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Dispersion properties of alkali produced from empty fruit bunches of three different species of oil palm

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Abstract

In this study, the crude oil in water dispersion performance of alkaline extracts from three different species of palm tree namely, *Elaeis Guineesis, Elaeis Oleifera and Elaeis Odora* was investigated. These extracts were used for the dispersion of crude oil at room temperature (30 ^{0}C) in the form of dry ash, and leachates from the dry ash. Results of the dispersion experiments using 14 cm^3 of the leachate extracts to disperse 4 cm^3 of crude oil in 10 cm^3 of fresh water showed that 62.5%, 55%, and 50% dispersion was achieved with *Elaeis Odora, Elaeis Guineesis,*and *Elaeis Oleifera* extracts respectively. The same analysis in 10 cm^3 of river water instead of fresh water showed that 75.0%,62.5%, and 55.0% dispersion was achieved with *Elaeis Odora, Elaeis Guineesis,*and *Elaeis Oleifera* extracts respectively. With the dry ash, optimum dispersion was obtained when 0.9 g dry ash was used to disperse 4 cm^3 of crude oil in 10 cm^3 of fresh water with 100%, 100% and 67.5% dispersion achieved with dry ash extracts from *Elaeis Odora, Elaeis Guineesis,*and *Elaeis Oleifera respectively.* The same level of dispersion was achieved when the experiment was repeated with river water. Spectrophotometric analysis of these alkaline extracts showed that they contain negligible amounts of poisonous substances. These extracts could therefore serve as "green" dispersants even as toxicity impacts of commercial synthetic dispersants remain a subject for debate.

Keywords: Oil spills; Crude oil dispersants; Empty fruit bunch

1.0 Introduction

During production and /or transportation of crude oil and its products, large scale spills can occur as a result of equipment failure, operational errors, or willful damage. Such spilled oils have deleterious consequences on marine life, fishing water quality, aquaculture and agriculture with associated economic woes. There are various remediation measures with the choice applicable to any case dependent on the nature of the terrain and magnitude of the spill. Although mechanical recovery is generally considered as the primary option for responding to spills, typical efficiencies cited for mechanical recovery are in the range of 10 – 20% of the spilled oil(Robert & Alun,1999). These low recovery values make the use of chemical agents almost imperative for effective oil spill control. There are different types of chemical agents that can be applied to an oil spill to assist in controlling clean up or recovery. These include (OSRRP,2008):

- Dispersants
- Surface washing agents
- Bioremediation Agents
- Miscellaneous oil spill control agents

Of these, dispersants are the most widely used. Dispersants are specially designed oil spill products that are composed of detergent like surfactants in low toxicity solvents. The dispersant technology began with the use of aromatic based solvent products on the Torray Canyon spill off the coast of England in 1967. These dispersants were toxic to marine life because of the presence of aromatics like benzene, toluene and xylene in their composition. Although none of these components is used in modern dispersants, the environmental acceptability of the product continues to be a subject for debate. Modern dispersants have generally been found to be much less toxic than the oils they are used to disperse (Robert and Alun,1999). For example, the dispersant response to the "Sea Empress" spill in 1996 demonstrated that dispersants can be very effective and prevent a much greater amount of environmental damage from being caused (Lunel et al,1997; SEEEC,1998).

Dispersants promote the formation of numerous tiny oil droplets and delay the formation of slicks because they contain surfactants with hydrophilic heads which associate with water molecules and oleophilic tails which associate with the oil. The formation of droplets increases the exposure of the oil to bacteria and oxygen favouring biodegradation. They hence function by enhancing the rate of natural dispersion caused by wave action (IPIECA,2005). Low toxicity dispersants known as "Type 1 dispersants" (UK Classification) were developed in the beginning of the 1970's. They are of relatively low effectiveness and need to be used at very high treatment rates. More efficient dispersants were produced using higher surfactant content. The higher viscosity of these dispersants made them difficult to apply using certain existing spray mechanisms, but this was later overcome by substituting some of the solvents with seawater. Such water-dilutable dispersants became known as "Type 2" (UK classification) dispersants. Higher performance dispersants using blends of different surfactant types were developed in 1972 and improvements in formulation continued into the 1990s (IPIECA,2005).

However, the toxicity concerns which arise with the use of dispersants necessitate further studies with a view to producing "green dispersants". This research reports the studies carried out on the dispersion proper ties of such "green dispersants" produced from alkaline extracts of 3 different species of palm trees namely *Elaeis Odora, Elaeis Guineesis,* and *Elaeis Oleifera.* This extract is obtained from the empty fruit bunch of these palm species. Although these empty fruit bunches are normally thrown away, they have been found to be useful as fuel and a source of sodium and potassium compounds for soap making (Onuchukwu,1989). The ash from these empty fruit bunches have also been reported to contain mainly Potassium Carbonate and Potassium Hydroxide (Taiwo and Oshinowo, 2001).Using such compounds from biological sources as dispersants has the advantages of biodegradability, ease of production from renewable sources and lower toxicity (Pekdekir et al,2005).

2. Materials and methods

2.1. Alkali preparation

Empty fruit bunches of three different species of palm tree namely *Elaeis Odora (+Ojukwu), Elaeis Guineesis (+Osukwu),*and *Elaeis Oleifera (+Okporoko)* were collected from a local palm oil processing factory in Egbuoma town, Oguta LGA of Imo state. The empty fruit bunches were sun dried for 4 days and finally ashed in an open incinerator for 90 mins. The ash produced was ground into fine powder. 420 g of each of these ash samples was dissolved in 2.5 litres of distilled water, stirred periodically and leached for 7 days. The leachate was obtained by filtration and stored at room temperature (28-32^{0}C) in dark coloured bottles initially rinsed with distilled water.

2.2. Spectrophotometric analysis and pH determination

The concentrations of mineral components of the samples were determined using the Philips Atomic Absorption Spectrometer model PU 9100X/14. The pH of the three leachate samples was obtained using a digital pH meter.

2.3. Volumetric analysis

Volumetric analysis of each of the leachate sample was performed to determine the alkali concentration of alkali of each sample. 1 M concentration of hydrochloric acid was prepared and titrated against 25 cm^3 of each leachate sample with methyl orange as indicator, and the titre values at end point noted.

2.4. Fresh water dispersion analysis using leachate samples

4 cm^3 of crude oil was collected with the aid of a plastic string and discharged into a 100 cm^3 separating funnel. 4 cm^3 of a leachate sample was added to this and the mixture shaken for 30 secs and subsequently allowed to stand for 5 mins. 10 cm^3 of fresh water was then added to the mixture in the separating funnel and the total mixture allowed standing for 60 mins. The mixture was seen to have separated into an undispersed oil layer, an oil-water emulsified layer, and a water layer containing dispersed oil droplets.

This procedure was repeated with different volumes of the leachate sample and for each of the leachate from the 3 palm species.

2.5. Fresh water dispersion analysis using dry ash samples

4 cm^3 of crude oil was collected with the aid of a plastic string and discharged into a 100 cm^3 separating funnel. 10 cm^3 of fresh water and 0.2 g of dry ash sample were added to the separating funnel and the mixture shaken for 30 secs and allowed to stand for 60 mins. The mixture was also seen to have separated into an undispersed oil layer, an oil-water emulsified layer, and a water layer containing dispersed oil droplets.

This procedure was repeated with different weights of ash sample corresponding to the different leachate to oil ratios used in the previous experiments involving leachate samples, and with ash from each of the empty fruit bunch of the three palm species under consideration.

2.6. River water dispersion analysis using leachate samples:

4 cm^3 of crude oil was collected with the aid of a plastic string and discharged into a 100 cm^3 separating funnel. 4 cm^3 of a leachate sample was added to this and the mixture shaken for 30 secs and subsequently allowed to stand for 5 mins. 10 cm^3 of water from a local river in Ndiakitikpo village, Uli Anambra State was then added to the mixture in the separating funnel and the total mixture allowed standing for 60 mins. The mixture was seen to have separated into an undispersed oil layer, an oil-water emulsified layer, and a water layer containing dispersed oil droplets.
This procedure was repeated with different volumes of the leachate sample and for each of the leachate from the 3 palm species

2.7. River water dispersion analysis using dry ash samples:

4 cm^3 of crude oil was collected with the aid of a plastic string and discharged into a 100 cm^3 separating funnel. 10 cm^3 of water from a local river in Ndiakitikpo village, Uli Anambra State and 0.2 g of dry ash sample were added to the separating funnel and the mixture shaken for 30 secs and allowed to stand for 60 mins. The mixture was also seen to have separated into an undispersed oil layer, an oil-water emulsified layer, and a water layer containing dispersed oil droplets.
This procedure was repeated with different weights of ash sample corresponding to the different leachate to oil ratios used in the previous experiments involving leachate samples, and with ash from each of the empty fruit bunch of the three palm species under consideration.

3. Results and discussion

The tables 1, 2 & 3 below show the concentrations of ions in the ash samples as indicated by spectrophotometric analysis of the samples, while the graphs in figures 1, 2, 3 & 4 show the results obtained when crude oil was dispersed with the dry ash samples and the leachate from these samples.

Table 1
Results of spectrophotometric analysis of samples

Element	*Elaeis Odora*		*Elaeis Guineensis*		*Elaeis Oleifera*	
	Concn(ppm)	% Composition	Concn(ppm)	% Composition	Concn(ppm)	% Composition
Sodium,Na	3.70	7.8	6.28	14	4.03	12.9
Potassium	15.75	33.4	13.20	30	10.13	32.5
Calcium,Ca	11.28	23.9	7.25	16.2	4.06	13.0
Lead, Pb	0.95	2.1	0.01	0.02	Nil	-
Chromium,Cr	1.02	2.2	0.86	1.9	0.03	0.1
Arsenic, As	Nil	-	Nil	-	Nil	-
Iron, Fe	3.90	8.3	6.22	13.9	2.19	7
Zinc, Zn	8.37	17.7	10.43	23.3	5.92	19
Copper, Cu	2.10	4.5	0.34	0.8	4.80	15.4
Cadmium,Cd	0.17	0.4	0.15	0.3	0.04	0.1

The following pH values were also obtained for each of the leachate samples:

Table 2
pH values of the leachate samples

Sample	*pH*
Elaeis Oleifera	10.36
Elaeis Guineensis	10.85
Elaeis Odora	10.95

The volumetric analysis gave the following potassium hydroxide concentrations for each of the leachate samples used.

Table 3
Potassium hydroxide concentration of leachate samples

Sample	*Concentration, mol/dm^3*
Elaeis Oleifera	0.67
Elaeis Guineensis	0.54
Elaeis Odora	0.82

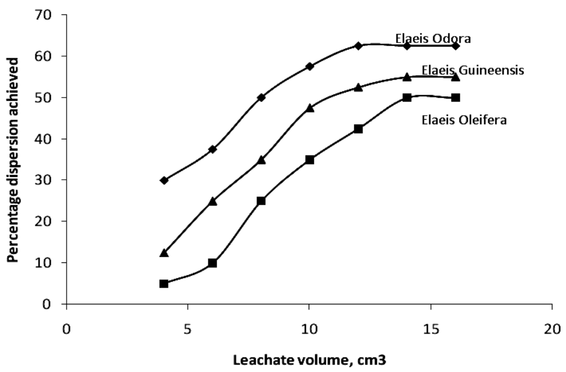

Fig. 1. Results of dispersion of 4 cm^3 of crude oil in fresh water using leachate extracts.

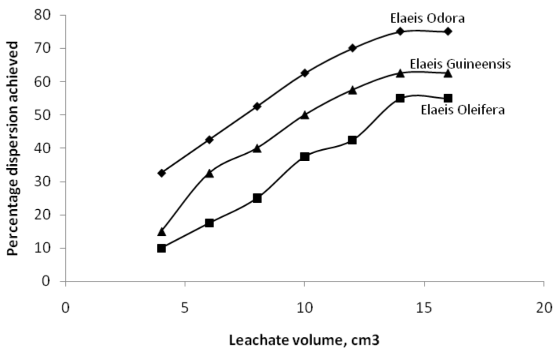

Fig. 2. Results of dispersion of 4 cm^3 of crude oil in river water using leachate extracts.

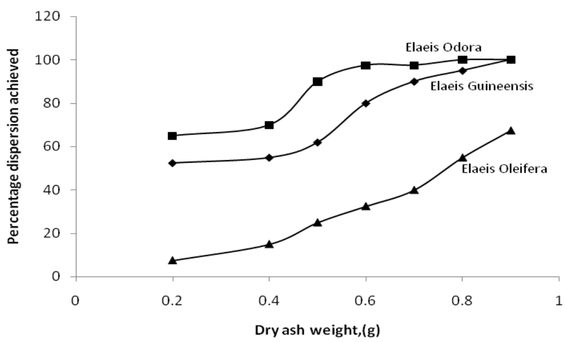

Fig. 3. Results of dispersion of 4 cm^3 of crude oil in fresh water using dryash samples.

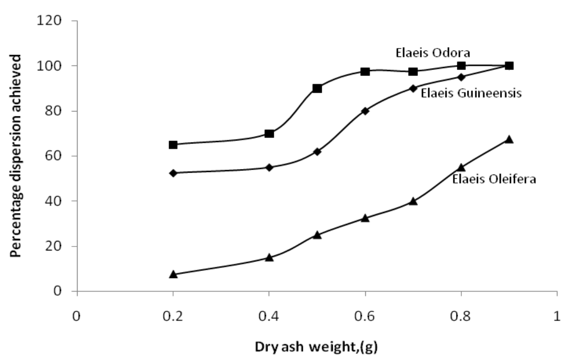

Fig. 4. Results of dispersion of 4 cm^3 of crude oil in river water using dryash samples.

Results of the spectrophotometric analysis of the ashes from the palm species *Elaeis Odora*, *Elaeis Guineensis* and *Elaeis Oleifera* show that the combined concentration of Sodium, Potassium, and Calcium ions is more than 58% in each of these samples. The high percentage of these ions is important since in the presence of water they form their hydroxides which being surfactants have the ability to reduce the oil/water interfacial tension hence promoting oil dispersion. That their hydroxides are actually formed in water is confirmed by the result of the volumetric analysis which shows that the concentrations of potassium hydroxide in the leachate vary correspondingly to the percentage composition of potassium in the ash samples. Furthermore, the PH of the leachate samples indicates that *Elaeis Odora* is more alkaline than *Elaeis Guineensis* which is in turn more alkaline than *Elaeis Oleifera*. This increase in PH values is seen to agree with the increase in the combined concentrations of these ions in the ash samples. Fig 1 shows the dispersion activities of the 3 leachate samples in fresh water. An increase in the percentage dispersion achieved is noticed until its maximum values are attained with a leachate to crude oil ratio of 3.5: 1. At this concentration, the dispersion activity of *Elaeis Odora* is the greatest (62.5%), followed by that of *Elaeis Guineensis* (55.0%), with *Elaeis Oleifera* having the least effect (50.0%). This same trend is observed in Fig 2 which shows the dispersion activities of the 3 leachate samples in river water. The only difference here is the increase in the percentage dispersion achieved in river water. This increase in percentage dispersion in river water (75% with *Elaeis Odora*, 62.5% with *Elaeis Guineensis* and 55% with *Elaeis Oleifera*) show the influence of electrolyte in the system. Since the majority of colloidal particles in aqueous dispersions are charged, the presence of salt in sea water not only reduced their surface potentials but also led to coagulation of the particles into flocs, which increased the interactions between the surfactant moieties (Pekdemir et al, 2005). Figs 3 and 4 show the dispersion activity of dry ash samples of the 3 palm species. A dry ash weight of 0.8g to 4 cm^3 of crude oil displayed maximum dispersion activity (100% with *Elaeis odora*, 95% with *Elaeis Guineensis*, and 67.5% with *Elaeis Oleifera*). The results are identical for both fresh and river water and are also better than those obtained with the leachate samples having the same alkali concentrations. These better results obtained with dry ash samples could be attributed to the adsorbent property of the ash which enables it adsorb some of the oil components and disperses it down the water column as it sinks.

4. Conclusion

The dispersion activities of alkali produced from empty fruit bunch of different species of palm has been studied. The alkali was used in both liquid and solid form to disperse crude oil in fresh and river water. The entire alkali samples showed remarkable crude oil dispersion activity with the dry ash samples found to be more effective than the leachates. However, alkali from the *Elaeis Odora* specie gave the best results. Although the dispersant to crude oil ratio required to achieve the results presented in this study is on the high side (i.e. 3.5 volumes of dispersant to 1 volume of oil, and 1 weight of dispersant to 4 weights of oil) when compared to the ratio of 1 volume of dispersant to 20 volumes of oil used with modern commercial dispersants (Ross, 2000), these alkali products are more environmentally friendly, being less toxic than their commercial counterparts.

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