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PRODUCTION OF BIOGAS USING AEROBIC AND ANAEROBIC DIGESTION OF PETROLEUM SLUDGE

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ABSTRACT

Petroleum Industries produces a considerable quantities of the oil sludge which is a combination of sand and mud contaminated by the crude oil in the procedures of oil extraction, storage, transportation and processing. These establishes health hazards to the personnel on the exposure and also produces environmental hazard on dumping if not appropriately treated before the disposal of this sludge. So before dumping these sludges can be used or treated for the production of the biogas which is a resource of maintainable energy useful for the power generation of the electricity and also be considered as a better substitute for the natural gas in that it comprises less content of the carbon and thereby results in less pollutant emissions. So the production of biogas from these petroleum sludge's can be done in two ways:
Anaerobic digestion of petroleum sludge in bioreactors
Anaerobic co-digestion of petroleum sludge with the use of corn Stover for efficient production of the biogas
Anaerobic digestion of the petroleum sludge in the bioreactors can produces the mainly of the biogas and also bio solids. The digestion of a 200 grams of sludge setup in an anaerobic container for a retention time of a 15 days produced 10,3000m3 per day and from this we can estimate that 1 gram of petroleum sludge can results in the yield of 820m3 of biogas from the retention time of biogas solids at a time of 15 days

Anaerobic co-digestion of a petroleum sludge is an ideal treatment method that majority helps for the solving of the problems that are being caused by hazardous waste oil and sand from the oil exploitation procedures and also the smelting procedure. The results revealed that the single-oil sludge wasn't appropriate for the production of gas as a digestive substrate due to the absence of organic substances and probable hazardous matters. So by the enhancing the quality of the exogenous organic matter (corn Stover) , the cumulative gas production capacity was comparative to the quantity of the corn Stover matter included.

1.0 INTRODUCTION

One of the major problems that are facing in the petroleum industries is the management and the treatment of petroleum sludge and hazardous waste oil and sand that is produced from the oil exploitation procedures and also the smelting procedure. This petroleum sludge containing a waste matter can cause health hazards to the personnel on the exposure and also produces environmental hazard on dumping if not appropriately treated before the disposal of this sludge. These industries generating an considerable quantities of sludge which has a major cause of the environmental pollution (Islam, 2015). Sludge's are hazardous waste according to the Environmental protection act and Hazardous waste handling rules. In Nigeria country the petroleum sludge are piled with the expectation of burning them in a burn ditch. This is evinced by the several visits to their petroleum industries. Petroleum sludge need to be treated and must be made unhazardous before they are being disposed. The management of petroleum sludge in bioreactors can exterminate the odour, health hazard and environment hazard that are being caused by the disposal of the untreated petroleum sludge. Furthermore, biogas a replacement for the natural gas will be produced from those petroleum sludges. Thereby develops the consciousness of the self-abundance in the section of the renewable energy resources. Incineration of petroleum sludge in the diligences must be blocked by the adaptation of anaerobic digestion procedures.

1.1 STEPS TO SLUDGE BIODEGRADATION:

Green & Perry (1997) expressed that petroleum sludge is primary hydrolyzed to develop water soluble and afterward lowered to generate unstable biologicalacids mostly acetic acid and hydrogen. Methanogenic bacteria afterward separate the acetic acid into methane and carbon dioxide (biogas).

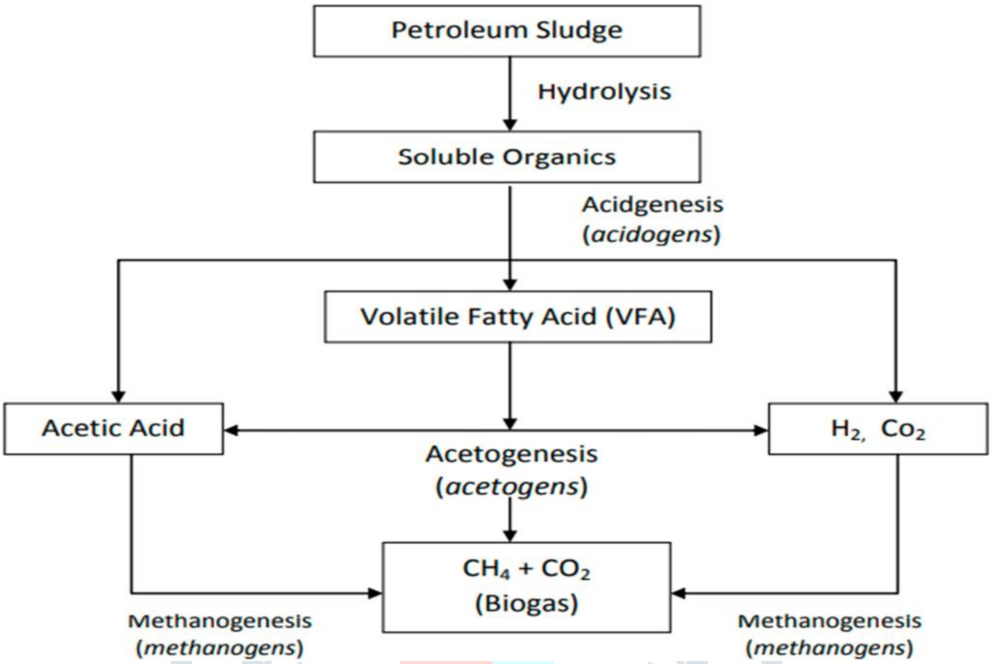

Fig1 : Steps in Anaerobic Digestion of Petroleum sludge

USES:

Technology:

- Suitability for sludge with high moisture content
- High energy content of biogas
- Potential for combined heat and power plant

Social and environment:

- Low carbon emission
- Local employment creation prospect
- Uses of residual as fertilizer

Economics:

- Eliminates transportation and disposal cost
- Sustainable profits with sale of fertilizer, digester, and biogas.

2.0 MATERIALS AND METHODS

2.1 Materials Sourced For The Explore:

The subsequent materials consumed aimed at the research are Ashles filter paper, kiln, desiccators, biochemical stability, filter paper, Muffle boiler LMF4, ceramic vaporizing dish,Inoculum,Deionized water, reagent dissolved oxygen container, Winkler A&B substance, strong sulphulric acid, sodium thiosulphate, thickener, gallenkamp incubator, Corn Stover,labtech anaerobic vessel, Bunsen burner, petroleum sludge gathered from a distinctive petroleum production. Methanogenic microbes (Methanobrevibacter) and a spatula kept in glycerin. Oxide An aero Gen TM AN 0035A vapor park ensued in Labtech anaerobic container to originate anaerobic state.

2.2 Pre-Treatment Of Petroleum Sludge:

The constituents of sludge consists of mixtures of biological matters such as carbohydrates, proteins, fats and oils, a variety of microbes (both active and deceased), and mineral rudiments which are considered through elevated energy contents. However, the possessions of petroleum sludge are vastly changeable and reliant on its source, wastewater management technique, ecological necessities, cyclical variants besides production procedures such that minimal treating such as aeration can definitely recover its biological substances and calorific value considerably. This formulates the alterability in sludge's chemical composition further intense in contrast with conventional biomass and coal samples. In additive to this, sludge has remained noticed to comprise of excessive water content, contaminated inorganics as cobalt chromium, nickel, mercury, silver, cadmium, zinc, copper, lead and arsenic, organic impurities and pathogens and biological pollutants. These strong metals ensue mainly impurities from physiochemical and organic procedures such as industrialized waste, erosion in pipes, nutrition, medication, fabric materials and cosmetics. The adjacent analysis of sludge is such that the unstable substance of biomass is developed whereas coal has lesser volatile contented incontrast to sludge.

2.3 pH Examination of Sludge:

An illustration stating the acidity otherwise alkalinity of a liquid upon a logarithmic range upon where 7 is neutral, inferior values remain more acid solutions and greater values are further alkaline solutions . The pH evaluate for petroleum sludge is about 7.5

2.4 Alkalinity:

A definition of would then be the buffering capability of a liquid form determine of the ability of the wet bulk to neutralize acid and base and thus conserve a stable P_H level. The alkalinity of the taken sludge sample is 900 ppm.

2.5 Hardness Of Sludge:

The quantity of the liquefied calcium besides magnesium in the liquid. Hardwater is great in dissolving minerals mainly calcium plus magnesium. The rigidity for taken sludge is 100-140.

2.6 Chlorides:

Sodium chloride may result a salty taste at 250 mg/l however cacl or mgcl is typically detected by taste level of 1000 mg/l Drinking water chloride level not surpass 250/l

2.7 Total Dissolved Solids of Sludge:

Total dissolved solid measured of the dissolved mingled content of all inorganic and organic substance present in a liquid inward molecular ionized or micro granular suspended form. TDS of taken sludge is 2500.

2.8 Electrical Conductivity:

Ability to conduct an electric current Electrical conductivity = tds /0.67

= 2500/0.67

= 3731.34

2.9 Moistness Contented:

Moisture is described as the quantity of liquid lost from dry matter upon drying to a constant weight, said as the weight per unit of dry substance or as the volume of water per unit bulk volume of the substance. Samples were taken from either raw or digestate waste. Aluminum trays were filled with around 1kg of sample and then place in oven 103-105°C for 24 hours, the weight losses were obtained.

The same technique was repeated until the difference of weight loss was less than 3%. Then the moisture content and entire solid was calculated.

Fig4. Removal of Moisture Content

Removal of moisture content:

%MC = $[1000\text{-}W_0/1000] \times 100\%$

= $[1000\text{-}300/1000] \times 100\%$

= 70

Where **W_0**: weight of sample after drying

Thus, the total solid is calculated by subtracting the percentage of Mc from 100

Total solid determination:

%TS = 100%-%MC

= 100-70

= 30%

2.10 Calculations For Production Of Biogas:

Econotres (2014) provided an equation for the yield coefficient:

$$\text{Yield Coefficient (Y)} = \frac{mg\ V_{ss}}{mg\ B_{COD}}$$

Appels and others (2008) gives an equation for Remaining quantity of cellmatter yielded per diurnal

$$P_x = \frac{\text{YES}_0}{1 + k_d \theta_c}$$

$$V_{CH4} = (0.35)\left[(s_o - s)(Q)\left(\frac{10^3 g}{kg}\right)^{-1} - 1.42P_x\right]$$

Where

S0 = The chemical carbonaceous Oxygen mandate of the influent petroleum sludge(S)

Q = Quantity of Sludge (m3/d).

0.35 is the theoretic alteration aspect for volume of methane generated in m3 from change of 1kg BCOD.

At 350C, the transformation factor is 0.40 and 1.42 is the transformation factor for cellular stuff hooked on the BCOD.

2.11 OIL SLUDGE:

Test samples are acquired from the primary position of the petroleum oil production from the petroleum sewage channel of the diverse tank of the 3- phase separator. The oil is common oil, not viscous oil. The oil movement manner signifies to liquid movement, and the major constituents were oil, water besides sand, without additional oil displacement constituents for example polymers. Furthermore, subsequent treating in the facade segment of the procedure, the sludge comprised around 100 ppm of demulsifier. The essential physicochemical physiognomies are recorded in the below Table 1.

Table 1. Characteristics of oil sludge, corn stover and the inoculum.

Parameters	Oil Sludge	Corn Stover	Inoculum
C/% [a]	27.76 ± 0.10	47.44 ± 0.20	30.17 ± 0.60
N/% [a]	3.11 ± 0.20	1.87 ± 0.02	5.01 ± 0.04
Ph	6.5-7.4	ND[b]	7.3-7.7
TS% [a]	64.89	96.75	8.77
VS% [a]	4.94	84.18	5.64

Data expressed as mean values±SD (standard deviation, n≥3); [a] Carbon content and nitrogen content in Volatile Solid (VS) were calculatbased on the sample Total Solid (TS) value; [b] sample not tested.

2.12 Corn stover:

Examples were occupied from farmland near District of Bincheng , City of Binzhou, Province of Shandong (Tencent Scott, N 37◦23051.0500 E118◦05042.2900). Deionized liquid was consumed to washing the corn stover substance to eliminate sand besides further contaminations, earlier tests were posited in oven at 40^{0}C to arid till the moistness contented was decreased fewer than 5%. Afterwards, the matter is compressed to 2-3 cm, the container was vacuum-packed, and it was remained at room temperature for further experimentations.

2.13 Inoculum:

The inoculum is attained from a high-temperature (55 ◦C) anaerobic fermentation chamber. The fermentation substrate is a by-product of granule ethanol fabrication afterward the fermentation of distiller remains

2.14 Effluent Treatment Plant:

The purpose of this Effluent treatment plant is to treat the effluents which are generated from different process units like GSU, GDU etc.before dispose into the marine aquatic; here we get different types of effluents that are listed below:

1. Oily Water System
2. Contaminated Rain Water System
3. Sewage Treatment Plant
4. Ex-SRU Effluent Treatment

Oily Water System:

The majorly treated influents in this system are Emulsified and Non-Emulsified Oils generating from process unit like draining of water from Stabilized condensate storage tanks etc. will collected in a receiving sump with a residence time of 15 minutes. By pumping from receiving sump to Equalized effluent tanks to provide enough retention time to homogenous/equalize the effluent and during retention time some free oil will float and will be skimmed through Oil skimmers. Equalized effluent transferred to the Tilted Plate Interceptor for the removal of TSS and free oil by using skimmers up to 60µ.

Emulsified oil of size less than 60µ will be removed by using De-aeration flotation system along with chemical dosing like Alum and DOPE. De-aeration flotation system shall comprise of Flash Mixing Tank, Flocculation Tank and Flotation Tank. Effluent after removal of free oil and emulsified oil will be sent to the OWS Dual Media Filter for the removal of residual suspended solids, residual hydrocarbons, undesirable colors and unpleasant odors and finally the treated water shall be routed to guard pond.

Contaminated rain water system:

Contaminated Rain Water (i.e. floor wash) comes to ETP battery limit by gravity through an underground pipeline. Floor wash (Dry weather) is received in a small sump called CRW receiving sump which is located within the large Surge Sump, which will accommodate contaminated rainwater during wet weather condition. The regular daily floor wash (dry weather) is pumped to the inlet of equalization tank and shall be treated in the main chain of treatment. During wet weather, contaminated rain water overflows Surge Tank for further treatment at a controlled rate in a CRW TPI Separator and a CRW Dual Media Filter, before discharged to marine.

In order to reduce the BOD and COD in effluents from both CRWS and OWS, provided by continuous dilution with DM, CPP and cooling water Blow downs which are less in BOD and COD. Both OWS and CRWS effluents are collected in Guard-pond-1/2/3 which on overflow flows into the Treated Effluent collection sump. By pumping effluent will be dispose to Sea.

Ex-Sru Effluent System:

The process effluent from SRU is stored in Ex-SRU effluent storage tank. Then it is fed to flash mixing tank by transfer pumps. Initially pH is adjusted by appropriate dosage of NaOH & H2SO4 in the flash mixing tank. Thio-sulphides are removed by H2O2 oxidation in the flash mixing tank. The treated effluent is sent to OWS DMF feed tank.

Sewage treatment plant:

Raw Sewage from different areas in plant is collected in a Raw Sewage Sump with suitable retention time. Raw sewage transferred to Aeration tank through bar screen and grit chambers to remove Inorganic matter. Retrievable type fine bubble diffused aerators are provided to meet the Oxygen demand as well as mixing requirement. After that mixed liquor enters the secondary clarifier where the aerated sludge settles down.

The V-notch overflow weir provided at the peripheral overflow launder of secondary clarifier shall ensure smooth overflow of the clarified treated sewage, reduces the changes of carryover of solids. Clarified treated sewage is collected in Treated Sewage collection tank from where it will be sent to Green belt. The Aerated sludge will be collected in Bio-sludge storage tank through the central pit of the secondary clarifier, from where a part of sludge shall be conveyed to the aeration tank to maintain the MLSS level in the Aeration tank. Collected bio-sludge will be sent to dewatering system along with DWPE chemical to remove water and sludge will be disposed off.

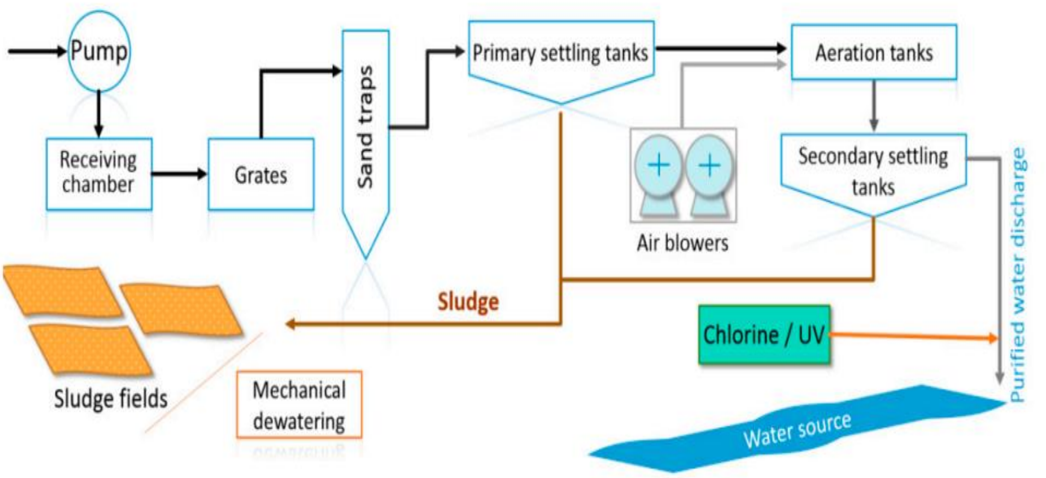

Figure8 Typical technological process of waste water treatment.

2.15 Slop And Sludge Handling System:

Wet Slop Oil System:

Wet slop oil that is collected from Equalization tanks, TPIs, DAF tanks shall be routed to Wet slop oil sump. Wet slop tank is provided for receiving from wet slop oil sump through pumps. This tank is provided with LP steam to ensure the separation between oil and water. Freed Oil will be sent to the slop tank in condensate storage tank area and water will be sent to the Drain and over flow sump.

Oily and Chemical Sludge system:

One no of Oily & Chemical Sludge Sump is used to receive sludge from TPI's, oily & chemical sludge , oily and bio sludge from packaged STP .The Oily & Chemical Sludge Sump is of RCC sump. The sump is provided with agitator to keep the solids in suspension. The oily and sludge from sump is pumped into the Oily &Chemical Sludge Thickener for thickening by Oily & Chemical Sludge Pumps. TheThickener is provided with centrally driven full diameter fixed bridge and picketsand fence type sludge scrapping mechanism and a scum skimmer. The scumand the bottom sludge are drained into Thickened Oily & Chemical SludgeSump.

The supernatant from thickener is routed to drain and overflows sump. The thickened oily & chemical sludge from Oily & Chemical Sludge Thickener is received into the Thickened Oily & Chemical Sludge Sump, by gravity. ThickenedOily and chemical sludge transfer pump is used to transfer the thickened sludge to dewatering unit. Solid Bowl type Oily & Chemical Sludge Centrifuge is provided to dewater thickened sludge and its operation is intermittent. The dewatering of solids is brought about by the centrifugal action. A dry sludgecake with solid content of 20% is achieved at the outlet of Centrifuge. 0.1% Dewatering polyelectrolyte is dosed at the inlet to Centrifuge to aid in thedewatering of solids. The dewatered cake is discharged through a chute into Dewatered sludge storage tank. The centrate from the Centrifuge is routed to the drain & overflow sump.

3.0 RESULT AND DISCUSSION

Sludge treatment section the analysis of the annual performances of the anaerobic digestion section showed a typical 21% TVS removal and the annual average GPR, SGP and SGP* were equal to 0.19 m3 biogas/m3 reactor, 0.18 m3/kg TVS feed and 0.86 m3/kg TVS destroyed, respectively. These values are comparable with typical literature data for digesters which treat wasted activated sludge as sole substrate. The digester feed was thickened in the typical effectiveness range of Italian plants (2–4% TS). The main characteristics and operational parameters of the sludge anaerobic digestion section in the four considered periods are reported.

As can be seen, the pH was in the range 7.2–7.5, therefore the anaerobic digesters worked in steady and stable conditions. For this range of values, a typical 66% of CH4 in the biogas was expected. Although the volatile suspended solids percentage in the mixed liquor of the wastewater treatment section decreased from period 1 to period 4 and the total solids loading increased from 1.2 to 2.0 kg TS/m3d, the total volatile solids loading to the digesters was quite constant: in the range 0.8–1.2 kg TVS/m3d. Also, the sludge retention time in the digesters was fairly constant: around 19–21 days.

Since the digesters worked in stable conditions of temperature, pH, solid retention time and volatile solids loading, the analyzed set of data was particularly meaningful for the aim of the study. According to the percentage of TVS removal (from 16 to 22.5%), the gas production rate (GPR) showed an increase from period 1 to period 2 and kept constant in period 3, whereas it decreased in period 4.The specific biogas production (SGP) was constant in period 1 and 2 (0.22– 0.23 m3/kg TVS feed), then slightly decreased to 0.20 m3/kg TVS feed in period 3, and to 0.15 m3/kg TVS feed in period 4. On the other hand, the exact biogas production, concluded on the demolished volatile solids (SGP*), decreased passing from 1.36 towards 0.67 m3 biogas per kg TVS destroyed. The first two SGP* values were higher than the typical ones reported in the literature. This was probably because of a high biodegradability degree of the volatile fraction in the waste activated sludge fed to the digester.

FEED CHARACTERISTICS	SLUDGE TREATMENT
Total solid	20%
Total volatile solid reactor%	57.3
Total volatile solid removal%	17
Moisture content	80%
Digester temperature°C	30-60°C
pH	7.5
Solid retention time	21
Gas production rate	65%
Electrical conductivity	3731.34

Feed characteristics and sludge treatment

4.0 CONCLUSION

On the origin of the contents of the paper the following conclusive remarks can be drawn. The statement that anaerobic digestion is suitable only for large WWTPs seems to be only a commonplace: the economic evaluation of well managed and designed plants shows that the anaerobic treatment is justified also for small size plants. In any case, the increase of involved per capita costs in the case of anaerobic digestion in BNR plants is very low and the aerobic treatment application becomes not sensible from an financial and an environmental viewpoint. In particular, the following should be emphasized. While designing anaerobic digestion reactors and facilities it has to be kept in mind that sludge loading rates no lower than 2 kg TVS/m3d have to be used in case of BNR processes or sole wasted activated sludge treatment. A sludge thickening at 5–6% TS is needed. This allows always a positive heat balance for the digester. Alternatively, a co-digestion process has to be introduced to increase the biogas production; Anaerobic digestion is environmentally more friendly than the aerobic stabilization processes. A reduction of 40%, as kgCO2/PE year, is achieved in CO2 emissions when anaerobic processes are applied if energy and heat from a CHP unit are recovered; considering both the effects of temperature and SRT in the BNR process the digester reaches the best performances (0.22 m3/kg VS fed) when Yobs reach values of about 0.25 kgVSS/kg COD; Accordingly, the use of SRTs larger than 12 days in summertime seems not to be sound and more cost effective management of the nitrification should be considered.

This preliminary study suggests further investigations about the relationship existing between wastewater and sludge treatment sections, considering other WWTPs, so as to implement a arithmetical model for the expectation of biogas productions upon the basis of the wastewater treatment line operational conditions. Addition of corn Stover can increase the anaerobic digestibility of oil sludge contrasted to single-oil sludge. Through the upsurge in excellence of exogenous biological material (corn Stover), the increasing gas production capacities were comparative to the quantity of corn Stover matter combined. It was founded that when the mass proportion of corn Stover to oil sludge remained 4:1, the gas production functioning was ideal. Furthermore, the inoculum capacity can similarly influence the biogas yield implementation. Through a ratio of corn Stover to oil sludge of 2:1 and an inoculum capacity of 30 mL/150 mL, the extreme accumulative biogas yield was created. This examination about the anaerobic co-digestion of oil sludge and corn Stover concluded the optimal mass proportion and inoculation quantity of substrates, which can not only resolve the problematic of sludge- related contamination, however also consent for energy production from the recycle of corn Stover.

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