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Technical Papers on Process Engineering

ICPE (2016-003)

Assessment of Embodied Energy and GHG Emission during the Brick Manufacture of Bangladesh

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ABSTRACT

This study investigates the embodied energy consumption and GHG emission analysis of various production stages of Brick manufacture in Bangladesh. The study were conducted from raw material extraction to delivery of the product integrated all the production stages. Verious production stages were considered to estimate the values as the methodological approach. Investigation shows that 17 litre diesel and 67 kg coal equivalent to total of 2088 MJ energy is required for the production of 1000 brick. Firing stage is the energy intensive stage consumes 78% of total energy consumption for the manufacture of brick. The estimated total CO_2 emission is 192 kg per thousand productions of brick. The other air emission is insignificant. The energy consumption and emission could be possible to reduce using the renewable energy resources in the firing stage and can contribute to build low energy and low carbon community.

Keywords: Embodied energy, GHG Emission, Brick manufacture, Bangladesh

INTRODUCTION

Energy availability and energy distribution is the present challenge of Bangladesh. Many technical and institutional reforms were taken to improve the energy sectors from 2008 (Ahmed et al., 2014), but current status of energy sectors highlighting the insignificant achievement from the year 2008. The fossil based electrification of the country is little bit higher than 50% implies the access of modern energy is not widely distributed over the country (Planning commission Bangladesh, 2010). Alarming rate of infrastructural development painting the energy requirements will be increase in future. At the same time country will contributes on global environmental impacts due to combustion of fossil energy.

Brick is the key materials for industrial and infrastructural development of the country is going on at significant rate in Bangladesh. More than 45,000 brick manufacture company producing and supplying brick as the building materials (Imran et al., 2014). Brick manufacture industry in Bangladesh usually use coal and diesel fuel for the production of brick. Every day the industry consuming significant coal and diesel fuel for the manufacture. Though brick have no adverse impact on environment during its application period but it has significant impacts on environment during the manufacture. It consumes energy and produces emissions during the extraction of raw materials, manufacture, transportation, etc. To investigate its impacts during the manufacture, all the production stages need to be considered for the analysis. The literature of energy and emission analysis on brick manufacture in Bangladesh is unusual. Hence energy and GHG emission analysis of various production stages of Brick manufacture in

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Bangladesh has been undertaken at RUET with an aim to investigate the embodied energy consumption and GHG emissions for the various production stages from raw material extraction to delivery of the product. Study will also investigate the energy and emission intensive stages and will put suggestion alternative for the improvement. The outcome of this study will be useful to the policy maker, national environmental regulatory team, industrialists to set control measures and help to mitigate the GHG contribution as well as discourage the use of conventional energy.

METHOD

The methodological approach for the estimation of energy consumption and emission of brick manufacture is shown in Figure 1. The flow chart of Brick manufacture process having several steps namely escavetion, transportation, mixing, drying, firing and releasing. The escavetion of soil is done by escavetor and send to soil kiln. The soil is mixed up with water by roller.These bricks are put under open sun for three days for preliminary drying to ensure the 56% moisture has been reduced.Then the bricks are ready for burning in the chimney. Bricks are burnt in 24 hours in the chimney.Then the bricks are released from the chimney after well burn and then the bricks are allow to cool under atmospheric air cooling method. The transportations are by van, small track and labour effort. In every production stage the input energy was estimated by field survey and corresponding emission were estimated using the national emission factor multiplying with the estimated MJ. The total value was estimated summing up all the stages and analyzed.
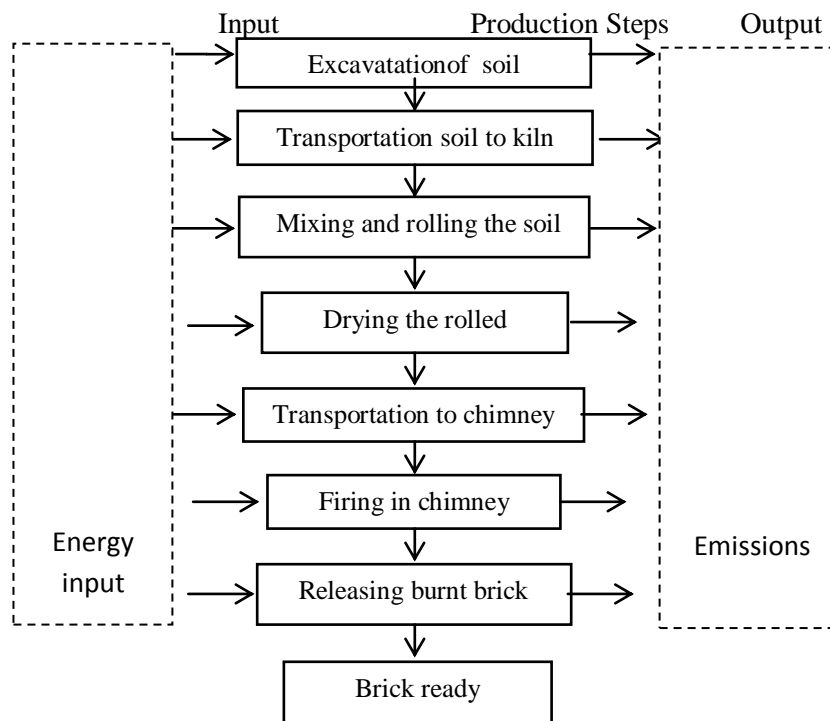

Figure 1: Methodolgical approach for the estimation of energy and GHG emission for the production of brick

RESULT AND DISCUSSION

The estimated energy consumption and corresponding emission for the production of brick is presented in this section.

Energy analysis

The estimated energy consumption at various stages for the production of brick is shown in Table 1. The energy content for diesel is 44.8 MJ/kg and coal is 23.9 MJ/kg was used for the energy estimation (Heat of combustion table).

Table 1. Energy estimation for various production stages per thousand brick manufacture

Name of the stages	Diesel (lit)	Coal (kg)	Energy(MJ)
Excavatation	0.457	-	17
Transportation to kiln	10.00	-	372
Mixing & rolling	2.84	-	105
Drying	-	-	-
Transportation to chimney	-	-	-
Firing	4.00	66.7	1594
Releasing	-	-	-
Total	≈17	≈67	2088

The total energy consumption is 2088 MJ estimated per thousand productions of brick. Two types of energy source namely diesel and coal is used at various production stage. Diesel is used as the energy source for most of the stages except firing stage. Firing stage uses both diesel and coal as the energy source. Firing stage is the 1st energy intensive stage has the magnitude of energy consumption is 1594 MJ per thousand brick manufacture. Transportation to kiln is the 2nd energy intensive stage has the magnitude of energy consumption is 372MJ per thousand brick manufacture. The magnitude of energy consumption for the other stages is insignificant. Drying is done under open sun for several days to reduce the moisture content. So, no energy input is required for this stage. The dried soil is then sent to chimney. The brick soil is then put under fire for prescribed time and release it manually by using labour.
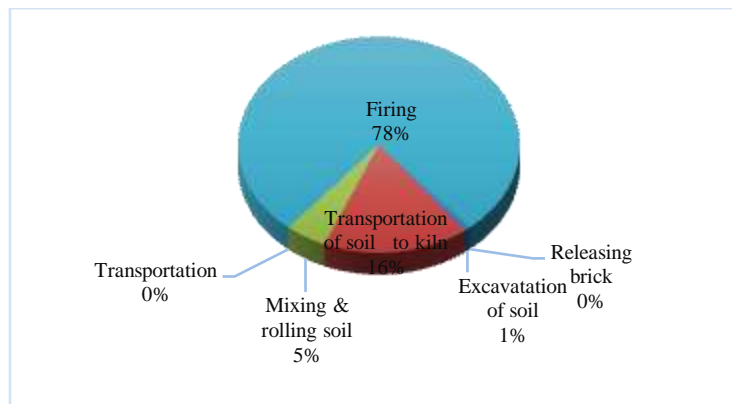

Figure 2: Percentage energy share at various brick production stage

The percentage energy share at various brick production stages are shown in Figure 2. Figure shows that firing stage is the higher energy intensive stage contributing 78% energy share of total energy consumption. Percentage contribution of energy consumption for the transportation of soil to kiln is 16%. Hence, there is a provision to take alternatives in the firing stage in target to mitigate the consumption of fossil energy.

Emission analysis

Table 2 shows the estimated values of major air emissions at various production stages of brick per thousand productions. Emission factors are used from Eggleston et al., 1993 and USEPA for diesel combustion and for coal combustion. The total CO_2 emission released per thousand brick manufacture is 192 kg. The NOx, CO and SO_2 emissions are lower and their estimated total values are 595, 643 and 2452 gm respectively. Firing stage is the highest emission intensive stage due to energy consumption in this stage is higher than that of other stages and transportation of kiln is the 2nd emission intensive stage.

Table 2. Emission estimation for various production stages per thousand brick manufacture

Name of the stages	CO_2 emission (kg)	NO_X emission (gm)	CO emission (gm)	SO_2 emission (gm)
Excavatation of soil	1.26	4	5	2
Transportation to kiln	27	96	100	46
Mixing & rolling	8	27	28	13
Drying	-	-	-	-
Transportation to chimney	-	-	-	-
Firing	156	468	510	2391
Releasing	-	-	-	-
Total	192	595	643	2452
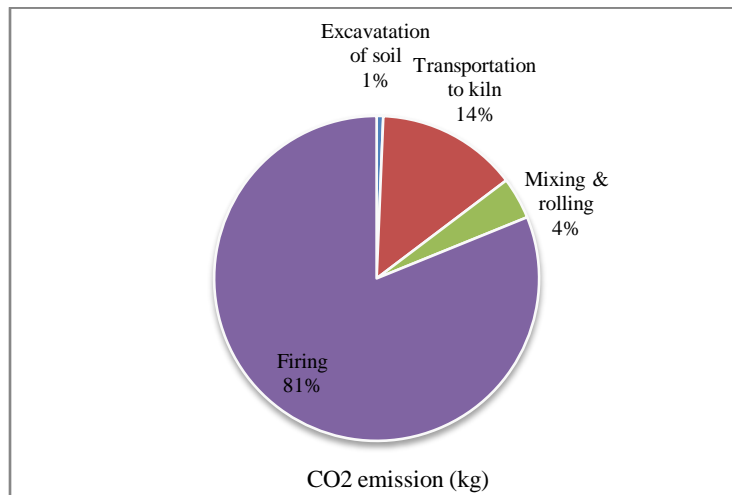
(a)
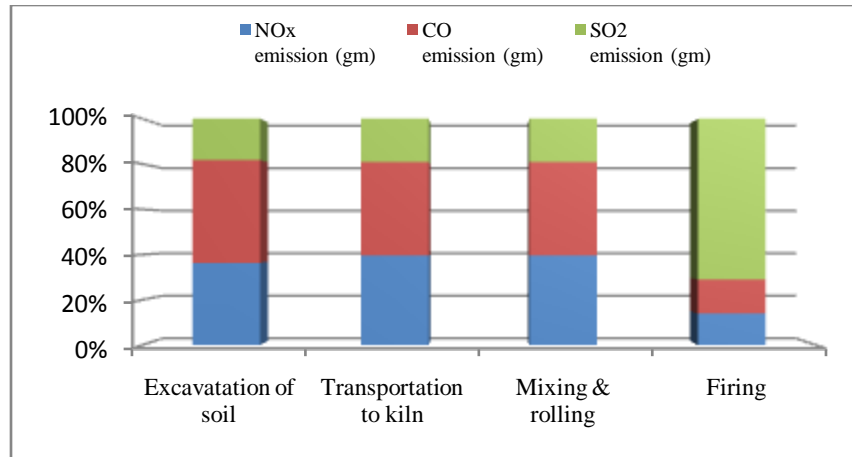
(b)

Figure 3: Contribution of emission at various brick production stage (a) CO_2 emission contribution (b) NOx, CO and SO_2 emission contribution

Figure 3 shows the contribution of emissions at various brick production stages. Contribution of CO_2 emission is significant among all the emission considered in all the stages. Firing satge contributing 81% of CO_2 emission (Fig.3a) since, fossil energy consumption in this stage is higher. Escavation of soil is the minimum carbon intensive stage contributing 1% of total carbon emission. The contribution of NOx, CO and SO_2 in three stages namely escavation, transportation and mixing are similar where CO emission is higher in magnitude (Fig. 3b). In firing stage, the contribution of NOx and CO emission is lower in magnitude where SO_2 emission is higher and its contribution is around 70%. SO_2 emission in firing stage is higher due to may be firing stage consume significant amount of coal contains sulpher. Hence, modification could be undertaken in the firing stage to save energy as well as harmful emission significantly.

CONCLUSION

Energy and GHG emission for the production of bricks in Bangladesh are investigated and analyzed in this study. The production stages are considered from raw materials extraction to final product to be ready for sale. The results shows that, 17 litre diesel and 67 kg coal is required for the production of 1000 brick. The estimated total CO_2 emission is 192 kg per thousand productions of brick. Firing stage is the energy and emission intensive stage. The stage contributes 78% energy share of total energy consumption magnitude of 1594 MJ per thousand production brick. CO_2 emission and SO_2 emission share is 81% and 70% respectively in this stage comparing with other stages. Hence, firing stage could be modified using alternative energy resources to mitigate the energy consumption and GHG emission. In this regard solar energy technologies could be incorporated to dry the wet brick before enter in the firing stage will save significant amount of fossil energy and GHG emission.

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A Feasibility Study on Solvent Extraction as Sustainable Alternative of Acid Treatment for Re-Refining of Used Lubricating Oil in Bangladesh

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ABSTRACT

Among a number of available processes for re-refining of used lubricants, some of them are proved to be hazardous for the environment. Regrettably the most practiced one in Bangladesh is Acid treatment, causes the most perilous effect on the surroundings. Although the Acid treatment has been banned by the Bangladesh government, it is still practiced illegally in most of the factories. The reasons behind this are economic fact and ignorance, as they are not concerned about the environmental impact of Acid treatment; moreover, fallaciously they found Acid treatment to be more profitable. This research is focused on the treating the used lubricating oil by Acid treatment and solvent extraction to find out the possibility and prospect of solvent extraction method as a better alternative for Acid treatment. Environmental sustainability and economic feasibility are two considered design criterion in this study. A laboratory scale setup of Solvent extraction and Acid treatment were established to re-refine used oil, those were collected from different sources in Chittagong city. A comparative study between characteristics of the re-refined oils from both processes was done later. The result shows that the pour point of feed oil is increased from -35^0C to -11^0C for acid treatment and -6^0C for solvent extraction. Sulfur content is found about 0.042wt% for acid treatment and 0.051wt% for solvent extraction. The flash point is 242^0C and 186^0C; Viscosity index is measured as 99 and 115 respectively. A higher yield of about 83% is achieved by using solvent extraction, whereas, it is just 63.76% for acid treatment. The quality of produced oil by both processes is acceptable in Bangladesh standard. The higher yield of solvent extraction is the assurance of better economic viability. The lower yield with Acid treatment process due to the removal of a high amount of contaminants, sludge, and metal which require prior treatment before disposal, in addition, the treatment process is very costly. The used acid and acid sludge in the acid treatment process has a severe toxic effect on both human health and on the environment, for example, the workers in Acid treatment plants are vulnerable to various fatal diseases. On the contrary, Solvent extraction is more environment-friendly than Acid treatment as there is no toxic waste like acid sludge in this process. As solvent extraction has a higher percentage of recovery and more environment friendly nature, we recommend that, it could be a better potential alternative for Acid treatment in Bangladesh.

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INTRODUCTION

Among a number of available processes for re-refining of used lubricants, some of them are proved to be hazardous for the environment. Regrettably the most practiced one in Bangladesh is Acid treatment. Assessment of risk related to used lubricants and acid treatment and possibility of solvent extraction as an alternative have been reviewed and discussed in this chapter. In addition to the major objective the other objectives of this research are enumerated as follows:

1. Evaluate the conventional technologies for the regeneration of used lubricants.
2. Comparative study of Acid treatment and Solvent extraction method of re-refining of lube oil.
3. Re-refine of used lube oil by Acid treatment and Solvent extraction with lab facilities.
4. Properties characterization of re-refined lube oil found from those methods.
5. Cost analysis of Acid/clay treatment and Solvent extraction.
6. Environmental impact analysis of current waste disposal of re-refinery in Bangladesh.
7. Finding out the prospect of solvent extraction for re-refining of lube oil for Bangladesh

The scientific approach used in this research consisted of following phases:

Phase 1- *Analysis of Used Lubricants*: Identification of the composition of used lubricants and the characteristics of its components by conducting a thorough literature review.

Phase 2 - *Evaluation of the Existing Used Lubricant Regeneration Technologies*: Evaluate the existing used lubricant regeneration technologies by conducting a thorough literature review.

Phase 3- *Experimental work:* Re-refine of used lube oil by Acid/clay treatment and Solvent extraction method and characterization of that re-refined lube oil properties.

 Phase 4- *economic analysis*: Do an economic analysis of the two processes based on local market experience to find out the economic viability of solvent extraction method

 Phase 5- *Analysis of environmental impact*: Focusing on the benefit of lube oil re-refining in environment and need for environment friendly technology in prospect of Bangladesh

 Phase 6- *Conclusion and Recommendations*: Summarize the experimental results and research from Phase 1, 2, 3, 4, and 5 for the further improvements and research.

OVERVIEW OF USED LUBRICANT

Composition of Used Lubricants: It is very difficult to classify used lubricants because the composition of used lubricants varies widely with the type and age of engines. It also varies with the service life of lubricant, collecting places, and variable operating conditions. Hydrocarbon Compounds (C_4 to C_{50})**,** Polycyclic Aromatic Hydrocarbons (PAHs)**,**Additives from Lubricant and Fuels**,** Soot Gel Networks, Water**,** Trace Metals and Metallic Fragments **,**Sand and dirt etc are the major constituents of used lubricating oil. [7]

Used Lubricant Regeneration Technology: The technologies and processes commonly used today for the regeneration of used lubricant are summarized as follows:

Atmospheric Distillation: Atmospheric distillation is mainly used for the distillation of light hydrocarbon compounds in used lubricants such as gasoline, diesels, solvents, and water in used lubricants. [5]

Vacuum Distillation: Vacuum distillation is commonly used for the distillation of hydrocarbon compounds that cannot be separated by atmospheric distillation. The typical pressure used in vacuum distillation is from 10 to 50 mm Hg. [4]

Acid treatment: In the case of used lubricants, the concentrated sulfuric acid is used to oxidize the impurities in used lubricants [3]. Acid sludge and acid gas emission generated during the process of acid treatment are extremely hazardous to the environment

Adsorption Process: Adsorbents like bauxite, silica gel, activated clay, are used to separate hydrocarbon compounds or impurities from used lubricants. The adsorption efficiency may decline when adsorbent is saturated with impurities. [1]

*Solvent Extraction***:** Solvent like carbon tetra chloride and benzene is commonly used to purify used lubricants by precipitating impurities out of oil phase. [8] Compared to other technology, solvent extraction is economical because solvent can be recycled.

*Centrifugation***:** Centrifugation is commonly used as a pretreatment to eliminate large and heavy such as metal fragments from tear and wear of moving parts and sands. [2]

Used Lubricant Regeneration Systems The conventional systems usually combine two or more processes in order to regenerate used lubricants into an acceptable quality.

Table-1: regeneration systems of used lubricating oil [10]

Process Name	Technologies
Solvent extraction	Dehydration +solvent extraction+ ammonium sulphate treatment
Clay bleaching	Atmospheric Distillation + Adsorption Process (Clay) + Centrifugation
Acid/Clay treatment	Filtration+ centrifugation+ acid treatment +Neutralization with base+ clay percolation
Propane System	Atmospheric Distillation + Propane Extraction + Vacuum Distillation + Adsorption Process or hydro process
Thermal System	Atmospheric Distillation + Thermal Process + Adsorption Process (Clay) or hydro process
Hydro system	Atmospheric Distillation + hydro process

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EXPERIMENTAL WORKS

Collection of oil sample: The used oil sample was collected from a service station Shikol Baha, Chittagong. Bangladesh. Three liters of used oil was collected for the samples.

Acid/Clay treatment

Reagents used were: Sulphuric acid, Caustic Soda, Fuller Earth

Equipment used: Buncher Funnel, Filtering Flash, Vacuum Pump, Beaker, Measuring cylinder, Water Bath, Filtering Paper, Centrifuge, Conical Flask/Round bottom Flask, Separating Funnels, Thermometer

Process Description: Filtration of the used oil was done to remove sand, metal chips and micro impurities with a vacuum pump, Buchner funnel and filter paper. The buncher funnel and the vacuum pump were connected to the filtering flask to which the funnel was fixed with a rubber stopper. One liter of the used oil was filtered for the sample. The lube oil was allowed to settle for twelve hours. The sample was further filtered by centrifugation for 25 minutes at 10,000 rpm and the suspended particles in the used oil allowed to settle at the bottom of flask, and the liquid portion was decanted. The decanted liquid was preheated to degrade some of the additives. 100ml of the pre- treated oil was measured into a beaker. The oil was treated with 10ml 98% sulphuric acid (H_2SO_4). The conical flask was shaken thoroughly for homogenous mixing and the samples were allowed to stand for thirty minutes. The oil samples were measured into a separating funnel; acids sludge was discharged at the bottom of the separating funnel. This was removed gradually. 30 grams of clay was packed in a buncher funnel, with a filter paper inserted in it. This was plugged to a vacuum pump, allowing the oil to pass through the bed of the clay.100ml solution of 10% NaOH was added to neutralize the acid of the oil sample.
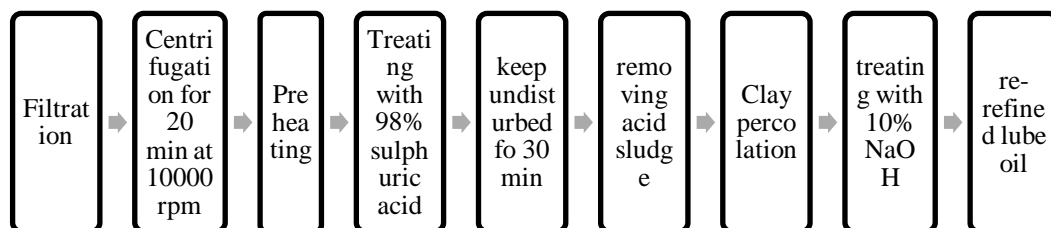
Filtration → Centrifugation for 20 min at 10000 rpm → Pre heating → Treating with 98% sulphuric acid → keep undisturbed fo 30 min → removing acid sludge → Clay percolation → treating with 10% NaOH → re-refined lube oil

Fig-1: Experimental process of Acid/Clay treatment of used lube oil re-refining

Solvent extraction:

Re-Agent Used: Carbon tetrachloride, Ammonium sulphate.

Equipment used: Separation funnel**,** Liebig condenser, Conical Flask, Water bath

Process Description: Firstly oil is dehydrated. For de-hydration oil is heated up to 140^0C so water is evaporated**.** After de-hydration used oil goes to extractor where re-cycled solvent or fresh solvent and polar addition i.e. Water is also added. Here Solvent extraction takes place. Separation time is about one hour. Here two layers appear. One is mixture of solvent and oil while other is raffinate which is mostly water with some undesirable material of oil**.** After extraction extract from extractor goes to stripping section where about 70% of solvent is stripped and re-cycled back. In Stripping section the extract

coming from extractor is heated just above the boiling point of solvent so that the solvent evaporate. After evaporation of solvent it is passed through the condenser where solvent again condensed**.** The treated oil is then sent to next section where it is treated with ammonium sulphate for metal treatment. Ammonium sulphate reacts with metal present in the oil and forms solid compounds which are precipitated out.

Dehydration of oil at 140°C → keep mixed with solvent for 1 hour → Solvent stripping → Ammonium sulphet treatment → Re-refined lube oil

Fig 2: Experimental process of Solvent extraction method of used lube oil re-refining

Properties characterization of re-refined lube oil: Hydro meter, Thermometer, Lovibond color comparator, Kinematic viscometer bath, Cleveland open cup flash point apparatus, Pour point apparatus, Muffle furnace, Copper strip corrosion test apparatus these apparatus were used for the characterization of re-refined oil; The obtained results are discussed in following sections.

Figure 3: Dehydration of used oil

Figure 4: Flash point determination

RESULT AND DISCUSSION

Table-2: Properties of re-refined oil

Properties of acid treated oil		Properties of solvent extracted oil	
Parameter		**Parameter**	
Appearance	Bright and clear	Appearance	Bright and clear
Water content v/v	0.40	Water content v/v	0.31
Specific gravity at 60°F	0.8814	Specific gravity at 60°F	0.6991
Viscosity index	99	Viscosity index	115
Flash point °C	242.00	Flash point °C	186
Pour point	-11.00	Pour point	-6.0
Sulphur content	0.04	Sulphur content	0.051
Iron (ppm)	2.60	Iron (ppm)	nil
Copper (ppm)	1.048	Copper (ppm)	nil
Yield, wt.%	63.76	Yield, wt.%	83.05
Colour	Less than 2	Colour	Less than 2

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Comparative Study:

Table -3: Comparative study of re-refined lubricating oil

Parameter	Fresh lube oil	Feed used oil	Solvent extraction	Acid/clay treatment
Viscosity index	100	110	115	99
Specific gravity	0.90	0.91	0.6991	0.8814
Flash point	188	120	186	242
Pour point	-9	-35	-6	-11
Sulpher content	0	0.80	0.051	0.04
Metal content	0	22.5	0	3.648
Total acid number	0	0.922	0.055	0.052

Viscosity Index: Viscosity is the most important consideration of choosing lubricating oils. The viscosity index (VI) refers to the changing degree of viscosity dependent on temperature. The higher VI means a lower viscosity change in the temperature change, and vice versa. [9] The VI of the re-refined base oils is higher than the feed and the virgin values. However, the result shows that the re-refining using solvent extraction gave the higher viscosity index.
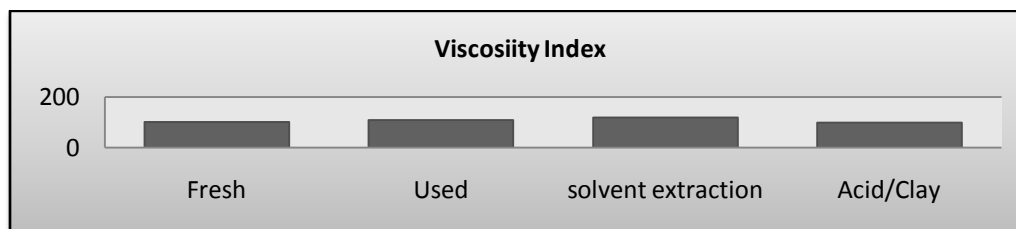

Fig-5: Comparison of viscosity index

*Specific Gravity***:** The specific gravity of the feed oil is higher than the re-refined oils and lower than the fresh lube oil (0.9). The results for the feed and re-refined oils with solvent extraction and acid/clay-percolation are 0.8652, 0.6991 and 0.8814, respectively.
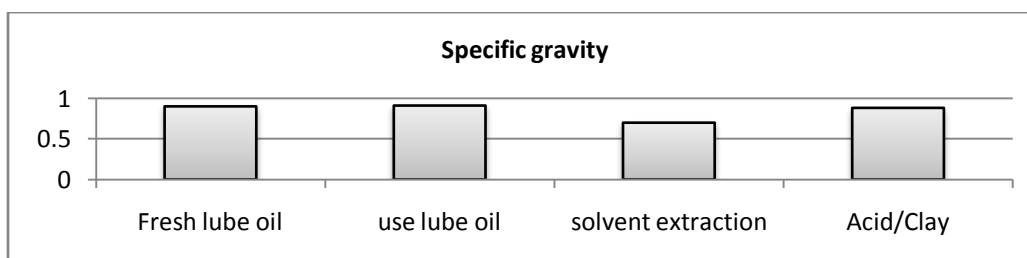

Fig -6: Comparison of specific gravity

Total Acid Number: Total acid number (TAN) is the quantity of base expressed in milligram of potassium hydroxide per gram of sample. Acid number is used as a guide in the quality control of lubricating oil and also as a measure of lubricant degradation in service. Here, feed oil was found to have

a TAN of 0.922 mg KOH/gm. while re-refined base-oils have about 0.055 and 0.052mg KOH/gm. TAN of solvent extracted oil is accepted in Bangladesh standard.
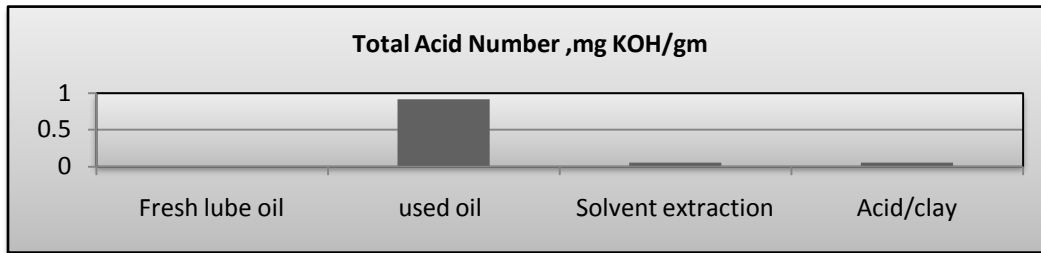
Total Acid Number ,mg KOH/gm

Fresh lube oil	used oil	Solvent extraction	Acid/clay

Fig -7: Comparison of total acid number

Flash point: Flash point of lube oil is another important property. Flash point is that temperature in which oil give the first flash of fire in presence of a fire source. Figure 8 shows the comparison of flash point re-refined from solvent extraction and acid/clay treatment. Comparatively lower flashpoint of solvent extracted oil will not be problem for practical use.
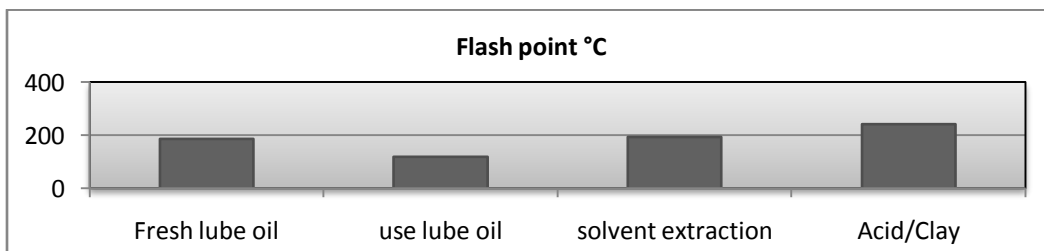
Flash point °C

Fresh lube oil	use lube oil	solvent extraction	Acid/Clay

Fig -8: Comparison of flash point

*Pour point***:** The oxidation products such as aldehydes and ketones have a low pour point. Because of their presence we may notice the pour point of the feed oil is low (-35^0C) .By treatments the pour point increases to -11^0C for acid treatment and -6^0C for solvent extraction.

Pour point

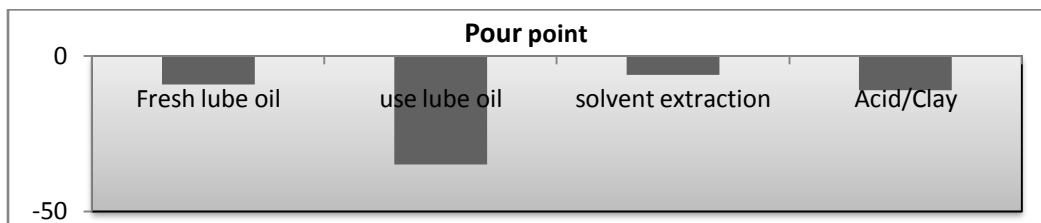|			
Fresh lube oil	use lube oil	solvent extraction	Acid/Clay

Fig -9: Comparison of pour point

Sulpher content: The sulpher content of used oil is due to the presence of wear caused between moving parts. Corrosion in engines is caused by mineral acids formed by the oxidation of sulfur compounds in fuel in internal combustion engines with lubricating oils. Sulfur content was found about 0.04 wt. % for acid/clay-percolation and 0.051 wt. % for solvent extraction.
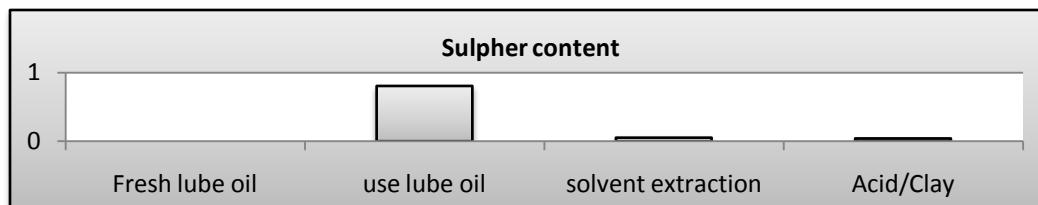
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Fig 10: Comparison of sulpher content

Metal content: The engine block is made of metal like aluminum, iron and leads, hence during the combustion wear of these metals are found in the used oil. In addition, the wear of these metals is result from corrosion. Metal contents was almost zero for solvent extraction
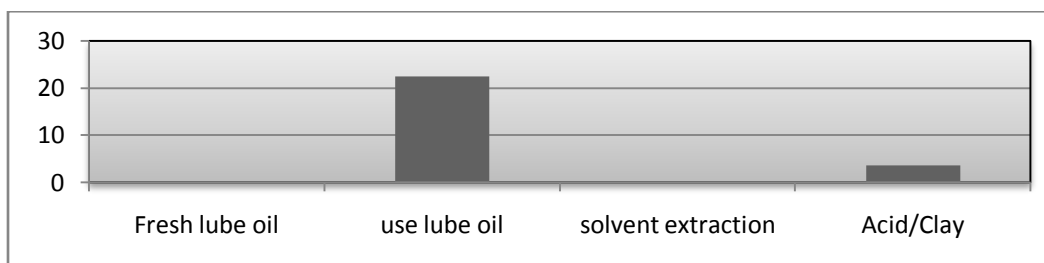

Fig- 11: Comparison of metal content

Yield: Yield is a very important factor as it reflects the effectiveness of the process and has direct relation to the process cost as high yield means more available material to sell and it increases the motivation for production. Yield of the base-oil was found to be 83 % and 63.8% with solvent extraction and acid treatment respectively.

ECONOMIC ANALYSIS

In economic analysis an idea of comparative cost related to both treatments was included. In this analysis the price of raw materials and required reagents was only considered. It was a limited study just to refute the fallacious idea about low cost of Acid/clay treatment. This pricing was done on the basis of information directly collected from local market whole seller of chemicals. The prices were given on Bangladeshi taka (BDT). The profit was estimated excluding used oil and infrastructure cost and was focused only to indicate comparative potential profit.

Acid/clay treatment: The price of sulphuric acid comparatively was lower than required solvent of solvent extraction. But the required sodium hydroxide to neutralize acidic oil was responsible for low net profit of acid/clay treatment. No used acid could be re used or recycled rather additional cost was added to treating acid sludge before dumping.

Table 4: Economic analysis of acid/clay treatment

Oil amount	Price of H_2SO_4	Price Fuller earth	Price of NaOH	Total cost	Oil yield	Oil price per litre	revenue	Profit (BDT)
For 100 ml oil	.1650(10 ml)	0.5	0.4	1.65	63.76	105	6.7	5.05
For 1000 ml oil	1.65(1 00 ml)	5	40	46.65	637.6	105	63.7	17.05

Solvent extraction: The price of carbon tetrachloride was relatively higher than sulphuric acid but one great benefit of this process is that the used solvent can be regained by distillation and can be re-used. More than seventy percent of solvent can be re-collected by this process.

Table 5- economic analysis of solvent extraction method

Oil amount	Price of carbon tetra chloride	Ammonium sulphate price	Total cost	Oil yield (ml)	Oil price Per litre	revenue	Profit (BDT)
For 100 ml	5.07	.0924	5.16	83.05	105	8.3	3.14
For 1000 ml (if it is done in 10 steps)	16.73	9.24	25.971	83.05	105	87.2	61.23

From economic analysis it can be clearly seen that, though initial cost of required material of solvent extraction was relatively higher but the reuse of it reduce the cost eventually. On the other hand the higher yield of solvent extraction makes it more profitable than acid treatment. Limited one time use of acid, neutralization cost of acid treated oil, comparatively lower yield and treating cost of acid sludge all these make acid/clay treatment more costly. On the other hand re use of solvent and higher yield of re-refined oil give solvent extraction more acceptances from economical point of view.

ENVIRONMENTAL IMPACTS

To make suitable for practical use some organic metallic additives have to be added so that the lubricant can reduce friction and heat in the engine. These additives are called poly-chloro-bi-phenyls (PCBs) and poly-chloro-ter-phenyls (PTBs) etc. [6]. These additives have been found environmentally hazardous and can cause cancer of liver and kidney and it also causes suffocation, deformities in newly born children and other animals if consumed in high dosages. The regular contact of used lubricant on human skin or entry of its additives in the food chain can cause cancer

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Re-refining of used oil can reduce the risks related to used lubricating oil. The regeneration of used lubricants not only helps the world to reduce hazards and wastes but also conserves a signification amount of energy. However, many conventional technologies used today may create environmental problems, such as acid treatment which produce highly toxic acid sludge that are very difficult to handle. If it is disposed to the environment, separated sludge can cause severe pollution as they are concentrated forms of contaminants, [11].

Unfortunately used oil collected is catered to oil reclamation industry, which has hefty growth in Bangladesh in the form both legal and illegal plants in various congested areas of Chittagong and other parts of Bangladesh. Although the government of Bangladesh banned acid treatment of used oil, this technology is still under practice by different industries in these areas. It is now an open secret and the authority is callous to taking effective measures. As result the environment and ecology of Bangladesh are losing their balance. The harmony of bio-diversity is destroying. The industries dump the acid sludge even in open areas. They even do not perform the pre-treatment of acid sludge before dumping. As a result the toxic element of it easily mixes with air and water. As the mass people of Bangladesh are not concerned about the perilous effect of acid treatment the situation is going to be worsened day by day. The havocs caused by these practices are immense and it is high time for the government of Bangladesh to take care of this genuine hazardous issues. Bangladesh is under serious threat of global warming and environmental pollution. Now it is very important to undertake proper step to replace this environmentally hazardous technologies with more sustainable and environmental friendly methods. Considering this solvent extraction could be a better alternative of acid treatment in re-refining of used lube oil.

CONCLUSION

Re-refining of lubricating oil helps us both economically and environmentally. Two different sets of processes were used to study re-refining used lube oil. Solvent extraction by carbon tetra chloride followed by further treatment with ammonium sulphate and acid treatment followed with the clay-percolation. The treated oils were analyzed for pour point, flash point, water content, viscosity index, total acid number (TAN), specific gravity, sulfur content and metal content. An economic analysis from market information was done and it clarifies the economic viability of solvent extraction. The hazardous effect of acid treatment to the natural and bio environment can be minimized to a safe level by adopting solvent extraction as the alternative. Environmental impact analysis clearly strengthens this fact. Since the efficiency of purification and hydrocarbon recovery of used lubricants depends on the degree of mixing between organic solvents and the components in used lubricants, improving the mixing mechanism in the purification and hydrocarbon recovery reactor is required in the future. For optimization of solvent performance different types solvent can be used for solvent extraction for example benzene and mono ethylene ketone can be used.

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ICPE – (2016-014)

Removal of Phenolic Compounds by Using Adsorption from Industrial Effluents

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ABSTRACT

Phenolic compounds exist widely in the industrial effluents such as those from oil refineries and the coal tar, plastics, leather, paints pharmaceutical and steel industry. Since they are highly toxic and are, in general, not amenable to biological degradation methods of treatment which are continuously being modified and developed. Possible methods include chemical oxidation, coagulation, solvent extraction, liquid membrane permeation and adsorption.

In the present study, three organic Phenolic compounds (Cresol, phenol and Nitro phenol) have been used to determine their adsorption from dilute aqueous solutions on cement kiln dust (CKD).

The adsorption studies were carried out in three stages. In the first stage the adsorption isotherm process was studied. A fixed amount of cement kiln dust (by-pass) with different initial concentration of the Phenolic compounds was used. The maximum adsorption capacity for cement kiln-dust CKD) was found to be:

q_{max} = 87 mg/g for Cresol, q max = 125 mg/g for phenol and q $_{max}$ = 101 mg/g for Nitro phenol.

An attempt has been made to represent the experimental data obtained by the Langmuir, Freundlich and Redlich-Peterson models. All the models were found to satisfactorily represent the experimental data under investigation with varying degrees of success. For solute systems, the experimental data were found to conform the Langmuir isotherm. Also, the results have been proven the favorability of such cement kiln dust for removal of the phenolic compounds

In the second stage batch process was carried out for phenolic compounds with different initial concentration and adsorbent masses, these variables affecting the external mass transfer coefficient. Different Design equations were obtained:

K_f = 0.9549 $M^{0.393}$ for the adsorption of cresol,

K_f = 1.918 $M^{0.983}$ for the adsorption of phenol and

K_f = 1.667 $M^{0.7217}$ for the adsorption nitro phenol.

K_f = 0.2043 $C_o^{-0.744}$ for the adsorption of cresol,

K_f = 0.7176 $C_o^{-0.983}$ for the adsorption of phenol and

K_f = 0.0997 $C_o^{-0.4775}$ for the adsorption nitro phenol.

The third stage of this work was carried using fixed bed column. The effects of process variables such as bed height, flow rate and breakthrough have been investigated. The results have been used to predict the effect of parameter changes on the system by using the bed depth service time (BDST) and EBRT model.

Key words: adsorption, mass transfer, wastewater-treatment process.

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INTRODUCTION

1. INTRODUCTION

Phenolic compounds are aromatic compounds containing hydroxyl group and Phenol is a colourless crystalline solid melting point 43 ^{o}c, boiling point 182 ^{o}C which turns pink on exposure to air and light. Phenol is used as antiseptic and disinfectant, and in the preparation of dyes, drugs, bakelite, etc [1].

they are classified as monohydric, trihydric phenols, etc, according as they contain one, two, three etc., hydroxyl groups [2].

Phenol, on treatment with chlorine or bromine water, gives an immediate precipitate of the 2, 4, 6-trihalgone derivative [3].

cresols (together with a little phenol) is known as cresylic acid or creosote, and is used for preserving purpose, e.g. timber, railway sleepers, etc. A solution of cresols in soapy water is known as Lysol, which is used as disinfectant [4].

Cresol occur in the middle and heavy oil fractions of coal-tar. The mixture of the three Nitro phenol when treated with nitrous acid, phenol forms mainly p-nitrophenol, and a small amount of the o-compound. p-Nitrophenol crystallizes from hot water in pale yellow needles which readily turn brown. On other hand, it crystallizes from either in brownish-green flakes. This colour suggests that p-nitrophenol may have a quinoid structure [5].

2. SELECTION OF WASTE WATER TREATMENT PROCESS

The selection of a wastewater-treatment process or a combination of processes depends on:

- The characteristics of the wastewaters. This considers the form of the pollutant, i.e., suspended, colloidal, or dissolved, the biodegradability, and the toxicity of the organic and inorganic components [6].
- The required effluent quality. Consideration should also be given to possible future restrictions such as an effluent bioassay aquatic toxicity limitation.3) The costs and availability of land for any given wastewater-treatment problem [2].

3. AIM OF THE WORK

The present work was aimed to use a solid waste (cement Kiln Dust, CKD) to remove different types of phenolic compounds from aqueous effluent. Two forms of cement kiln dust were tried, a powder form and some pellets from. They were used to remove:

Phenol, Cresol, and Nitrophenol.Different adsorption isotherms were tested to reach the optimum condition for cleaning an effluent containing phenolic compounds. The Batch and the fixed bed process were also investigated for the phenolic solute compounds adsorption.

3.1. Material used

Phenolic Compounds (as adsorbate) Phenol (Hydroxytoluene), Cresol, and Nitrophenol.
Cement Kiln Dust (as adsorbent) The by-pass-kiln dust was collected from Al-Koms Portland Cement Factory
The sieve analysis proves that the particle size ranged between 0.3 mm to less than 0.075 mm with 85% less than 0.18 mm diameter.

3.2. Experiments

Equilibrium isotherm experiments:

A fixed amount of adsorbents was added to bottles containing 0.025 L of organic solution (different initial concentrations C_0). The bottles were sealed and shaked at room temperature (22 ^{0}C $\pm$ 2) for a period of 3 days till equilibrium is attained. Resultantsolution concentration (Ce) was determined using UV-Spectrophotometer.

Adsorption Reactor
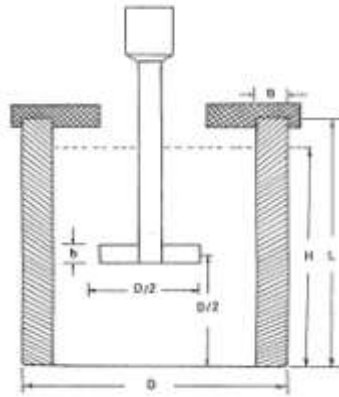
L	D	H	B	B
20 cm	13 cm	D	0.075 D	0.1 D

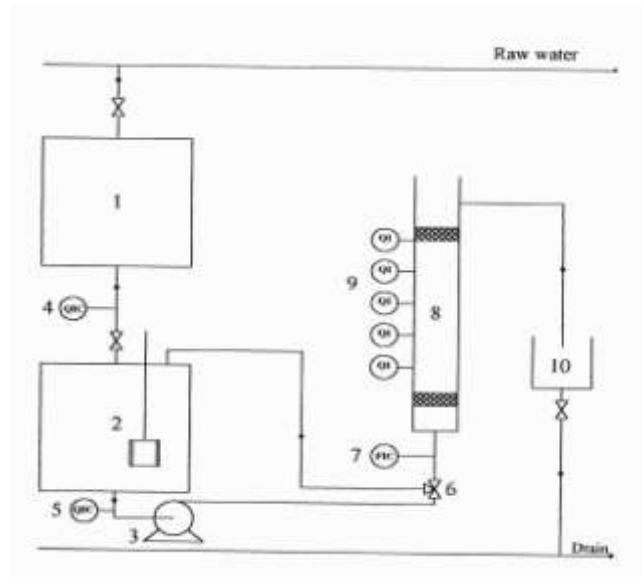Figure 1: Batch Adsorption

Fixed Bed Reactor

Figure 2: Schematic Diagram of Fixed Bed System

3.3. Equilibrium Isotherm

The three general isotherm models used in this study in their linear form:

> Langmuir, $C_e / q_e = (1/K_L) + (a_L / K_L) C$ (1)
> Freundlich, $\log q_e = \log KF + (1/n) \log C_e$ (2)
> Redlich-Peterson, $\log \{[(k_{RP} C_e)/qe] - 1\} = \log a_{RP} + \beta \log C_e$ (3)

3.4. Kinetic Studies

Adsorption Mechanism and process can be described by three steps:

i)   Mass transfer from the bulk solution to the particle surface
ii)   Adsorption of solute onto active sites.
iii)   Internal diffusion of solute
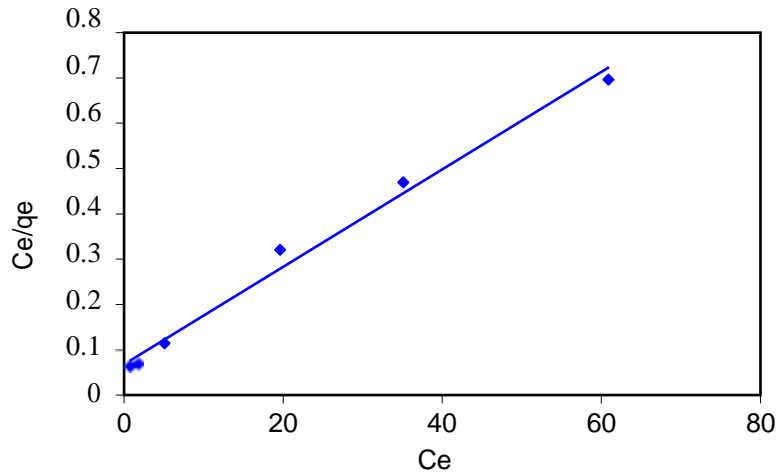
4. RESULTS AND DISCUSSION

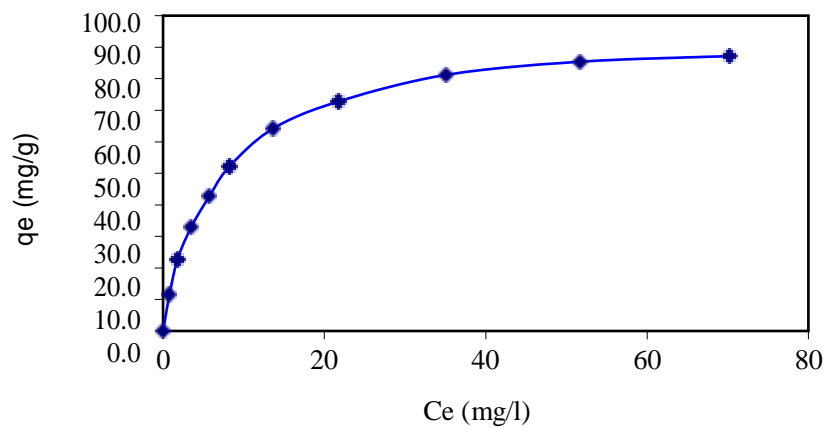Figure 3: Equilibrium Adsorption Isotherm for Cresol onto CKD

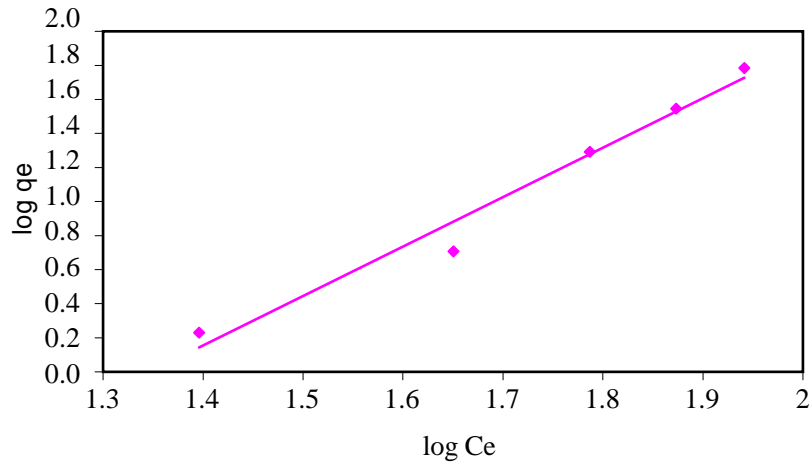Figure 4: Langmuir Isotherm for Cresol onto CKD

Figure 5: Freundlich Isotherm for Cresol onto CKD

Figure 6: Redlich-Peterson Isotherm for Cresol onto CKD
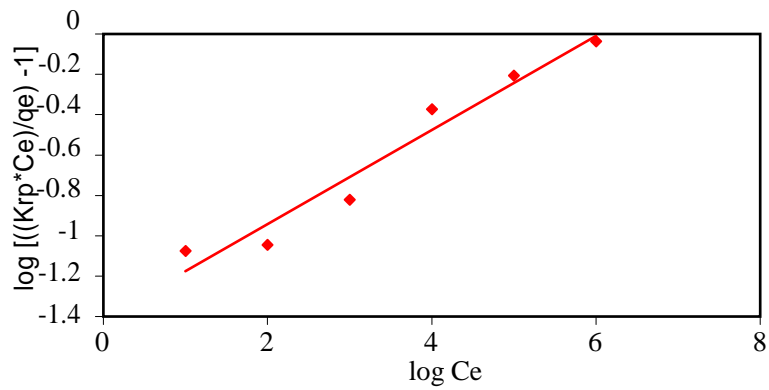
Isotherm Shape: The essential characteristics of Langmuir isotherm may be expressed in terms of a dimensionless equilibrium parameter R (235), which is defined by:

$$R = 1/(1 + a_L c_O) \qquad (4)$$

Table 1:

Value of R	Type of isotherm
R >1	Unfavourable
R=1	Linear
0 < R < 1	Favourable
R = 0	Irreversible

The equilibrium parameter R, indicates the isotherm shape. R values are incorporated in Table 2. they are in the range $0 < R < 1$, which means that the adsorbent chosen are Favourable. Data from equilibrium studies proved that at initial concentration between 140 to 10 mg/l, the percentage removal of Cresol ranging from 49.8 % to 92%, for the removal of phenol was from 71.4% to 93% and for Nitrophenol removal was from 57.9% to 95 %.

Table2: Langmuir constants for Phenolic solute adsorption systems:

Adsorbent	Cement Kiln-Dust				
	K_L dm^3/g	a_L dm^3/m	q_{max} mg/g	R	r^2
Cresol	14.707	0.158	87.2	0.0953	0.989
phenol	14.771	0.069	125.1	0.281	0.991
Nitro phenol	19.94	03575	101.4	0.374	0.96

Table 3: Freundlich constants for Phenolic solute adsorption systems:

Adsorbent	Cement Kiln-Dust		
	K_F dm^3/g	b_F	r^2
Cresol	17.644	2.409	0.944
phenol	16.271	1.512	0.989
Nitro phenol	15.848	2.071	0.996

Table 4: Redlich-Peterson constants for Phenolic solute adsorption systems

Adsorbent	Cement Kiln-Dust			
	K_{Rp} dm^3/g	B_{Rp} dm^3/mg	β_{Rp}	r^2
Cresol	14.335	0.039	0.233	0.868
phenol	13.293	0.0816	0.338	0.931
Nitro phenol	19.94	0.0362	0.882	0.895

4.1. Kinetic of Adsorption in Batch Adsorption

It is necessary to study the kinetics of adsorption in batch systems in order to determine the rate limiting step in adsorption process. System kinetics has been obtained by the mathematical modelling of mass transfer mechanism in adsorbate/adsorbent contact systems. Basically, the adsorption process is described by the following three steps:

i. Mass transfer of solute from the bulk solution to the particle surface (external mass transfer) .
ii. Adsorption of solute onto active sites; and;
iii. Internal diffusion of solute via either a pore diffusion, or a homogeneous surface diffusion model.
In the process of establishing the rate limiting step (s), step (ii) is assumed rapid and thus not considered in any kinetics analysis in the present work. Consequently, the two-rate limiting steps

considered are external mass transfer and intra-particle diffusion. The development of models base on two such mass transfer steps occurring simultaneously is quit complex, therefore
simplifying assumptions were made and attempts to describe the adsorption processes in terms of either an external mass transfer or an internal diffusion mass transfer parameter have been undertaken. Powdered cement kiln-dust was used during these kinetic studies.
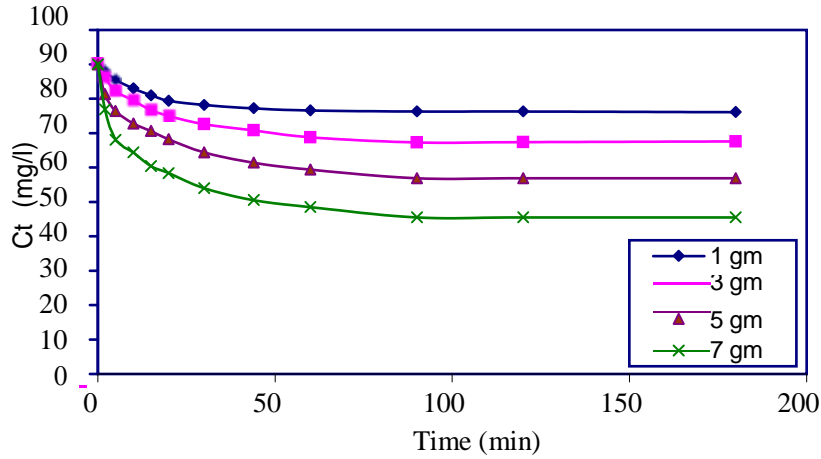

Figure 7: Effect of CKD mass on the concentration decay curve for Cresol

4.2. External mass Transfer

Resistance to mass transfer lies mainly in boundary layer film around the adsorbent particles. So, experiments, therefore, were taken at a well agitated vessel to achieve completely mixed systems consequently, there was a considerable shear force on the boundary layer film which made this initial resistance to mass transfer layer film fairly low, and hence the intrinsic adsorption rate was rapid until an external surface coverage of phenolic compounds (adsorbate) had occurred on the adsorbent. A more rapid model method of determining external mass transfer coefficient (K_f) is possible, from the boundary condition shown in Equation (5)

$$K_f = -\frac{V}{A_P}\left[d\left(\frac{C_t}{C_O}\right)\Big/ dt \right]_{t=0} \tag{5}$$

V is the solution volume and A_p is the external surface area of the adsorbent. The total outer surface area of the adsorbent particle can be determined from the mass (m) and density (ρ) for solid and by assuming spherical particle of constant diameters, dp, that is

$$A_P = 6m\Big/\left[\rho\, d_p\left(1-\varepsilon_p\right)\right] \tag{6}$$

The K_f values can be correlated by an equation of the general form:

$K_f = A(\text{variable})B$ (7)

or in the logarithmic form

$\log K_f = \log A + B \log(\text{variable})$ (8)

where the variable can be adsorbent mass and initial adsorbate concentration.

4.3.   Effect of adsorbent mass

The effect of cement kiln-dust mass on the adsorption of the three solutes of phenolic compounds were shown in Figures 6. and 7. respectively. In all cases the rate of phenolic solute compounds uptake
increased with increasing adsorbent mass. The external mass transfer coefficient, K_f, were determined using Equation (5) and are plotted as log K_f against log M as shown in Figure 8.
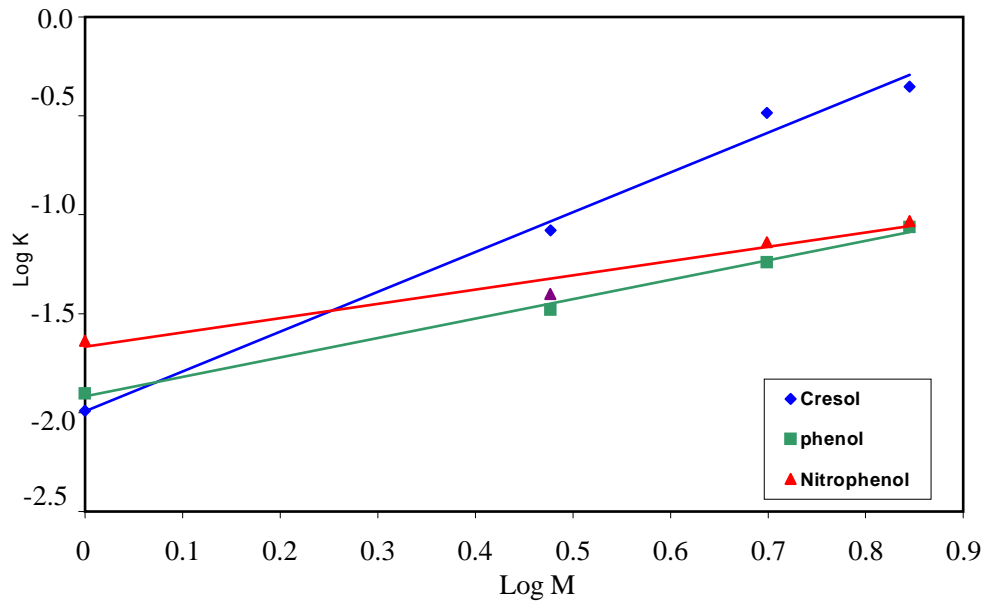

Figure 8: Effect of CKD masses on the external mass transfer coefficient

The external mass transfer coefficient depends on the driving force per unit area, and in this case, since C_0 is constant, increasing the mass of adsorbent increases the surface area for adsorption and hence the rate of adsorbate removal is increased.

The data given in Figure 8. fit the equations:

$K_f = 0.9549 \ M^{0.393}$ for the adsorption of Cresol,

$K_f = 1.918 \ M^{0.983}$ for the adsorption of phenol and

$K_f = 1.667 \ M^{0.7217}$ for the adsorption Nitrophenol.

5. CONCLUSION

From the set of experimental and theoretical analysis on adsorption of phenolic solute compounds the following conclusions can be made:

i.   The of the three solutes of phenolic compounds using cement kiln-dust indicates that it has a good ability to adsorb considerable amount of phenolic solute compounds. Adsorption.

ii.   The obtained results indicates that the cement kiln dust maximum adsorption of phenolic compounds were as follows: cresol = 87.2 mg/g, phenol = 125 mg/g, nitrophenol = 101.4 mg/g.

iii. Adsorption isotherms for the three solutes under study were determined and the data obtained were analyzed using Langmuir, Freundlich and Redlich-Peterson isotherms models.

iv. A comparison between experimental and calculated data using the previous models indicates that Langmuir model shows a better agreement than the others while Freundlich gives some disagreement than the others.

v. The maximum uptake for the powdered cement dust were calculated and it was found: cresol = 92 %, phenol = 93 % and nitrophenol = 95 %.

vi. Kinetic study using batch processes for the adsorption of the three solutes were made.

vii. Analysis of the contact time data gives an indication of the mechanism and the external mass transfer involved in an adsorption techniques using different concentration and masses. The following equations were obtained:

$K_f = 0.9549 \, M^{0.393}$ for the adsorption of cresol,

$K_f = 1.918 \, M^{0.983}$ for the adsorption of phenol and

$K_f = 1.667 \, M^{0.7217}$ for the adsorption nitro phenol.

$K_f = 0.2043 \, C_o^{-0.744}$ for the adsorption of cresol,

$K_f = 0.7176 \, C_o^{-0.98}$ for the adsorption of phenol and

$K_f = 0.0997 \, C_o^{-0.4775}$ for the adsorption nitro phenol.

viii. The sorption of phenolic compounds by cement kiln-dust pellets a fixed bed column was studied. The experimental results showed that the adsorbent removes the phenolic compounds effectively and the change in the column operating parameters, such as flow rate and bed height.

ix. A bed depth service time model (BDST) has been applied as a quick design method for a fixed bed and has been successfully applied to the adsorption system where the variables studied include bed height and flow rate.

x. The Empty Bed Residence Time (EBRT) technique has been applied successfully to optimize the adsorption process variable. Plots were relative to the liquid retention time. obtained which could be used to predict the optimum CKD exhaustion rate.

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Impact of Oil spillage on Agricultural Production

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ABSTRACT

World economy largely hinges on agriculture and the agriculture is fostered by environment. Several reasons are responsible for the degradation of environment and oil spillage is one of the critical factors. The main purpose of this study is to examine, highlight, and understand the devastating impact of oil pollution on agricultural production in Bangladesh by observing the devastating impact of oil spillage due to some adverse results including leakage , sabotage etc. on the life of the ecosystem. Bangladesh has experienced such types of catastrophe in 2014 after the oil spillage in Shela River due to the collusion between oil-tanker and cargo vessel in Sundarban. This study is a combination of both qualitative and quantitative research methods for finding the impact of oil spillage on agriculture. Qualitative research method runs the gamut of Personal interviews, Observation and Focus Group Discussion (FGD). Questionnaires are the primary Quantitative instrument employed in collecting data. The result of the study describes certain factors such as irrigation problem due to the pollution of surface water, bio-diversity losses and hazardous impact on human health and high rate of environmental degradation. It can be recommended that to mitigate the degradation of environment and lessening the impact on agriculture by oil spillage, control should be taken to transport oil throughout the river and EIA must be ensured by Bangladesh Petroleum Corporation (BPC) to mitigate the pollution executed by petroleum industries of Bangladesh.

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INTRODUCTION

The coast of Bangladesh is familiar as a zone of multiple susceptibilities as well as opportunities. It is prone to several natural disasters and devastating situations, such as storm surges, cyclones, floods and river erosion. Apart from these, in combination with the other natural hazards, man-made hazards in various forms and degrees like land-based pollution from agricultural, chemical, industrial residues are also familiar in Bangladesh coastal zone. Farm effluents, solid waste, sewage disposal and top of all pollution from ships are occurred sonorously due to both operational and accidental oil spillage. The impact of oil spillage has so much dangerous and environmentally deleterious impact for agricultural society who lives their lives depending on agricultural practice, catching fishes. On 9th December 2014, an oil tanker accident in the Sundarbans of Bangladesh led incontrovertibly to the release of approximately 358,000 liters of heavy fuel oil into the river and mangrove ecosystem [1].The response to the accident was conducted by the Ministry of Environment and Forests along with its affixed departments, Department of Forest and Department of Environment, with the help of local commodities. Concern about the potential impacts of the oil to the ecosystem and the communities that depend on it for their livelihoods, led the Government of Bangladesh on 15 December 2014 to request the United Nations Development Program (UNDP) provide technical assistance in evaluating the impacts of this oil spillage and supporting the response[2]. The number of factors including timely tidal variations and resolution to veto the tanker traffic in the river has minimized gradually the puncturing of oil into the mangrove ecosystem.The lack of a quick oil spill contingency plan which requires sharply an appropriate competent authority to oversee the response to the impact of oil spillage. The past recent oil spillage occurrence in Bangladesh is including a rail bridge broke down over nearby Boalkhali canal, oil-filled train wagons to loco mote and spill thousands of liter of furnace oil. The oil wagons started from Chittagong Port with approximate 240000 liters of furnace oil and were headed to Dohajaree for 100MW Dohajaree Peaking Power Plant has created a serious caution light[3]. At the same time these incidents provide a stunning knowledge–sharing opportunity to make healthy the national oil spill preparedness, and a sonorous response capacity[4]. It is possible and also it is the chief impetuous to establish robust mitigation measurements to mitigate the conflicting of oil tankers in the river and to mitigate the impact of oil spillage and also appropriate safeguards for all significant marine routes with immediate attention. It is important to recommend improvements in national oil spill preparedness and a quick response to the impact of oil spillage and improved vessel traffic management.

METHODOLOGY

The present study has been carried out by questionnaires method and Focus Group Discussion (FGD) in the commodities nearside Karnaphuli River on 24th June, 2015.The ecosystem of Karnaphuli river has been facing a huge threat after a rail bridge broke down over nearby Boalkhali canal, oil-filled train wagons to loco mote and spill thousands of liter of furnace oil. The oil wagons started from Chittagong Port with approximate 240000 liters of furnace oil and were headed to Dohajaree for 100MW Dohajaree Peaking Power Plant. Overall two focus group discussions (FGDs), four semi-structured interviews (SSIs), and 100 household interviews have been conducted as part of the rapid and robust evaluation. Respondents have been chosen randomly; capturing the main occupational groups of the affected areas.

Of the total household interviews, 43 were male and 27 were female. The average age was 35-40 years [5]. The interview survey has been focused on livelihoods and health perceptions. FGDs and SSIs have been conducted to assess the perceived health and livelihood impacts over a wider area and also tomeasure out the interview survey results. The respondents of the assessment are heterogeneous with regards to livelihood, with the oil collectors and non-collectors having the professions of shrimp post larvae collectors, housewives, fish businessmen.The oil contains many compounds that have detrimental and acrimonious effect to humans, primarily volatile organic compounds (VOCs), including PAHs, as well as sulphur- and nitrogen-containing compounds and metals. When oil is burned, additional PAHs can be formed as combustion by-products along with small dust particles. Actually, the oil spillage occurrence that stumbled on in Karnaphuli River is not so much big incident if we compare it with the incident of Sundarban oil spillage incident. In Bangladesh, the main acrimonious incident of spilling oil was brought to light in Sundarban River on 9 December, 2014 at around 5 a.m local time due to the colliding of two oil carrying vessel and tanker. The incident occurred in Shela River and about 357,664-liter heavy fuel oil spilled and dispersed in the river[6]. The Sundarban oil spillage incident created so much devastating and topsy-turvy situation for Bangladesh. The Department of Forest and the Department of Environment, (MoEF) was about to response on 10th December. Bangladesh Petroleum Corporation started buying collected oil from the commodity on 11th December and on 12-13 December; MoEF assessment team that runs the gamut of 13 people just visited the incidental area. On 15 December, GoB just created an interministerial body which was robustly commanded by the Ministry of Shipping to mention the spill of oil. UNDP proposal was approved by Ministry of Finance, Economic relations Division on 16 December. On 18 to 20 December, a UN-led team just arrived in Bangladesh from France, Japan, Switzerland for assessment.21st December, BPC reported collection of oil was 68200 liters[7]. After robust evaluation and assessment finally, on 1-15 January, assessment team integrated feedbacks from key stakeholders and submitted the final compendium report to GoB. Even if the team, the ministry, and other associate department did their activities sonorously to investigate oil spillage, that spillage caused huge loss to the aquatic environment, wildlife and ecosystem, human health and socio-economic activities. The devastating impact or result of this oil spillage is being discussed in the result section.

RESULT AND DISCUSSION

In result and discussion chapter, the overall impact of devastating oil spillage on population, wildlife species and fishes are discussed in the case of Sundarban and in the case of commodity beside Karnaphuli River. Table 1 shows the population of affected communities. Table 2 summarizes the results of the various forms of visible oil. Table 3 shows the results of the various forms of non-visible oil. Figure 1 provides the visible forms of oil. Figure 2 shows the Distribution of wildlife species and observed oiling status. Figure 3 provides the Collection of fish after the spill. Figure 4 shows the impact of oil spillage in the community beside Karnaphuli River.

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Table 1: Population of affected communities (Source: Union Parisad E-service centre)

Union: Chila, Upazila: Mongla, District: Bagerhat						
Ward No	**Ward- 4**	**Ward- 5**	**Ward- 7**	**Ward- 8**	**Ward- 9**	**Total**
Name of Village (14 villages)	**Gabgunia**	**Paschim Chila**	**Dakhin Joymony**	**Moddhya Joymony**	**Uttar Joymoni**	
Total number of families	352	544	429	265	452	2042
Total population	1442	2196	1570	1586	1579	8373
Male	739	1102	801	789	813	4244
Female	703	1094	769	797	766	4129

Table 2: Results of oil surveys for different visible fractions

Forms	Aspects	Control /result mission	Recommendations
Visible	Oilcoatedvegetation	Survey / High evidence	Updateand extent the survey
	Stranded oil	Survey / No evidence	
	Floating oil	Survey / No evidence	
	Oileddebris	High evidence	None

Table 3: Results of oil surveys for various non-visible fractions

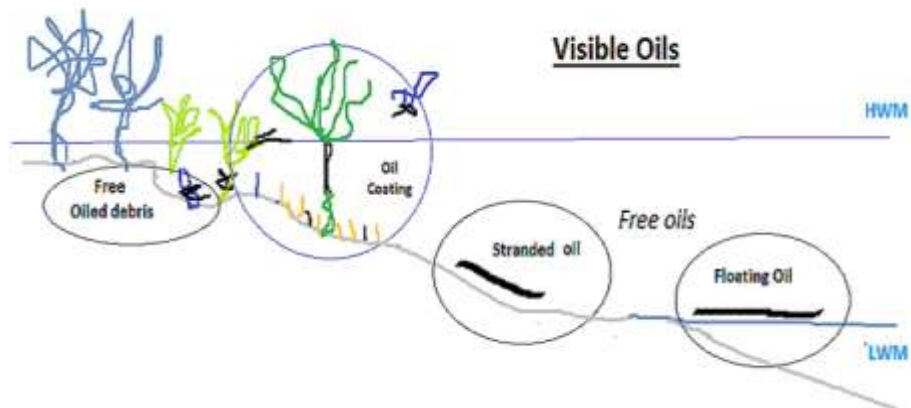| Forms	Aspects	Control /mission result	Recommendations
Non Visible	Buried stranded oil	Observation (1) 4 controls (no evid.)	Local checking (eventualsurvey, if positive)
	Dispersed oil Dissolved oil Ingested oil	Sampling Control (no evidence)	Monitoring on a regular basis
	Sunken oil	Survey / No evidence	Update and extend the survey

Figure 1: Visible oils in the environment (HWM– high water-mark, LWM– low water-mark)

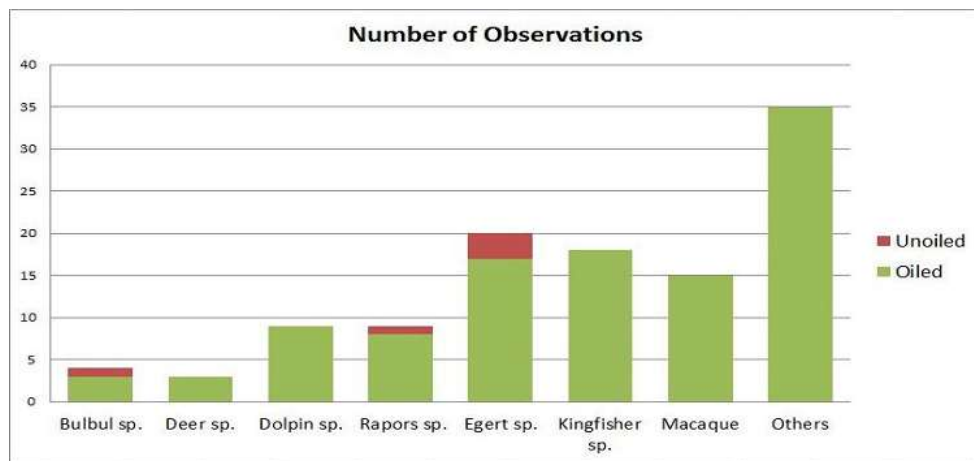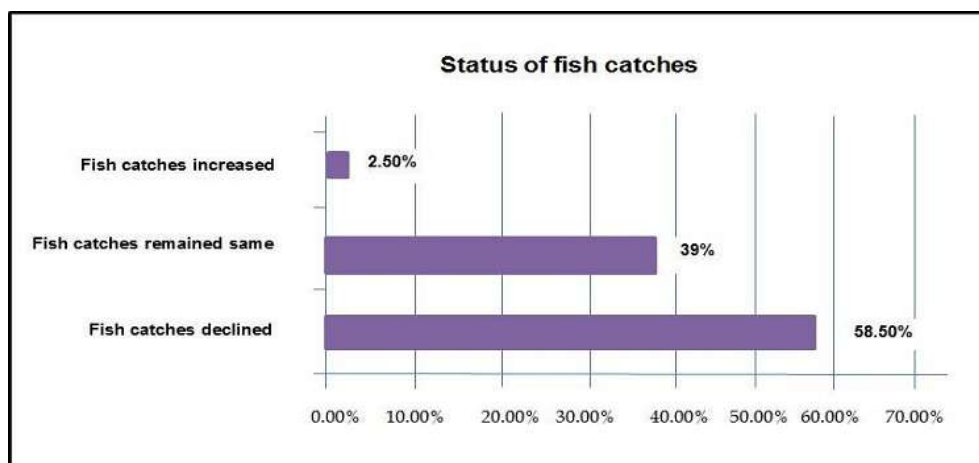Figure 2: Distribution of wildlife species and observed oiling status

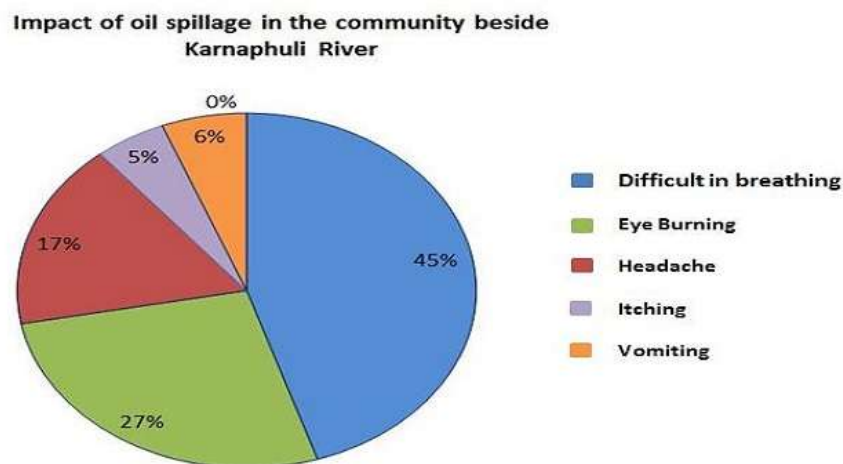Figure 3: Collection of fish after spill

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Figure 4: impact of oil spillage in the community beside Karnaphuli River

CONCLUSION AND RECOMMENDATION

Some recommendations are required to investigate and mitigate the impact of oil spillage in Bangladesh. Action plan should be developed in consultation with all affected stakeholders -including all pertinent Ministers, and also must identify level-headed parties, timelines and necessary resources to supervise and evaluate the impact of oil spill.

In this paper we were focus on the following case:

- Addressing the impact of oil spill on environment and affected communities and making effort to wipe out the risk and danger of spilling oil is also the chief impetuous in mitigating oil spillage.
- Speed up efforts to quickly and safely dispose of all solid oiled debris and improve and implementan inclusive managementplan to ensure the waste does not pollute again the environment. Continuing oil spill supervision with the help and advocate of Department of Forest.
- Safely reducing gradually oiled nipa leaves and disposing them sonorously are also most indispensible in mitigating devastating impact of oil spillage.
- Promoting community responders with health check-ups and health monitoring and evaluating program should be under consideration and also should be directed properly.
- It is also important to recommend improvements in national oil spill preparedness and a quick response to the impact of oil spillage and improved vessel traffic management.Moreover,tracing avenues are palatable for compensation or requital and fostering pertinent livelihoods for Sundarbans resource dependent communities.
- Long term environmental monitoring plan is necessitate which will aid us with providing useful data for impact evaluation and observing the efforts in the event of future pollution disturbances.
- Moreover, without beefing up the inland vessel management which is required to control marine traffic in Sundarbanand without arrogating oil pollution response regulations in surveillance with

international best practices, it will be quite impossible to mitigate the acrimonious and incompatible situation of oil spillage.

- Finally Bangladesh Government should device its obligation under the International Convention on oil pollution Preparedness, Response and Co-operation (OPRC) to mitigate the devastating and catastrophic results of oil spillage in Bangladesh.

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ICPE (2016-057)

Review on Thermodynamic Applications for Natural Gas Liquid (NGL) Extraction from Natural Gas in Cryogenic Gas Processing

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ABSTRACT

This paper has applied thermodynamics principles to evaluate the reliability of Natural Gas Liquid (NGL) recovery from the process natural gas. In the production of natural gas products, Joule Thomson or Turbo-Expanders are widely used in the recovery of Natural Gas Liquids (NGL). Turbo-Expanders are used to recover cryogenic liquids from lean natural gas or to convert the energy of a gas stream into mechanical work as the gas or vapor expands through the expander. These liquids are what are commonly referred to as NGL. The turbo expander replaces the Joule-Thompson expansion valve used in a conventional refrigeration system. The expansion valve is isenthalpic (constant Enthalpy, no work or heat transfer) while the turbo expander takes work out of the system making it isentropic. The use of Turbo-Expanders, however, does not eliminate the need for the Joule Thompson valve. This is typically referred to as the expander bypass valve, but operates under the Joule Thompson effect. The second law of thermodynamics was applied in analyzing the refrigeration unit. The thermodynamics equations were utilized in the evaluation and characterization of key process parameters in natural gas liquid extraction plant.

Keywords: Natural Gas Liquids, Joule Thomson, Turbo-Expanders, Thermodynamics.

INTRODUCTION

The production and availability of natural gas liquid depend largely on the supply of raw natural gas from production wellhead and the operating conditions of the process unit that makes up the extraction plant[1].The composition of natural gas is an important factor in deciding what process configuration to employ for recovering natural gas liquids (NGLs). There is worldwide drive toward increasing the

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utilization of natural gas and the need to minimize energy consumption associated with the process. An important requirement in natural gas processing is that the process should be designed to be flexible to accommodate a range of natural gas compositions. The process choice is also guided by the cyclical nature of the market preference for ethane and propane. Traditionally, the ethane-plus richness determines the type of the process to be employed. The NGLs may be recovered by many methods. Some of them are: Compression, Straight Refrigeration, Cascade Absorption, Ambient Temperature Absorption, Adsorption, Joule-Thomson Expansion and Expander. Lean natural gas usually is processed by a cryogenic turbo-expander (TE) process while rich gas is separated using a non-cryogenic adsorption process.

The recovery of NG liquids (NGLs) has become increasingly economically attractive because a number of its components are often isolated and sold separately. Consequently, numerous methods exist to increase NGL recovery from a feed gas, with potential enhancements involving integrated processes. In a typical natural gas processing plant, various components of NGLs are separated one by one from the natural gas stream applying a series of fractionation columns namely demethanizer, deethanizer, depropanizer and debutanizer. Many studies have examined different techniques for the separation of natural gas liquids (NGL) and the different processes for natural gas dehydration. [2-4]

Natural gas liquid (NGL) is a general term applied to all the liquids recovered from natural gas and refers to ethane and heavier products. Natural gas contains valuable liquid components which can be efficiently extracted. Several extraction processes are proposed. The most important requirement imposed to their flexibility providing adjustment to a range of natural gas compositions and corresponding conditions. The natural gas liquids (NGL) may be recovered by compression, straight refrigeration, cascade absorption, ambient temperature absorption, adsorption and Joule-Thomson expansion [5].

Until the 1960s, the Joule Thompson (J-T) expansion valve was the only way to the cool gas plant streams by a pressure drop. Herrin in 1966 proposed the first turbo expander gas processing plant. The reversible expander cycle provides two distinct improvements over the J-T valve expansion. First in the reversible expansion, a large fraction of the work required to compress the gas can be recovered and used elsewhere in the cycle, thereby increasing the cycle efficiency [6]. Secondly, the reversible process results in a much larger cooling effect. Expander processes are simple in operation and provide several benefits compared to mixed refrigerant (MR) processes.

Cryogenic refrigeration liquefies Natural Gas Liquids (NGL) by operating at low temperature. These temperatures are achieved by the refrigeration system, typically Turbo-Expander/ Joule Thomson valve (throttling effect). At these low temperatures, ethane and heavier NGL in the gas stream condense, while methane remains in gas form. This allows for the NGLs to be separated in a de-methanizer column. Lowering the cryogenic refrigeration temperatures increases NGL yield, but at the cost of added energy. In addition, energy on the expander side is recovered to re-compress the gaseous methane effluent on the turbo-compressor side of the equipment. The cryogenic processes are categorized into turbo-expansion, Joule-Thomson (J-T) expansion, cascade refrigeration, and multi-component refrigeration in the gas processing industry. Due to the operating and economic advantages of turbo-expander plants, gas

processing industries mainly employ the processes based on turbo-expander plants for ethane recovery at different levels [7, 8].

A comparative study between different processes based on turbo-expanders with a typical natural gas feed is operated [9]. Based on the de-methanizer column pressure and the gas composition of the inlet feed [8] optimized a conventional turbo-expander process to attain the highest level of process profit surveyed processes using refrigeration cycles in ethane recovery plants by performing energy analysis[10, 11].

This paper examined the reliability of a cryogenic liquefaction of natural gas and the thermodynamic applications (Joule Thomson and Turbo-Expander, Fig.1) of Natural Gas Liquids (NGL) production in cryogenic gas processing.

THERMODYNAMIC APPLICATION FOR NGL EXTRACTION ISENTHALPIC PROCESS: JOULE THOMSON APPLICATION

Cooling of natural gas can be achieved by expanding high pressure gas to a lower pressure across an expansion valve. This is a constant enthalpy process, and the amount of the temperature reduction depends on the pressure ratio of initial pressure divided by the final pressure, the absolute pressures and the starting temperature, as well as the gas composition. This is a practical method to cool gas and extract hydrocarbon liquids. It is also a more practical process than the turbo-expander process for low gas rates, especially if the gas rates fluctuate. The main process equipment is the expansion valve. The high-pressure gas then flows through the expansion valve, which drops the pressure of the gas to the design pressure. Simultaneously, a reduction in temperature occurs. Depending on the gas composition and the pressure and temperature of the gas mixture, a certain amount of the mixture will condense and form a liquid hydrocarbon stream.

If a gas initial condition is P_1, V_1 and T_1. The gas was forced into a system and the gas came out of the system at P_2, V_2 and T_2. The system is insulated and $\Delta q = 0$. The work has two terms, Work done on the system to force the gas through the system and the work done by the system on the surroundings as it came out the other side of the plug.

Now the total work of the system, $W = P_1V_1 - P_2V_2$

As $\Delta q = 0$, the change in internal energy of the gas, $\Delta U = \Delta q + W = 0 + P_1V_1 - P_2V_2 = P_1V_1 - P_2V_2$

Now the system enthalpy, $\Delta H = \Delta U + \Delta(PV) = P_1V_1 - P_2V_2 + P_2V_2 - P_1V_1 = 0$

So Joule-Thompson's effect (Throttling process) is a constant enthalpy process. Co-efficient of Joule-Thompson's effect, μ_{JT} can be defined as: [12].

$$\mu_{JT} = \left(\frac{\partial T}{\partial P}\right)_H = -\frac{\left(\frac{\partial H}{\partial P}\right)_T}{\left(\frac{\partial H}{\partial T}\right)_P} = -\frac{\left(\frac{\partial H}{\partial P}\right)_T}{c_P}$$

For the liquefaction of the gas, the coefficient of J-T effect is important. It tells whether a gas cools or heats on expansion. The coefficient of J-T is a decreasing function of temperature and it passes through zero at the Joule-Thompson inversion temperature. In an expansion dp<0, whether dT is positive or

3

negative depends on the sign of μ_{JT}. It can be seen that if μ_{JT} is positive then dT negative upon expansion so that the gas cools. On the other hand, if μ_{JT} is negative then dT is positive so that the gas warms upon expansion [13]. In order to liquefy a gas by a Joule-Thompson expansion the gas must first be cooled to below the J-T inversion temperature.

ISENTROPIC PROCESS: TURBO EXPANDER APPLICATION

The turbo-expander's main application is treating natural gas streams for high liquids (NGL) recovery. The process achieves very low temperatures and, therefore, liquefies a substantial portion of the ethane and heavier compounds in natural gas. The turbo expander removes energy from the near isentropic expansion of a gas stream, which results in a drop in pressure and temperature by extracting useful mechanical energy. By using an expander to recover energy from the high pressure gas: the refrigeration effect is enhanced the reduction in gas temperature is greater than can be obtained by simple isenthalpic (Joule-Thomson) expansion across a valve Turbo-Expander process configurations can vary greatly. The turbo expander is likely the best choice for recovering ethane and heavier hydrocarbons from natural gas requires considerable analysis.

An isentropic process is a constant entropy process. If a control mass undergoes a process which is both reversible and adiabatic, then the second law specifies the entropy changes to be zero. A steady state reversible flow through an adiabatic controlled volume also has no entropy change from inlet to outlet. Both are isentropic processes. Although an isentropic process might be an idealization of an actual process, it serves as a limiting case, for particular applications.

Before expansion, the entropy of an ideal gas is S_1 and after expansion, it is S_2. Now the entropy change for an ideal gas as-

$$s_2 - s_1 = \int_{T_1}^{T_2} c_v \frac{dT}{T} + R \ln \frac{v_2}{v_1}$$

C_v = sp. heat of gas at constant volume

$$s_2 - s_1 = \int_{T_1}^{T_2} c_P \frac{dT}{T} - R \ln \frac{P_2}{P_1}$$

C_P = sp. heat of gas at constant pressure

For control mass undergoes (reversible and adiabatic process), the thermodynamic second law specifies the entropy changes to be zero. A steady state reversible flow through an adiabatic controlled volume also has no entropy change from inlet to outlet. So, $S_2 - S_1 = 0$

$$0 = \int_{T_1}^{T_2} c_v \frac{dT}{T} + R \ln \frac{v_2}{v_1}$$

$$0 = \int_{T_1}^{T_2} c_P \frac{dT}{T} - R \ln \frac{P_2}{P_1}$$

By integrating the above two equations,

$$0 = c_v \ln \frac{T_2}{T_1} + R \ln \frac{v_2}{v_1}$$

$$\Rightarrow \left(\frac{T_2}{T_1} \right)_s = \left(\frac{v_1}{v_2} \right)_s^{R/c_P}$$

$$0 = c_P \ln \frac{T_2}{T_1} - R \ln \frac{P_2}{P_1}$$

$$\Rightarrow \left(\frac{T_2}{T_1} \right)_s = \left(\frac{P_2}{P_1} \right)^{R/c_P}$$

Where, the subscript s indicates that the process occurs at constant entropy. The power on each expression is rewritten in terms of $k = c_P/c_v$ by noting that $c_P - c_v = R$, so $R/c_P = (k-1)/k$. So,

$$\left(\frac{T_2}{T_1} \right)_s = \left(\frac{v_1}{v_2} \right)_s^{k-1}$$

$$\left(\frac{T_2}{T_1} \right)_s = \left(\frac{P_2}{P_1} \right)^{\frac{k-1}{k}}$$

These equations are specified relations that are used for an ideal gas undergoing ideal process if the specific heats are considered to be constant. If the specific heat cannot be assumed as constants then the temperature dependence of the specific heats must be included. The variable specific heat solution for an ideal gas is undergoing an isentropic process [14].
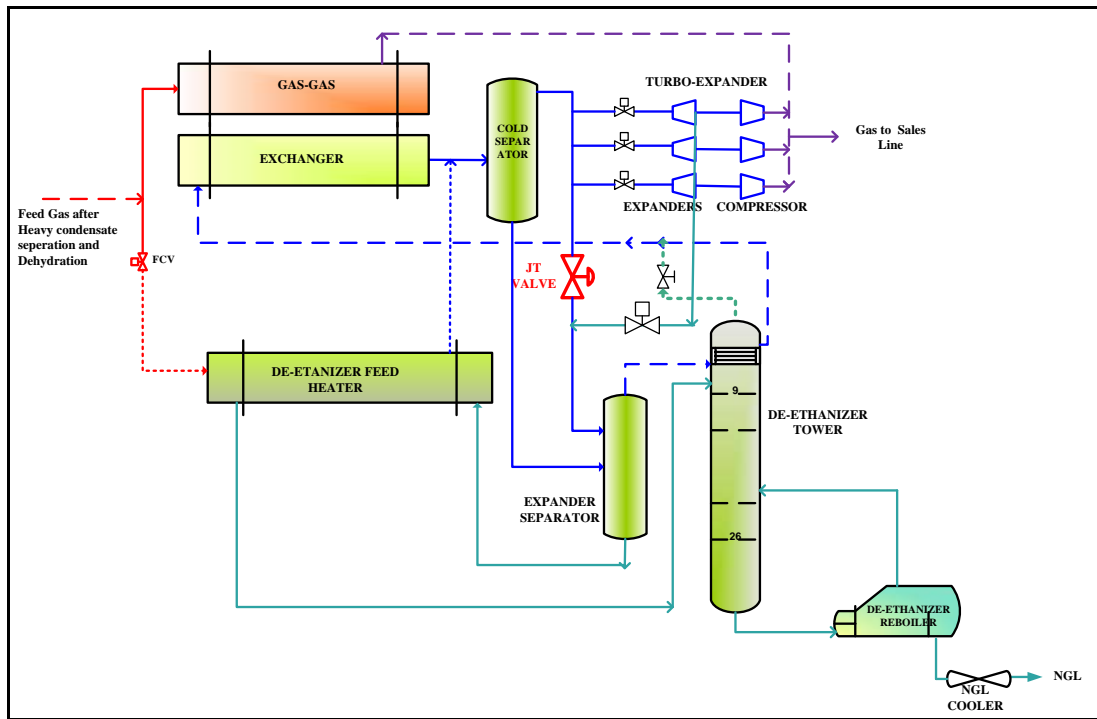

Fig.1: Cryogenic process flow diagram of NGL extraction by Turbo-Expander/Joule Thomson (J-T) valve from the process gas.

CONCLUSIONS

The feasibility of Natural Gas Liquids (NGL) recovery from the process gas depends on raw natural gas and applied thermodynamic application. The Joule Thomson process/Turbo-Expander applied process techniques and economic views related with the specified feed gas. Turbo-Expander process is technically and economically more feasible for NGL plus ethane recovery. With contrast, expansion across a valve (J-T) is isenthalpic producing no work. Resulting temperatures are not as low as those achieved by the expander and less liquefaction takes place.

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