AN ALTERNATIVE METHOD OF PETROLEUM WASTE (SLUDGE) DISPOSAL USING CAPSULATION METHOD

(A CASE STUDY OF PPMC KADUNA)

BY

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A PROJECT SUBMITTED TO THE DEPARTMENT OF CHEMICAL ENGINEERING SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA NIGER STATE.

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DECLARATION

I ABDULAZEEZ JAMILA declare that this project presented for the Award of Bachelor of Engineering in Chemical Engineering under supervision of has not been presented either wholly or partially for any degree elsewhere.

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ABDULAZEEZ JAMILA. DATE

DEDICATION

I dedicate this project work to almighty Allah who is the author of all lifes. So also I dedicate this project to my beloved parents Alh. and Hajia Abdulazeez, Alh, and Hajia Abdulwahab and all my siblings; Mohammad Kazim, Abdulhafiz, Aisha and Nafisat.

I love you and may almighty Allah bless you all (amin).

CERTIFICATION

This is to certify that this project titled "AN ALTERNATIVE METHOD OF PETROLEUM WASTE (SLUDGE) DISPOSAL USING CAPSULATION METHOD, under the supervision of Engr. Elizabeth Eterigho and submitted to Chemical Engineering Department of the Federal University of technology, Minna in partial fulfillment of the requirement for the award of Bachelor of Engineering (B. Eng) Degree in Chemical Engineering.

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ABSTRACT

This research looked into the present petroleum waste (sludge) disposal and an alternative method was proposed. The method used in this project is the "capsulation method". During the process a mixture of gases was collected during the reaction which contain methane as the predominant gas. With equal proportion of sludge and quick lime about 94.46% of methane gas was produced. Greater proportion of sludge gave 1.64% of methane gas, and when the proportion of quicklime was increased than the sludge, 98.9% of methane gas was produced.

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CHAPTER ONE

1.0 INTRODUCTION

Pollution can be defined as the contamination of the environment by man – made substances or energy that has adverse effect on living or non-living matter. These contaminations of air, H_2O or soil materials interferes with human health, the quantity of life, or the natural functioning or ecosystem simple terms, pollution can be seen as the substances in the wrong place in the wrong quantity at the wrong time. This implies that harm is caused to the environment and if the same substance is present at level too low to cause harm, then it can be considered as contamination. Many substances that can be pollutants also occur naturally, in which case they are not classified as pollutions. However, other pollutant s result entirely from human activity such as artificial form of radioactivity particular from nuclear waste and most toxic organic compound e.g. Petroleum waste (sludge) (Encarta Encyclopedia standard, 2005).

Pollution of water, air, atmosphere etc. means to make them, dirty, impure and dangerous for people, plants and animal chemical. Pollution therefore is the process of polluting the available H_2O resources, air, and atmosphere etc. pollution could make human and animal existence very unbearable if not controlled (Odigure, 1998).

Hydro-carbon is a major constituent of petroleum sludge is a compound of hydro-carbon found in liquid solid or gaseous state. Is also an environmental pollutant.

Petroleum generally, is a mixture of alkanes containing 85-86% carbon 12-14% hydrogen, Oxygen, nitrogen, sulphur aromatic hydrocarbons and impurities. Petroleum is further defined both in a standard Nigerian oil mining lease in section 14 (1) of the petroleum act as "mineral oil" or any related hydrocarbon and natural gas as it exist in it sedimentation debris (sludge) of product storage tanks in oil refineries (Duffus, 1980)

Petroleum sludge which constitute environmental nuisance if not properly disposed off is a chemically derived hydro-carbon slurry sedimentation at the bottom of oil storage tanks. It is a flow of very wet, semi solid, highly mobile mud of hydrocarbon deposits. (Monkhonse, 1976).

Although presently, there is a great amount of environmental impact awareness, most of which industries still discharge without proper treatment which result into migration of oil in to the water table is dangerous to both plants and animals.

Based on the problem caused by the charged pollutants into Nigeria's environs, (land, and water,) and the Federal Environmental Protection Agency (FEPA) (Decree # 48) decrees at encouraging industrialist to take waste minimization and management into serious consideration. In any waste management operation the two main objectives are:

- To conserve valuable resources used in production and
- To ensure that any discharge into the environment does not have harmful effect on human, animal and plant life (James, 1981).

With an appreciationable amount of sludge generation. From the Nigeria oil sector. It is desirable to put in check method(s) of petroleum waste (sludge) disposal. Thus, having identified sludge generation, the capsulation method is aimed at providing an alternative method to petroleum waste disposal in Nigeria..

Capsulation is a term applied to mean confirmation of ingredients, the sludge inclusive such that the wrapped materials do not escape to the adjoining vicinity.

1.1 AIM AND OBJECTIVES

The major aim of this project is to develop an alternative way of waste disposal by using the capsulation method.

The aim of this research work will be achieved via the realization of the following objectives.

- To study or examine the present method of petroleum sludge disposal.
- Determine the inadequacies of the different method of petroleum sludge disposal.
- Proposed a new method [capsulation method] of sludge disposal.

1.2 SCOPE OF WORK

The petroleum industry in Nigeria is perhaps the most active and important in terms of scale and finance. The scope of the study is centered mainly on the treatment and disposal of sludge. During the course of the study, different methods of sludge disposal which can be used or applied generally to almost all oil producing company will be discussed but the work is more limited to the operation of pipeline and product marketing company (PPMC, Kaduna)

1.3 JUSTIFICATION

Good waste disposal methods are of great importance all over the world with Nigeria (one of the longest oil providing country) not being left out. Research into an alternative method (Capsulation method) is not to reduce the rate of environmental pollution but would be of great domestic importance

CHAPTER TWO

2.0 LITERATURE REVIEW

Pollution generally, is the introduction by man into the environment of substance or energy liable to cause hazards to human health, harm to living resources and ecological systems, damage to structure or amenity or interference with legitimate uses of environment. [Holdgate, 1980].

The significance of this definition is that, pollution results from substances causing damages to targets. With regards to petroleum (oil) pollution it has been defined as not too different from the above general definition of pollution. It has been defined as anthropogenic (human) input of oil into the environment such that the biotic (of or appropriate to life) and biotic (lifeless structure) components of the environment are adversely affected. (Monkhouse, 1970).

The above of environmental pollution by oil appears to encapsulate the major issue of oil pollution such as the effect of oil pollution on the environment and the respective environmental media proper (water, land, and air). These issues constitute a substantial part of the literature on the effect of improper method of petroleum sludge disposal.

Hydrocarbon, a major constituent of petroleum sludge is a compound of hydrogen and carbon found in liquid, solid, or gaseous state.

Petroleum sludge which constitute environmental nuisance if not properly disposed of is chemically derived hydrocarbon slurry sedimentation at the bottom of oil storage tanks. It is also a flow of very wet, semi solid, highly mobile mud of hydrocarbon deposits. (Monk house, 1976)

Disposal methods refer to various ways in which petroleum sludge is removed from sites of its generation such that environmental damage or impact is minimized.

Water – table is the upper surface of the zone of saturation impermeable rock; this level varies seasonally with the amount of percolation. The slope of the water table is inversely proportional to the permeability of an aquifer. Potable water is extractable from the water – table. (Monk house, 1970).

Finally, capsulation is a term applied to mean confinement of ingredients, the sludge inclusive such that the wrapped materials do not escape to the adjoining vicinity.

2.1 SOURCES OF WASTE

According to the Environment Act 1995, waste is defined as "any substance or object which the holder discards or intends or is required to discard." Waste is a complex mixture of different substances and objects, only some of which are intrinsically hazardous to health. However, any type of waste has the potential to affect health depending on the collection system used, the location where waste is generated, and the waste management strategy employed. For example, a plastic bottle is unlikely to be responsible for any adverse health effects when buried in landfill. However, the same plastic bottle burned in a poorly managed incinerator could generate dioxins which could potentially lead to an increased risk of cancer in people working in or living down wind of the incinerator.

Sewage is any type of waste that passes through the sewage treatment process. As well as pathogenic micro-organisms from human excrement, sewage contains many other hazards to health – heavy metals and toxic compounds from road run-off waters, toxic and endocrine-disrupting compounds from toiletries, cosmetics, and detergents, pesticides from surface water run-off, and natural hormones from human urine.

2.2 QUANTITY OF WASTE

In the South West, 11 million tonnes of controlled waste were handled, treated or disposed of in the year 1998/99. This included 5.2 million tonnes of commercial and industrial waste and 2.5 million tonnes of municipal waste but does not include sewage sludge. The amount of waste produced in the South West did not exceed 12% of the total for England and Wales, which is proportional to the number of people and industries based in the South West. In addition, approximately 14.5 million tonnes of waste was produced by the agricultural sector.

2.3 TYPES OF WASTE

Accurate exposure assessments are not possible without detail information on the different types of waste.

2.3.1 Municipal Waste

Municipal wastes are whatever local authorities collect and dispose of. About 90% of municipal waste comes from households (DETR 2000). The rest consists of some commercial waste, road and pavement sweepings. Extensive data are collected about municipal waste (DETR 2000). For the past four years, a questionnaire has been sent annually to all waste collection authorities, waste disposal authorities and unitary authorities asking about the amount of municipal waste collected and disposed of, the levels of recycling and recovery of household and municipal waste, methods of waste containment, levels of service provision and details of waste collection and disposal contracts.

2.3.2 Commercial and Industrial Waste

In 1989–99, a survey providing baseline information of some 20,000 businesses was carried out (Strategic Waste Management Assessment – South West, Environment Agency 2000). The information collected for each business included the type of waste (i.e. mixed, special or packaging) the quantity of waste, the waste form (i.e. solid, liquid or sludge) and the waste management method.

2.3.3 Agricultural Waste

The South West produces nearly a quarter of all the agricultural waste produced in England and Wales (Environment Agency 2001). There is little information available on the management of agricultural waste and by-products although compounds in quantities significant to health are produced of pesticide washings, plastics, tyres, oils and sheep dip (Environment Agency 2000 SWMA).

2.3.4 Special/hazardous Waste

The Environment Agency has a Special Waste Tracking database, SwaT, but it is difficult to calculate how much special waste is produced. The factors that make it difficult are discussed in Chapter 2 of the Strategic Waste Management Assessment – South West, 2000 (Environment Agency 2000).

2.4 DEFINITION OF SLUDGE

Water treatment sludge is defined as 'the accumulated solids or precipitate removed from a sedimentation basin, settling tank, or clarifier in a water treatment plant'. The accumulated solids are the result of chemical coagulation, flocculation, and sedimentation of raw water. There are two types of water treatment sludges:

1. Coagulation sludge
2. Softening sludge

2.4.1 Coagulation Sludge

These sludge have a gelatinous appearance are produced from clarifier operations and from the backwashing of filters. They contain high concentrations of aluminum or iron salts with a mixture of organic and inorganic materials and hydroxide precipitates.

Dewatering of coagulation sludges is a difficult task and in the past the sludges were discharged into a water source, like a river or a lake. However, nowadays the sludge is processed for ultimate disposal and backwash and clarifier water is returned to the treatment facility for reprocessing.

2.4.2 Softening Sludge

These sludges contain mainly calcium carbonate and magnesium hydroxide precipitates with some organic and inorganic substances. These sludges dewater easily and processing for ultimate disposal is common and feasible.

The unit operations and processes for sludge handling in water treatment facilities areas follows:

- Discharge into sewer systems
- Thickening
- Conditioning
- Dewatering
- Coagulant or lime recovery
- Ultimate disposal

a. Discharge into sewer systems

This technique of disposal is used mainly for coagulation sludge, which can be processed by a waste treatment facility with additional capacity. Softening sludges cannot be disposed in this manner because they have a higher volume and encrust weir, channels, digesters, piping, etc.

b. Thickening

Gravity thickening is used for both types of sludges. The following table illustrates the change in solids concentration:

Table 2.1: Summary of Change in Solids Concentration

Sludge type	*Original solids concentration*	*Solids after gravity thickening*	*Thickener loadings, lb/day-ft² (kg/day-m²)*
Lime softening	1%	30%	12.5 (61)
Alum coagulation	1%	2%	4 (20)

Source: AWWA, 1969

c. Conditioning

To achieve better dewatering results, the coagulant sludge may be conditioned through heating in reactors or by freezing and thawing, which causes the bounded water to be released due to extreme temperature and pressure conditions. Using heat treatment and the freezing and thawing techniques, the solids concentration can go up to 20%.

d. Dewatering

The results from dewatering are different for the two sludges since the coagulant sludge is harder to dewater than the softening sludge. The following table shows a range of solids concentrations for different dewatering techniques :

Table 2.2: Range of Solids Concentrations for Different Dewatering Techniques

Sludge type	*Rotary vacuum filter*	*Centrifugation*	*Filter presses*	*Lagoons*
Coagulation	29-32%	N/A	40-50%	1-10%
Softening	65%	55-60%	60-65%	50%

Source: Reynolds & Richards, 1995

e. Lime or Coagulant Recovery

Lime sludge from water softening may be separated into calcium carbonate and magnesium hydroxide by centrifuges through calcification. Lime is recalcined to produce reusable quicklime. Alum recovery is not very commonly used but is accomplished through acidification with sulfuric acid.

f. Ultimate disposal

The ultimate disposal of water treatment sludge entails two techniques:

1. Landfilling
2. Land application

➢ **Landfilling**

Landfills may be on public land such as a municipality owned landfill, or on private land. Landfill operators commonly require 15 to 30 % sludge (solids). The minimum concentration required is often determined by local sanitary landfill regulations.

For alum sludges, (the most common in the US drinking water plants) effective landfilling requires the solids concentration to be at least 25%. At lower concentrations, land application is more appropriate.

- **Land application**

Alum sludge, at concentrations less than 25%, is best land applied. Sludges may be applied to croplands, to marginal land for land reclamation , to forest land or to dedicated sites. Other than at dedicated sites, usually no more than 20 dry tonnes of sludge per acre is land applied.

- **Cropland**

Sludges are applied to cropland either by surface spreading, or by subsurface injection. Surface irrigation methods include specially equipped farm tractors, trucks or special applicator vehicles. Sludge is usually applied once a year to a given area.

- **Marginal land**

Sludge has been applied to marginal land for recalmation in Pennsylvania and in other states successfully. This is usually a one-time process and a continual supply of land must be provided for future applications.

- **Forest Land**

Application to forest land has been done successfully in Michigan, Washington and South Carolina. It is determined by sludge characteristics, e maturity, species, soil etc. Application to a specific site is often done y at multi-year intervals.

Dedicated sites

ice such sites are exclusively used for land application, the application es are much higher than in the other means discussed above, ranging from to 200 dry tonnes of solids per acre of land. Sludge can applied to dicated sites throughout the year.

Costs of ultimate disposal of sludge

osts can be an important concern in waste disposal and often play an portant part in determining the disposal method used. This program mputes Capital and O&M costs for landfilling at a municipal landfill and for land application to farmlands. For landfilling, the input requires the annual volume (million gallons) of sludge to be landfilled on a 20% solids basis. For land application, two inputs are required. The annual volume of 5% sludge to be land applied and the number of days per year for which land application is performed

2.5 METHODS OF SLUDGE DISPOSAL

The various methods are carry out in PPMC (Kaduna depot) are briefly reviewed before the introduction of the capsulation method of sludge disposal. They are as follows:

2.5.1 Direct Burial

This method of petroleum sludge disposal is described as a crude way of waste management. This assessment is based on its attendant environment hazard of contaminating the water-table. (DOE, 1975)

The method is very simple and involves dumping the petroleum sludge in an excavated pit unwrapped and covering same with top soil. The advantage which is contamination of the water-table with oil weighs the advantage.

The total consequence of the method is the migration of oil into the water –table such that slicks of oil is detected in wells and drinking water of communities amount such disposal sites.

2.5.2 Open Incineration

This method of petroleum sludge disposal as its name suggest is simple and involves burning the sludge in the open.

Petroleum sludge is deposited on a concrete plat form and burnt unconfined. Due to the flammable nature of petroleum sludge, combustion is aided by the oil contained in the sludge such that very high emission of smoke, carbon gases, particles and nitrogen gases are released into the atmosphere.

The main disadvantage of this method is that in trying to dispose of petroleum sludge the atmosphere is consequently enriched with pollutants. The product of the incineration is rendered inert (inactive) as a result of the incineration and does not contaminate the water –table since the constituents of the sludge is rendered inactive.

The disadvantage of this method is the specially designed sludge incinerator is expensive but the advantage of compacting and reducing the bulky sludge outweighs this advantage.

2.5.3 Sludge Farming

This method involved laying and spreading of petroleum sludge on a concrete platform and subjected to the intensive rays of the sun.

The drying process results in caking of the sludge. The caked sludge is mixed with soil and scattered over farm land. In the drying process, the moisture content of the sludge evaporates into the atmosphere thus enriching the atmosphere with petroleum vapour containing oxides of nitrogen and carbon. These gases are implicated in the incidence of photochemical smog and acid rain. The disadvantages of this method considerably outweigh the advantage which is the simplicity of the method.

2.5.4 Capsulation Method

This method involves mixing the petroleum sludge with quicklime (calcium hydroxide) and deposited in a lined pit and as overlapping linear is used to wrap the sludge while more top soil is deposited on the wrapped sludge.

After sometimes " digestion" take places, the process of sludge digestion is the liquefaction of organic material by anaerobic bacteria which produce an alkaline reaction. When sludge is first buried, acid digestion with the production of noxious gases results, but eventually alkaline digestion prevails and once established the alkaline condition remains for an indefinite period of time.

The gases given off during digestion are mainly methane with some CO_2 and smaller quantities of other gases. A stem hollow pipe is pierced through the capsulated sludge to aid aeration and to allow escape of methane and other gases generated from the sludge degradation process.

The digestion process takes places in three stages;

1). A short period of rapid digestion, during which pH value of sludge decreases

2). An extended period of slow digestion during which the pH value rises slowly with low gas production.

3). During the third stage, it attain a pH of 7.0 and gas production is maximum.

The advantage of this method are realized in respect of long pollution monitoring.

1). Water-table contamination by oil eliminated as the degraded sludge mixes with the soil and becomes inert.

2). There is no seepage of oil and therefore no oil migration to the water-table.

3). The methane gas produced from this process is another way of generating methane gas which is use as fuel either by itself or mixture with other gases.

4). It is used for making hydrogen, carbon black, anaesthetic used in surgical operations e.t.c.

5). The method is not capital intensive as the cost of purchasing the chemicals is minimal.

2.5.4.1 RATE OF REACTION

A spontaneous reaction shows that the reaction is possible or feasible. Thermodynamic assume that the reaction takes place. Therefore, to know if the reactions are fast or slow the knowledge of rate of reaction is required.

- The reactants must collide together
- The more particles there are in a given volume, the, more likely they are to collide and react together.

This gives us a clue as to why the rates of reactions often change when concentration change.

- The reaction must have right energy

This is especially true the reaction between covalent substances for example between the sludge which is an hydrocarbon and calcium hydroxide. For methane gas to be produced new bond has tomust be formed.also, one or more of the original bond has to breaking breaking bond energy. If the molecules collide only weakly, they may not have enough energy to break the necessary bonds.

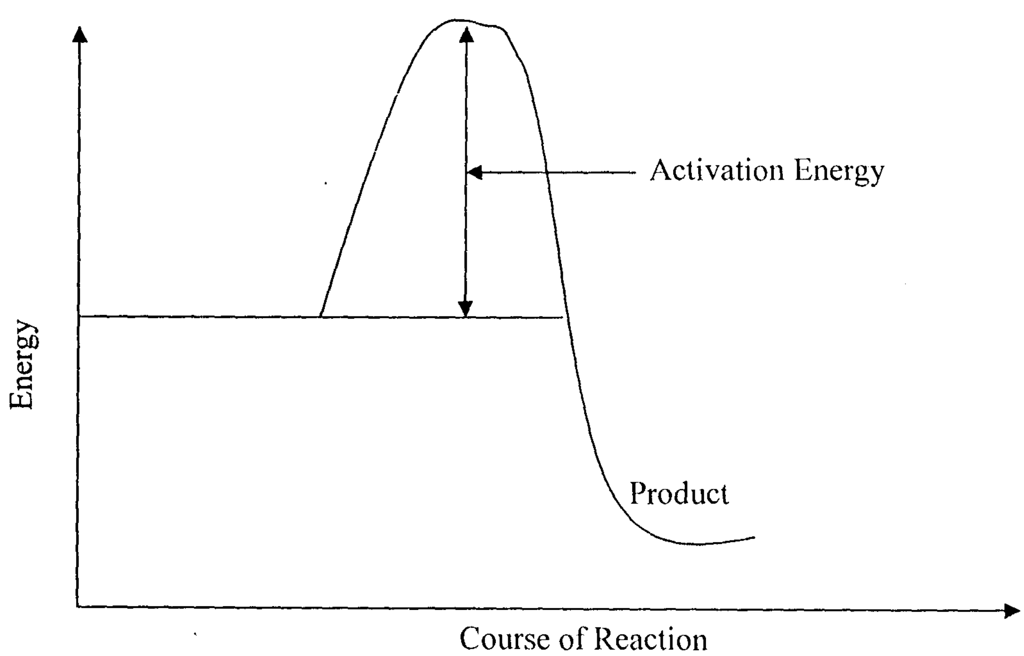

Fig. 2.1: The activation energy is the minimum energy that the reactant must have before they can change to products.

2.5.4.2 Temperature

The most well known method of making reactions go faster is to heat the reactant. The higher the temperature the greater the activation energy. Since the sludge and hydrocarbon have low activation energy the reaction can take place at room temperature ($250^{o}{}_{C}$).

2.5.5 GAS ANALYSIS

The gas generated was injected into a gas solid chromatograph instrument for analysis and the result was obtained immediately.

2.5.5.1 PRINCIPLE OF GAS SOLID CHROMATOGRAPH

The gas is passed over a solid, which act as a support for the stationary liquid phase while the mobile phase is gas. An inert solid is used to support the stationary liquid phase and is packed into a steel coil kept in a thermostatted oven to maintain an oven temperature$100^{o}{}_{c}$. The sample is injected into the coil through septum. The temperature of the oven must be high enough to vaporize the sample, which is carried through the coil by a stream of inert gas such as Nitrogen. After leaving the coil, the samples, and carrier gas, pass through a detector. This usually works by measuring the thermal conductivity of the gas passing by the electronics in the detector amplifiers the signal and it is sent to a chart recorder.

The chart shows a peak for each component in the original mixture. One of the good things about the chart is that the area under each peak is proportional to the amount of the substance present, so the experiment can give us quantitative and qualitative information.

- Retention time is considered under the gas chromatograph

2.5.5.2 RETENTION TIME

The time required for the maximum solute peak to reach detector in a gas chromatograph column is called retention of time.

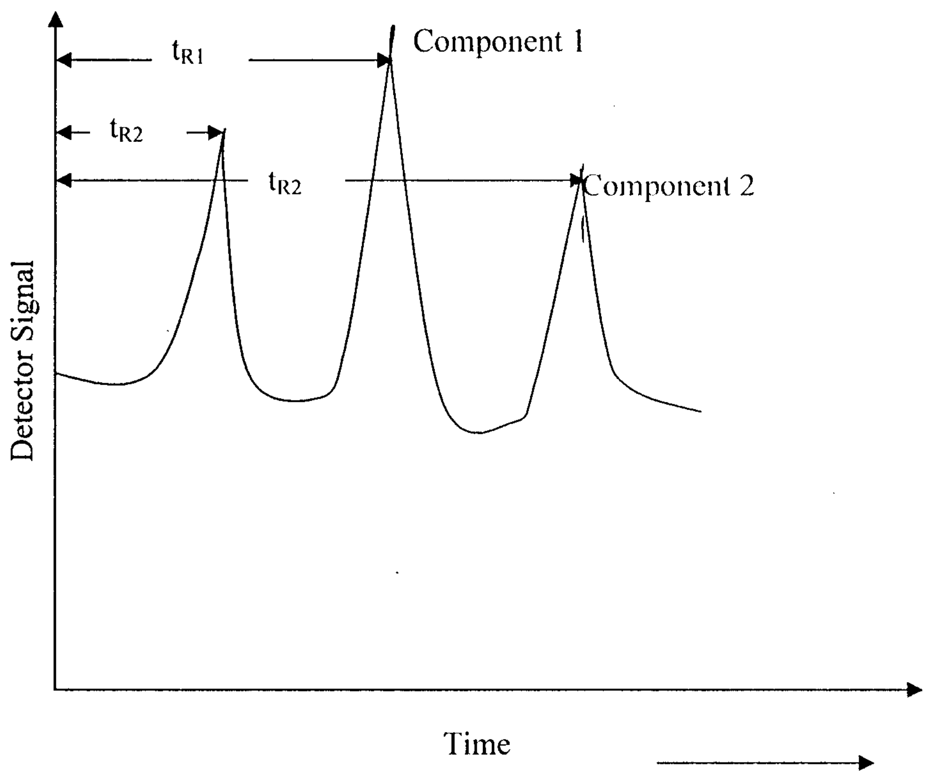

Fig. 2.2 Gas chromatograph for a two – component system in the liquid phase is extremely low (oxygen or air) for example. It rate of movement will approach the rate of flow of the carrier gas and solid phases, note the air peak in the figure above.

The retention volume V_R of a component is defined as the volume of gas required to carry a component maximum through the column. This quantity is related to retention time by;

$$V_R = t_R F_c \qquad \text{.............................2.1}$$

Where F_c is the volume flow rate of the gas at the outlet corrected to the temperature of the column. For a component that does not partition appreciably with the solid phase.

$$V_{Gr} = t_{Gr} F_c \qquad \text{........................2.2}$$

A more useful term is the corrected retention volume $V^o{}_R$, which is the volume corrected to the average pressures in the column. James and Martin have shown that

$$V^o{}_R = J t_R F_c \text{ and } V^o{}_G = j t_G F_c \qquad \text{.......................2.3}$$

Where

$$j = \frac{3[(pi/p_o)^2 - 1]}{2[(Pi/P_o)^3 - 1]} \qquad \text{...................2.4.}$$

Where Pi =P_0 are the gas pressure at the inlet and the outlet of the column

The retardation factor R_F is the ratio between the rates of movement of sample and carrier gas through the column. If the column has a length L

$$\text{Rate of movement for component} = \frac{L}{t_R}$$

Similarly,

$$\text{Rate of movement for carrier gas} = \frac{L}{t_G}$$

Thus, $$R_F = \frac{L/t_R}{L/t_G} = \frac{t_G}{t_R} \quad \text{..........................2.5.}$$

Combination of equation (2.3 and 2.4) gives R_F in terms of corrected retention volumes that is,

$$R_F = \frac{V^o{}_G}{V^o{}_R} \quad \text{.......................... 3.6}$$

2.6 WASTE MANAGEMENT METHODS

This section explores the different types of waste management methods that are available and considers some of the issues associated with the various approaches.

2.6.1 Waste Minimisation

Waste minimisation aims to reduce the amount of waste being produced, and therefore results in savings in both raw materials and disposal costs as well as to reduce the potential environmental impact of waste. Waste minimisation can also play an important role in reducing growth rates in the production of household waste. However measures are difficult to implement within households and success cannot be guaranteed.

This method is therefore most easily applicable to industrial wastes, which are produced in bulk and where the manufacturing process can be redesigned to reduce the amounts of raw materials, or energy used or the amount of waste produced.

- **Advantages**
    - Conserves resources
    - Savings in raw material costs
    - Savings in waste management charges
    - Reduces environmental impacts
    - Reduces demand for landfill and other waste management capacity.
    - Can result in a slowing in waste growth

- **Disadvantages**
    - Not possible for Local Authorities to control and deliver targets
    - Relies on members of the public taking action and choosing less wasteful products
    - In industry it can involve capital outlay to redesign processes
    - Requires staff commitment
    - Difficult for smaller companies and non manufacturing companies to implement

2.6.2 Re-Use

Re-use involves putting an item to another use after its original function has been fulfilled, a familiar example of re-use are returnable bottle schemes. Re-usability can be designed into some products, but the key issues are the ability to return the re-usable product to the supplier efficiently and the provision of an infrastructure to facilitate the return. However the re-use of materials is generally labour intensive and more expensive than using raw materials.

- **Advantages**
  - Saves on raw materials
  - Saves on disposal, and waste management costs
  - Saves on energy needed for reprocessing
  - Reduces demand for landfill and waste management capacity

- **Disadvantages**
  - Can be difficult to persuade suppliers to provide re-usable packaging, or goods
  - Requires commitment of staff or householder
  - Difficult for smaller companies and nonmanufacturing companies to implement
  - Not possible for Local Authorities to control

2.6.3 Recycling

Recycling is the collection and sorting of materials to produce a useable raw material or product. In relation to the role of local authorities this usually involves the following three phases:

- Collection
- Sorting
- Resale

➢ **Advantages**

- Environmental and other cost savings (including raw materials, energy, transport and processing) as the life of raw materials is extended and the value extracted from them is maximized.
- Reduce disposal needs and costs
- Consumer participation through enhanced public awareness and understanding of environmental issues

➢ **Disadvantages**

- The costs and practical difficulties of collection, transportation and reprocessing
- The occasional higher cost of recycled materials
- The instability of markets for recycled materials, which can rapidly be distorted by changes in the international or domestic supply or demand for these materials
- Disamenity associated with recycling facilities such as transport movements and unsightliness.

2.7 CIVIC AMENITY SITES

Civic amenity sites can help to encourage active participation in recycling as waste is delivered to the facility by members of the public using their own vehicles. Historically these facilities were provided by the local authority as an amenity for the public to dispose of waste items too large to be handled by the normal collection system. More recently a significant amount of recycling can be undertaken at CA sites from the waste delivered to the site. These may include scrap metal, household white goods and other items of commercial value. In many cases these facilities have evolved to incorporate a wide range of recycling activities, including cans, bottles, textiles, florescent tubes, paper, waste oil, cardboard, green waste and construction and demolition waste.

2.8 Kerbside Collection

Various alternative methods have been tested for the kerbside collection of recyclable materials. These include the following systems:

- Green bin
- Blue box
- Split bin

❖ Green Bin

This is the system employed by all of the kerbside systems currently operating in Northern Ireland, probably because all of the Local Authorities in Northern Ireland already use 240 litre wheeled bins for their refuse collection. With the green bins system the householder is provided with a wheeled bin specifically for the collection of recyclables. The green bins can be collected by conventional refuse collection vehicles equipped to handle wheeled bins. If a range of dry recyclables are collected, they need to be taken to a Materials Recovery Facility (MRF) where the material is sorted and the recyclables densified and/or bailed for dispatch to market.

❖ Blue Box

The blue box system involves issuing a rigid plastic box to householders in to which they are asked to place dry recyclables. The crew of the vehicles collecting the recyclables then sort the contents of the box placing them into the appropriate part of a compartmentalised vehicle. The recyclables are taken to a storage/transfer facility for bulking and transport to markets.

- **Split Bin**

With split bin systems the householder is provided with a wheeled bin, which is divided into two compartments. In one compartment the householder places dry recyclables (or compostable materials) and in the other compartment other wastes. Specialised vehicles are employed which have a horizontal or vertical divide for the co-collection of the source-separated materials.

2.9 Materials Recovery Facilities (Mrf's)

The main objective of an MRF is to process solid wastes (can be mixed or partially source separated material from the kerbside collection of household waste, and from industrial, commercial sources) to recover commodity grade materials for sale, or onward processing (paper, aluminum, plastic, biodegradable matter etc.) and to thereby increase the profitability and viability of recycling. MRF's can divert considerable volumes of waste from landfill into recycling activities.

The type, quality and quantity of wastes received and most importantly the marketable

commodities produced at a MRF are important elements which dictate the type and size of plant used to process the solid waste and generate recyclable materials. These factors will influence both the capital and running costs of the plant. MRF's tend to combine the use of both mechanical means and labour intensive sorting to separate out the various fractions of the recyclables.

Another important issue in MRF design and operation is that of "dirty" versus "clean" MRF's. "Dirty" MRF's which receive mixed solid wastes, which undergo no source separation, will require a greater range of equipment in order to achieve the separation of recoverables. Whereas "Clean" MRF's receiving partially source separated and industrial/commercial waste stream tend to have a lower throughput of material but exhibit much higher separation/recovery efficiencies.

2.10 COMPOSTING

Composting plants convert organic and/or green wastes into a reusable compost by an aerobic degradation process. Composting can be approached in two ways:

- Centralised Composting
- Home Composting

2.10.1 Centralized Composting

Centralized composting options can range from mechanical method of composting (windrowing technology) to in-vessel technology using forced aeration. The former is a slower less efficient low technology option than forced aeration, but is the more widely used because the technology employed is relatively simple. Successful composting relies on efficient materials segregation and the removal of any contaminants such as glass, metals, plastics which can adversely affect the potential use and marketability of the compost product. The use of household waste within the composting facility also requires segregation to ensure that only material suitable for composting is collected (e.g. kitchen peelings and garden waste).

This is best done at source. This material can be collected via either civic amenity sites or specially designed "compostainer" brown bins for kerbside collection.

2.10.2 Home Composting

Through the supply of home composting containers to households, combined with education and awareness programmes, home composting has the potential to divert a significant proportion of putrescible waste away from the bin. Home composting combines the advantages of centralised composting with added advantages such as:

- Reducing impacts from transport and processing
- Avoids the need to establish markets for compost based product.

2.11 ENERGY FROM WASTE

There are several types of combustion technologies commercially available and the two most commonly used systems for municipal waste incineration are Moving Grate Furnaces (Mass burn) and Fluidised Bed Furnaces. *Moving Grate furnaces (Mass Burn)* move the waste through an inclined combustion zone by mechanical means. The methods typically used include a series of rotating drums or rollers, moving bars or rockers.

Fluidised Bed furnaces combust the municipal waste on a bed of inert material such as sand or limestone. The bed is fluidised by bubbling air through the bed to the waste. The high flow of air required for fluidisation carries part of the inert bed material out of the combustion zone. This material is removed from the flue gas and returned to the combustion zone.

2.12 ANAEROBIC DIGESTION

Anaerobic digestion is the degradation of organic waste under controlled conditions and in the absence of oxygen resulting in the generation of a biogas (primarily methane) which can then be utilised. The digestion reactor usually consists of a large vessel in which the shredded waste is fed and continuously mixed to ensure even distribution of the temperature. Following the digestion process, the digestate is usually too wet to produce a usable dry compost, and therefore requires de-watering. This is usually achieved by using a centrifuge which separates wastewater from the solid component. The wastewater requires further treatment before it can be disposed to sewer or to a local watercourse. It is essential if the process is to be employed, that there is a use for the biogas, either directly as a fuel, or for the generation of electricity. Anaerobic digestors have been used for many years for the treatment of agricultural and sewage sludges.

2.13 GASIFICATION

Gasification is a process in which both organic and inorganic wastes are thermally treated at high temperature (2000oC) with air/oxygen injection to produce metallic and minerallic solid residues and synthesis gas. The synthesis gas can be used for energy production. However a consistent feed to the furnace is required and therefore there is the need for considerable pretreatment of the waste. There are currently two wood based gasification plants contributing to the grid in Northern Ireland (one in Armagh and one in Derry) However, gasification of mixed MSW presents a range of problems and the commercial viability of plants processing mixed MSW has yet to be proven.

2.14 PYROLYSIS

Pyrolysis is the thermal degradation of organic wastes at temperatures of between 400oC and 800oC either in the complete absence of oxygen or with a limited supply of oxygen to ensure that gasification does not occur. The products of pyrolysis always include gas, burnable liquid and solid char, however the quantity and quality of the products are dependent on the type and operation of the process. Pyrolysis of MSW on a large scale has yet to be proven.

2.15 TRANSFER STATIONS

Transfer stations are used to bulk wastes collected by refuse collection vehicles for onward freighting. These may include wastes being shipped for disposal or recyclables for onward processing, or delivery to market.

2.16 Landfill

Whatever combinations of integrated waste management options are developed landfilling will continue to be required. Modern landfills accepting municipal solid waste, are designed to meet the requirements of the Landfill Directive and will incorporate a complete basal lining and leachate drainage system. Leachate will be removed for on site treatment prior to discharge. The site infrastructure will include provisions for full gas collection and flaring. Sites will also require restoration and aftercare provisions to ensure the site has stabilised.

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CHAPTER THREE

3.0 MATERIAL AND METHODOLOGY

The method used involves the collecting of sludge sample from the deposit tank (premium motor spirit).

3.1 Materials

3.1.1 Equipments

1. Conical flask
2. Weighing balance
3. Gas – solid chromatograph
4. Beaker
5. Cork
6. Spatula
7. Blood bag

3.1.2 Reagent

1. Calcium hydroxide

3.2 Methodology

3.2.1 Capsulation procedure

Capsulation method was used and described as followed:

The petroleum sludge cemetery is nominated. A known dimension of pit relative to the quantity of sludge to be disposed of is excavated in a rectangular or square form at room temperature.

However, the walls of the pit are lined with polyvinyl chloride it liner (PVC) in order to avoid contamination with the ground. It is then reinforced with capped asbestos roofing nail for the reaction to occur aerobically.

More so, the petroleum sludge is mixed with top soil and quicklime (Calcium hydroxide) and deposited in the limed pit. The overlapping (PVC) liner is used to wrap the sludge, with more top soil deposited on the wrapped sludge.

In addition, the capsulated sludge in the pit is covered with more soil thus making a sludge mound or grave.

Lastly, a stern hollow pipe is pierced through the capsulated sludge to aid aeration and allow escape of methane gas generated from the sludge degradation process. During this process, the time it takes for methane to be produced was noted.

The quicklime added to the sludge due to it effervescence (bubbling) property aids bio and chemical degradation of the sludge and release of methane gas through the stern hollow pipe.

3.3 EXPERIMENTAL ANALYSIS

Apparatus setup

The apparatus are set up by connecting empty conical flask with the tube and gas collector (blood bag) to collect the gas sample.

3.3.1 Analysis of sludge

PROCEDURE

- 100g of sludge and 100g of reagent (Calcium hydroxide) was weighed accurately into the pan using the weigh balance.
- The total weight of the pan and sample was taken and then it was transferred into the conical flask at room temperature ($25^{o}c$)
- The conical flask was corked (for the reaction to take place in the absence of air) and shook vigorously for proper mixing of the sludge and quicklime.
- The sample was kept then a period of an hour
- Then gas was produced after sometimes which was collected in a blood bag initially connected was then sealed and weighed.
- Ratio test was repeated using various proportions of sludge and quicklime.
- A second test was run by analyzing the sludge without quicklime following the same process.

For the above step, parameter like temperature and rate of reaction are considered.

3.3.2 Gas analysis

The gas was collected in a blood bag and taken into a gas-solid chromatograph for analysis

Procedure

- The gas was injected into the gas-solid chromatograph through an injector and passed over a solid at 100^0C.
- The sample was then injected into a coil through a septum.
- After the gas left the coil, the samples, and carrier gas was passed through a detector and the thermal conductivity of the gas was measured by passing the gas through a detector amplifier.
- The result was then recorded in a signal form on a chart recorder

CHAPTER FOUR

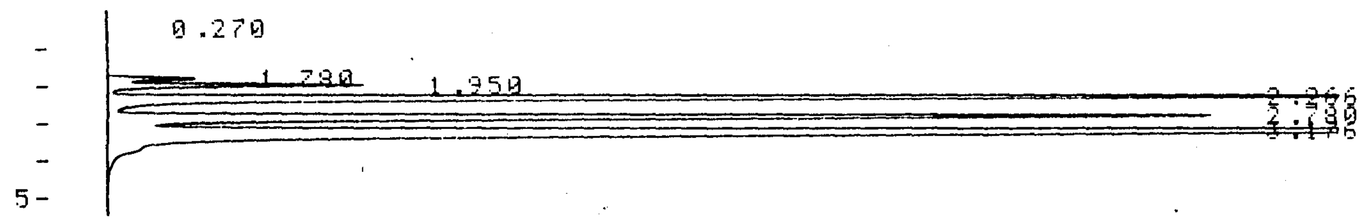
4.0 RESULT AND DISCUSSION OF RESULT

4.1 RESULTS

This chapter outlines the result of the analyzed gas sample from the gas chromatography recorder, which shows the retention time of each gas and mole percentage.

Table 4.1: Standard Value from Gas Chromatograph (Courtesy KRPC)

CH. 1 C.S 5.00 ATT 7 OFFS 0 ?9/13/05 11:54



D-2500 09/13/05 11:54

METHOD: LPC TAG: 62 CH: 1

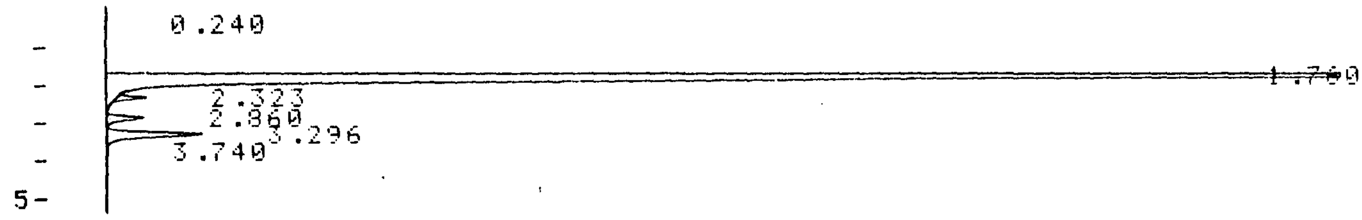
FILE: 0 CALC-METHOD: AREA% TABLE: 0 CONC: AREA

NO.	RT	AREA	HEIGHT	MOLES%	FACTOR	BC	NAME
1	0.270	907	17	0.020	1.000	BB	
2	1.780	51134	9272	1.139	1.000	BV	
3	1.950	151881	26747	3.382	1.000	VV	
4	2.266	1113441	153380	24.795	1.000	VV	
5	2.780	1006421	114762	22.412	1.000	VV	
6	3.176	2166856	174198	48.253	1.000	VB	
TOTAL							
		4490640	478376	100.000			

PEAK REJ : 0
STORAGE FULL

Table 4.2: Equal Proportion of Sludge and Quick Lime

CH. 1 C.S 5.00 ATT 7 OFFS 0 09/13/05 12:12



D-2500 09/13/05 12:12

METHOD: LPC TAG: 63 CH: 1

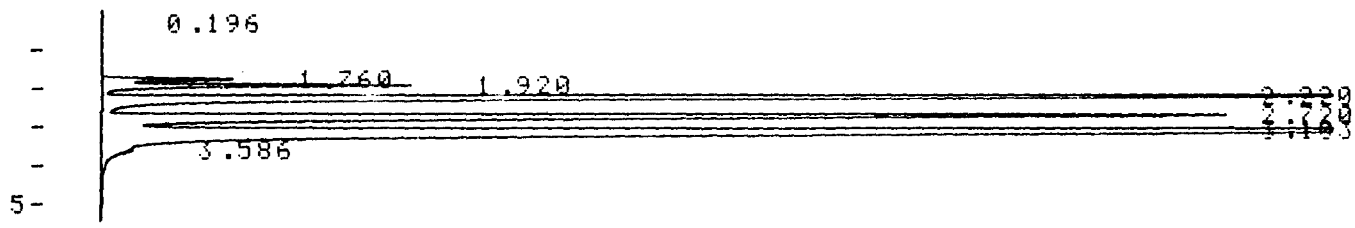
FILE: 0 CALC-METHOD: AREA% TABLE: 0 CONC: AREA

NO.	RT	AREA	HEIGHT	MOLES%	FACTOR	BC	NAME
1	0.240	507	13	0.019	1.000	BB	
2	1.760	2508092	407134	94.466	1.000	BV	
3	2.323	18299	3071	0.689	1.000	TBB	
4	2.860	30367	3798	1.144	1.000	TBV	
5	3.296	96479	9976	3.634	1.000	TVV	
6	3.740	1285	134	0.048	1.000	TVB	
TOTAL		2655029	424126	100.000			

PEAK REJ : 0
STORAGE FULL

Table 4.3: Proportion of Sludge Greater than Quicklime

CH. 1 C.S 5.00 ATT 7 OFFS 0 09/13/05 11:47



D-2500 09/13/05 11:47

METHOD: LPC TAG: 61 CH: 1

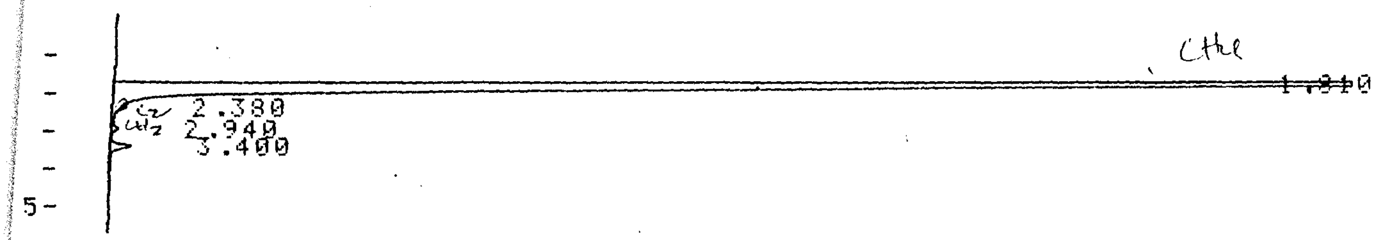
FILE: 0 CALC-METHOD: AREA% TABLE: 0 CONC: AREA

NO.	RT	AREA	HEIGHT	MOLES%	FACTOR	BC	NAME
1	0.196	534	11	0.013	1.000	BB	
2	1.760	69565	13891	1.645	1.000	BV	
3	1.920	164922	32307	3.899	1.000	VV	
4	2.220	1078633	161470	25.499	1.000	VV	
5	2.720	936797	116917	22.146	1.000	VV	
6	3.103	1976212	174968	46.717	1.000	VV	
7	3.586	3479	427	0.082	1.000	TBB	
TOTAL							
		4230142	499991	100.000			

PEAK REJ : 0
STORAGE FULL

Table 4.4: Proportion of Quicklime Greater than Sludge

. 1 C.S 5.00 ATT 7 OFFS 0 09/13/05 11:24



-2500 09/13/05 11:24

METHOD: LPC TAG: 60 CH: 1

FILE: 0 CALC-METHOD: AREA% TABLE: 0 CONC: AREA

NO.	RT	AREA	HEIGHT	MOLES%	FACTOR	BC	NAME
1	1.810	2668855	421237	98.912	1.000	BV	
2	2.380	2632	520	0.098	1.000	TBB	
3	2.940	5756	740	0.213	1.000	TBB	
4	3.400	20974	2204	0.777	1.000	TBB	
TOTAL							
		2698217	424701	100.000			

PEAK REJ : 0
STORAGE FULL

2 DISCUSSION OF RESULT

From the experimental work carried out, table 4.1 clearly shows ndard value of gas mixture from Kaduna refinery and petrochemical RPC). The standard retention time for methane, ethane, propane, butane, tane and hexane are 1.780, 1.950, 2.266, 2.780 and 3.176 respectively.

Table 4.2 shows the comparison between the standard value of gas ture from KRPC and the result obtained from the analysis. Methane duced fro equal proportion of sludge and quicklime (1:1) were mixed, the ention time for methane was 1.760 which falls within the standard value ile ethane, propane, butane, pentane and hexane have 2.323, 2.860, 3.296 d 3.740 respectively which registered a high mole percent of methane 4.46%) which is predominantly of all the gases.

Table 4.3 reveals that when the proportion of quicklime to sludge is 2, 1.645% of methane was obtained with retention time 1.760 which ows that the amount of methane obtain is low.

Table 4.4 has the best and highest percent of methane gas (98%) at ention time 1.810 compared to the standard value which was reported in le 4.1 above 1.77 therefore, the result falls within the range. The reaction sludge without quicklime produces no gas.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

Sludge is an environmental pollutant, it also as an economical importance. it can be used in the methane production when certain amount of quicklime is added to it. Methane gas which is useful industrially for the production of carbon black, hydrogen, carbon (iv) sulphide, alkyne and anesthetic used in surgical operations.

From the analysis, when equal proportion of sludge and quick lime (100g each) were used, 94.46% of methane gas was produced. 100g of sludge and 50g of quick lime gave 98.4% methane. But when 100g of quick lime and 50g of sludge gave 1.64% of methane. It was concluded that large percent of quick lime favored the generation of methane gas. The reaction of sludge without quicklime produces no gas.

5.2 RECOMMENDATION

It is recommended that methane can be used as another source of raw-material in production of methane sludge. Also, sludge should rather be use as raw-material rather than waste product.

It is recommended that a collection bag should be used for collection of gas in order to obtain a more accurate result.

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