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Evaporation of Heavy Crude Oil in Soil

Etini Etefia[1*] and L. O. Odokuma[2]

[1]Department of Microbiology, World Bank Africa Centre of Excellence in Oil Field Chemical Research (Ace-Cefor), University of Port Harcourt, Nigeria.
[2]Environmental Microbiology, University of Port Harcourt, Nigeria.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Heavy crude oil spillage on soil threatens productivity and affects the natural biota of the ecosystem. Evaporation is an important parameter increases crude oil density, viscosity and fraction of lower molecular weight substances which reduce its infiltration into the soil and groundwater. The evaporation of heavy crude oil showed API of 21.5, viscosity of 15mm^2/s, density 0.8952 g/cm^3, pour point of 11.37. The crude oil was exposed to solar radiation for 35 days. The percentage reduction in mass of the crude oil and temperature on five day interval showed 8.22(38^{O}C) on day 0, on day 5 was 8.13(34^{o}C), on day 10 was 5.92(39^{o}C), on day 15 was 5.38(39^{o}C), on day 20 was 3.16(37^{o}C), on day 25 was 2.94(31^{o}C), on day 20 was 2.56 (41^{o}C) and on day 35 was 1.79(38^{o}C). The lighter molecules evaporated first leaving the heavier molecules behind causing a reduction in the rate of evaporation with time. This analysis will be provide insight to modelling oil spill in terrestrial ecosystem.

Keywords: Evaporation rate; viscosity; density; natural biota; ecosystem.

1. INTRODUCTION

Evaporation of crude oil is an influential behavioral component after oil spillage on terrestrial habitat [1,2]. It is the process whereby a substance changes from the liquid phase to the vapor phase (at conditions that do not result in boiling). Evaporation occurs when molecules in the liquid substance have enough kinetic energy to overcome the intermolecular forces in the

**Corresponding author: E-mail: etinietefia@gmail.com, etinietefia@yahoo.com;*

liquid phase. The tendency for a substance to evaporate is dependent on the liquid's volatility and temperature [3]. A huge difference is observed few days following oil spill. Light crudes can evaporate as much as 75% of the starting oil mass from fluid to viscous and medium crudes up to 40%. Heavy or residual oils may only evaporate to the extent of 10% and may become tar-like [4,5]. Most oils after long evaporative exposure form asphalt balls [6]. Many spill simulations incorporate evaporation as a component of their extrapolation because of the large changes in mass balance [7]. The volatile fraction of heavy crude oil will evaporate once the oil is spilled thereby increasing the oil specific gravity and viscosity [8]. This results in reduction in the penetrability factor leading to increase in permeation of oil into the soil (Overton *et al*. 2016). When this volatile components of the crude oil have been evaporated, there will be crude oil stabilization and the rate of infiltration into the soil and groundwater is reduced [9]. Several studies have focused on the crude oil evaporation based on parameters such as density, wind speed, time and vapor pressure but according to Fingas, [10], the important factors for the evaporation of petroleum compounds in the soil are time and temperature. Evaporation can be predicted even more simply by an equation of the form: Ev= T Int where: Ev is the percentage evaporating per unit time, t T is the temperature tis the time [11,12].

2. MATERIALS AND METHODS

2.1 Crude Oil Characterization

The following parameters were determined; hydrogen Sulphide content, specific gravity, Water content, API, density, pour point. The standard methods used and the results obtained are presented in the Table 1.

2.2 Crude Oil Evaporation

Evaporation rate was measured as weight loss by using an electronic balance with an accuracy of ±0.01 g. The daily mass of heavy hydrocarbon loss and the temperature were measured [10]. Temperatures were measured between 10:00 am and 2:00pm at an interval of five days [Table 2, Fig. 1]. The difference in mass evaporated was noted at zero time and the mass after evaporation was calculated. Evaporation loss was calculated using the formula:

% Evaporation=$100*(w_o-w)/wo$ [12,13].

3. RESULTS AND DISCUSSION

3.1 Crude Oil Properties

The properties of the crude oil that influence its evaporation rate are presented in Table1.

3.1.1 Chromatographic analysis

Table 1. Physicochemical properties of heavy crude oil

Sample	Parameter	Test method	Result
Heavy crude oil	^{O}API	ASTM 5002	21.5
	Density		0.8952 g/cm^3
	Viscosity at (40^{o}C)	ASTM D445 and ISO 3104	15.0mm^2/s
	Pour point	ASTM D5853	11.37
	Water Content, mg/l		0.18

Table 2. Percentage evaporation of heavy crude oil

Day	Temperature(^{o}C)	Mass of heavy crude oil Evaporated	Evaporation [%]
Day 1	38	1.973	8.22
Day 5	34	1.952	8.13
Day 10	39	1.421	5.92
Day 15	39	1.292	5.38
Day 20	37	0.758	3.16
Day 25	31	0.706	2.94
Day 30	41	0.615	2.56
Day 35	38	0.430	1.79

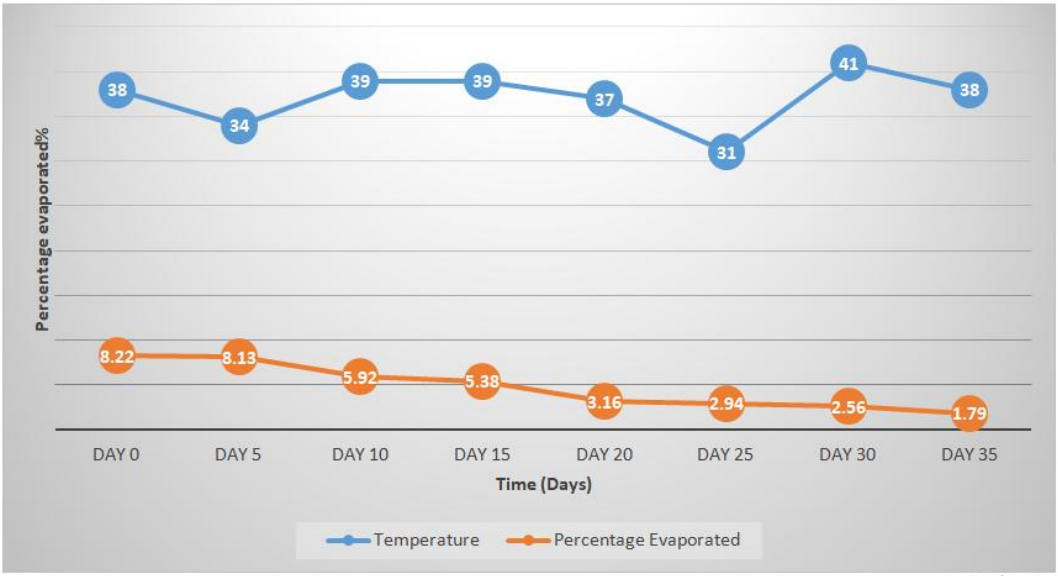

Fig. 1. Percentage of crude oil evaporated in relation with temperature and time

Evaporation is a primary process that affects oil spill in soil. This removes lower molecular weight hydrocarbon within days. The studied crude oil is heavy with API of 21.5, viscosity of 15mm^2/s, density 0.8952 g/cm^3, pour point of 11.37 and water content of 0.18mg/l [Table 1]. When the heavy crude oil was exposed to solar radiation for 35 days(five day interval), the degree of crude oil evaporated was slower on day 20-35 as the volatile fraction of the crude has evaporated massively on day 0 to day 15 [Table 2]. The mass evaporated per day increased with temperature. For the same temperature [Fig. 1], the evaporated mass decreases with time. This is was due to the depletion of petroleum volatile components (Bufarasan *et al.,* 2002).

4. CONCLUSION

When large Crude oil spill occurs in the soil, the oil immediately manifests chemical and physical transformations. This research shows clearly that rise in temperature makes the oil more viscous thereby increasing the kinetic energy of molecules as such increasing the rate of evaporation oil the crude oil spilled. This removes lower molecular weight hydrocarbon within days and pave way for easy cleanup of the oil spilled.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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