Current Trends on Oil Sludge Characterization, Toxicity and Treatment Systems

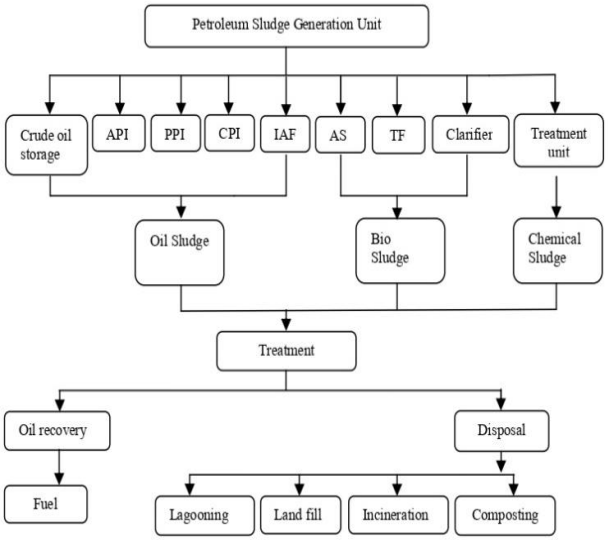
K.Suganya, C.Sivapragasam, Naresh K Sharma, S.Vanitha

Abstract— Oily sludge produced in the refineries contains various harmful contaminants and difficult to analyse Treatment of Petroleum Sludge is a major problem all over the world. More strict regulations are being imposed, which preservere the treatment technologies capable to deal with the hazardous pollutants. The inadvisable disposal of oil sludge leads to hazardous, due to the presence of high concentration of harmful substances. This paper presents critical review on the production, characterization, toxicity and biological treatment of petroleum sludge reported in various studies. Compared to usage and production of petroleum and oil based products, the pace of knowledge acquisition on treatment of petroleum and oil sludge is slower despite the availability of numerous treatment and remediation options. Also, the differences in performance of treatment methods and results reported from various literatures have been addressed to pave a way for a customized treatment solution to oil sludge contamination. There is a need to identify a cost effective solution through which toxic pollutants in the sludge is treated effectively with a potential to reuse as manure for cultivation of crops.

Keywords—Oil sludge, toxic pollutants; treatment methods, sludge characterization

I. INTRODUCTION

In India, petroleum treatment facilities by and large create roughly 20,000 tons of oily sludge per annum[1].It is additionally stated that while oil sluge generated every year amounts to more than 600 lakh tons, it is assessed that more than 10000 lakhs tons of sludge are amassed around the world[2]. A lot of petrochemical wastewater was produced in the oil refining industry and the assembling procedure of various natural synthetic compounds and crude materials, which has turned out to be a standout amongst the most difficult issues[3].The treatment of industrial sludgeis the major issue of real concern these days, increasingly exacting guidelines are being forced, which need to create and utilize the treatment innovations[4]. Safe handling of huge volumes of sludge is a serious concern for petroleum industries. Fig .1 Shows the process unit of petroleum sludge generation and its treatment methods.



API – Americal Petroleum Institue Separator
PPI – Parallel Plate Interceptor
CPI – Corrugated Plate Interceptor
IAF – Induced Air Flotation Unit
TF – Trickling Filter
AS – Activated Sludge

Fig.1.Flow chart –Petroleum sludge generation unit

Oily sludge in considerable amount is one of the by-products from the petroleum refineries which is typically composed of water, metals, suspended soilds and hydrocarbon. Petrochemicals, sometimes petroleum chemicals, can be described as any chemicals which are derived from petroleum or natural gas. Major challenge is posed by the waste oil in both the wastewater treatment and in the petroleum sludge treatment techniques. High oil substance rich petroleum sludge would devour increasingly synthetic conditioners [5]. In the most demanding issues concerning environmental studies, under the present scenario, the issue of sludge management stands out with associated high expenses [6]. This demands a paradigm shift by bringing in more robust methods for processing of petrochemical sludge and its utilization. Treatment technologies studied by the researchers for the biological treatment of petroleum refinery sludge include lagooning, landfilling, incineration and composting. After pre-treatment of oil sludge, the land treatment is reported to be the most appropriate method ([7-8]). Oil Sludge comprise of waste water, oil waste and mineral particles [9].

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As per Environmental Protection Agency (EPA) regulation, sludge is classified as hazardous and toxic waste which are differentiated as chemical, oily and bio sludge [10]. Particularly, oily sludge has been classified as hazardous substances [11] because it contains significant amount of petroleum hydrocarbons (PHCS) [14]. Oil storage tanks and refinery wastewater treatment plants are believed to be the two major sources of oil sludge [12]. Sludge is usually found to accumulate in refinieries under conditions such as draining of oil from tanks, draining of oil from operation units, failure of pumps, ruptures in pipe lines and maintenance activity involving the cleaning of storage tanks [13]. There are various treatment techniques, this review investigates on characteristic of oily sludge, process and identification of suitable solution for treatment of oily sludge waste. Fig.2 shows the increase in generation of refinery outputs in countries all over the world.

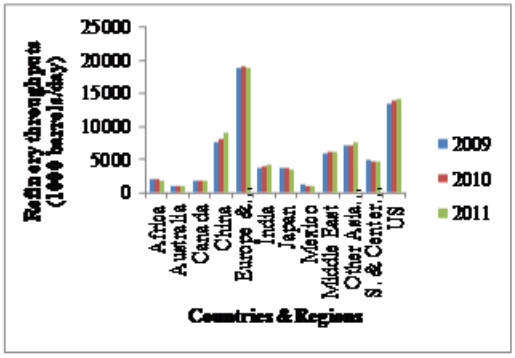

Fig.2.Refining throughputs-worldwide

a) Toxicity of Oily sludge

Due to the presence of high fixation poisonous substances, the inappropriate transfer of oil sludge can cause threats to the acquiring habitat. Consequent to entering the earthly condition, the physical and chemical properties of accepting soils can be distressed by the oil sludge, thereby prompting soil morphological change [14]**.** Fig.3 shows various impact of oil sludge**.** When the oily sludge is disposed to the environment without proper treatment, the presence of poly aromatic hydrocarbons (PAHs) and heavy metals can lead to various toxic effects [2].

Fig.3.Various impacts of oily sludge

b) Characteristic of oily sludge

Ubani et al., [1] described how the composition of oily sludge differs due to the raw materials used in the manufacturing of crude oil and the process used for the oil water separation. Robertson et al., [14] reported that petrochemical sludge contains oil, metal salt, sulphide, volatile phenol and other substances apart from nitrogen and phosphorus. Fig.4 shows the basic composition of oily sludge. The petroleum sludge usually contains propane, hydrocarbons, ethane, methane, butane, and various aromatic hydrocarbons and organic compounds like Sulfur Nitrogen, Oxygen, and pinch amount of metals such as Vanadium, Nickel, Iron and Copper. In summary, it is seen that oil sluge mainly comprises of alkanes, aromatics, alphaltenes and resin with composition of oil and solids typically as 80% and 20% respectively [16].

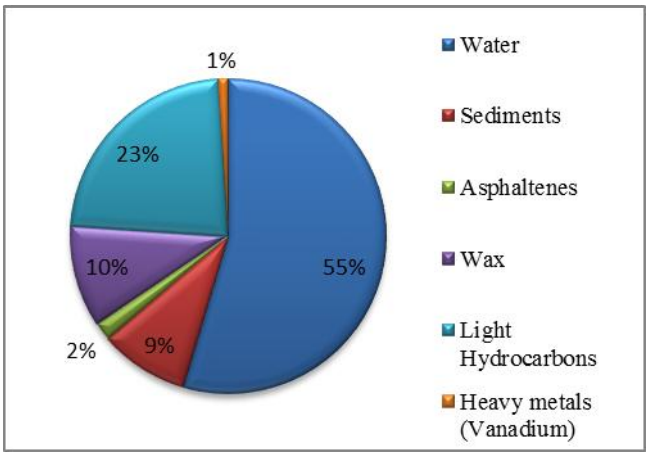

Fig.4.Basic composition of oil sludge

TABLE I: TOXIC POLLUTANTS PRESENT IN OILY SLUDGE

S.no	Toxic Pollutants present in oil Sludge	References
1.	Asphaltenes, Alkanes, Resin and Aeromatics	[16]
2.	Semivolatile organic carbons(SVOCS) and Volatile organic Carbons(VOC_s)	[17],[18]
3.	Anthanthrene, Fluoranthene, Acenapthylene, Naphthalene Phenanthrene, Benzo[a] anthrancene,Benzo[ghi]perylene.,Benzofluoranthenes,Benzopyrenes,	[19]
4.	Poly Aromatic Hydrocarbon(PAHs)	[20]
5.	Pyrene,Dibenzo(a,h)anthracene,Benzo(ghi)perylene,Fluorene,Phenamthrene,Anthracene,Fluoranthene,Pyrene,Benzo(b)fluoranthene,Benzo(k)fluoranthene,Benzo(a)Pyrene,Indeno(1,2,3-cd),Naphthalene,Acenaphthylene,Acenaphthene	[21]

II. OIL SLUDGE TREATMENT METHODS

Petrochemical sludge is considered to be complex combination of various organic and inorganic compounds and difficult to dispose without proper treatment to the environment. In fact, improper treatment and refining of such sludge could be potentially highly dangerous to the environment which is a growing concern all over the world [23].

Kripsalu et al., [22] investigated that biological treatment is the utilization of microbial digestion of organic matter and making the pollutants as harmless. One of the by-products of the biological treatment process is the production of excess sludge which adds to serious issue in the treatment of wastewater. The production of such sludge may even account for even 60% of total associated cost and energy demands. These factors need to be taken into consideration while choosing the biological process for treatment. [24], [25] reported that techniques such as bioreactor, land farming, composting, etc., are very much effective for the degradation of PAHs in soil

The various treatments of oil sludge includes,

1) Lagoon / Pit

Although use of cement and brick lined lagoons are scientifically proven methods for discarding oily sludge, the associated problems such as that of odour and fire hazards cannot be neglected [26]. Such method of deposition of refinery oily sludge is also identified to contribute to the atmospheric volatile organic compounds (VOCs) [27]. Minimum studies are reported in the lagooning treatment and this technique should be adopted with caution as it will tend to emerge various toxic gases.

2) Incineration

Incineration is a technique used for the process of burning of oily waste within the sight of abudance air and fuel,and it is generally accepted as an effective method in many processing plants for sludge treatment, and more particularly in refineries. However, the associated problem involves production of CaO, SiO_2 and MgO from such incineration of the sludge. These oxides are found to have the same physical properties as powedered minerals. [6] and [28] found that the cost effectivenss of the incineration process is as function of weather condition. Hu et al., [13] and Hung et al., [31] reported that the oily sludge contains substances that are resistant to combustion process and are present in high concentration which in turn will end up in high operating and capital cost. From the advantage point of view, burning of sludge in incinerator can be valuable energy sources which can result in cost effectiveness by using this energy for driving steam turbnines in a waste oil reclamation industry. It should be noted that, however, such energy recovery can be done at the cost of evolving of toxic gases in the process [27]. Vesilind [32] reported that oily sludge with excess dampness should be pretreated to improve its ecofriendliness. Another reported advantage in this process is considerable reduction in volume and improved energy efficiency [33]. Incineration process requires high capital and operating cost and the incomplete combustion would cause atmospheric pollution.

3) Landfilling

Due to the rigidity in environmental protection and control regulations by almost all the government bodies as well as due to scarcity of land, landfilling may no longer be a preferred technique for sludge disposal [32]. Jacques et al., [20] reported the pseudomonas isolates may be effective for PAHs degradation. Demastas et al., [33] stated that cement and fly ash have been accounted for a satisfactory choices to treat and anticipate draining of substantial metals sorted as lethal and unsafe. The prevailing humid conditions in a landfill will lead to decrease in incineration efficiency with increase in dampness of the waste mass [6]. Bhattacharya et al., [26] found that land farming treatment cost is much higher and hence, in many countries like Taiwan, landfill treatment is limited by both cost and space [33].The various impacts of landfilling site are,

1. Surface and groundwater pollution due to leaching of pollutant and surface runoff.
2. Emission of polluting gases like CH_4, H_2S etc.
3. Changes in soil characteristic and texture.
4. Fire and Health Hazard
5. Decrease in land value.
6. Effect on natural vegetation and plant growth.

4) Composting

Variuos works have been described the use of composting for the treatment of refinery oil sludge. Hu et. al., [2] reported that composting of oil sludge has earned enlarged consideration as alternate innovation for land cultivation which frequently requires a huge land zone. The term 'Biopile' is commonly used to refer to transforming of waste materials into piles of 2 to 4m height which can be subject to degradation by microorganisms – both indigenous or extraneous. Compared to composting for bioremediation, which has not received wide acceptance, the physical, chemical and biological methods are neither cost effective not environment friendly [35]. Sergvi et. al., [36] found that due to the addition of phosphate fertilizer that lead in oily sludge will get reduced. Ling et al., [37] reported that, over a 9 weeks study period, contaminated soil added to sewage sludge has resulted in a maximum removal of 65.6% of oil and grease. Milne et al., [38] found that hydrocarbon removal can be enhanced by addition of plant material soil. Chang et al., [39] found that about 55% reduction of TPH was achieved by using solv-II as a bulking agent/nutrient source when compared to heat treated peat moss and barley straw both of which ended up with a maximum of 30% reduction. Piskonen et al., [40] reported that biostimulation, a process by which nutrients are added to stimulate either growth or degradative ability of indegeneous microorganisms, can increase the availability of hydrocarbons present in the oily sludge and thus improve the biodegradation process of oil sludge.

III. RESEARCH GAP

Growing interest has been seen in the development of efficient, economic and environment friendly means of processing of oily sludge. Many technologies have been developed all over the world like advanced oxidation treatment but its reaction end products are usually more biodegradable, but when treating the large volume of oily sludge, the oxidation may require a large amount of chemical reagents. However currently it is difficult to identify one single method or set of methods which are most successful. Sludge disposal methods like lagooning, landfilling, incineration and composting which are discussed in this study shows that it takes more time to degrade the oily sludge. On the other hand, incineration and landfilling can cause environmental pollution and leachate formation which should be taken into consideration while choosing these methods. Many studies reported that these two methods are less efficient. Bioremediation process can be implemented in composting by Rapid composter –bioreactor

IV. CONCLUSION

Petroleum and oil refinery sludge produces very toxic effect to the environment. The various compounds contained in the oily sludge and their toxic effects have been discussed. This study gives insights in to various disposal and treatment methods of oily sludge along with their advantages and limitations. The physical and chemical methods require extensive usage of chemicals which may produce toxic secondary sludge while the bioremediation process can be implemented to reduce the decomposition rate time. Although the bioreactors can be introduced to avoid the foul and toxicity of the sludge to reuse eco-friendly manure, there are a few challenges in identifying and acclimatizing suitable microbes for effective treatment. There is a major gap in designing engineered biosystems customized for oil sludge bioconversion to organic manure.

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