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The Use of Some Solid Waste Materials (feather, goat-hair, corncob, and cotton) as Oil Spill Mops on Water Surfaces

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Abstract

Powders of chicken feather, goat hair, corncob and cotton, were used to mop spills of crude oil, diesel, kerosene and petrol from water surfaces. It was observed that the four sorbents mopped up appreciable amounts, often more than 500% of their weights of the hydrocarbon sorbates, within the first one hour of contact. The ability of the sorbents to absorb the hydrocarbon liquids was in the order: feather > cotton > goat hair > corncob. Furthermore, it was evident that large quantities of the absorbed oil were recovered from the sorbents by draining and by mere pressing. The latter observation is attributable to the fact that the weak physical adhesive forces binding the hydrocarbons to the sorbents become easily deactivated by pressing. This high degree of absorption and recovery suggests that the four sorbents have good potentials as mops in water environments.

Key words: feather, goat-hair, corncob, cotton, oil spill, mops, water.

Introduction

Along with coal, petroleum is the primary source of many organic chemicals. Though the major use of these fossil fuels is energy production, about 10% is used to make the numerous industrial products that contain carbon (Birk, 1994). Crude oil from which myriad of fractions can be obtained, is a dark, thick, odoriferous liquid composed of about 95% hydrocarbons such as alkanes, cycloalkanes and aromatics.

In the course of the 20th century, the world's consumption of crude oil has increased exponentially, owing mainly to the rapidly growing demand for petrol and heating oil (John, 1982). This has necessitated transporting some thousand million tonnes of crude petroleum each year from the producing countries to the consumers mostly in tankers. It is inevitable that from time to time one of these giant vessels is involved in an accident caused by storms and mechanical failure, resulting in massive spillages of oil into the sea. Although, tanker accidents are spectacular and well-published events causing severe contamination locally, they account for only about 25% of the total spillages (Oyefolu and Awobayo, 1979). Other sources include natural seeps from the seabed via fissures in rocks, offshore oil seeps from drilling and oil exploration, air-borne oil droplets from unburnt fuel and combustion engines on land, and discharges from shipping as well as deliberate discharges into the sea as ecological terrorism (Kerin and Lewis, 1993). It has been established that the main causes of oil pollution in Nigeria include flow line/pipeline leaks, over-pressure failure of process equipment components, sabotage to well heads and flow lines, hose failure on the tanker loading system and failures along discharge due to vibrational effects.

The fate and the effects of oil spills have attracted a spate of voluminous literature (e.g. Kerin and Lewis, 1993; John, 1996) while the various procedures for combating the menace have been extensively discussed (Okonkwo and Eboatu, 1999; Singer *et al.*, 2000). In this article, we report on the use of some solid wastes as oil sorbents in contradistinction from conventional materials such as perlite, talc, vermiculite, straw, sawdust, bark, peat, polyurethane, polystyrene, polyesters and urea formaldehyde.

Materials and Methods

Chicken feather and goat hair were collected from a local abattoir near Udoka Housing Estate Awka, Anambra State. Cotton lint was obtained from a nearby ginnery at Ugwuoba in Oji River, Enugu State, Nigeria while corncob was received from the Ministry of Agriculture. Nylon 6.6 fabrics were used to make pillowcases to contain the waste materials used. These waste materials include: crude oil; diesel (AGO), kerosene (DPK) and petrol (PMS), all of which were sourced from a refinery.

Preparation of the sorbents

The materials were thoroughly washed with detergent solution, rinsed with distilled water and then dried in the sun. Corncob, goathair and feather were separately ground into fine powders using a manual kitchen grinder. Several pillows were made by encasing exactly 7g of sorbent in 2.2g nylon bags.

Mopping of oils by the sorbents

Exactly 200cm^3 of crude oil was added into a glass beaker containing an equal volume of tap water and the mixture was stirred with mechanical stirrer for 2 minutes, to simulate an oil slick in a stormy sea. The prepared feather pillow was completely immersed into the solution. After a resident time of 30 min, the pillow was removed and hung in air to drain. The volumes of oil and water recovered were measured. The pillow was then pressed with a metal press of 5kg weight, for 20 secs, and the volumes of oil and water recovered were also taken. This procedure was repeated four times with different pillows prepared with the same material and the average volumes of oil and water recovered were determined. This exercise was carried out for each sorbent – sorbate pair at different time intervals (1h, 2h, 5h, 10h, and 24h) after soaking. The volume of the absorbed oil was determined as the difference between the original volume (200 cm^3) and the quantity remaining after the soaking programme. The same treatment was also adopted for water. By noting the specific gravities of the liquids, volumes were converted to weights.

% weight absorbed was formulated as:

$$\text{weight of sorbate/ weight of sorbent} \times 100/1$$

Similarly, % weight drained, expressed or retained was calculated. In all cases, mixtures of water and hydrocarbon were separated by means of a separatory funnel.

Results and Discussion

The results of the absorption, draining, expression and retention of the hydrocarbon and water by the different sorbents are shown in Figs. 1 and 2. The following observations were evident from the investigation:

(a) Weight of hydrocarbon absorbed: The ability of the sorbents to absorb the hydrocarbon liquids was generally in the order: feather > cotton > hair > corncob.

Generally the sorbents, to varying degrees, absorbed appreciable quantities of the hydrocarbons.

(b) Weight of water absorbed. On the average, the capability of the sorbents to take up water roughly followed the trend: cotton > hair > feather > corncob; except for crude oil where feather imbibed more water than hair.

(c) Weight of hydrocarbon drained: The greatest amount of hydrocarbon was drained from goat hair. In diesels and in petrol, the order was: goat hair > feather > cotton > corncob. In crude oil on the other hand, it was hair > corncob > feather > cotton; while in kerosene the order was slightly different: hair > corncob > cotton > feather.

(d) Weight of water drained: The trend here is roughly of the order: cotton > hair > feather > corncob for diesel and petrol. For crude oil it was feather > cotton > hair > corncob, while for kerosene it was cotton > hair > feather > corncob.

(e) Weight of hydrocarbon expressed: The largest quantity of crude was expressed from cotton, feather, corncob and hair, in that order. Diesel was not expressed from corncob, kerosene not from goat hair, while petrol was only expressed from cotton. Generally the order of the sorbents to release absorbed hydrocarbon by pressing was: cotton > feather > corncob > hair.

(f) Weight of water expressed: For diesel and kerosene, more water was expressed from cotton than from feather; none was expressed from either corncob or hair. For petrol, water was recovered only from cotton. From crude oil the trend was: cotton > feather > hair. Therefore in general the order of the sorbent to release water was: cotton > feather > hair > corncob.

(g) Weight of hydrocarbon retained: Retention of the hydrocarbon liquids by the sorbents is in the order: cotton > feather > corncob > hair.

(h) Weight of water retained: in crude oil and petrol, the sorbents retained water in the order: cotton > feather > hair > corncob (feather did not retain any water).

The effects of contact time on the quantity of hydrocarbon or water absorbed by the different sorbents are shown in Figs. 3 and 4. Evidently the bulk of the hydrocarbons were mopped up within 1h. The differences in absorption profiles of the various sorbents as observed in this investigation can be explained. The rate and extent of absorption by the sorbents depend upon various factors such as their nature-particle size, porosity, presence or absence of specific interaction sites, and the viscosity and molar sizes of the sorbates. The nature of the absorbent material influences their affinities for the hydrocarbon liquids. Cotton and corncob are cellulosic while hair and feather are protein-based. It has been reported by Nduka (2000) that feather possesses both oleophilic and aquaphobic qualities, i.e. it readily absorbs large quantities of oil through capillary action; the same can be said of hair keratin protein. Cotton and corncob, being cellulosic tend to be hydrophilic and would absorb water more readily than oil. These expectations are borne out by these results**.**

The surface areas of the sorbents (the reason for pulverization) are another factor to be considered. Cotton fiber has a very large surface area made of the convolutions, lumens and inter-fibril/fiber spaces. The other powdered sorbents may not have such large surface areas. Thus, it is hardly surprising that this material absorbs very appreciably. Feather comes next after cotton. The latter would have absorbed the hydrocarbons readily on account of the large surface area but for its hydrophilicity, i.e. would tend to absorb more water than the rest of the sorbents (Fig. 2a).

The hydrocarbon and water molecules are bound to the sorbent external and internal surface walls by means of weak physical adhesive forces such as Van der Waals, London forces, as well as by mere physical entanglement, which are easily broken on application of pressure. It is also seen that the nature of the hydrocarbon somewhat determines the relative affinities for the sorbents. This is attributable to the chain length (molar mass) of the hydrocarbon. Those with longer chains (e.g. crude oil) are likely to be absorbed more slowly but retained better than smaller molecular chain species (e.g. petrol), which are more loosely held, as well as desorb more readily, (Fig. 1a). The trend by which the hydrocarbons were absorbed/adsorbed by each of the sorbents is as follows:

Feather: crude oil > diesel > kerosene > petrol.
Goat hair: Diesel > crude oil > kerosene > petrol.
Corncob: Crude oil > petrol > kerosene > diesel.
Cotton: crude oil > diesel > petrol > kerosene.

Conclusions

The following conclusions are drawn from this study:

- The four solid waste materials show excellent abilities to absorb the hydrocarbon liquids from water surfaces.
- Large proportions of the absorbed oils are recoverable by draining and mere pressing, at room temperature.
- Appreciable quantities of the hydrocarbons were mopped up within 1h of contact with the sorbents.
- The quantity of hydrocarbon removed depends on the nature of the sorbent: protein – based samples perform better off-shore (in presence of water) while the cellulosic ones are more suited to on-shore (absence of water) applications.
- Feather is the best mop for the hydrocarbon liquids on water environment in that it preferentially absorbs more of oil than water.
- The amount of the hydrocarbons absorbed does not depend on the sorbents only; the molar chain length of the hydrocarbons is of important consideration.
- This technique is a cheap and ready way of mopping/cleaning a water environment contaminated by hydrocarbon slicks. This has far-reaching implications in that these otherwise solid wastes, have now found excellent utility in combating a major problem of the oil industry. These wastes abound in Nigeria. Moreover, they are all biodegradable.

References

Birk, A. (1994) *Chemistry*. Houghton-Mifflin Company, New York, PP 980 & 981.

Hicks, J. (1982) *Comprehensive Chemistry*. 3rd ed. Macmillan Education Ltd., Houndmills, Basinstoke, Hampshire.

Hunt, J.M. (1996) *Petroleum Geochemistry and Geology*. 2nd ed., W.H. Freeman and Company, New York, pp 23 & 24, 453 & 454.

Nduka J, K. (2000) Use of some solid wastes as oil mop. Unpublished MSc. Thesis, Department Pure and Industrial Chemistry, Nnamdi Azikiwe University, Awka, Nigeria.

Okonkwo, E.M. and A.N. Eboatu, (1999) *Environmental Pollution and Degradation*. Onis Excel Publishing, Zaria, Nigeria, pp 94-97.

Oyefolu, K.O. and O.A. Awobayo (1979) Environmental Aspects of the Petroleum Industry in the Nigeria Delta, Proceedings of the Nov. 1979 Seminar on the Petroleum Industry and the Environment of the Niger Delta, Port Harcourt, Nigeria. pp 102-107.

Pickewing, K.T. and L.A. Owen (1993) *An Introduction to Global Environmental Issues*. pp150-152

Singer, A.C., E.S Gilbert, E. Lucpromchaic and D.E Crowley (2000) Bioremediation of Polychlorinated Biphenyl – Contaminated Soil Using Carvone and Surfactant – grown Bacteria. *Appl. Microbiol. Biotechnol.* 54: 838-843.