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Techno-economic feasibility of different sobents for Oil Spill prevention in Seawater

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Abstract- Oil Industries are playing vital role in economy and prosperity of any countries in the world. Oil Spill is one of the major environmental issue. The immediate and long-term impacts of oil spills on marine life, human health and revenue of a country is huge and irreversible.
Out of many techniques being used for Oil Spill clean-up, use of Sorbents provide useful resource in response to spill of oil.
In this thesis, various sorbents are evaluated for its sorption capacity, effectiveness and feasibility in removal of spills. The experiments are carried out in the laboratory scale. This studies concentrate on the technical and economic feasibility of the sorbents used in the oil spill prevention.
Three different sorbents Natural Organic Sorbent , Synthetic Organic Sorbent and Synthetic Inorganic Sorbent were examined and evaluated for their techno-economic feasibility against three different oils i.e. Crude Oil, Light Chain Oil and Light Gas Oil.
The results showed that natural organic sorbent in Crude Oil and LGO cases, have higher absorption capacities comparable to other two sorbents, while Synthetic Inorganic Sorbent shows better in Light Chain Oil. The experiments showed Natural Organic Sorbent is best for crude oil spilled on the sea water surface.

Keywords- *Crude Oil, Inorganic sorbent, Natural sorbent, Oil spill, Synthetic sorbents*

I. INTRODUCTION

Crude Oil - the most desirable state of a free-flowing flammable liquid that can be pumped out of the earth's crust both from on and offshore, it makes up the foundation for the any nation's economy. As the demand for oil surges, companies push further under the ocean in search of petroleum, drilling through miles of water, rock and salt. Offshore drilling operations are tremendously risky to both humans and to the environment. Such risks include brine wastes, platform runoff, pipeline leaks, platform fires, large oil spills and catastrophic oil blowouts. This vital source of energy can lead to catastrophic consequences when handled improperly or released into the ocean or land unsupervised.

In the wake of the current oil spill in the offshore operations, oil clean-up is still a major challenge due to the limitations and high cost of current clean-up practices.
The common clean-up techniques that have been used include

- In situ burning of oil on water,
- Mechanical tools (booms and skimmers),
- Use of chemical dispersants, and
- Synthetic sorbents.

Sorbents are materials with high attractions for oil and repellent for water. Sorbent materials remove oil by two mechanisms. These can either be done by adsorption or absorption. Adsorption involves the adherence of oil to the sorbent material which is dependent upon the viscosity of the oil. The more viscous the oil, the thicker the layer that will adhere to a given material. On the other hand, absorption relies on capillary attraction; oil fills the pores within the material and moves upward (uptake) into the material due to capillary force. Sorbent can be grouped as inorganic minerals and synthetic, organic, and organic (agricultural) products.

Aim of the study : The aim of this study is to incisively analyse and compare oil clean-up capacity of the various sorbents and advise best techno-economic sorbent to be used for oil clean-up in seawater.
Objectives of the study: To analyse selected sorbents against three different oils in laboratory on the test model for their spilled oil absorbing capacity and categorise highest absorbing sorbent first and compare all with others. Based on the literature surveys, lab analyses and result data collection; suggest the most feasible and preferred sorbent

II. PROBLEM STATEMENT

Though the requirement of Oil and Gas for this developing world is one of the most essential for each and every countries of the world, but the oil spill is one of the hidden problems adhere with the production of Oil & Gas.

Nowadays, oil spill is one of the most serious pollutants that have negative effects on the ecosystem and marine life. Environmentalists face major challenges in the treatment of spills and in developing an alternative product with low cost.
Oil spills frequently kill marine mammals such as whales, dolphins, seals and sea otters. Oil coats the fur of otters and seals, leaving them vulnerable to hypothermia. Even when marine mammals escape the immediate effects, an oil spill can cause damage by contaminating their food supply. The risk of oil spills is a major environmental issue in the sitting of proposed coastal refineries, oil terminals, deep-water ports, and in the leasing of offshore lands for oil exploration and development.
World has consider Oil Spill as one of the most high priority long term incident which need immediate control measures as per international standards and conventions.
By studying and comparing laboratory results of various sorbents, technically and economically feasible sorbents decided.

III. LITERATUR SURVEY

Literature review is one of the most vital chapter of this theses. Research papers / Review published by technocrats after extensive study, experiments and research on "Techno-economic feasibility of different sorbents for Oil Spill Prevention in Seawater" were thoroughly studied and used as reference in this theses.

1 ***Clean-up of water surface from oil spills using natural sorbent materials [1]***
Authors: *Rotar Olga V., Iskrizhitskaya Darina V., Iskrizhitsky Alexandr A. and Oreshina Alexandra*
This theses was published an article in "Science Direct" which was originally published in XV International Scientific Conference "Chemistry and Chemical Engineering in XXI century"and dedicated to Professor L.P. Kulyov. It describe that the peat moss carbonized at the temperature of 200-250 °C and modified by acetic acid has high sorption capacity. The sorbents introduced can increase the efficiency of water surface cleaning up until the water is almost clean and the residual oil content in water is less than 0.03 g/l. As the calcification degree of the sorbent increases, its technical application characteristics improve. Further increasing of the calcification degree does not change the oil capacity of the sorbent.

2 ***A sustainable approach to controlling oil spills [2]***
Authors: *Abdul Aziz Al-Majed, Abdul Rauf Rasheed Adebayo and M. Enamul Hossain*
This theses was published from Department of Petroleum Engineering, King Fahd University of Petroleum & Minerals, Dhahran 31261, Saudi Arabia in July 2012 which describe about huge economic and environmental destruction from oil spills, studies have been directed at improving and deploying natural sorbents which are not only the least expensive but also the safest means of spill control. This research reviews the limitations and environmental impact of existing clean-up methods. It also justifies the need for concerted research effort on oil spill control using natural and sustainable technology concepts. The article proposes future guidelines for the development of a sustainable clean-up technology.

3 ***Use of Sorbent Materials in Oil Spill Response [3]***
Author: *ITOPF – The International Tanker Owners Pollution Federation Limited from London, UK* has published a Technical Information Paper on the clean-up of sea water surface from oil spill by using natural sorbent materials. This paper describe How sorbents works for oil spill prevention by considering Absorption, Adsorption and Wetting properties in selection of correct sorbent, various types of sorbent materials , various different Bulk, Enclosed, Continuous and Fibre type sorbents and criteria to select appropriate sorbent.

4 ***Oil Spill Sorbents Effectiveness [4]***
Authors: *Wáodzimierz KoĔczewicz, Oliwia Grabowska, Dawid Lachowicz, Zbigniew Otremba*
This thesis describes about effectiveness of various Sorbents being used in the Oil Spill. The paper presents search for objective and quantitative method of determination usefulness of various loose sorbents destined for cleaning surfaces polluted with oil. The motivation to take up the topic is that oil pollution emergence in marine areas remains still as the environmental problem. During the ship exploitation there is possibility of appearing of the fuel oil, lubricating oil, hydraulic oil or even transformer oil leaks on the board which might be erased by washing or using sorbent powders and granules or mates. In the case of disposing the washing liquids, the large volume of oil-in-water emulsion is forming which is gathered in a tank and further transported to the vessel cleaning system. In the case when sorbents are applied in an early phase of oil leakage, the vessel cleaning system is less overloaded which reduce the probability of failure.

5 ***Superhydrophobic and Oleophilic Calcium Carbonate Powder as selective oil sorbent with potential use in oil spill clean-ups[5]***
Authors:*Tina Arbatan , Xiya Fang and Wei Shen*
This theses describe about Super hydrophobic and Oleophilic Calcium Carbonate Powder as selective oil sorbent with potential use in oil spill clean-ups. This review covers ctive, and large-scale technology to minimize environmental consequences caused by such disasters. The feasibility of using superhydrophobic and Oleophilic mineral powders to selectively absorb oil from water is thus of great interest. In this communication we report the preparation, characterization and laboratory testing of superhydrophobic calcium carbonate powder treated with fatty acid as selective oil sorbent to separate oil from an oil–water mixture.

6 Surface modification of high calcium fly ash for its application in oil spill cleanup[6]

Authors: *O.K. Karakasi and A. Moutsatsouhas*

This theses was published an article in ELSEVIER on 19th March 2009 and describe about Surface modification of high calcium fly ash for its application in oil spill clean-up. This research paper covers utilising an inorganic industrial by-product, high calcium fly ash (HCFA), in an environmental field: oil spill clean-up. Properties, such as fine particle size, floating ability, hydrophobic character and porosity, make this material attractive for such a use. In order to investigate the oil sorption behaviour of HCFA an oil spill has been simulated, by using artificial ocean water and three types of oil (heating oil (HO), light cycle oil (LCO) and Iranian light crude oil (ILCO)

7 Biodegradable Waste as Sorbent in Oil Spill [7]

Authors: *J. Idris,G. D. Eyu,A. M. Mansor,Z. Ahmad and C. S. Chukwuekezie*

This theses publish an article review paper in The Scientific World Journal, Hindawi Publishing Corporation on 7th November, 2017 which describe about use of Biodegradable Waste as Sorbent in oil spill.

The need for cost-effective and environmental friendly sorbent materials for oil spill clean-up cannot be overemphasized. The research paper focuses on the preliminary study of empty palm fruit bunch fibre as a promising sorbent material. The morphology of the unmodified empty palm fruit bunch, EPFB fibre, was examined using an optical microscopy, scanning electron microscopy coupled with EDX and X-ray diffraction. The effects of oil volume, fibre weight, and time on oil absorption of EPFB fibre were evaluated with new engine oil from the model oil. The results show that EPFB fibre consists of numerous micro pores, hydrophobic, and partially crystalline and amorphous with approximately 13.5% carbon. The oil absorbency of the fibre increased with the increase in oil volume, immersion time, and fibre weight.

8 Oil sorbents with high sorption capacity, oil water selectivity and reusability for oil spill clean-up[8]

Authors:*Daxiong Wu, Linlin Fang, Yanmin Qin, Wenjuan Wu, Changming Mao and Haitao Zhu*

This theses / research paper was published in Marine Pollution Bulletin in 2014 which describe about various Sorbents with high sorption capacity, oil water selectivity and reusability for oil spill clean-up.

A sorbent for oil spill cleanup was prepared through a novel strategy by treating polyurethane sponges with silica sol and gasoline successively. The oil sorption capacity, oil/water selectivity, reusability and sorption mechanism of prepared sorbent were studied. The results showed that the prepared sorbent exhibited high sorption capacity and excellent oil/water selectivity. 1 g of the prepared sorbent could adsorb more than 100 g of motor oil, while it only picks up less than 0.1 g of water from an oil–water interface under both static and dynamic conditions. More than 70% of the sorption capacity remained after 15 successive sorption–squeezing cycles, which suggests an extraordinary high reusability. The prepared sorbent is a better alternative of the commercial polypropylene sorbent which are being used nowadays.

9 Oil Spill Clean-up by Structure Fibre Assembly

Authors: *C. Praba Karan, R.S.Rengasamy and Dipayan Das*

This theses / research paper was published as an review article in Indian Journal of Fibre & Textile Research, Vol. 36, June 2011 which describe about clean-up process of oil spill by using structure fibre assembly.

Sorbents made from structure fibre assembly are found to be the best material to clean up the oil spill. The oil sorption and retention behaviour of sorbents are influenced by the material and structure of the sorbents and oil physical characteristics. For sustainable environment, disposal of used sorbent is major issue. In this context, the naturally available biodegradable materials have great potential then synthetic ones. This paper reviews about oil spill cleanup, characteristics of oil sorbent materials, fluid flow through fibrous materials, types of fibre material envisaged for making sorbents and test methods for oil sorbents.

10 Rice Husk Ash for Oil Spill Clean-up

Authors: Yerdos Ongarbayev, Zulkhair A. Mansurov, Marat I. Tulepov and Ye. Tileuberdi

This theses / researche paper was published as review paper in Research Gate in November 2013 about using Rice Husk Ash for oil spill clean-up.

In this work, we report rice husk ash prepared via a thermal treatment process used as oil sorbents for oil spill cleanup. The oil sorbent with highly porous structures shows a crude oil sorption capacity of 15 g/g. The rice husk ash was studied on the basis of phase composition, microstructure and morphology using X-ray diffraction analysis, FTIR spectrometry and scanning electron microscopy (SEM). The results of the SEM studies strongly indicate that thermal treatment is a suitable method to improve structure of husk particles regarding porosity compared to virgin samples.

IV. METHODOLOGY

Three different oils are selected in the experiment to check the absorption rate of five different sorbents in laboratory scale.

1 Crude Oil (Iranian Heavy / Gulf Crude)
2 Light Cycle Oil and
3 Light Gas Oil

The specifications of the three different types of oils used in the experimental procedure are listed in Table 1

Property	Crude Oil (Iranian Heavy / Gulf Crude)	Light Cycle Oil LCO	Light Gas Oil LGO	Method
Density , g/ml	0.8692	0.9550	0.8411	ASTM-D-1298
^{0} API Gravity	31.00	16.66	36.73	ASTM-D-1298
Viscosity 40^0C cST	11.05	3.86	3.36	ASTM-D-445

Table 1: Oil Properties

Sorbent materials:

Following sorbents were used in the experiment :

1. Expanded Perlite 1 - Synthetic Inorganic Mineral Sorbents
2. Expanded Perlite 2 - Synthetic Inorganic Mineral Sorbents
3. Expanded Perlite 3 - Synthetic Inorganic Mineral Sorbents
4. Polypropylene - Synthetic Organic Sorbents
5. Cellulosic Fibre – Non woven web - Natural organic (agricultural) Sorbents

Descriptive characteristics of the materials used in this study are given in Table 2.

Type of Sorbent	Description of material	Mesh	Density g/l
Expanded Perlite 1	Granular form	0-5	0.20
Expanded Perlite 2	Granular form	1-6	0.20
Expanded Perlite 3	Granular form	0-5	0.20
Cellulosic Fibre	Wooden chips / Saw Dust	20	0.11
Polypropylene	Non woven web	-	-

Table 2: Properties of the Sorbents used

Procedure :

A 500-ml sample of seawater was placed in an 800-ml glass beaker. The desired amount of oil (10, 20, 30, 40, 50g) was added to the beaker. The beaker containing crude oil and seawater was mounted in a shaking apparatus. Approximately 1g of a sorbent material was added in the system, which was shaken for 10 min at 98 cycles/min. The wetted sorbent material was weighted after being drained for 1 min in the sustainer.

Water content of the sorbent was analyzed by the distillation technique described in ASTM D 95 [12]. A mixture of toluene and xylene (20/80, v/v) was used as the carrier solvent. The amount of oil sorbed by the sorbent was determined by subtracting the water content and the initial sorbent weight from the total weight of the wetted sorbent.

Experimental Analysis Results in Crude Oil

Oil in g	Oil g/g in Expanded Perlite 1	Oil g/g in Expanded Perlite 2	Oil g/g in Expanded Perlite 3	Oil g/g in Cellulosic Fibre	Oil g/g in Polypropylene
10	1.8	**1.7**	**3.1**	**5.3**	**3.3**
20	2.2	**1.8**	**3.0**	**5.5**	**3.8**
30	2.9	**2.3**	**3.3**	**5.6**	**4.3**
40	3.2	**2.2**	**3.2**	**5.6**	**4.6**
50	2.7	**2.3**	**3.0**	**5.5**	**4.4**

Table – 3 Absorption Capacity of Sorbents in Crude Oil

Experimental Analysis Result Graph in Crude Oil :

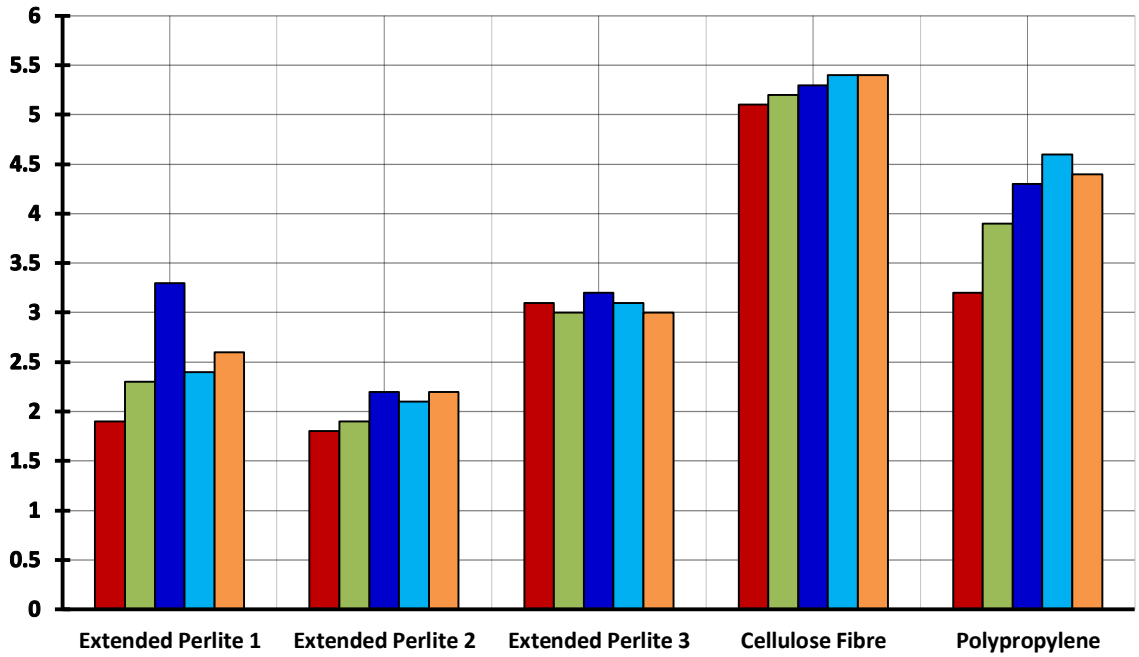

Fig 1: Absorption capacity of sorbents in Crude Oil

Experimental Analysis Results with Light Chain Oil (LCO)

Crude Oil in g	Oil g/g in Expanded Perlite 1	Oil g/g in Expanded Perlite 2	Oil g/g in Expanded Perlite 3	Oil g/g in Cellulosic Fibre	Oil g/g in Polypropylene
10	1.9	2	2.6	2.5	3.2
20	2.2	1.7	3.1	2.8	3.7
30	2.9	1.6	3.2	2.7	4.3
40	3.1	1.5	3.5	2.4	4.5
50	2.8	1.9	3.2	2	4.4

Table – 4 Absorption Capacity of Sorbents in Light Chain Oil

Experimental Analysis Result Graph with Light Chain Oil :

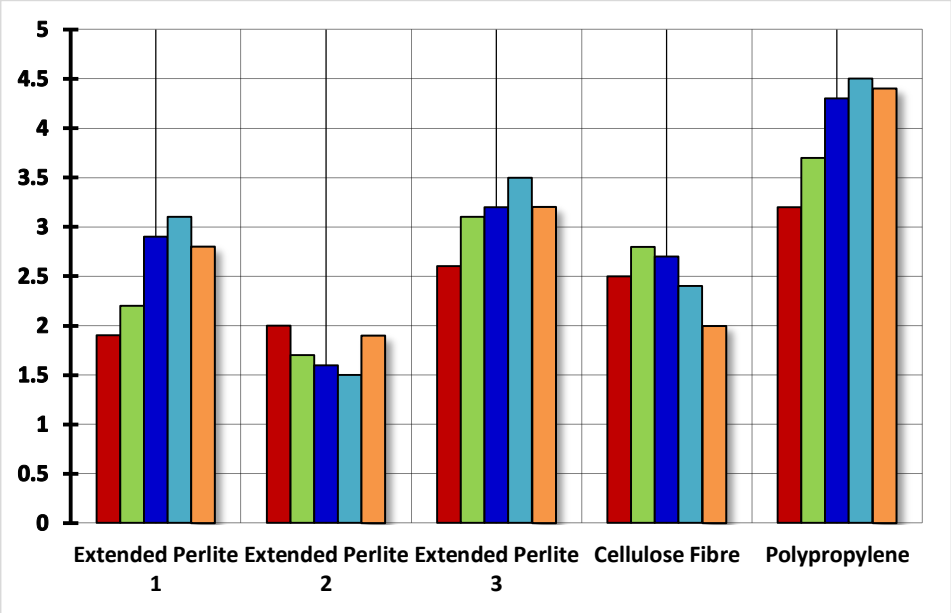

Fig 2: Absorption capacity of sorbents in Light Chain Oil

Experimental Analysis Results with Light Gas Oil (LGO)

Oil in g	Oil g/g in Expanded Perlite 1	Oil g/g in Expanded Perlite 2	Oil g/g in Expanded Perlite 3	Oil g/g in Cellulosic Fibre	Oil g/g in Polypropylene
10	1.2	0.9	2.1	3.3	3.8
20	1.2	0.7	2.4	3.7	3.9
30	1.1	0.8	2.7	3.8	4.3
40	1.2	0.75	3.1	3.8	4.3
50	1.2	0.7	3	3.1	4.1

Table –5 Absorption Capacity of Sorbents in Light Gas Oil

Experimental Analysis Result Graph with Light Gas Oil :

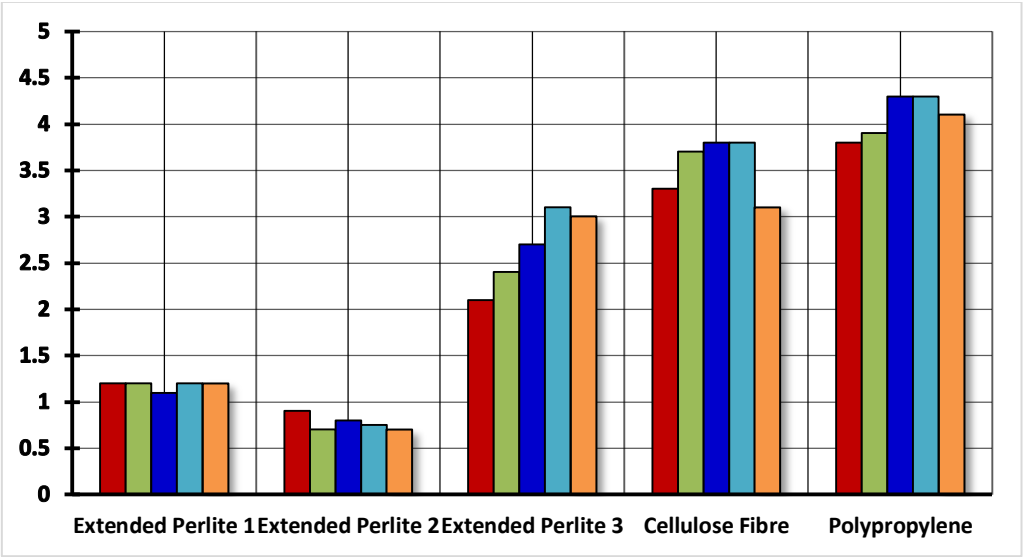

Fig 3: Absorption capacity of sorbents in Light Gas Oil

V. CONCLUSION

The oil sorption capacities of the sorbents in the seawater bath, containing different amounts of oil, are shown in Figs. 1-3 for CRU, LCO and LGO respectively.

1 Polypropylene showed the highest oil sorption capacity for LCO and LGO followed by expanded Perlite 3 and cellulosic fibre.
2 The oil sorption values of expanded Perlite 1 and 2 were generally lower compared to the other materials used. Despite the fact that expanded Perlite 1 and 3 have similar physical properties, the hydrophobicity of the latter due to chemical alteration makes them perform totally different in a water medium.
3 Expanded Perlite 2, intended for horticultural applications, has natural hydrophilic performance, absorbing twice as much water than oil in all cases. Expanded Perlite 3 sorption capacity was greater than the other two types of Perlite because it is waterproof.
4 In the case of crude oil, the absorption capacity of cellulosic fibre was the highest of all materials used, being able to absorb the whole amount of oil in the seawater bath, the reason may be the hydrophobic interaction and Van der Waals forces, which would occur between the crude oil in the bath and wax in the natural sorbent.

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