# ORIGINAL RESEARCH ARTICLE

# ASSESSMENT OF HAZARDOUS WASTE MANAGEMENT IN OIL DRILLING FIELDS IN TURKANA



ABSTRACT

The assessment of hazardous waste management at the oil drilling fields of Lokichar basin, Turkana County has been analysed. The area is known as Block 10BB and 13T of the oil exploration in Kenya. The study examined the types of waste generated by the activities in the study area and characterized the waste into different streams and classes. The classes of waste examined were primarily hazardous waste or non-hazardous waste contaminated with hazardous materials. Kenya's National Environment Management Authority's(NEMA) Waste Management Act of parliament, 2006 was used to classify waste into different streams, and also as a yardstick against which the compliance level of the waste management strategies in the oil fields were gauged.
Primary data was obtained using questionnaires and schedules as the main tools. These were administered on the environmental department of the oil drilling company, which was the key respondent in this study. The approach used in this research is majorly a case study. One questionnaire and direct interviews were administered on the environmental monitor of the oil drilling company.
The hazardous waste contained hydrocarbons and other oily substances. Chemical wastes were also seen in the waste generated from the drilling muds. These were classified as directly-generated waste. Some of the waste, especially timber and plastics were generated as a result of transportation of cargo that contaminated the packaging. These were classified as indirectly-generated waste.

Keywords: hazardous waste management, drilling muds, packaging, oil drilling

## Introduction

### 1.0. Background to the study

Kenya began oil and gas exploration the year 2012, having successfully tendered its potential oil producing blocks to International oil drilling companies. The regions with potential to produce hydrocarbons in Kenya were classified into blocks in the tendering process and the Lokichar basin with the confirmed highest potential was falling under the blocks 10BB and 13T. These two blocks forms the study area of this research as shall be discussed later on the study area. The blocks were tendered to an England based company, Tullow Oil PLC. The Company announced its success in exploration in the very year, 2012, and thus the genesis of active oil drilling in Kenya.
During oil exploration and drilling, a lot of environmental liabilities are anticipated. Among the problems is hazardous waste which facilitates pollution and degradation of natural resources. This is even a threat to natural flora and fauna and depletes the natural heritage for the wildlife which is found in these habitats. Hazardous waste introduces foreign substances and chemicals which may be dangerous to the

natural environment if not well managed. Some of the effects may be long term and may take a long time for the natural processes of the ecosystem to deal with.

This forms a situational analysis of the hazardous waste management in the oil drilling fields of Block 13T and 10BB in the Lokichar Basin, Northern Kenya. It is recommended that best practices both technologically and institutionally will contribute to the options in the country to deal with the hazardous waste related with oil and gas exploration and drilling. The impacts, their magnitude and the existing controls to mitigate the prevailing issues have been analyzed through interviews of key informants in the project. Mitigative measures have been formulated to the challenges identified and appropriate recommendations thus issued. These have been deemed helpful to both the drilling contractors and the government at large.

The legal measures and controls have also been analyzed with various case studies with similar operations to come up with scenario modeling solutions for Kenya, with a main objective of turning this problem into opportunity for the immediate potentially affected parties.

There is a strong relationship between the health of the ecosystem and the health of the human system. Waste generation is moderated by drivers that can be manipulated through a wide variety of responses by policy actors and decision-makers to ensure the mitigation of negative impacts of wastes and the adoption/adaptation measures, (Adipepe, 1991). There are many people who have fallen victims of poor waste management in the world and specifically waste derived from mining works. Environmental degradation is one key issue associated with poor waste management as well as degrading the aesthetic value provided by nature of the ecosystems.

In other countries where oil drilling and production have been taking place the following strategies have been used to manage the waste from the rigs; Bioremediation/land farming, Cuttings slurrification and re-injection (CRI), Dewatering and water treatment, Stabilization, Thermal processing, Cuttings drying, Vacuum collection and Pneumatic cuttings transport. This specific research work has investigated the existing methods and also recommended more cost effective methods of managing the waste from the drilling operations.

The HDPE liners are sometimes discarded by the drillers and scavenged by the local community. These are used to construct the *Manyattas (Turkana's traditional huts)* and shield the communities from rain during such seasons. Nevertheless, the communities at times raise complains concerning the impacts of these waste and some of the impacts may be directly or indirectly related the waste issues.

Since the drilling company has contracted a hazardous waste management company that deals with all the hazardous waste, the local community and the environment has minimal or no interaction with the hazardous waste. All the hazardous wastes from the operations are removed from the sites for safe disposal at the authorized hazardous waste disposal site in Nairobi. Moreover the drilling muds that could be contaminated with oil are processed in the thermal desorption unit which extracts the oils and reused in the drilling cycle. As such there are very minimal impacts of the waste on the local environment and population.

**METHODOLODY**

Analysis and assessment of drilling waste and the associated streams in this context involved use of primary and secondary data collection. Various online resources were key in obtaining the qualitative and quantitative data. The principle source of primary data was from the environmental department of the oil drilling company.

### General Approach and Scope

This research was based on waste characterization approach. This is where waste is tracked from the cradle to the grave to analyze the characteristics in both nature and methods of handling. The legislative frameworks were also closely assessed to find out the relevance and compliance. Secondary sources of data have been widely used to enable the research realize most of the objectives. Each of the objectives has been given an approach unique to it and has been handled in separate context. The research scope covered one rig site for primary data, which has been extrapolated to estimate the values and characteristics of the wastes from other rig sites and within a given period of time.

Drilling waste forms the centre for which this research is based and this has been given close and informed study, by use of both secondary and the primary sources of data. The main objective was realized by drawing conclusions from the specific objectives of the study.

Study Area

This study was done in Turkana County in the Lokichar basin where oil exploration and drilling has taken an active course, carried out by Tullow Oil. The Lokichar Basin is found in Lodwar County, in Nothern part of Kenya. The Basin is an extension of the Kerio Valley Basin, which forms the drainage basin within which River Turkwel falls. It is demarcated as block 10BB of the oil exploration in Kenya. So far, about nine wells have been drilled and more are being executed now more rapidly than during the initial stages. The following is a map showing the block 10BB and 13T, where the research was being done

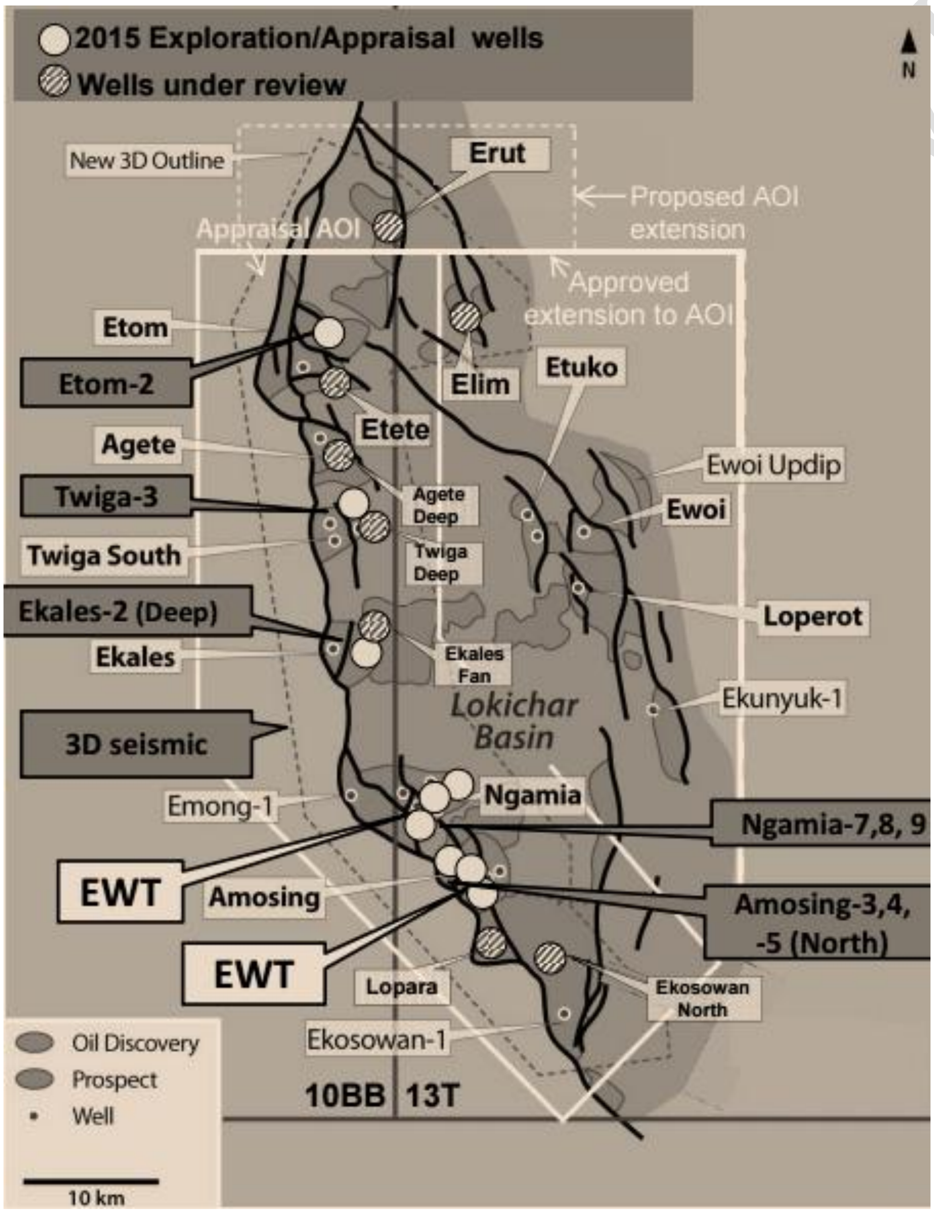


***Figure 1: Map showing the research location area (Oil wells in Turkana County)***

***Figure 2: Satellite picture of rig site (Source; Google maps)***

According to 2009 census, Lodwar County has a population density of 563 persons per sq.Km. Lokichar Ward has a total population of 44,028 as per USAID and KNBS, 2005/6. If this is to go by, then the area covers 78.23 $Km^2$.

Generally, Turkana County has an arid and semi arid climate. As such it receives low rainfall average per year and the vegetations are scanty. There is a wildlife ranch in the southern part of the region and one main river Turkwel that is used for irrigation and electricity generation. The population relies widely of livestock and practices nomadic pastoralism. It was possible to notice coral rocks at some points of the region. However, the greater part of the county is covered by sand. Like any other desert, the region has numerous laggers which cuts off roads whenever it rains and makes it difficult to pass. These cut-offs usually last between few minutes to three hours.

## 1.1. The Research Approach

This research has used both primary and secondary sources of data to gather information and compile the final deductions. Interviews by use of questionnaires were conducted among the key persons in the drilling field and the NEMA experts. Stakeholders of the project were also probed for their knowledge and opinion. The methodology is specific for each research question and the details are as follows:

### 1.1.1. Characterization of the hazardous waste

To attain this objective, the data of the waste collected from the rig site was sampled and studied against the set standards and description of hazardous waste as per the Kenyan waste management regulation, (GoK, 2006). The data obtained provided a window for classifying the waste and determining the proportions thereof. The data was obtained from the disposers of the said waste, by the authority of the key informant in charge of environment. Different types of waste were categorized into different classes depending on the source and way in which they have been derived. This was done using the schedule below;

*Table 1: Waste streams at the drilling sites*

| Waste Stream | Quantity (Kgs/Ltrs) | % Quantity by mass |
|---|---|---|
| Waste water | | |
| Drilling Muds | | |
| Used Chemicals and chemical containers | | |
| Other field operations related waste | | |

#### 1.1.2. Analysis of existing waste management systems used by the oil drilling company and identification of any operational gaps in meeting the legislated requirements.

This was achieved by the use of questionnaire (annex 2) administered on the drillers environmental department. Site visits and surveys also revealed the systems put in place in managing the hazardous waste in the exploration fields. The field-based results were closely analysed against the existing regulations in Kenya that governs waste management in Kenya.

#### 1.1.3. Reviewing the adequacy of the existing legal framework that governs hazardous waste management.

A checklist was used to probe the adequacy of the existing regulations from the authority in governing the guidelines for hazardous waste management, especially with regards to oil and gas exploration. This was in the inclusion to questionnaire administered upon the drilling company. The secondary data obtained was also key in finding out the existing regulations, both local and multilateral and their adequacy in monitoring the waste management strategies. Daily practices with verifiable evidence were investigated alongside some major articles of the relevant legislations to find out the level of compliance by the oil explorers to such regulations. As such it was possible to gauge the impending impacts of the activities and identifying the existing gaps thereof, for making accurate recommendations. In this case, observation was used as the major tool for the data collection.

The main waste management regulation in Kenya, EMCA Waste Management regulation 2006 was used as a yard stick to measure the level of compliance. This was done through a rating checklist. The checklist was graded in a rating of 1-10, where 1 was the least compliance and 10 most compliance. The summation was converted into percentage. Other related regulations were also compared alongside this Waste Management Regulation, 2006. The observable practices were screened against the legal requirements to determine the compliance level.

The following checklist was used to screen the relevant multilateral legal frameworks that were influencing the drilling activities and processes.

*Table 2 . Multilateral regulations checklist*

| Relevant Multilateral Regulations | Compliance (√) |
|---|---|
| 1. International association of Oil and Gas Producers (IOGP) | |
| 2. Kuwait 1978 | |
| 3. UNCLOS 1982 | |
| 4. EMEP 1994 | |
| 5. UNEP (Drilling) | |
| 6. Montreal Protocol | |
| 7. Basel Convention | |
| 8. Helsinki 1992 | |
| 9. UN Law of the Sea | |
| 10. UNFCC | |
| 11. Convention on Migratory Species | |

### 1.2. Research Design

During this study, both primary and secondary data have been collected. The data collection tools therefore shall included all the techniques that generated the required data to accomplish the research objectives as envisaged earlier mentioned.

Purposive sampling was used where one active rig, Amosing_1 site was sampled to generate the data requirements, and then extrapolated with the number of rigs to obtain the overhaul impacts. These have been obtained from the key informants of the drilling company. Such data are used to obtain the direct and indirect impacts of the hazardous waste in the study area. Moreover, the regulatory framework to which oil and gas explorers are bound to, have been closely investigated. NEMA Kenya was also approached for data concerning the regulations and measures put in place to ensure sound management of the hazardous waste in the study area, and especially the waste from the rigs, to avoid future environmental liability.

### 1.3. Primary data Collection

The research used primary data heavily to achieve objectives 1, 2 and 4. One rig site (Amosing_1) was purposively sampled for the case study. This is follows the assumption that the waste streams from the rigs are almost the same as activities and processes are identical. The Company man at study rigs was approached; who gave the required technical data to achieve the intended objectives. From the data, it was possible to identify direct, indirect, positive and negative impacts of the waste from the drilling operations. The direct environmental impacts of the drilling waste are perceived to be manifested on the immediate ecosphere.

Schedules in the questionnaires were also be used to obtain quantitative data. This was helpful in getting to know such values as the amount of waste generated from the rig camps, the waste quantities disposed and the method of disposal used.

To achieve the third objective of this study, a checklist was used to ascertain the level of legal compliance and identify the gaps in the legal framework. The checklist was used to obtain data from the Contractor and also from NEMA's website. Some multilateral agreements screened against the existing policies and practices to find out the level of compliance. The research structure can therefore be summarized as shown in table 3

***Table 3: Research structure and Data Collection Tools***

| Respondent | Type of Data | Sample Size | Data Collection Tool |
| --- | --- | --- | --- |
| Oil drilling company | Primary and Secondary data | 1 purposively sampled rig camps (Key Informant – EHS Rep) | • **Interview/Questionnaire**<br>• **Checklist**<br>Journals, publications and EIA reports for well site |

At least two samples of the hazardous waste from the rig camps were also taken and classified using the waste management regulation 2006, to ascertain the risk level and thus the hazard identification of the said chemical waste.

**Secondary Data**

Secondary data have been obtained from the libraries in SEKU, UNEP, World Bank UoN and other e-resources such as journals and use of www.googlescholar.com Knowledge expansion was mostly possible by extensive reading on the rig waste from the available online resources. Technical data and case studies were purely done online and the main focus remains the African cases.

### 1.4. Data Collection Tools

The data collection tools that were used to achieve the objectives of this study include: Questionnaires, checklists and schedules. A questionnaire with checklist for legal compliance was sent by correspondence to oil drilling company, through email. This was filled and sent back for which the analysis has been done. Schedules were filled from the waste management end of the drilling company. Field trips were done for which observation and still photos were taken as evidence of the state of waste handling and management in the study area.

### 1.5. Data Analysis

The data collected have been analyzed using MS-Excel data analysis software. The checklists were converted to semi-quantitative mode for easy interpretation. The outcomes have been presented in graphs, charts and tables for easy reading and interpretation.

# RESULTS

## 4.0. CHARACTERIZATION OF THE HAZARDOUS WASTE PRODUCED IN THE STUDY AREA.

### 4.0.1. Drilling waste analysis

From the research that was done to analyze waste produced by the oil drilling activities, it was possible to obtain the waste quantities and characteristics. The major areas of hazardous waste that were found include; produced water, commonly known as silicate water, drilling muds, commonly known as cuttings and chemical waste from spills and used chemicals. The table below shows the proportions of these wastes as they are produced from the oil drilling activities.

TABLE 1.. WASTE STREAMS PROPORTIONS, DISPOSED, THE RESIDUALS AND THE METHODS OF DISPOSAL

| Waste Stream | Amount Produced in Kgs per week | % By Proportion | Amount Disposed | Residual Amount | % Disposed | Disposal Method |
|---|---|---|---|---|---|---|
| Produced water (silicate water) | 610,000 | 71.30 | 580,000 | 30,000 (%) | 72.29 | Evaporation |
| Drilling mud produced | 147, 000 | 17.18 | 132,000 | 15,500 | 16.45 | Incineration/ TDU |
| Drilling chemical waste | 24,000 | 2.80 | 19,500 | 4,500 | 2.43 | Incineration |
| Produced oil | 58,000 | 6.78 | 56,250 | 1,750 | 7.01 | TDU |
| Others | 16500 | 1.93 | 14,600 | 1,900 | 1.81 | Incineration |

From the schedule above, the following can be deduced:

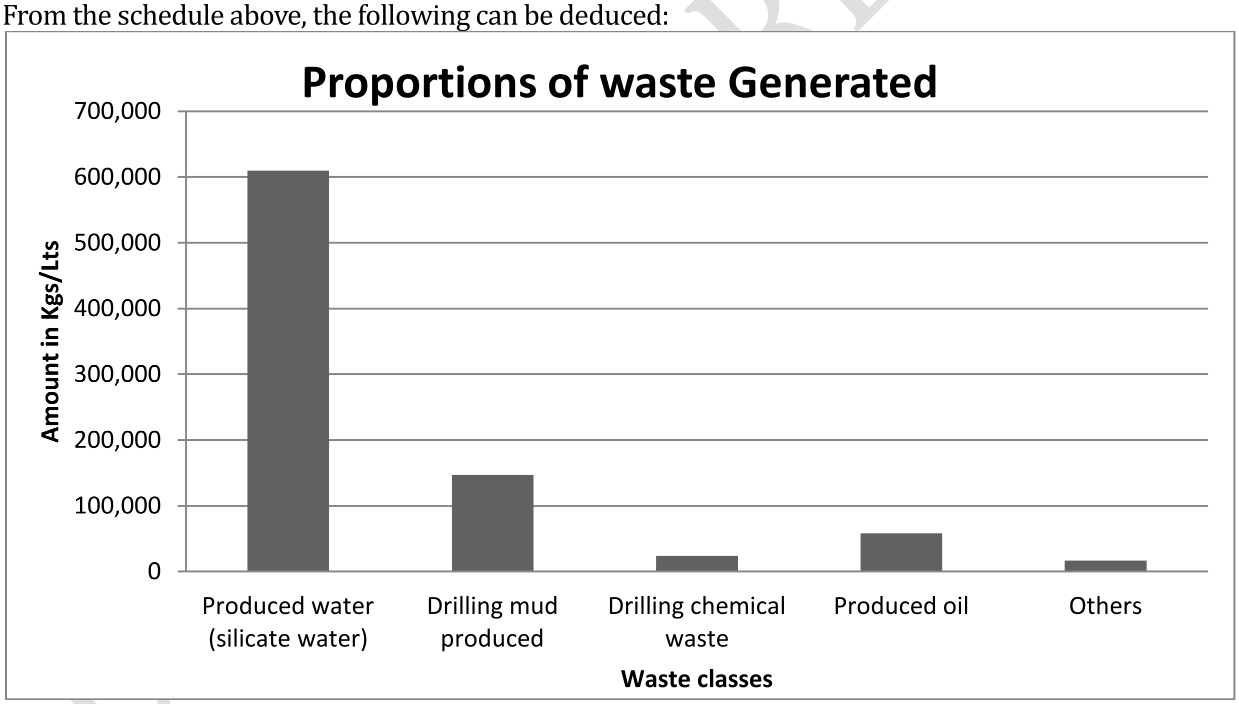


FIGURE 3: PROPORTIONS OF WASTE GENERATED FROM THE RIG SITES

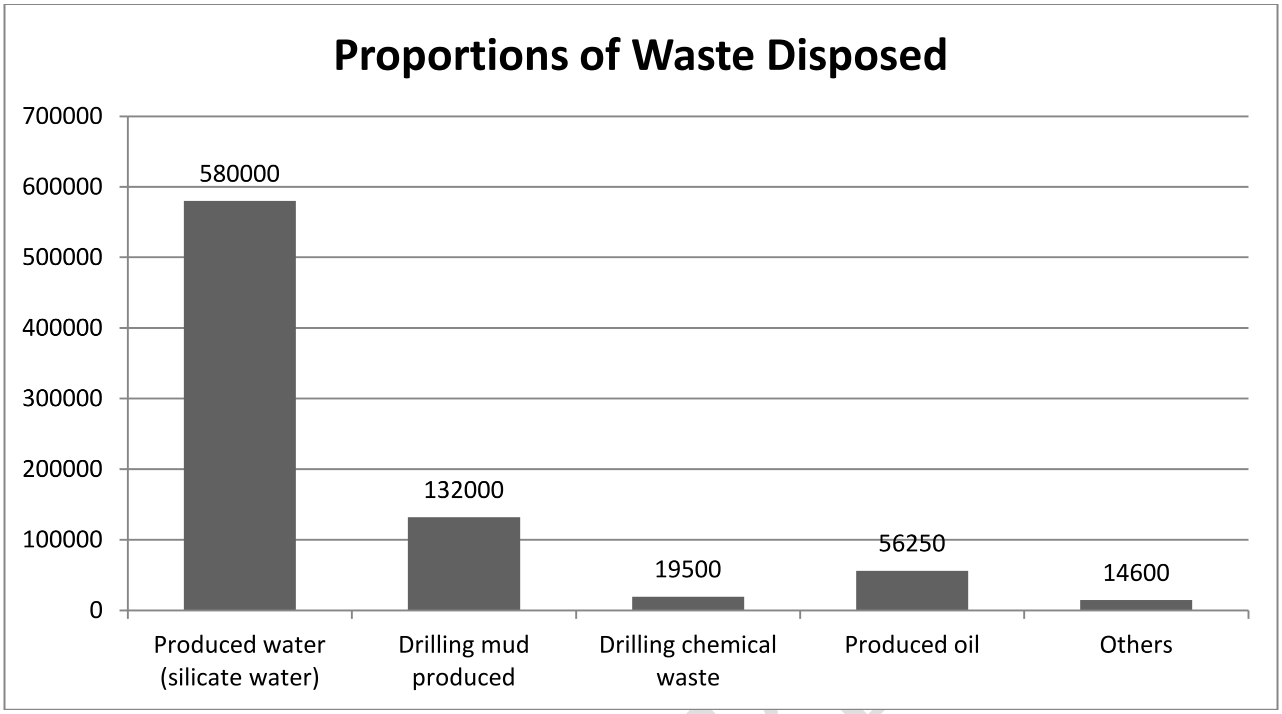


FIGURE 4. WASTE PROPORTIONS DISPOSED FROM THE RIG SITES

From Figure 4, it is evident that produced water forms the bulk of the hazardous waste produced. This makes 71% by proportion. This was translated from 610, 000litres of water produced per week. The drilling operations at the site from which this data was obtained took four weeks to complete active drilling. This means that the total amount of produced water for the entire well is 2,440,000litres. This water contains sodium silicate as the active ingredient.

The mud produced from the drilling operations forms the second largest by volume. This is basically synthetic based mud that is often used by the drillers. At the case study sites, the drilling mud, commonly known as SBM was found to form 17% of the hazardous waste in the drilling operations. This amounted to 147,000kgs by volume. This waste contains various chemical components with varying proportions, depending on the formulation of the drilling mud. This formulation is however dictated by the permanent rock structures at the well site. Nonetheless, the chemicals used tend to be similar in almost all the drilling fluids.

The next category of the drilling waste in the operations is the produced oil. This emanates from flaring and extended well tests processes. This formed 7% of the total hazardous waste produced in the processes. The 7% as per the chart is 58,000lts. The variations may be high, depending on the hydrocarbons in the deposits and the depth of the well at final drilling process.

The chemical waste forms 3%, while other chemical contaminated items and waste from chemical ills form 2% of the volume. The volumes are 24000kgs and 16500kgs respectively. The chart below shows the amounts of waste produced verses the amounts disposed. It was discovered that the drilling company takes the initiative to dispose almost all the waste produced, if not, well managed.

Figure 4 shows the proportions of waste disposed from the rig sites. It shows that 6.27% of the total waste generated had not been disposed as at the end of the drilling process. This is distributed unevenly among the different streams of the wastes. The following chart shows the variations.

#### 4.0.2. Impacts of the waste

Different streams of hazardous waste have varied hazard levels, depending on their toxicities to the environmental ecospheres. The EU classification hierarchy in table 5. has been used to draw an analysis of the hazard levels of the different streams of wastes from the rigs. The following table shows the data received as far as the waste toxicity levels are concerned.

**1 – Carcinogenic 2. – Chronic 3. - Greenhouse effect 4. – Soil/ vegetation toxicity**

| Waste Stream | Hazard level (1-4 as above) | Pollutants present e.g. PCBs, heavy metals |
|---|---|---|
| Produced water (Silicate water) | 4 | Hydrocarbons |
| Drilling mud produced **(OBM)** | 1,2 | Hydrocarbons, heavy metals |
| Drilling Chemical Wastes | 1,2 | Barites, hydrocarbons |
| Produced oil | 3,4 | Hydrocarbons, metals |

TABLE 5. WASTE HAZARD LEVELS ANALYSIS AND POLLUTANTS

It is evident that the drilling chemicals and muds have the highest toxicity levels, followed by produced oil and water respectively. The waste at the top of the hierarchy has been denoted as 1 and has the greatest or most detrimental health impacts, with 4 denoting the least of the impacts. The greatest impacts are those with the potential to cause cancer, known as carcinogenic. Those with mild impacts may only intoxicate the soil, leading to nutrients toxicities and thus less soil productivity.

### 4.0.3. Other Drilling-Related Waste

Other functions of oil drilling also include camp operations and management, transport and other extramural activities. These functions also generate waste and may be associated with drilling operations, though indirectly. Such categories of waste include, grey and black water, sewerage/effluents, used oil from vehicles and machineries, and contaminated wood, construction waste (rubbles and cement), clinical waste. All these are under hazardous and/or biohazardous waste.

It is noteworthy that rig camps are usually very temporary and hardly last for more than 45days. During such periods, domestic and utility wastes are usually generated and have to be properly managed to avoid epidemics. To begin with, there has to be sufficient water to cater for the huge workforce in the rigs. Therefore, grey water, black water, food waste and clinical wastes emanates from the camps' activities. All these fall under the category of related waste and are still hazardous.

The table below shows the amounts of different related wastes produced in one rig site that existed for four weeks.

TABLE 6. AMOUNTS OF ASSOCIATED WASTES AND DISPOSAL METHODS

| Waste Stream | Amount Generated in Kgs | % Proportions | Method of disposal | Period of Production |
|---|---|---|---|---|
| *Black/Grey water* | 110,000 | | Bio-treatment | 4 weeks |
| *Sewerage/Effluents* | 81,000 | | Bio-treatment | 4 weeks |
| *General Non-hazardous solid waste* | (segregated to all the other classes) | | Landfill | 4 weeks |

| | | | | |
|---|---|---|---|---|
| *Used oil from vehicles and generators servicing* | 24,000 | | Incineration | 4 weeks |
| *Wood waste* | 8400 | | Charcoal/fuel | 4 weeks |
| *Plastics* | 6250 | | Recycling | 4 weeks |
| *E-waste* | 600 | | Incineration | 4 weeks |
| *Construction waste (Concrete, rubbles etc)* | 35250 | | Landfills | 4 weeks |
| *Clinical waste* | 450 | | Incineration | 4 weeks |

These waste ranges from offices, which produces mainly E-waste like printing cartridges, electronic parts, cables and A/C parts. The e-waste forms a fraction by percentage of the total waste in this section. From vehicles and equipment maintenance emanates the used oils and filters. This forms 9% in the category of other related wastes. Waste water can be seen to form the largest by volume in this category. This includes water from washrooms and cleaning activities. The amounts usually vary with the number of people staying in each camp per drilling session. The more the number of personnel, the more the amount of used water. Closely and related to this is the sewerage/effluent from the toilets. These are considered as bio-hazardous waste. They can pose serious infection if not well managed in such scenarios.

Another category of the hazardous waste is the construction waste or rubbles recovered from the construction concrete works. These are usually emanating from camp constructions and pads. As much as they are not generated quite often, their volumes are usually high during camp decommissioning. They comprise 13% of the category of drilling-related wastes from figure 4. above.

Contaminated plastics and wood wastes form 3% and 2% respectively by volume. These are mostly from items delivered in pallets, which include chemicals and engineering parts. Wooden pallets are used for loading of such goods on transit and are mostly discarded upon delivery, thus forming part of hazardous waste when contaminated with chemicals.

## 4.1. EXISTING HAZARDOUS WASTE MANAGEMENT STRATEGIES

During the time of research, various strategies of waste handling and management were seen to be in place. The following section describes how various streams of waste were being managed and handled in the area of study.

### 4.1.1. DRILLING MUD

The strategies for managing this waste category in the area of study include: Incineration, Thermal Desorption Unit (TDU) and Block making. During drilling process these waste are generated in terms of oil mixed with mud and cuttings. They may also contain spills of drilling chemicals and are usually deposited in the waste pit that is constructed next to the well bore. This is illustrated in the diagram below;

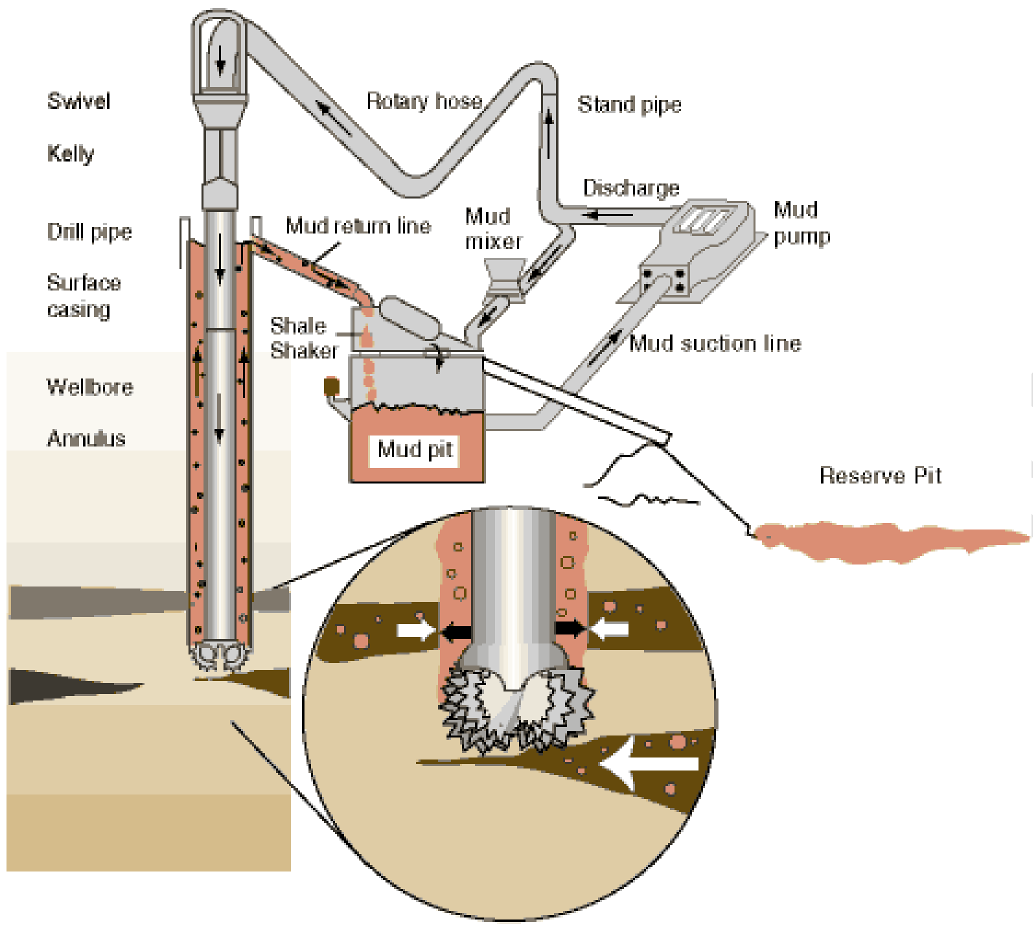


FIGURE 5: PRODUCTION OF MUD WASTE (SOURCE: BLOCK 13T EIA REPORT, TULLOW KENYA)

The pit is bunded with a High Density Poly Ethylene (HDPE) liner which is leak-free. Therefore it contains the sludge during the period within which the well drilling is on course. Cuttings that comes directly from the well bore is collected in a containment next to this pit and transported daily to an accumulation site for processing and decontamination.

The cuttings are passed through a thermal desorption unit (TDU) which recovers the Oil Based Mud and dries up the cuttings to form a dry soil. TDU technology is whereby the wet cuttings are heated indirectly to raise its temperature to around 400°C. This will vaporize the hydrocarbon components of the cuttings which can then be condensed in coolants to recover the oil. This oil is taken back for use in the drilling process. This lowers the cost of drilling and at the same time leaves the soil clean and free from hydrocarbons. The by-product soil can then be used for spreading on the roads, in farms and making building blocks. The next step with the processed cuttings has not been established yet by the drillers. The drillers have engaged the services of a waste management company who have established a TDU to carry out this process so as to recover the drilling fluid and clean the cuttings. It is noteworthy that these cuttings can be rich in minerals and thus proper for farming. They however, may contain heavy metals that may need to be tested and verified in thus absence. Therefore, until the specific contents of the cuttings are established through lab tests and approved by NEMA Kenya, they are not authorized for third party use.

The highly contaminated sludge and mud is usually taken up for incineration in a NEMA licensed facility. This ensures that all the hydrocarbons are destroyed and major pollutants are broken down to less harmful states. This also includes the residual products of the TDU process. The drillers have obtained the services of a licensed company that deals with hazardous waste. This usually safeguards and removes such contaminated waste from the various sites for incineration and/or further safe treatment as deemed fit by the authority. Wider specs of wastes are usually treated through this method to ensure proper disposal.

### 4.1.2. PRODUCED WATER (SILICATE WATER)

This is usually collected in silicate water pit during the drilling period. Large volumes of this water are left to evaporate in the air, leaving sediments to settle down. In cases where the produced water supersedes the pit capacity, which is often the case, then this water is transported in tankers made and labeled as 'silicate water' and transfer to specially made evaporation pits at waste management site designated for handling the drilling waste. The evaporation pits are wider and shallow depressions sunken slightly below the surface and lined with HDPE sheets, with sand berms circumference. With the high temperatures in the region, it is possible to evaporate thousands of liters of silicate water in these evaporation ponds each day. It is a cost effective way of disposal and environmental friendly, since the evaporating water is UV treated. This method however can have various disadvantages, as some harmful chemicals maybe volatilized into the atmosphere. These may pose various risks to the local community.

FIGURE 6: EVAPORATION PONDS FILLED WITH SILICATE WATER    FIGURE 7: AFTER EVAPORATION OF THE SILICATE WATER

The sediments that remain in the silicate pits and the evaporation pits are safeguarded and removed from the sites for incineration. The pits are then restored, whereby the liners are recovered and the pits backfilled once the site is abandoned.

### 4.1.3. CHEMICAL WASTE

These are harmful and not exceptional in this area of study. Thousands of tons of chemicals are used in the drilling process and these have a lot of detrimental effects if not dealt with properly. During the study, it was noticed that all the spilt chemicals and their remnants of drilling were being clustered together in one segment and collected whenever the quantities were enough for a truck load. These were then collected and taken to a licensed site for waste disposal. The contracted disposer operates a high temperature incinerator that is licensed by NEMA to dispose of hazardous waste. Therefore the wastes are collected and transported all the way to Nairobi, a distance of about 600Km for final disposal. The transporting vehicles were also licensed to transport hazardous waste from countrywide to the disposal facility.

FIGURE 8: CHEMICAL WASTE AND THE TRANSPORTING TRUCK

There were occasional chemical spills experienced. The spills were usually contained and emerging wastes safeguarded for collection and disposal. The greatest here is that these spills could find their way to the pastures and consumed by the livestock. These could be harmful to both fauna and flora in the surrounding areas.

The other classes of waste are also disposed alongside these chemical wastes are the e-waste and clinical/biohazard wastes. The biohazard wastes are normally collected on regular basis from the clinics at the sites.

## 4.2. DRILLING ASSOCIATED WASTES MANAGEMENT STRATEGIES (TABLE 7)

Bulk of the related-wastes is basically the effluents and waste waters. These are usually pre-treated through biological digesters. They are fabricated bio-boxes with cultured micro-organisms that help in breaking down the harmful organisms and materials in the effluents and sewerage. They also help in purifying the mix and clean water with acceptable parameters is released from these systems to the environment. In fact this water is used to irrigate tress to compensate for the lost vegetation during site preparations. This water is also used to suppress dust on the roads for enhanced visibility for drivers in while veering the roads. The roads are usually graded seasonal roads that can be very dusty during the dry spell, which is normally the case. Concrete rubbles from constructions are used to make roads as a blinding material. The contaminated ones are disposed off through the disposing contractor. Treated grey water is used to irrigate planted vegetation as way of compensating for the lost vegetation during well pad construction. The figure 9 below shows an irrigated plant using treated grey water.

FIGURE 9: EFFLUENT TREATMENT BIO-BOX AND VEGETATION IRRIGATED BY TREATED WASTE WATER

Scrape metals were taken to scrape yards, where they were eventually taken for recycling. The contaminated ones were sent to the licensed disposer.

Though non-hazardous waste, plastics have formed the largest non-drilling waste by volume. This is due to the fact that a lot of water is consumed and the bottles collected per day are so enormous. With an average of five bottles per day per person, it simply means that 6000people will consume 30,000 bottles of 1litre of water. In cases where half litre bottles are used, then a total of 60,000bottles are used (Tullow, 2015). This can fill a 6tonne truck each day. The company has contracted a non-hazardous waste management company to dispose these wastes in at designated disposal sites. This water bottles menace was however brought to an end when water igloos and water purifying plant was installed at the main camp. This means that every person was given an igloo and would fetch drinking water from the purifying plant his own convenience. This is a reduction method of waste management.

## 4.3. COMPLIANCE TO THE LOCAL LEGAL AND REGULATORY FRAMEWORKS.

***The Waste Management Regulation, 2006*** was used to screen the major activities regarding hazardous waste management at the study area to gauge the compliance level. The observable practices were compared and contrasted against this regulation's requirements using a checklist and scored as shown in the table below. It also shows that the compliance level was rated at 66.43%. Other regulations that are closely related to this regulation were also compared alongside as per the degree of influence in each practice identified. The screening was done as per the table 7 below:

TABLE 7. SCORES OF PRACTICES AGAINST COMPLIANCE LEVEL.

Score of the major practices in regards to hazardous waste management against the requirements of the waste management regulation of Kenya, 2006.
*(Scale of 1-10, with 1 being least compliance and 10 being most compliance*)

| S/No | Observable Practices | Regulations Requirement | Score against Waste Management Regulation, 2006. |
|---|---|---|---|
| | **Average** | | **6.643** |
| | **% compliance level** | | **66.43%** |

EIA regulation of the EMCA1999 of Kenya requires that prior to every project, an Environmental Impact Assessment is done and to which a public participation is mandatory.

Environmental Impact Assessment (EIA) was evidently done in the area of study as was observed. During the EIA process, there was public participation to ensure the local community views were taken into account in order to mitigate the foreseen environmental impacts. (Earthview, 2012). The photo below shows a public participation session during an EIA process.


FIGURE 10: PUBLIC PARTICIPATION SESSION (SOURCE: BLOCK 13 EIA REPORT)

The issue of health and safety under The Mining Act is regulated by the Mining (Safety) Regulations which prescribe rules relating to general precautions, surface protection, underground workings, winding and hauling, raising or lowering persons by mechanical power as well rules on ventilation and sanitation, workmen, explosives, machinery and mine plans as well as procedures in cases of accidents and incidents. At the study site, rigorous EHS system for risk assessments prior to any duty and stringent measures for emergency rescues have been established. Housekeeping procedures to keep work places clean and neat are also made mandatory by ensuring there are designated areas for litter and waste holding.

The Explosives Act, cap115 puts restrictions on the storage and possession of explosives. A permit is required to purchase and use blasting materials as well as to convey explosives within Kenya. An inspector of explosives may prohibit, or restrict the use of explosives in places where blasting may endanger life or property. The use or transport of explosives, in the working of a mine, quarry, excavation or other project is forbidden, unless an explosives manager has been appointed and the inspector notified in writing. The explosives manager is responsible for the safety and security of all explosives used, transported or stored, until they are handed to the blaster for use. During this study, it was identifiable that a Kenyan Police personnel is appointed as an explosives inspector, who oversees the use of explosives which are stored and transported as per the OGP regulations and the explosives act, cap115 of Kenya.

The Kenyan Occupational Safety and Health Act, No. 15 of 2007 legislation applies to all workplaces. Every occupier must ensure the health, safety and welfare at work of all the people working in his workplace as well as protect other people from risks to safety and health occasioned by the activities of his workers. The occupier's duty to ensure the safety, health and welfare of all persons at work in his premises includes providing a working environment and work procedures that are safe. The likely emission of poisonous, harmful, or offensive substances into the atmosphere should be prevented, and where such incidents occur, they must be rendered harmless and inoffensive. Machinery, protective gear, and tools used in all workplaces have to comply with the prescribed safety and health standards. Dust, fumes or impurity must not be allowed to enter the atmosphere without appropriate treatment to prevent air pollution or harm of any kind to life and property. There was a certificate of work place registration for the study site, annual audits were also done, and this served as a proof for some level of compliance to this regulation.

The National Museums and Heritage Act, Cap. 216 assert that the Minister may prohibit or restrict access or any development, which in his/her opinion is liable to damage a monument or object of archaeological or paleontological interest there. All antiquities lying in or under the ground, or on the surface of any land protected under the law as a monument, or being objects of archaeological, paleontological and cultural interest are the property of the Government(Sections 25, 34, 35, 46). This statute relates to the disturbance of, and interference with, sensitive cultural, natural heritage and archaeological sites. At the study area, it was observed that consultative meetings with officers from the Kenya Museums to identify and map the areas of national heritage was done prior to the activities. These were safeguarded and protected against human interference. The figure below shows such protected artifacts.

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FIGURE 11.PALEONTOLOGICAL ARTIFACTS FROM TURKANA REGION

Section 115 part (b) of the ***Water Act*** states that, no person shall without authority under this act, throw or convey, or cause or permit to be thrown or conveyed, any rubbish, dirt, refuse, effluent, trade waste or other offensive or unwholesome matter or thing into or near to any water resource in such manner as to cause, or be likely to cause, pollution of the water resource. From the study, a contractor is involved who treats the biological effluents before they can be discharged into the environment. Moreover, these are tested in accredited laboratories to confirm if they meet the required standards for discharging.

Section 89 of ***The Wildlife Act, 2013*** states that, any person who discharges any hazardous substances or waste or oil into a designated wildlife area contrary to the provisions of this Act and any other written law; pollutes wildlife habitats and ecosystems; discharges any pollutant detrimental to wildlife into a designated wildlife conservation area contrary to the provisions of this Act or any other written law, commits an offence and shall be liable upon conviction to a fine of not less than two million shillings or to imprisonment of not less than five years or to both such fine and imprisonment. The study has shown some commitment of ensuring that waste is not spilled to the wildlife ecosphere situated closer to the oil fields. The drillers carry out green days every Sunday, where all the personnel are charged with the responsibility of collecting any discarded waste in the natural ecospheres. The following shows accumulated waste collected and safeguarded, waiting for disposal. From the observable practices, it was not clear how the waste was traced to ensure no bit spills into the wildlife habitats.

FIGURE 12; SAFEGUARDED WASTE

Generally, whether the practices were compliant to various local regulatory requirements or not were summarized in the table 8. below, as a checklist:

TABLE 8. LOCAL REGULATORY COMPLIANCE CHECKLIST

| | **National Regulation** | **Compliance** *(Tick as appropriate)* | |
|---|---|---|---|
| | | YES | NO |
| 1. | The Kenyan Constitution | √ | |
| 2. | EMCA Act 2015 | √ | |
| 3. | Occupational Safety and Health Act, Regulation 2007 | √ | |
| 4. | Waste Management Regulation 2006 | √ | |
| 5. | Turkana County laws and by-laws on Waste Management | √ | |
| 6 | The Wildlife (Conservation and Management) Act, Cap. 376 | √ | |
| **6.** | The National Museums and Heritage Act, Cap. 216 | √ | |
| **7.** | The Land Act, 2012 | √ | |
| **8.** | The Petroleum Exploration and Production Bill 2014 | | √ |
| **9.** | The Water Act, 2012 | √ | |
| **10.** | Mining Bill 2014 | √ | |

**5.0. DISCUSSIONS**

The area of study was a new venture in the country Kenya that has been exhausted in terms of literature within the nation. It is noteworthy that that as much as oil and gas exploration has never been done in Kenya, the main environmental issues that affect the sector worldwide remains constant. The only great difference is that there have never been specific regulations that are put in place to safeguard the environment from pollution by the waste from the drilling operations.

The findings here were based on one well site where synthetic based mud was used in the drilling process. These are usually easy to recycle and reuse, and thus reduces the cost of drilling. Moreover, the phases of oil and gas extraction are normally categorized into; exploration, appraisal, drilling, extended well tests and production. At each of these stages, different classes of wastes are usually produced and in different proportions. The results presented in this research are mainly based on the drilling phase of the cycle. However, this is deemed to be the most critical stage where the highest amounts of waste are produced. The previous and subsequent stages may not yield as much waste as have been seen in this stage. However, it is expected that a lot of hydrocarbon waste maybe produced during the production stage.

**5.2. Challenges facing drilling waste disposal**

The drilling wastes are usually very voluminous and high risks in terms of chemical composition. This makes it a complex issue to handle. They remain a great challenge to the oil and gas industry all over the world and must be handled with a lot of caution. From the research, it was revealed that the cost of transporting and disposing a kilo of hazardous waste in approximately KShs. 100. Therefore, to dispose adequately the drilling muds and the chemical wastes the drillers require at least KShs. 68,850,000. This excludes the produces water which is still evaporated at the evaporation pits and the sediments still incinerated. This may pile up financial burden as far as the waste management is concerned for the drilling waste.

The waste disposal site is about 700Km away from the drilling sites and this also raises the cost of disposal. The risk of spills is also on high due the distance. The road to and from the drilling sites are also dilapidated and the trucks find very hard times in accessing these sites. Some queasy disposers have tried to make their way into the rigs and collect wastes with doctored documents. There is no government's site where hazardous wastes are disposed or treated. Climatic factors also influence the waste management a great deal in this region. This is because when it rains, the waste pits are usually filled such that the level of the sludge in greatly increased. This helps to increase the cost of disposal. During the dry spell, the pits dry faster and the remaining sludge can be easily scooped and transported for disposal.

The waste pits also pose risk to wild animals and the birds. When these access the site, they would strive to drink this contaminated water and this causes them to slide into the pits and drown. Swarms of insects have been trapped into these water pits and lost. Reptiles like snakes and lizards which are numerous in these places have also been found struggling to get out of these pits after falling in. This means that the biodiversity is greatly affected due to the waste pits.

The legislative frameworks that exist in the country are not adequate in the management of oil and gas drilling waste. There is no specific regulation that has ever been enforced to guide the drillers on how to manage the waste from these sites. This means that initiatives that have been put by the drillers are mainly from the codes of practice by the drilling parties. There is need for clear guidelines for site commissioning and decommissioning.

The environmental effects of oil spills and gas flaring could be damaging to communities near oil extraction and this could put communities in conflict with oil companies who are often accused of destroying the environment. This has the potential of disrupting oil operation. Again, spills and flaring of gas adversely affect livelihoods.

Both the state and oil companies are at the risk of losing substantial revenues during oil spills as a result of committing large amount of resources to compensate affected communities. Compensation against damage or pollution from spills could run into several millions of dollars in a lifetime. This is why a "preventive policy" is preferred to a "response policy".

It is important to mention however that, Kenya's environmental laws and regulations have not been updated yet to address oil-related environmental challenges. Also, Kenya's environmental institutions have limited capacity to deal with both onshore and offshore oil waste and other environmental hazards. The capacity challenge ranges from training deficits to logistics constraints. (KCSPOG, 2014)

The only way to mitigate land and environmental risks is to ensure that local community groups participate meaningfully in investment decisions and project development via the implementation of well-thought out community engagement processes.

With over three million kilos of waste to dispose, it simply becomes an expensive affair for the drilling company to manage. Note that this is only based on one well site. The drilling process now takes one month to complete one well, and thus approximately 3million kilos of waste is produced every month. So far, over twenty seven wells have been completed and this extrapolates to about 81 million kilos of waste. Nevertheless, there is never a debate on where to dispose as the regulations have to be followed to the latter.

Before the waste disposal method to be used is established, several factors influence the decision and these include and not limited to; financial implication, waste type, toxicity level of the waste material, available technology and the legal requirements to dispose that particular waste.

### 6.1. Conclusions

Oil and gas exploration activities usually pose great environmental liabilities whenever they are carried out. There could also be some benefits and therefore a balance must be struck. In order to achieve this, the environmental regulating institution must draw up stringent measures to help curb the problems before they become overwhelming to the ecosystems that host such activities in Kenya. There's generally a great change in lifestyle around these areas and human-wildlife conflicts will start to emanate in this area of study due to sprawling human population. It is noteworthy that this area has very minimal resources and as such low carrying capacity as far as the natural ecosphere dictates. Therefore, environmental sustainability must be given the top priority while these operations are taking place. Waste must be properly handled using both in-situ and ex-situ Best Available Techniques (BAT) of waste management.

### 6.2. Recommendations

During the research there were environmental issues that were pointed out which needs actions to ensure sustainability in terms of resources development. These were related to waste management and the hazardous materials handling during oil and gas extraction process. The following recommendations have been suggested by the research in order to close the gaps identified in the study area.

The government through the ministry of environment and natural resources development should draw regulations that guides disposal of oil and gas production-related wastes. Clear guidelines that states commissioning and decommissioning requirements must be drawn in such regulations and rules and gazette in the Kenyan laws.

Waste disposal facilities that can handle all sorts of hazardous waste should be put up by the government through private public partnerships to increase the capacity of waste disposal and avoid the risk of inappropriate disposal. These should be placed in every county to avoid inter-county movement of the hazardous waste, and only allow the small amount that must be transferred to major disposal facility.

The government through the ministry of environment and natural resource management need to offer a curriculum for training on hazardous waste handling to equip the handlers with proper information.

At times, the well sites could be abandoned and these could remain with a good quantity of hazardous waste. Therefore, clear guidelines on minimum requirements on well site abandonment should be drawn.

The oil drillers needs to work closely with the government agencies in charge of the environment to protect the natural heritage and collect the artifacts found on drilling sites

An initiative to plant trees should be done through village appraisal programmes. This can be very possible when environmental education is practiced in the local community. Organized groups can used such as focus groups, youth and women groups to ensure biodiversity in enhanced in places where vegetation have been cleared to create room for oil drilling. This will serve as carbon sinks for the hydrocarbons released by machineries and vehicles.

The 3Rs (Reduce, Reuse, Recycle) of waste management should be utilized to reduce the cost of waste management

The existing legal framework needs to be institutionalized to ensure keen follow up for compliance.

There needs to be further study to decipher whether the chemicals waste have any direct health impact on the local community and livestock. This means sampling of soil and water around the areas of operation to carry out lab tests and analyses so as to determine the effects and the impacts.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.



**REFERENCES**

Adipepe, A. E. (1991). The Making of the Nigerian environment policy. *Proceedings of the International Workshopon the Goals and GUidelines of National Environmental Policy for Nigeria* (pp. 1-329). Lagos, Nigeria: Federal Environmental Protection Agency.

Amoasah, G. (2010). *THE POTENTIAL IMPACTS OF OIL AND GAS EXPLORATION AND PRODUCTION ON THE COASTAL ZONE OF GHANA.* Accra, Ghana: Wegeningen University.

Bashat, H. (2002). Managing Waste in Exploration and Production Activities of the Petroleum Industry. *Environmental Advisor, SENV* , 1-37.

Carson, P., & Murmford, C. (2005). *Hazardous Chemicals Handbook.* Amsterdam: Oxford.

Commission, E. (2006). *Integrated Pollution Prevention and Control.* New York : European Union.

Environmental Agency, U. (2006). *Treating waste by thermal desorption.* London: Environmental Agency.

EPA. (2013). *Hazardous waste Interpretation of the definition and classification of hazardous waste.* New York: EPA.

GoK. (2006). *Environmental Management and Co-ordination (Waste Management) Regulation.* Nairobi: GoK Press.

Holdway, D. A. (2002). The acute and chronic effects of wastes associated with offshore. *Marine Pollution Bulletin* , 185-203.

Iheoma M.et al. (2013). *www.intech.com*. Retrieved 4 2, 2015, from (http://creativecommons.org/licenses/by/3.0): http://dx.doi.org/10.5772/56526

Nagy, C. Z. (2002). *Oil Exploration and Production Waste Initiative.* Carlifornia: Carlifornia Environmental Protection Agency.

Nwakaudu, S. I. ( June 2012). Drilling Wastes Generation and Management Approach. *International Journal of Environmental Science and Development, Vol. 3, No. 3, June 2012* , 252-257.
Rangarajan T. Duraisamy, A. H. (2013). *State of the Art Treatment of Produced Water.* Intech International: Rangarajan T. Duraisamy, Ali Heydari Beni and Amr Henni (2013). State of the Art Treatment of Produced Water, Water Treatment, Dr. Walid Elshorbagy (Ed.), ISBN: 978-953-51-0928 InTech, DOI: 10.5772/53478. Available from: http://www.intechopen.com/books.
Reiss, J. C. (1996). *Environmental Control in Petroleum Engineering.* Houston, Texas: Gulf Publishing Company.
Smith, P. G., & Scott, J. S. (2005). *Dictionary of water and waste management.* Oxford: Elsevier.
UNEP. (May 2000). *BASEL CONVENTION ON THE CONTROL OF TRANSBOUNDARY MOVEMENT OF DANGEROUS GOODS.* Geneva: United Nations.
UNEP. (2010). *Sustainable Development:.* New York: United Nations.
Vázquez-Luna, D. (2014). *Chronic Toxicity of Weathered Oil-Contaminated Soil.* Various: INTECH.
Welch, D. W. (2011, 12). *www.googlescholar.com.* Retrieved 03 17, 2015, from openoil.net: http://openoil.net/wp/wp-content/uploads/2011/12/Chapter-2-reading-material.pdf
World Bank, IFC. (2007). *Environmental, Health, and Safety Guidelines.* New York: World Bank Group.