

Analysis of Crude Oil Removal from the Environment Using Activated Carbon Produced From Rice Husks

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ABSTRACT

Rice Husk an abundant, cheap, biodegradable agricultural waste which absorbs water due to its hydrophilic group. To make it useful as a sorbent for crude oil removal, it was activated with concentrated H_3PO_4 acid. Sorption capacity of crude oil, diesel, kerosine and petrol onto activated carbon produced from Rice Husk was assessed to determine the performance for removal of crude oil, diesel, kerosine and petrol from the environment, by comparing its oil uptake with a standard; conventional synthetic sorbent used in crude oil removal. The experiment was conducted by batch adsorption method, sorption of the oils displaced on water onto Rice Husk adsorbent and the standard adsorbent was also investigated to ascertain suitable applicability of Rice husk adsorbent. The result of the study shows that, the standard adsorbent sorbed 16.50 mg/g of crude oil, 15.38m g/g of diesel, 13.20mg/g of kerosine and 11.30 mg/g of petrol while Rice Husk adsorbed 9.15 mg/g of crude oil, 8.27 mg/g of diesel, 7.66 mg/g of kerosine and 7.40 mg/g of petrol. Standard adsorbent shown higher values than Rice Husk adsorbent which makes it a better sorbent than Rice Husk adsorbent, but rice husk retained more oil than the standard sorbent, implies that Rice Husk adsorbent is a good sorbent for oil removal from the environment since it has ability to absorb and retain oil are features of good sorbents.

KEYWORDS: Activated carbon, adsorption isotherm, adsorption kinetics, crude oil, equilibrium adsorption capacity, Rice Husk.

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INTRODUCTION

Rapid industrialization has led to the release of a variety of pollutants into the environment especially potentially toxic metals. This worldwide problem has attracted a great deal of attention [25, 10]. One of the major sources of contamination in Nigeria is crude oil for various activities such as fuel filling station, auto-mechanic activities [2]. These filling stations, auto mechanic workshops are found in clusters of open plots of land in the vicinity of urban towns and cities [23, 24]. Within the clusters are people who specialize in electrical aspects of auto repairs, while others engage in repairs of brakes and steering wheels, automatic or standard transmission engine, and spray-painting, recharging of auto batteries, welding and soldering and many other activities. Soils are regarded as the ultimate sink for pollutants discharged into the environment [8]. Oil spill also have detrimental effects on the environment, for this reason, steps are taken to clean up the environment. There are several methods involved in oil spill clean-up, these, include; oil containment, recovery of oil and oil removal. Oil is contained through the application of booms and ancillary equipments, while, it is recovered using skimmers, sorbents and manual recovery. In-situ burning, chemical agents and biological agents are used for oil removal [16]. Sorbents are insoluble materials or mixture of materials used to recover liquids through the mechanism of absorption, or adsorption, or both [30]. Sorbents are

categorized into natural and synthetic sorbents: Synthetic sorbents include; polyurethane, polystyrene, polyester and urea formaldehyde. Natural sorbents can be organic or inorganic: natural inorganic sorbents include; perlite, talc and vermiculite. Natural organic sorbents are straw, bark, peat E.T.C. Among the various sorbents that have been employed for oil spill remediation, synthetic materials are the most commonly used commercial sorbents due to their oleophilic and hydrophobic properties [31]. However, these materials are not biodegradable, which is a major disadvantage [24]. To abate these problems various studies have been conducted on the viability of natural materials as oil spill sorbent because of their low cost and biodegradability. The main draw-backs of plant-derived sorbents are their relatively low oil sorption capacity, low hydrophobicity and poor buoyancy compared to synthetic sorbents [1, 2, 7, 8]. Once plant-derived sorbents are applied to saturated environments, preferential water sorption is favoured over the sorption of oil because the sorbents are typically hydrophilic in nature, due to their associated hydroxyl functionalities [22 13, 14, 15]. These groups are abundantly available in all three major chemical components of plant-based materials. To be useful in combating oil spill, sorbents need to be both oleophilic and hydrophobic [31]. The effectiveness of plant-derived sorbents in saturated environments would be enhanced when the density of the hydroxyl functionalities is decreased [10]. This may be achieved through conversion of a plant material to activated carbon; also conversion of plant material to activated carbon may increase sorption capacity because of increased porosity and surface area [18-20, 29].

Rice Husk is a biodegradable, available and abundant agricultural waste is grown widely throughout the world, it is produced annually than any other grain and it is the most important staple food in sub-Saharan Africa and Latin America. Nigeria is the largest rice producer in Africa. Rice Husk is generated in large quantities in Nigeria and is hardly managed as Nigeria faces the problem of solid waste management. Rice Husk is composed of cellulose, hemicelluloses and lignin; these three major chemical components of Rice Husk are rich in hydroxyl group, which makes it hydrophilic in nature. Apart from the three major chemical components of Rice Husk that are rich in hydroxyl group, the mineral composition of raw Rice Husk contains high quantity of Si, K, Fe, Al and P. These minerals contribute to the hydrophilic nature of the material [26, 33]. Mineral composition of materials can be reduced when activated [2]. Conversion of materials to activated carbon yields product that is carbonaceous with large surface area and high porosity. During the activation process the precursor is converted into a hydrophobic carbonaceous material which has surface functional groups that are hydrophilic [32]. The assessment or performance of sorbing materials often needs to be compared. This helps in efficient application of sorbents. Efficient application of sorbents requires knowledge of data on the sorbent sorption capacity and a good understanding on the basic mechanism behind the sorption capabilities [28]. The sorbents can be compared by their respective maximum equilibrium adsorption capacity values which are calculated.

This research work aim to assess the removal crude oil and crude oil products from the environments, using activated carbon produced from Rice Husk as an adsorbent.

MATERIALS AND METHODS

Collection of materials

The crude oil used in this study was obtained from NNPC Kaduna Depot, Kaduna state, Nigeria. Diesel, kerosine and petrol were obtained from various filling stations, Kaduna, Kaduna State, Nigeria. Rice Husk was obtained as waste material from rice mill located in Benue and Taraba state, Nigeria. Conventional synthetic sorbent mat used as standard in this study was obtained from NNPC Kaduna, Kaduna State, Nigeria.

Preparation of sample

Rice Husk was washed with water to remove dirt, rinsed severally with distilled water and dried under the sun for some weeks. The production of activated carbon by chemical activation method as described by Gamal *et al.*, [17] was used for the preparation of activated carbon from Rice Husk. Rice Husk were grained and sieved to an average particle size (0.05 mm). The raw material was subjected to chemical treatment followed by pyrolysis. The activation was carried out by impregnation of the Rice Husk samples with phosphoric acid in a ratio of 1:2 (w/w) for 24 h, and then washed with distilled water several times until pH reached 4. After that, the samples were dried at 100°C then pyrolysed in a muffle

furnace in absence of air at 400°C for 2 h. After pyrolysis, the resulting samples were washed with distilled water until the pH of the washing solution reached 7. The activated carbon samples were dried at 100°C and kept dry for analysis.

Ash content determination

Ash content determination was done according to the ASTM D2866-94, 1999 method [6]. 5.00 g of dry activated carbon sample was placed in to a clean, dried and weighed porcelain crucible and transferred into a preheated muffle furnace set at a temperature of 750° and heated for one hour to constant weight after which the crucible and its content was transferred into a desiccator and allowed to cool. The crucible and content was re-weighed and the weight of the sample before heating and after heating was determined. Ash was determined as the residue after heating to constant weight at 750°C. The % ash content (dry basis) was calculated from the equation:

$$\text{Ash (\%)} = \frac{\text{Ash weight (g)}}{\text{Dry weight of activated carbon (g)}} \times 100$$

Moisture content determination

Moisture content was determined according to ASTM 2867-99, 1999 [5] standard method. 5.00 g of dried activated carbon sample was weighed into cleaned, dried and weighed crucible and dried in an oven at 105° C to constant weight for 3 hours. The crucible and its content was removed from the oven and cooled in a desiccators and reweighed. The difference between the initial weight and final weight of the sample represents the water content in the sample. The moisture content in percentage was calculated from the equation:

$$\text{Moisture content (\%)} = \frac{\text{Loss in weight on drying (g)}}{\text{Initial weight of sample (g)}} \times 100$$

Volatile content determination

Volatile matter content was determined according to ASTM 5832-98, 1999 [4] standard method. 5.00 g of dried activated carbon was weighed into a closed crucible of known weight and heated at 950°C for 7 minutes. The difference in weight between the weight of sample before and after heating was used to determine the amount of volatile matter in the sample. The percentage volatile matter content was determined from the equation:

$$\text{Volatile content (\%)} = \frac{\text{Loss in weight on drying}}{\text{Initial weight of sample}} \times 100$$

Fixed carbon determination

Fixed carbon content was determined by subtracting the sum of percentage compositions of volatile matter content, moisture content and ash content from 100 [25, 24].

$$\text{Fixed carbon (\%)} = 100 - (\text{ash content} + \text{moisture content} + \text{volatile content})$$

Determination of textural properties of activated carbon obtained from Rice Husk

Apparent density determination

Apparent density was determined according to ASTM D 2854-96, 1999 [3] standard method. A specific gravity bottle of 25 ml capacity was filled with the adsorbent (activated carbon/synthetic sorbent) and packed in a rubber stopper. The weight of the adsorbent was determined. The weight (g) divided by the volume (ml) gives the apparent density (g/ml) of the adsorbent.

Bulk density determination

This was determined by measuring the volume of water displaced when 2.00 g of activated carbon/synthetic sorbent was weighed into a pre-washed and dried 100 cm³ calibrated measuring cylinder, with tapping. The measuring cylinder contained 50 cm³ of water [9].

$$\text{Volume of water displaced (cm}^3\text{)} = \text{Final volume} - \text{Initial volume}$$

$$\text{Bulk density (g/cm}^3\text{)} = \frac{\text{Mass of sample}}{\text{Volume of water displaced}}$$

Porosity of the adsorbents was computed using the following relationship [1]

$$\% \text{ Porosity} = \frac{\text{Apparent density} - \text{Bulk density}}{\text{Apparent density}} \times 100$$

Estimation of specific surface area

Specific surface area and pore size distribution of Rice Husk adsorbent and synthetic sorbent were determined by N₂ adsorption on the surface of the sorbents at 77K using Autosorb-1-C Quantachrome, USA.

Boehm's titration

The presence of surface functional groups in the activated carbon was determined by Boehm titration method [11,12]. About 1.0 g of activated carbon was mixed with each of 50 ml solution (0.1 M) of NaOH, NaHCO₃ and Na₂CO₃ respectively, for 24 hours with continuous stirring. Then, the solid phase was separated from the aqueous solution by vacuum filtration. 10 ml of each filtrate was used for the excess acid titration by 0.1 M HCl (hydrochloric acid). The phenolic group content on the carbon surface was determined as the amount of 0.1 M NaHCO₃ consumed by the sample. Lactonic group content was calculated as the difference between the amounts of 0.1 M Na₂CO₃ and 0.1 M NaHCO₃ consumed by the activated carbon sample. Carboxylic group determined by subtracting the amount of 0.1 M Na₂CO₃ consumed by the activated carbon from the amount of 0.1 M NaOH consumed. This method was used to calculate the concentration of acid groups on activated carbon surface under the following assumptions. Sodium hydroxide (NaOH) neutralizes carboxylic, phenolic and lactonic groups. Sodium carbonate (Na₂CO₃) neutralizes only carboxylic and phenolic groups. Sodium bicarbonate (NaHCO₃) only neutralizes carboxylic groups. The basicity of the surface-oxygen groups was determined by neutralization with 0.1 M HCl.

The functional groups present in the synthetic sorbent were determined by FTIR spectroscopy.

Determination Of Equilibrium Adsorption Capacity, Oil Recovery And Oil Retention Capacities.

1 dm³ of crude oil, diesel, kerosine and petrol whose weight had been predetermined were each put in a pre-cleaned 2 litres beaker. The beaker containing petrol was covered during the experiment. The weight of each sorbate was used as the initial concentration of each sorbate. Five (5) g of Rice Husk and synthetic sorbent was weighed and added into the beaker and left for a required contact time at 28^o C. The contact times used in this study ranged from 10 to 100 minutes at 10 minutes interval. At the end of each contact time, the content in the beaker was passed through a sieve of 350µm into another pre-cleaned and pre-weighed 2 dm³ beaker and allowed to drain. The weight of the 2 litres beakers containing unabsorbed sorbate was weighed, after which, the weight of the 2 litres beaker subtracted from it to obtain the weight of unabsorbed sorbate. The weight of the unabsorbed sorbate was used as final concentration of each sorbate.

The amount of sorbate adsorbed onto a unit mass of Rice Husk and synthetic sorbent was calculated from:

$$q = \frac{C_i - C_f}{M}$$

Where q = Amount of sorbate adsorbed onto a unit mass of Rice Husk sorbent and synthetic sorbent.

C_i = Initial concentration of sorbate in grams (g).

C_f = Final concentration of sorbate in grams (g).

M = Mass of sorbent in grams (g).

Or

$$q = \frac{\text{Initial weight of sorbate} - \text{Final weight of sorbate}}{M}$$

The amount of each sorbate recovered from each sorbent was determined by removing the sorbent from the sieve, weighing it and afterwards subjecting it to pressing using a carver hydraulic press, Model M, serial No. 12000 – 137, operated at a pressure of 25 tonnes, for five minutes, at 28^oC. After pressing, the sorbent was re-weighed; the weight of sorbate recovered was determined by weight difference.

The amount of sorbate recovered per unit mass of sorbent was determined from the expression:

$$q = \frac{\text{Initial weight} - \text{Final weight}}{\text{Mass of sorbent}}$$

Mass of sorbent

The amount of sorbate retained per unit mass of sorbent was obtained from the expression:
 $q = \text{Quantity of sorbate adsorbed per unit mass of sorbent} - \text{Quantity of sorbate recovered per unit mass of sorbent}$.

Each experiment was performed in triplicate, the average and standard deviation was calculated and used.

Verification of Adsorption Process of Crude Oil, Diesel, Kerosine and Petrol onto Rice Husk and Synthetic Sorbent using Adsorption Isotherm.

The verification of adsorption process of the sorbates onto Rice Husk and synthetic sorbent was done using Langmuir, Freundlich, Elovich, Temkin and Dubinin – Radushkevich adsorption models. Five different initial concentrations of each sorbate; 0.5 dm³, 0.75 dm³, 1.00 dm³, 1.25 dm³ and 1.5 dm³ were used for the experiment. The sorbate – sorbent system was left in contact for 80 minutes. Triplicate determination was conducted and the average used. The experimental data obtained were fitted into Freundlich, Langmuir, Elovich, Temkin and Dubinin-Radushkevich adsorption models.

Determination of mopping ability of crude oil of Rice Husk and synthetic sorbent.

In order to determine suitable environment applicability of activated carbon produced from Rice Husk and synthetic sorbent, the experiment was repeated with crude oil and its lower fractions displaced on water. 1 litres of water was poured into a 2 litres beaker, 0.2 litres of sorbate was added to the water. Five grams of Rice Husk and synthetic sorbent was weighed and added into the sorbate displaced on water and left for 80 minutes. At the end of contact time, the sorbent was carefully separated from the sorbate displaced on water by passing it through filter paper fitted onto a glass funnel inserted into another 2 dm³ beaker. The sorbate was carefully removed using syringe and added to the filtrate (sorbate) in the beaker. The volume and weight of separated water from sorbate was determined.

RESULTS AND DISCUSSION

Characterization of sorbents

Result of the proximate analysis of Rice Husk adsorbent is presented in Table 1. The result shows that Rice Husk adsorbent has low ash content (20.10 %). This low ash content makes it suitable for use in removal of oil from an aqueous medium, as ash content can lead to increase hydrophilicity, which indicates that the surface of Rice Husk adsorbent is mainly acidic; this result is consistent with some of the previous results of Ketcha *et al*, [21] and confirms the report of Sheikha, [27] who reported that chemically activated carbons are characterized by domination of surface acidic groups.

The result of porosity (%) and surface area of Rice Husk and synthetic sorbent are presented in Table 2. The result show high porosity for both adsorbents. However, the surface area of Rice Husk adsorbent is larger than that of synthetic sorbent.

Equilibrium adsorption capacity of crude oil, diesel, kerosine and petrol onto Rice Husk and synthetic sorbent are presented in Table (3 – 10). The results show that the equilibrium adsorption capacity of crude oil, diesel, kerosine and petrol onto Rice Husk adsorbent are 9.15mg/g at 80 minutes (36 % of crude oil absorbed by standard), 8.26 mg/g at 100 minutes (31 % of diesel absorbed by standard), 7.66 g/g at 80 minutes (32 % of kerosine absorbed by standard) and 7.40 mg/g at 60 minutes (38 % of petrol absorbed by standard) respectively, while, the equilibrium adsorption capacity of these oils onto the synthetic sorbent are 16.50mg/g at 40 minutes (crude oil), 15.38 mg/g at 40 minutes (diesel), 13.20 mg/g at 40 minutes (kerosine) and 11.30 mg/g at 40 minutes (petrol). These results reveal that Rice Husk adsorbent has lesser oil sorption capacity than the synthetic sorbent. Some of the factors may have contributed to the lesser oil sorption capacity of Rice Husk adsorbent compared with that of the synthetic sorbent are percentage fixed carbon, surface chemistry and surface area, as presented in Tables 1 and 2. The equilibrium adsorption capacity of Rice Husk adsorbent seems to be directly related with the percentage fixed carbon; the oils are predominantly hydrocarbons, therefore, they would be more attracted to the non polar active carbon site than to the polar surface functional groups of Rice Husk adsorbent which are polar in nature. Nitrogen adsorption isotherm of Rice Husk adsorbent at 77K, Type 1 isotherm is produced by microporous materials. This indicates that Rice

Husk adsorbent is microporous. The nitrogen adsorption isotherm of synthetic sorbent at 77K in Fig. 2, indicate the existence of a large fraction of mesoporosity. Mesoporous structures have higher pore volumes and diameters. The mesoporous nature of the synthetic sorbent contributed to its higher oil uptake, while the microporous nature of Rice Husk adsorbent suggests the higher surface area.

Oil recovery and retention characteristics

The results of crude oils recovered from and retained by Rice Husk and synthetic sorbent are presented in Table 3-10. 12.07 mg/g of crude oil, 13.36 mg/g of diesel, 13.28m g/g of kerosine and 12.08 mg/g of petrol were recovered from Rice Husk adsorbent, while, 14.68 mg/g of crude oil, 13.48 mg/g of diesel, 11.50 mg/g of kerosine and 10.56 mg/g of petrol were recovered from the standard. 7.08 mg/g of crude oil (50 % of absorbed crude oil), 6.90 mg/g of diesel (58 % of absorbed diesel), 6.38 mg/g of kerosine (52 % of absorbed kerosine) and 6.32 g/g of petrol (55 % of absorbed petrol) were retained by Rice Husk adsorbent, while, the synthetic sorbent retained 6.80 g/g of crude oil (16 % of absorbed crude oil), 6.96 g/g of diesel (19 % of absorbed diesel), 6.60 g/g of kerosine (20 % of absorbed kerosine) and 6.74 g/g (28 % of absorbed petrol). The high volume of oil recovery and lesser oil retention by the standard (synthetic sorbent) can be attributed to its mesoporous nature which enables more sorbates diffuse into the pores and effuse easily. The high retention of the sorbates by Rice Husk adsorbent proves that it is suitable for removal of the sorbates.

Adsorption isotherm studies

The amount of water sorbed together with each sorbate onto Rice Husk adsorbent and synthetic sorbent is 8 ml (0.70g) for Rice Husk adsorbent and 11 ml (1.2 g) for the standard. These amounts are minimal for each of the sorbent, indicating that Rice Husk adsorbent can be employed in oil spill mop in an aquatic environment.

Table 1: Result of surface acidity and surface basicity (Meq/g) of Rice Husk adsorbent

Ash content	15.1± 1.21
Moisture content	11.05 ± 0.87
Volatile content	28.36 ± 0.88
Fixed carbon	45.49 ± 1.87
Carboxyl	0.25 ± 0.03
Carbonyl	0.31 ± 0.05
Lactonic	0.15 ± 0.08
Phenolic	0.22 ± 0.03
Total acidic	0.93 ± 0.12
Totalbasicity	0.11 ±0.01

Table 2: Result of the Porosity and surface area of prepared activated carbon (Rice Husk) and synthetic sorbent

Sample	Rice Husk Adsorbent	Synthetic sorbent
Apparent density (g/cm ³)	2.94	3.95
Bulkdensity (g/cm ³)	0.18	0.11
Porosity (%)	0.83	0.87
S _{BET} (m ² g)	885.00	1266.00

Table 3: Amount of crude oil sorbed, recovered and retained by Rice Husk adsorbent(mg/g)

Crude oil sorbed	Crude oil recovered	Crude oil retained	Contact time
8.75± 0.23	6.90 ±1. 01	6.85	10.00
8.80 ±0.59	7.00 ±0.97	6.80	20.00
8.83 ±1.21	7.01±0.92	6.82	30.00
8.96 ±0.45	7.05 ±1.80	6.91	40.00
9.02 ±0.67	7.06 ±1.05	6.96	50.00
9.14 ±0.91	7.07 ±0.78	8.07	60.00
9.13 ± 0.65	7.07 ±0.98	8.06	70.00
9.15±0.61	7.07±0.90	8.08	80.00
9.12 ±0.91	7.06±0.76	8.06	90.00
9.12±0.97	7.06±0.52	8.06	100.00

Table 4: Amount of diesel sorbed, recovered and retained by Rice Husk adsorbent(mg/g).

Diesel sorbed	Diesel recovered	Diesel retained	Contact time
8.83 ± 0.78	6.22 ±0. 01	6.61	10.00
8.90 ± 0.66	6.25 ±0.82	6.65	20.00
9.01 ± 0.34	6.27±0.54	6.74	30.00
9.07 ± 0.32	6.31 ±1.21	6.76	40.00
9.20 ± 0.90	6.34 ±0.95	6.86	50.00
9.21 ± 0.78	6.34 ±0.81	6.87	60.00
9.27 ± 0.74	6.36 ±0.60	6.91	70.00
9.27± 0.65	6.36±0.53	6.91	80.00
9.25 ± 0. 92	6.35±0.42	6.90	90.00
9.26 ± 1.06	6.36±0.63	6.90	100.00

Table 5: Amount of kerosine sorbed, recovered and retained by Rice Husk adsorbent(mg/g).

Kerosine sorbed	Kerosine recovered	Kerosine retained	Contact time
7.41 ±1.21	6.20 ±0.98	6.21	10.00
7.53 ±0.87	6.25 ±0.54	6.28	20.00
7.55 ±0.68	6.25±1.10	6.30	30.00
7.61 ±1.80	6.27 ±0.43	6.34	40.00
7.65 ±0.81	6.27 ±0.72	6.38	50.00
7.66 ±0.91	6.28 ±1.11	6.38	60.00
7.65 ± 1.21	6.27 ±0.93	6.38	70.00
7.66±0.72	6.28±1.30	6.38	80.00
7.64 ±0. 85	6.27±0.78	6.37	90.00
7.64±0.90	6.27±0.63	6.37	100.00

Table 6: Amount of petrol sorbed, recovered and retained by Rice Husk adsorbent(mg/g).

Petrol sorbed	Petrol recovered	Petrol retained	Contact time
7.30 ± 0.21	6.00 ±0.09	6.30	10.00
7.34± 0.11	6.02 ±0.64	6.32	20.00
7.37 ± 0.72	6.06±0.51	6.31	30.00
7.40 ± 1.80	6.08 ±0.52	6.32	40.00
7.40 ± 1.09	6.07 ±0.97	6.33	50.00
7.40 ± 1.00	6.08 ±0.31	6.32	60.00
7.39 ± 0.21	6.07 ±0.33	6.32	70.00
7.40± 0.41	6.08±0.70	6.32	80.00
7.38 ± 0. 53	6.07±0.61	6.31	90.00
7.40 ± 0.18	6.08±0.87	6.32	100.00

Table 7: Amount of crude oil sorbed, recovered and retained by synthetic sorbent (mg/g).

Crude oil sorbed	Crude oil recovered	Crude oil retained	Contact time
16.40 ±0.50	14.50 ±0. 69	11.90	10.00
16.50 ±0.65	14.60 ±0.55	11.90	20.00
16.50 ±0.61	14.65±0.98	11.85	30.00
16.50 ±0.23	14.68 ±0.46	11.82	40.00
16.52 ±0.11	14.72±0.33	11.80	50.00
16.50 ±0.27	14.70 ±0.39	11.80	60.00
16.50 ±0.78	14.70 ±1.04	11.80	70.00
16.51 ±0.30	14.70±0.72	11.81	80.00
16.45 ±0.42	14.60±0.94	11.85	90.00
16.44 ±0.30	14.60±0.87	11.84	100.00

Table 8: Amount of diesel sorbed, recovered and retained by synthetic sorbent (mg/g).

Diesel sorbed	Diesel recovered	Diesel retained	Contact time
16.35 ±1.00	14.72 ±0. 57	7.63	10.00
16.38 ±0.43	14.60 ±0.48	7.78	20.00
16.37 ±0.90	14.47±0.83	7.90	30.00
16.38 ±0.71	14.48 ±0.74	7.90	40.00
16.38 ±0.56	14.44 ±0.85	7.94	50.00
16.38 ±0.87	14.43 ±0.71	7.95	60.00
16.37 ±0.94	14.43 ±0.92	7.94	70.00
16.36 ±0.66	14.40±0.81	7.96	80.00
16.38 ±0.69	14.44±0.60	7.94	90.00
16.35 ±0.87	14.40±0.74	7.95	100.00

Table 9: Amount of kerosine sorbed, recovered and retained by synthetic sorbent (mg/g).

Kerosine adsorbed	Kerosine recovered	Kerosine retained	Contact time
14.18 ±0.83	12.28 ±0.11	7.90	10.00
14.20 ±1.12	12.40 ±0.75	7.80	20.00
14.20 ±0.67	12.50±0.47	7.70	30.00
14.20 ±0.98	12.50 ±0.33	7.70	40.00
14.20 ±0.99	12.50 ±1.03	7.70	50.00
14.20 ±1.00	12.50 ±0.92	7.70	60.00
14.20 ±0.65	12.60 ±0.12	7.60	70.00
14.22 ±0.78	12.50±0.10	7.72	80.00
14.20 ±0.94	12.60±0.51	7.60	90.00
14.20 ±0.34	12.50±0.46	7.70	100.00

Table 10: Amount of petrol sorbed, recovered and retained by synthetic sorbent (mg/g).

Petrol sorbed	Petrol recovered	Petrol retained	Contact time
12.28 ± 0.23	10.57 ± 0.30	7.71	10.00
12.30 ± 0.81	10.56 ± 0.62	7.77	20.00
12.30 ± 0.44	10.56± 0.67	7.34	30.00
12.31 ± 0.42	10.56 ± 0.98	7.75	40.00
12.30 ± 0.89	10.56 ± 0.40	7.74	50.00
12.30 ± 0.80	10.56 ± 0.41	7.74	60.00
12.30 ± 0.41	10.56 ± 0.32	7.74	70.00
12.30 ± 0.90	10.56 ± 0.64	7.74	80.00
12.28 ± 0.77	10.54 ± 0.21	7.74	90.00
12.30 ± 0.79	10.56 ± 0.44	7.74	100.00

CONCLUSION

Activated carbon prepared from Rice Husk performed less than the conventional synthetic sorbent in terms of oil removal, and Rice Husk has lesser oil sorption capacity than the conventional synthetic sorbent. The difference in performance can be attributed to difference in surface area, surface chemistry of both sorbent and functional group present in each sorbent. The quantity of oil sorbed on the sorbents depends on contact time, hydrocarbon chain length and viscosity of sorbates. Activated carbon from Rice Husk has high oil retention which is a feature of a good sorbent. The standard (conventional synthetic sorbent) has high oil recoverability which makes the standard better in terms of oil recovery. Though the standard has higher oil sorption capacity than activated carbon from Rice Husk, but activated carbon from Rice Husk has good oil sorption capacity and high oil retention which makes it viable for use in oil spill cleanup exercise.

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