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Remediation of a simulated petroleum polluted water using pulverised used: Water sachet (Polyethylene)

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The potential of using used-water-sachets, a synthetic polymeric waste, which is not only readily available but indiscriminately littered around Nigerian urban and rural areas, as an adsorbent in removal of oil spilled on water was investigated. Used-water-sachets, a waste generated all over the country, has been converted into a low cost adsorbent. The sachets were collected, pretreated and pulverised to adsorb crude oil from water at various time intervals. The study examined the removal efficiency of pulverized used-water-sachet polyethylene (PUWSP) of crude oil spilled on the surface of water. It was observed that PUWSP was capable of adsorbing the artificially spilled crude oil on the water surface. The crude oil was approximately 100% cleaned up within 3 h time interval.

Key words: Crude oil, sachet polyethylene, pulverized used-water.

INTRODUCTION

Accidental and deliberate crude oil spills have been, and still continue to be, a significant source of environmental pollution. These oil spills pose a serious environmental problem primarily due to the possibility of air, water and soil contamination (Atlas and Bartha, 1992).

The serious adverse effects of crude oil spills on economy, health and environment are much and regulatory measures put in place by government and relevant authorities in handling of crude oil only minimize the chances of these spills but do not eliminate it. As such the Nigerian petroleum industry expends so much resource on importing crude oil spill adsorbents for combating and cleaning of these minor spills (Ayotamuno et al., 2002). Estimated costs of spill clean up stand at 2 billion dollars per annum (Egwaikhide et al., 2007).

The purpose of this research work is to produce an adsorbent with large surface area and strong affinity to hydrocarbon compounds using cost effective, inexpensive and readily available inert agent (used-water-sachet) to remove crude oil from a simulated petroleum polluted water. Thus, this research work reports on the use of polyethylene in the production of adsorbents for use in crude oil spillage.

MATERIALS AND METHODS

Materials sourcing and preparation

Used-water-sachets were collected from Agama Pure Water Company, Minna. The polyethylene wastes were soaked in hot boiled water with detergent for ten minutes, then washed with a sponge and subsequently were dried under the sun for two days.

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Table 1. Clean-up levels at various time intervals of the total aliphatic hydrocarbon (TAH) content (mg/L) in the artificially petroleum polluted water in contact with the pulverized polyethylene.

Components (mg/L)	Sample A (0 min)	Sample B (45 min)	Sample C (90 min)	Sample D (135 min)	Sample E (180 min)
Nonane	18.270	0.619	0.004	0.000	0.000
Decane	51.554	0.697	0.006	0.000	0.000
Dodecane	572.612	1.292	0.029	0.019	0.000
Tetradecane	81.574	0.204	0.008	0.000	0.000
Hexadecane	18.555	0.799	0.016	0.010	0.000
Octadecane	0.924	0.213	0.012	0.008	0.000
Nonadecane	4.215	0.023	0.017	0.000	0.000
Eicosane	0.184	0.015	0.008	0.000	0.000
Docosane	0.416	0.095	0.013	0.002	0.000
Tetracosane	0.126	0.039	0.000	0.000	0.000
Hexacosane	0.031	0.000	0.000	0.000	0.000
Octacosane	0.000	0.000	0.000	0.000	0.000
Triacontane	0.000	0.000	0.000	0.000	0.000
Hexatriacontane	0.000	0.000	0.000	0.000	0.000
Total	**748.461**	**3.996**	**0.114**	**0.039**	**0.000**

The dried polyethylenes were ground to pulverized state using an improvised manually-operated hand grinder and were sieved with a standard 2 mm A.P.I sieve to obtain a relatively uniform size pulverized waste polyethylene material of less than or equal to two millimeters (≤ 2 mm).

Application of pulverized used-water sachet and crude oil adsorption

0.020 L of crude oil was slowly poured into a basin (surface area of 15.211 m^2) containing twenty liters of tap water. The polluted water was left undisturbed in open air for thirty minutes hence the surface of the polluted water was completely covered with a thin layer of oil. The assessment of the artificially polluted water involved sample collection, extraction, and analysis. The extraction involved the following; liquid-liquid extraction for total petroleum hydrocarbon (TPH) contents, for oil and grease (O and G) content and benzene-toluene-xylene (BTX) determination. Gas chromatograph and atomic absorption spectrophotometer were the major analytical equipment used for analyzing the polluted water samples for chemical contaminants and metal contents. The polluted water samples were subjected to liquid-liquid extraction using solvents like dichloromethane or n-hexane to remove the organic analytes from the water matrix. The extract containing dissolved contaminants or analytes in turn, were injected into the gas chromatograph or spectrophotometer for TPH, O and G, BTX and metal content analysis.

The pulverized used-water-sachet was applied to treat the polluted water and this was carried out by manually spraying twelve grams of the pulverized used-water-sachet over a water surface area of 15.211 m^2. This polyethylene material which is hydrophobic eventually served as an adsorbent that adsorbed the oil from the water surface thereby separating the oil from the water. At intervals of 0, 45, 90, 135 and 180 min, samples were collected from the polluted water and analyzed to check for the extent of cleaning up. Porous mesh screen was used to remove the polyethylene material from the surface of the water after remediation.

Percentage clean-up determination

After the application of the pulverized polyethylene, the collected samples from the polluted water at intervals of 45, 90, 135 and 180 min were analysed to check the extent of clean-up. The percentage clean-up was calculated with the formula below.

$$\%\ \text{Clean-up} = \left(\frac{100 - \text{volume of adsorbate (mg/L)} \times 100}{\text{Initial volume (mg/L)}} \right)$$

RESULTS AND DISCUSSION

Total petroleum hydrocarbon (TAH and PAH) contents

From Tables 1 and 2, the total petroleum hydrocarbon content in the artificially petroleum polluted water (that is, summation of the total aliphatic hydrocarbon and polynuclear aromatic hydrocarbon contents) was 850.287 mg/L and was reduced to 4.186 mg/L (99.508% reduction) in 45 min, 0.270 mg/L (99.968% reduction) in 90 min, 0.061 mg/L (99.993% reduction) in 135 min and 0.004 mg/L (that is, 99.999% reduction) in 180 min. The result of the analysis showed that the pulverized polyethylene material was very effective for adsorbing total petroleum hydrocarbons in an oil spilled water surface as high as 99.999%.

Benzene-toluene-xylene (BTX)

From Table 3, benzene, toluene and o-xylene were

Table 2. Clean-up levels at various time intervals of the polynuclear aromatic hydrocarbon (PAH) Content (mg/L) in the artificially petroleum polluted water in contact with the pulverized polyethylene.

Components (mg/L)	Sample A (0 min)	Sample B (45 min)	Sample C (90 min)	Sample D (135 min)	Sample E (180 min)
Naphthalene	18.856	0.014	0.005	0.002	0.000
2-Methylnaphthalene	25.608	0.010	0.009	0.000	0.000
Acenaphthalene	41.533	0.018	0.012	0.002	0.000
Acenaphthene	11.536	0.007	0.005	0.002	0.002
Florene	2.596	0.014	0.009	0.003	0.000
Phenathrene	1.698	0.009	0.006	0.003	0.000
Anthracene	0.000	0.041	0.041	0.000	0.000
Fluoranthene	0.000	0.041	0.041	0.000	0.000
Pyrene	0.000	0.029	0.029	0.010	0.002
Benzo(a)anthracene	0.000	0.000	0.000	0.000	0.000
Crysene	0.007	0.007	0.000	0.000	0.000
Benzo(b)fluoranthrene	0.000	0.000	0.000	0.000	0.000
Benzo(a)pyrene	0.000	0.000	0.000	0.000	0.000
Benzo(k)fluoranthrene	0.000	0.000	0.000	0.000	0.000
Indeno(1,2,3)perylene	0.000	0.000	0.000	0.000	0.000
Dibenzo(a,h)anthracene	0.000	0.000	0.000	0.000	0.000
Benzo(g,h,i)perylene	0.000	0.000	0.000	0.000	0.000
Total	**101.826**	**0.190**	**0.156**	**0.022**	**0.004**

Table 3. Clean-up levels at various time intervals of the benzene-toluene-xylene (BTX) content in the artificially petroleum polluted water in contact with the pulverized polyethylene

Components (mg/L)	Sample A (0 min)	Sample B (45 min)	Sample C (90 min)	Sample D (135 min)	Sample E (180 min)
Benzene	1.216	0.279	0.219	0.200	0.010
Toluene	0.421	0.029	0.000	0.000	0.000
Ethylbenzene	0.000	0.000	0.000	0.000	0.000
P-Xylene	0.000	0.000	0.000	0.000	0.000
M-Xylene	0.000	0.000	0.000	0.000	0.000
O-Xylene	1.289	0.000	0.000	0.000	0.000
Total	**2.926**	**0.279**	**0.219**	**0.200**	**0.010**

present in trace quantities in Sample A, while ethylbenzene, p-xylene and m-xylene were not detected. Benzene content of 1.216 mg/L in Sample A was reduced by 77.056, 81.990, 83.553 and 99.178% in 45, 90 135 and 180 min respectively. Toluene content of 0.421 mg/L was reduced by 93.112 and 100% in 45 and 90 min respectively. O-xylene content of 1.289 mg/L was completely cleaned (100%) after 45 min of application of remediation material.

Oil and grease

From Table 4, the analysis of Sample A, showed high content of oil and grease (1342.771 mg/L) and was reduced by 99.600, 99.768, 99.922 and 100% in 45, 90 135 and 180 min respectively.

Metals

From Table 4, the petroleum polluted water was tested for the following metal contents; Fe, Cr, Zn, Ni, Cu, Pb and Mn but less than 0.001 ppm metals were detected in the polluted water.

DISCUSSION

The crude oil adsorption was carried out within the time

Table 4. Clean-up levels at various time intervals of the metals, oil and grease contents in the artificially petroleum polluted water in contact with the pulverized polyethylene.

Field code	Fe (ppm)	Cr (ppm)	Zn (ppm)	Ni (ppm)	Cu (ppm)	Pb (ppm)	Mn (ppm)	Oil and grease (mg/L)
Sample A (0 min)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1342.771
Sample B (45 min)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	5.369
Sample C (90 min)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	3.116
Sample D (135 min)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1.050
Sample E (180 min)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.000

limit of 180 min. There was an initial rapid crude oil uptake between 0 to 45 min as can be observed in the various Tables 1 to 4 and after 45 min contact, only infinitesimal changes were observed. It could therefore be inferred from this experiment, that the equilibrium contact time was 45 min. From the results, 3 h of contact time was seen to give maximum clean-up level of the artificially polluted water. However, approximately 100% clean-up was achieved in this present work, maybe because of increased time of contact. Also in the course of applying the pulverized polyethylene, it was observed that the oil on the surface tends to move towards the applied pulverized polyethylene. This means that there is a strong force of attraction between the oil and the pulverized polyethylene (Halmos, 1985). This attraction was very visible at the onset of the application of the polyethylene because there was greater rate of adsorption of the crude oil within the first 45 min of the contact with the adsorbent, thus showing that the pulverized polyethylene is highly oleophilic. From Tables 1 to 4, it was observed that the amount of the aliphatic hydrocarbon present in the polluted water was completely adsorbed with time by the polyethylene material, while trace quantities of PAH and Benzene were still detected, though reduced to below regulatory limits (< 0.01 mg/L) by the Federal Environmental protection Agency. Thus could also be deduced that 100% clean up was impossible for Polynuclear Aromatic Hyrdocarbon and Benzene using pulverized polyethylene.

Okoh and Trejo-Hernandez (2006), in their work using vulcanized rubber for adsorption of oil spillage, showed that the adsorbent is capable of adsorbing all the petroleum products after a 2 h resting period. In their experiment, pure rubber was added to the vulcanized rubber pieces to lower its density for the result to be achieved. Though the time of cleaning was reduced, but the cost and availability of the raw material when compared with used-water-sachet is far more expensive.

Conclusions

The following conclusions are based on the results obtained in the present study. The pulverized used-water-sachet polyethylene which has high adsorption capacity for hydrocarbons was successfully achieved. This adsorbent can remove oil originating from an oil spill from a surface such as water in a safe, rapid, inexpensive manner which is harmless to the environment. The rapid rate of adsorption process makes this oleophillic material suitable for adsorption of crude oil from water surface. The use of polymeric scrap such as used-water-sachet to clean up an environmental oil spillage pollution in water makes it relevant in the elimination of pollution.

Conflict of Interest

The authors have not declared any conflict of interest.

REFERENCES

Atlas RM, Bartha R (1992). Bioremediation advances in microbial ecology. Hydrocarbon Biodegrad. Oil Spill 12:287-338.

Ayotamuno MJ, Akor AJ, Igho TJ (2002). Effluent quality and wastes from petroleum-drilling operations in the Niger Delta, Nigeria. Environ. Manag. Health 13(2):207–216. http://dx.doi.org/10.1108/09566160210424626

Egwaikhide PA, Akporhonor EE, Okieimeh FE (2007). Utilization of coconut fibrein the removal of soluble petroleum fraction polluted water. Int. J. Phys. Sci. 2(2):47-49.

Halmos G (1985). Enhanced biodegradation of oil spill. Conference Proceedings, American Petroleum Institute, Washington, DC, USA, pp. 531-53.

Okoh AI, Trejo-Hernandez MR (2006). Remediation of petroleum hydrocarbon polluted systems, exploiting the bioremediation strategies. Afr. J. Biotechnol. 5(25):2520–2525.