parameters for hydrocarbon contaminated samples for all three heads of spilled oily wastewater

Head m	Contamination results	C (kPa)	Φ (degree)
o.5	0.53	17.17	18.5
1.0	0.78	16.92	18.75
2.0	1.2	16.5	19.2

CONCLUSIONS

In this study, the following conclusions have been reached;

1. The results showed that the diffusion rate is proportional with the height of the spilled oily wastewater. For vertical direction, the diffusion rate was faster than the horizontal direction; this was due to the effects of gravity and interfaced tension.
2. The effect of viscosity and density of the fluid used on the diffusion rate was almost limited because it contains more than 80% water.
3. The degree of soil chemical contamination with the oily wastewater was flocculated for all six chemical contamination parameters; high results were observed for hydrocarbon with increase of the head of spilled wastewater and low results recorded for other chemical contamination parameters.
4. The percentages of chemical soil contaminations with oily wastewater would give us an indication that oily wastewater has a negative effect on environmental problems; therefore, steeps would be taken by refinery authorities to decrease or overcome the various expected environmental problems.
5. Percentages of chemical soil contaminations have been varied between 5% and 20% for all three heads of spilled oily wastewater.
6. A slight decrease in the values of Cohesion and slight increase of angle of internal friction has been observed.

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