Waste Management in the Oil and Gas Industry in Guyana: A Qualitative Study

Abbreviations and Acronyms

Abbreviations	Acronyms
ANOVA	Analysis of variance
BEST	Bahamas Environment Science and Technology Commission
CO_2	Carbon Dioxide
E&P	Exploration & Production
EBSA	Ecological & Biological Significant Areas
EEPGL	Esso Exploration & Production Guyana Limited
EIA	Environmental Impact Assessment
EOR	Enhanced Oil Recovery
EPA	Environmental Protection Agency
FPSO	Floating Production Storage and Offloading Vessel
GESAMP	Group of Experts on the Scientific Aspects of Marine Environmental Protection
IRB	International Review Board
ITOPF	International Tanker Owners Pollution Federation
LNG	Liquefied Natural Gas
MD	Medical Doctor
MOH	Ministry of Health

MPA	Marine Protected Areas
NAF	Non-Aqueous Fluid
TDU	Thermal Desorption Unit
TRG	Tiger Rentals Guyana
UNEP	United Nations Environmental Program

VIR	Visible Infared Radar
WHO	World Health Organization
WMP	Waste Management Plan
WWTP	Wastewater Treatment Plant

Abstract :

The purpose of this research was to assess the Exploration and Production methods used during the process and the challenges faced in waste management in the oil and gas industry in Guyana. The substantial environmental impact is due to the oil and gas industry's ineffective waste management practices. Oil and gas operations are placed kilometers off Guyana's coast, where waste from the rigs may be dumped in the ocean, which supplies the country with water. The oil and gas industry are known to be one of the sectors that contribute to the environmental impacts on the world. Guyana's neighbor, Trinidad & Tobago, a thriving oil-and-gas industry that has already allowed the Caribbean nation to build a strong manufacturing sector, is set for further significant gains. The main risk areas for oil spills are from ships, which are at the passages where the density of traffic is particularly high. This study established an understanding of methods of waste management. The researchers revealed the methodology implemented for proper waste management at the Exxon Mobil and Tiger Rentals Guyana companies.

Keywords: Waste Management in the Oil, Spills in the oil and gas industry, Gas Industry Guyana, Tiger Tank Guyana and Spills, First oil Guyana.

INTRODUCTION

Background of Study

Oil and Gas History in Guyana

"In the 1700s several inconsequential oil seeps were discovered. Dutch explorers in the 1750s discovered flotsam pitch", [1]. This was the beginning of the search for oil in the land of Guyana.

A flurry of deep-water discoveries in the Atlantic off Guyana's coast has changed the future for the small South American nation [2]. In 2015, the Cooperate Republic of Guyana became a subject of interest among the oil industry operators. After decades of the granting of an exploration license in the Stabroek block, Exxon Mobil notified the discovery of prolific oil reservoirs [3]. In 2019, in cooperation with the World Bank, the Guyana Petroleum Resources Governance and Management Project were launched. The objectives of the project are to support Guyana in the process of improving its regulatory and institutional framework, as well as to strengthen the capacity of key institutions to manage the oil and gas sector in the country [4].

[5], in one of its editorials, stated that the search for petroleum off the coast of Guyana commenced in 1958 when California Oil Company performed seismic surveys before abandoning the project in 1960. Other businesses followed, and several licenses were granted. Tenneco was the first firm to spud a well in 1967 when Guyana Offshore # 1 and # 2 were drilled. This comes with its own implications of oil waste, spill, and other related challenges and interest.

"In the late 1950s, McBride Oil and Gas Corporation investigated Guyana as well as Standard Oil of California. This process was proven unsuccessful. After a hiatus, there was no further exploration conducted until 1965" (pg.1). [1].

According to Malaysia's Environmental Quality Act 1974, waste can be defined as "any matter prescribed to be waste and any matter, whether liquid, solid, gaseous, or radioactive, which is discharged, emitted or deposited in the environment in such volume, composition or manner as to cause an alteration of the environment" [6].

Oil and Gas takes on the Caribbean and South America

Guyana's neighbor, Trinidad & Tobago, a thriving oil-and-gas industry that has already allowed the Caribbean nation to build a strong manufacturing sector, is set for further significant gains. Further, the island country is a major exporter of liquefied natural gas (LNG), with an estimated 24 billion cubic meters (850 billion cubic feet) of gas located within its maritime area. It is said that the offshore output has been declining in recent years, but the country has alternatives, and is hoping to benefit from Venezuela's relatively pristine offshore gas reserves as a supply for its LNG plants—thanks to the 2007 Framework Treaty between the two nations, which addresses the unitization of hydrocarbon reservoirs that extend across the delimitation line between the countries [7].

In a press conference article, Trinidad and Tobago's Prime Minister K. Rowley stated that gas production from the Manatee field, which is part of the 283-billion-cubic-meter (10.04-trillioncubic-foot) Loran-Manatee shallow-water natural gas field straddling both countries, could begin by 2024 at rates of between 7 and 11 million cubic meters (270 to 400 million standard cubic feet) per day (8). The field, according to Rowley, represents a landmark in the two countries' cross-border relationship, as it is likely to have favourable implications for the development of additional cross-border fields—including the Manakin-Cocuina and the Kapok-Dorado, which together are

estimated to have a sizeable 850 billion cubic feet of natural gas within the Trinidad and Tobago maritime area [7].

Oil and Gas Spill Challenges

The oil and gas industry are known to be one of the sectors that contribute to the environmental impacts on the world [8]. The challenges this industry brings to the environment, beg for proper waste management practices and policies in place for effective operation. [9] defines waste management as "the collection, transport, recovery, and disposal of waste, including the supervision of such operations and the after-care of disposal of waste, including actions taken by a dealer who purchases and subsequently sells waste or a broker who acts on behalf of others in arranging recovery or disposal waste," [9].

The main risk areas for oil spills are from ships, which are at the passages where the density of traffic is particularly high. The busiest passages are through the Yucatan Channel, the Bahamas Channel, and the Florida Strait [10].

The [11], proposed an estimated 250 oil spills in the Gulf of Mexico and the Caribbean Sea annually. The world's largest-ever tanker spill occurred off Trinidad and Tobago in 1979 when two tankers collided, and 287,000 tons of crude oil was discharged to the sea [11].

The second-largest oil spill in history occurred in the Gulf of Mexico in 1979 during a blowout of Ixtoc *I*, an exploratory oil well, spilling 454 000- 480 000 tons of crude oil into the marine environment.

According to the 2004 **"**GIWA Regional Assessment 4 for the Islands of the Greater Antilles**"**, generally, over 160 million liters of oil are carried across the waterways of this sub-region, and around 50 000 ships pass through the Caribbean. Because of the active shipping channels notably via the Old Bahamas Channel, the potential of significant oil spills in this sub-region is also quite

high, with a devastating impact on the region [12]. It was discovered that Tar balls were detected on the beaches of Cuba, Puerto Rico, and the Bahamas, which are mainly the result of oil tankers discharging residuals when cleaning at sea, according to studies [13].

Oil and Gas on a Global Scale

[14] conducted a case study to analyze oil exploration and production waste generation in offshore platforms and the management procedures and practices in Nigeria. The case study approach was implemented using 6 offshore platforms of Total Exploration and Production (E&P) of Nigeria Limited. The data collection processing of the (E&P) waste generation in the platforms case, were collected from 2010 – 2013. The analysis of variance (ANOVA) statistical method was employed, along with the F – Test to assess the significance of the null hypotheses. The test showed the acceptance of the null hypothesis, H_0A, and the rejection of the null hypothesis H_0B. Thus, concluding that the increase in usage or years (Aging) of offshore oil platforms do not cause a significant difference in the quantity of E & P waste generation in the platforms, [14].

Marcellus Shale and other geological formations in Pennsylvania had substantial development in oil and gas over the last decade and have generated large volumes of liquid and solid waste. In 2017 oil and gas wastewater was reused at well pads to enable more hydrocarbon production while the solid waste by volume was disposed of at in-state landfills [15].

Statement of the Problem

The substantial environmental impact is due to the oil and gas industry's ineffective waste management practices. Oil and gas operations are placed kilometers off Guyana's coast, where waste from the rigs may be dumped in the ocean, which supplies the country with water. The researchers investigated and analyzed how waste from oil and gas exploration and production is managed, as it poses a serious danger to human health and the environment.

Purpose of the Study

The purpose of this research was to assess the Exploration and Production methods used during the process and the challenges faced in waste management in the oil and gas industry in Guyana.

Objectives of the Study

The overall aim of this study was to assess the methods used and challenges faced in waste management in the oil and gas industry in Guyana. The principal objectives were:

1. To determine the waste management practices of the oil and gas operation in Guyana.
2. To determine the effectiveness of waste management practices.
3. To identify the potential environmental impact from the generation of waste at the site.
4. To recommend practices that can isolate waste in and/or around the Exploration and Production

   (E&P) areas.

Research Questions

1. What are the current executive orders on waste management?
2. What is the most accurate and efficient method for collecting and treating waste?
3. What are some preventative measures that can be used to ensure waste does not cause harmful effects on persons and the environment?

Significance of the Study

This study established an understanding of methods of waste management. The researchers revealed the methodology implemented for proper waste management at the Exxon Mobil and Tiger Rentals Guyana companies. Thus, the researchers presented the efficacy of the approach to bringing awareness to this industry.

Assumption of the Study

The researchers assumed that they will be able to identify environmentally friendly waste control methods for this study, but they may be challenged in obtaining transparent information.

Assumed Limitation of the Study

The problems that were expected during this study were as follows:

- The researchers assumed that the current pandemic would hinder the face-to-face operation for the collection of data.
- There would be no accommodation of site visits and verification of data collected would be based on reports of the experts.

Chart 1 : Definition of Terms/ Operational Definitions

Terms	Definition
1. Drilling Waste	Chemicals such as crude oil, natural gas, Carbon Dioxide (CO_2), heavy metals, etc., along with used muds and other additions, produce what is known as drilling waste in the exploration and development process, [16].
2. Drilling	Drilling is the method of cutting holes into the Earth's surface employing a pivoting cutting device [17].
3. Drilling Fluid	Any fluid that is circulated in the borehole to help in carrying out a cost-effective and efficient drilling operation resulting in a stable and gauged borehole to targeted depth with minimum possible damage to prospective formations [18].
4. Ecosystem	The whole system (in the sense of physics) including not only the

organism-complex but also the whole complex of physical factors forming what we call the environment of the biome-the habitat factors in the widest sense [19].

5. Health A state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." They assert that physical and mental well-being is a human right, enabling life without limitation or restriction (World Health Organization [20].
6. Landfill A system of trash and garbage disposal in which the waste is buried between layers of earth to build up low-lying land [21].
7. Offshore Connected to the production of oil and gas at a distance from the land or under the sea [17].
8. Onshore Moving towards land from the sea, or on land rather than at sea [17].
9. Pollution Pollution is the introduction of harmful materials into the environment [22].
10. Recycle The process of collecting and processing materials that would otherwise be thrown away as trash and turn them into new products [23].
11. Reuse Reusing in environment health and safety or waste prevention terminology means using an object or resource material again for either the same purpose or another purpose without changing the object's structure in a significant way [24].
12. Waste Minimization Waste minimization is a process of reducing the amount and activity of waste materials to a level as low as reasonably Achievable [25].

Summary

This research aimed to identify the exploration and production practices by the industry on waste management in Guyana. Waste management is an important process in this industry because of the implications for human and environmental health. [9] concluded that waste management includes a systematic process of supervision, operations, and after-care of disposal of waste. Though history has proved that these measures are usually in place for efficacy, companies around the world have still encountered varying challenges. Thus, the researchers hoped to find reliable policies and practices in place that would prevent hazards to the health and wellbeing of the populace and the environment of Guyana.

REVIEW OF LITERATURE

This chapter reviewed literatures that highlighted the effects of proper or improper waste disposal and treatment, and methods documented different studies on the results of the various methods used.

Review of Literatures

Waste management is considered the principal issue in the petroleum industry [26]. This has often thrown the industry into numerous challenges including technological development to ensuring a clean and safe environment [27]. Any operations associated with oil and gas exploration, production, storage, and transportation generate waste that poses a risk to the environment. Drilling operations, production operations, completion operations, work-over operations, and gas plant operations are examples of these practices [28]. According to [29], the treatment and disposal of petroleum sludge have created a major challenge in recent years.

[28] explained that drilling oil and gas wells produce huge amounts of drill cuttings and used mud. When treating these drilling wastes, onshore and offshore companies used several approaches. Cuttings reinjection, underwater discharge, and shipping to an onshore storage plant are the only solutions available offshore. This is due to the limited space and strict environmental restrictions that control offshore drilling operations. As a result, some offshore waste must be shipped to a site on land for storage and disposal. Onshore processes, on the other hand, have more waste disposal opportunities. The selection of a disposal method for a particular location depends on a number of factors, which must be evaluated extensively before implementation. The main aim should be towards ensuring an environmentally safe waste disposal approach [28].

Inadequate treatment of waste can threaten human health and safety as well as the environment.

The management of the potential impacts of Exploration and Production (E&P) operations on the environment is to identify the activities that potentially cause environmental pollution [30].

Various methods used in the treatment and disposal of petroleum sludge such as Incineration, stabilization/solidification, oxidation, and biodegradation are explained fully and other techniques utilized in oil recovery from petroleum sludge such as solvent extraction, centrifugation, surfactant EOR, freeze/thaw, pyrolysis, microwave irradiation, electro-kinetic method, ultrasonic irradiation and froth flotation [29].

In a systematic review, [6] revealed that offshore production accounts for 30% of the world's oil and gas production and is expected to increase in the future. This understanding was also concor that deeper waters and harsher environmental challenges such as the Artic, is one of the most challenging for a safe and environmentally sound operation. [27] found an important method for minimizing the amount of potentially toxic wastes generated is to use fewer toxic materials for the various operational processes.

[27] revealed data on oil and gas management in a Cross-Sectional study that "Effective waste management is an ongoing process within which the waste management plan can be revised as new waste management practices or technological options of responsible disposal are identified".

[30] added that oil and gas exploration and production activities are responsible for a variety of environmental incidents around the world, including oil spills during transportation and distribution; waste from E & P operations in the form of oil sludge, waste drilling fluid/mud; and waste treatment plant residue (oil separator, oil catcher, dissolved air flotation); leakage from floating storage, tankers, and storage tanks. Findings from the study revealed the cleaning activities of oil and gas, which includes waste management, well completion, treatment, and stimulation

fluid. In addition, produced water, offshore well-drilling leakage, as well as the distribution of oil leaked from the well to the tanker, and finally, the tanker to the mainland were also revealed [30].

In the stages of drilling oil and gas wells, there are different designs necessary for operations for the construction of drilling fluid, saline water muds, and oily muds with special chemical additives [26].

[31] recommended three strategies that can be adopted for the treatment and management of oily sludge, which includes quality reduction, recyclable and harmless. These strategies include (1) Promoting the improvement of production technology of the petroleum industry, thus reducing the amount of oily sludge produced by petroleum and petrochemical enterprises from the headstream. (2) Extract and recycle the reusable petroleum energy from the existing oily sludge. (3) Apply different technologies to treat non-recoverable oily sludge residue or the oily sludge itself, to prevent the environmental pollution caused by oily sludge [31].

[32] concur that various authorities have documented different methods for the management of petroleum-related waste which include barrier walls and permeable reactive barriers, steam injection, and bio-slurry methods. Other methods include bioremediation, phytoremediation, nanotechnology, and sludge treatment. [32], in their ongoing review stated that oil spills upstream and midstream, insufficient wastewater treatment from refineries and petrochemical plants, leakages from flow stations, depots, petrol stations, and transport and storage facilities (depots), are all potential sources of oil contamination in a surficial environment that has not received enough attention in the Niger Delta. However, in some developing countries, the best practice aim is to eliminate, minimize, or reuse (recycle) petroleum waste wherever possible. According to [33] in recent years, many changes in technological approaches for advanced treatment as well as pre-treatment were done except for the physical separation due to its efficiency in petroleum wastewater.

[26] revealed in their findings from a comprehensive review of inofranian's oilfield stated that corral systems, drying-shaker and auger, and disposal sites are considered as most common recycling systems which provide suitable results for the drilling of Iranian's oilfield.

[26] discovered that though small amounts of drilled solids are incorporated into a drilling fluid they are not generally considered detrimental, but if continued over time, serious problems can develop due to the recirculation of particles. These solids can be classified as coarse particles-those greater than 2,000 microns, intermediate particles those from 250 to 2000 microns, medium particles from 75 to 249 microns, fine particles from 45 to74 microns, ultra-fine particles from 2 to 44 microns, colloidal particles less than 2 microns, by their particle size, expressed in microns.

[9] explained in a Case Study that the only waste treatment activity permitted on-site is the disposal of ballast water in the Wastewater Treatment Plant (WWTP). All other wastes are required to be safely collected, segregated, and contained on-site and transported to off-site permitted facilities for treatment. If a new technique for treating waste on-site is to be introduced, it must be accompanied by a new environmental permit application.

He further explicated that after collection, temporary storage of waste (if required) is carried out primarily for economic and logistical reasons. Transport movements on/off-site are greatly decreased when their use is improved in terms of the quantity loaded and the number of trips within site and to off-site treatment facilities [9]

[34] recommends that the preferred sequence of drilling waste management options should be source reduction, waste recycling or reuse, waste treatment, and waste disposal.

In the opinions of [32], the non-availability of waste treatment or disposal facilities, caused a serious dilemma in the management of these waste streams, coupled with the non-availability of analytical instruments in petroleum industries to measure some toxic contaminants present in

petroleum waste. These are major contributors that hinder the proper management of petroleum-related waste in the Niger Delta.

[34] concluded that the first and most important action in the waste management hierarchy is to reduce the volume of waste generated. The next is to recycle or reuse the wastes or materials in the wastes. Only after these goals are achieved should the remaining wastes be treated and disposed of, and thus, would be able increases the volume of waste to be disposed of, and ultimately minimized disposal cost.

[27] had similar principles as [34] who proposed that the first and most preferred option is source reduction. The next preferred option is recycling. Recycling is the reclamation of the useful constituents of waste for reuse or the use or reuse of waste as a substitute for a commercial feedstock or as a feedstock in an industrial process. Together, source reduction and recycling comprise waste minimization. The last two options and least preferred, in the hierarchy, are treatment and disposal [27].

Summary of Literature Review

The literature reviewed and the findings discovered revealed many similarities in best practices and even challenges in the industry. Some studies revealed that the waste management hierarchy or some aspects of it were implemented for the achievement of goals. These studies also discovered common issues found in oil and gas waste such as difficulty to manage and control the system. The findings of the studies proved that the wastes from the Exploration and Production (E&P) are responsible for environmental and human issues as a result of the nature of the operations in the oil and gas industry. The most popular methods that were discovered in studies were recycling, reducing, and reusing. Thus, oil and gas can be human and environmentally friendly, if the principles and policies are implemented and followed.

METHODOLOGY

This chapter dealt with the approach chosen for the planned study. The purpose of this research study was to investigate the methodologies and best practices in place for the oil and gas management in Guyana, Exxon Mobil operation. The research design, data collecting, and research analysis, among other aspects, were discussed. This research study's ethical considerations were discussed in full. It is envisaged that the methods used would yield useful information through the collecting and analysis of data on Exxon Mobil and Tiger Rentals Guyana activities.

Research Design

A study's research design explains the researchers' core approach to answering the research question(s) [35]. It was critical that the researchers choose the most appropriate design for attaining the study's goals and objectives in order to satisfy the study's goals and objectives [36].

The Qualitative Study was carried out to determine how waste is disposed of, and treated in the oil and gas industry in Guyana. The study allowed a flexible approach, which garnered all related information that was available in videos, documentaries, and during the process of the research for a valuable investigation of the study. The study involved the waste management plant of Exxon Mobil and Tiger Rentals Guyana. The data collection tool used consisted of a questionnaire with open-ended questions. This survey intended to gather information on current work ethics as they relate to waste management, as well as the knowledge and experience of the employees of the respective companies. This qualitative study began in November 2020 and concluded in September 2021.

Target Population

The target population of this study was the representatives of the two companies responsible for the Waste Management Departments of their respective companies, Exxon Mobil and Tiger Rentals Guyana. Through inclusion/exclusion criteria, the population was reduced to a small, homogeneous group. The people that emerge as a result make up the target demographic.

Sampling Technique

A purposive sampling was used for the best suited Qualitative research technique that matches this study. Purposeful sampling is a technique widely used in qualitative research for the identification and selection of information-rich cases for the most effective use of limited resources [37]. The reason for this choice was to give the researchers control over the selected group that was qualified for the pre-selected criteria that match with the research objectives. The participants were selected based on status or experience or are known to possess special knowledge of the research objectives and aims.

Sample (including Inclusion and Exclusion Criteria for Selection)

Inclusion Criteria: Workers who are stationed in the waste management department as well as the head of the department.

Exclusion Criteria: Workers who are not designated to the waste management department. Thus,

The workers and the heads of the waste management department, fitting the above criteria were selected for the population. These persons were required to be working in their respective companies for more than two (2) years and have the knowledge and experience of the operations.

Data Collection Instrument

Data were collected in a systematic, and reproducible manner to complement the objectives of the project. Two primary data collection tools were used to collect the information for this study. A questionnaire was chosen as the main data collection instrument for this study, thus one instrument was designed for Exxon Mobile and the other for Tiger Tank Guyana. In addition, a self-administered approach was implemented to answer the questionnaires distributed to both the Exxon Mobil and TRG representatives. The questionnaires consist of open-ended questions that were adopted from previous studies like this study in oil and gas management in Guyana. The questions were sent to the representatives, and the answers were returned in the same fashion.

The other sources of information used for data collection during this study were secondary data sources from the World Wide Web (www.) using online databases, and online books/journals/articles that are related to the research topic. Further, these include online databases; Research Gate, United Nations Library, Google Scholar, EBSCOhost, SAGE Journals, and Sematic Scholar were used to gather such information.

Data Management and Analysis Technique

This research used the qualitative research process. The qualitative process was used to obtain non-statistical data. The type of qualitative data analysis that was best fitted for this research was the Quality Content Analysis. Such an approach was effective for the management of the types of wastes produced, methods of disposal for each type of waste, and the effectiveness of these methods used. The data was stored on both researchers' computers and made secured by passwords as part of the quality assurance process.

The researchers directed the data management process overall, with the guidance of the University of Guyana research supervisor. The researchers as well as the research supervisor were responsible for ensuring metadata production, day-to-day cross-checks, backup, and quality control activities were maintained.

Ethical Considerations

The participants of this study were given the option to participate in the study voluntarily. During the research process, open communication between the researchers and participants was implemented. The researchers were obligated to be transparent and honest with all related questions and issues to this process. The researchers remained committed to the goals and objectives outlined to the participants and companies that were involved in all aspects of the study.

A proposal was produced that explained the research's aim, approach, and dissemination strategy (including plans to share data), as well as an associated consent form (containing intentions to

share data). Each questionnaire gave a detailed written explanation. The participants were give the free will and the option of leaving some of the questions unanswered if they would infringe on the confidentiality of their institutions. As such, questions were left blank, or portions of text were removed from shared answers in such cases.

The data created was shared and owned by the organizational partners. In the database and research results, online and archival sources were recognized and properly acknowledged. Online, through institutional websites, was the most appropriate way of disseminating the data created by the project. Following the completion of this study, the researchers would like to publish the project's findings for the public's edification of the oil and gas operation in Guyana.

The International Review Board (IRB) of the Ministry of Health (MOH) was approached for ethical approval for the conduction of this study in the submission of a proposal to ensure ethical principles are in place to avoid future dilemmas. This permission was granted

Summary

The completion of this research made known the ethical practices that were in place for the disposal and treatment management of the wastes in the industry. The participants cooperated during the research process and provided the 95% of information requested. Thus, the participation of the questionnaire aided the researchers' pertinent information to bring a conclusion to this research.

DATA ANALYSIS, PRESENTATION, INTERPRETATION AND DISCUSSION

The outcomes of the data collecting instrument (a questionnaire) were discussed in this chapter of the study. The data were compared with the responses obtained from the kinds of literature, to note the differences and the similarities noted by scholarly authors, and the researchers contested the research.

Data Analysis

The qualitative research technique was utilized to carry out this process, as described in the methodology of this research. Since the data collection process used was not statistical data, the alternative was most successful during the process.

The study was originally planned with the intent of using the virtual Zoom platform interview approach during the data collection process. Due to constraints beyond the researchers' control, the Exxon Mobil and Tiger Rentals Guyana officials decided to participate in the process by completing the questions through a mailing format. The representatives for the respective companies were provided with the questions, and who was responsible to provide true and correct responses and returned via the emailing system. The questions were answered and verified by numerous workers at their respective institutions. The questions for both Exxon Mobil and Tiger Rentals Guyana consisted of 24 interview questions for the Exxon Mobil representatives and 19 questions for the Tiger Rentals representatives respectively. In both companies, some of the questions were omitted because of confidentiality and relevance to the project.

Presentation of Data and Data Relationship

The Exxon Mobil and Tiger Rentals Guyana representatives' results are compiled and given in text and tabular format. The researchers also utilized diagrammatic presentation to best capture the findings of this research.

Exxon Mobil Results from the Questions Asked

International Regulations/ Guidelines used by Exxon Mobil for Offshore Waste Management

The waste management activities for the various offshore and onshore operations are conducted in accordance with applicable Guyana regulations and guidelines, as well as applicable international conventions and oil and gas standards/guidelines/practices, including Esso Exploration and Production Guyana Limited (EEPGL) corporate standards and practices. Examples of the conventions, standards, and guidelines are as follows:

The primary international convention governing general maritime waste management operations is the International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978 (MARPOL 73/78) (IMO, 2019).

- Maritime transport of wastes (hazardous/dangerous) worldwide is generally governed by the International Maritime Organization (IMO) International Maritime Dangerous Goods Regulations Code (IMDG) [IMO IMDG Code].
- The environmental protection agency in Guyana has in place strategies for the offshore Exploration and Production (E&P) waste management operation, which is governed by the following guidelines:
    - International Association of Oil & Gas Producers (IOGP)
    - International Petroleum Industry Environmental Conservation Association

- IOGP Guidelines for Waste Management—with special focus on areas with limited infrastructure (2008)

Local Regulations used by Exxon Mobil for its Guyana Operations

The waste management activities for the various offshore and onshore operations are conducted in accordance with Guyanese law, including

- Guyana's Environmental Protection Act of 1996;
- Guyana Regulations made under the Environmental Protection Act 1996 (No. 11 of 1996) of 2000;
- Guyana's Environmental Guidelines for the Transportation, Storage and Occupational Handling of Chemical/Industrial Hazardous Waste of 2011 (as applicable);
- Guyana's Environmental Guidelines for Removal, Treatment & Disposal of Oily Sludge of 2011 (as applicable) and
- Guyana's Environmental Guidelines for the Storage, Transportation & Occupational Handling of Biomedical Waste of 2011 (as applicable).

Types of Wastes

Exxon Mobil has several wastes from its operations as well as its day-to-day work on its ships. See Table 1.1. (The typical Marine Vessel Wastes).

The general types of Esso Exploration and Production Guyana Limited (EEPGL) wastes currently being discharged offshore include Non-Aqueous Fluid (NAF) mud and drill cuttings; water-based mud and drill cuttings; various tank wash waters, slops, and other wastewaters that pass static sheen or other tests; bilge water that has <15 parts per million (ppm) hydrocarbon oil content; inert materials, including cement, barite, bentonite, calcium carbonate, gravel pack, sand, etc.; food

waste <25 millimeters; and treated sewage. See Figure 1.1. & 1.2 (The current waste management technologies currently employed at Exxon Mobil; Waste Management Hierarchy, respectively).

The dedication to the waste management hierarchy underpins EEPGL's waste minimization policy. When possible, waste generation should be avoided, averted, or reduced at the source. When possible, non-prevented wastes should be reused or recycled in an environmentally friendly manner. Wastes that cannot be prevented or recycled should be treated in an environmentally safe manner wherever possible; and, ultimately, any waste disposal should be carried out in accordance with any legal requirements.

Waste Storage

Proper storage of generated wastes requires the accurate characterization and classification of each waste stream. Based on the waste characterization and classification, appropriate containers are selected for waste storage, handling, and transportation. During this operation a container selection is evaluated on the following:

- Physical matrix (solid, liquid, sludge), chemical properties (pH, density, viscosity, reactivity, flammability, and so on.)

- Compatibility of wastes with container material construction and design;
- Container secondary containment requirements, waste volume (large vs. small quantities); and
- Container handling requirements (crane, forklift, and truck transport compatibility).

Each maritime vessel has designated waste storage areas, and these waste storage areas are often on multiple decks to facilitate operations. As per the MARPOL 73/78 and IMDG requirements, each vessel is required to have pollution control measures that are related to all operations, including waste storage operations.

Tiger Rentals Guyana Results, see Tables 1.2. Waste Categories for the different wastes at Exxon Mobil during Operations, and Table 1.3. Waste Techniques used for the different Waste Types

Waste Collection Process

The generator must furnish a manifest with a waste profile before waste can be collected. This will be reviewed), once TRG is able to collect, delivery will be scheduled. TRG verifies garbage in accordance with the manifest and assigns treatment. All differences are noted for the customer, and once the garbage fits the manifest, a TRG signs the receiving waste.

After the TRG team determines the proper treatment, the waste is staged for treatment, and all internal waste movement forms are filled out, as well as destruction certificates, after disposal.

Lab Testing

The analytical parameter for testing is guided by requirements as outlined in the environmental permits or related management plans. The integrity of analytical results is directly related to proper sampling techniques. Preparation is critical to the success of a sampling event. The following provides guidance on a possible list of items required.

- All required sample containers and bottles (amber or clear bottles as required by the specific parameter), labels, and preservatives as instructed by the laboratory conducting the analyses.
- Calibration of onsite equipment (pH, temp, etc.) using certified calibration standards.
- Coolers and ice packs for storage and transportation of samples.
- PPE as determined for the sampling Risk Assessment
- Documentation (Hazmat documentation where applicable, Chain of Custody for samples).

Interpretation of Exxon Mobil Data

Exxon Mobil

International Regulations/ Guidelines used by Exxon Mobil for Offshore Waste Management The international regulations/guidelines followed by Exxon Mobil help guide the way the company functions and indicated in this research is based on waste management. The regulations range from marble regulations on pollution to the transfer of ways performance and promoting good practices as well as guides for waste management that focuses on infrastructure. These regulations were hand in hand with each other and are as follows.

- **International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978 (MARPOL 73/78):** The MARPOL Convention is the main international convention that focuses on the prevention of pollution of the marine environment by ships from operational or accidental causes. It is a combination of two treaties adopted in 1973 and 1978, and it was updated by amendments through the years**.**
- **Maritime transport of wastes (hazardous/dangerous) worldwide is generally governed by the IMO IMDG Code:** The IMDG Code is the international reference for shipping dangerous packaging and storage requirements for all regulated hazardous materials.

- **International Association of Oil & Gas Producers (IOGP):** According to IOGP their objective is "We are the global voice of our industry, pioneering excellence in safe, efficient and sustainable energy supply - an enabling partner for a low carbon future".
- **International Petroleum Industry Environmental Conservation Association:** IPIECA operation helps the oil and gas industry to improve its environmental and social performance by Developing, sharing, and promoting good practices.

- **IOGP Guidelines for Waste Management—with special focus on areas with limited infrastructure (2008):** These guidelines have been developed to assist OGP Member and Associate Member companies in their developing efforts to manage the wastes associated with their exploration and production operations, especially in areas with less established oil and gas industry activity. The regulation on the industry experiences the best practice and set out generic considerations that give companies flexibility to address their needs in ways that are appropriate to their specific situations.

Local Regulations used by Exxon Mobil for its Guyana Operations

International regulations are not only used when operations are in effect. Local regulations are also in used to comply with the practices of the country. Guyana uses the following regulations:

- **Guyana's Environmental Protection Act of 1996 (No. 11 of 1996) of 2000:** This Act deals with the management, conservation, protection, and improvement of the environment. It also aids with the prevention or control of pollution, the assessment of the impact of economic development on the environment and the sustainable use of natural resources and other related matters in Guyana.
- **Guyana's Environmental Guidelines for the Transportation Storage and Occupational Handling of Chemical/Industrial Hazardous Waste of 2011:** These guidelines' purpose is basically to provide information to persons on the correct procedures for the transport, storage, and occupational handling of chemical/ industrial hazardous waste. In addition to providing guidance for environmental officers in the field.
- **Guyana's Environmental Guidelines for Removal, Treatment & Disposal of Oily Sludge of 2011:** This Guideline provides information to persons on the proper methods of Removal, Treatment, and Disposal of Oily Sludge.

- **Guyana's Environmental Guidelines for the Storage, Transportation & Occupational Handling of Biomedical Waste of 2011:** The main purpose of these Guidelines is to protect human health and the environment against biological hazards. It provides general information on the proper storage, transportation, and handling of biomedical waste and on various treatment methods that are applicable to Guyana. However, it is applicable to any person who operates a business or facility that generates, stores or transports biomedical waste.

Types of Wastes

These ways from Exxon Mobile are generated from all of their daily operations. These wastes are all different and consistent with different materials that require specific methods to be properly disposed of. Such ways as medical waste consists of different materials such as vials syringes et cetera that cannot be disposed offshore.

Not always can be treated offshore with such as food wastes, drill cuttings, treated sewage et cetera cannot be treated onshore and is transported to an offshore facility.

The current waste management technologies currently employed at Exxon Mobil

Figure 1.1 shows that Exxon Mobil uses six waste management methods for the waste that they do treat.

- **Separation**: Waste is separated from each other based on the state it is received or collected (liquid or solid or sludge) or according to its toxicity (hazardous or non-hazardous) etc.
- **Incineration**: Incinerators designed to handle the types and number of combustible wastes and can eliminate hazardous constituents in those waste streams may be included in the design basis for drill ships and FPSOs. For hazardous and nonhazardous wastes that cannot be managed offshore, EEPGL's contracted waste service providers may use incineration or other

forms of thermal treatment. Burned solid wastes can be reduced by 75 to 85 percent by volume, while incinerated liquid wastes can be reduced by a much higher percentage.

- **Thermal Unit (VIR/TDU)**: Thermal desorption is a reclamation method for extracting hydrocarbons from a variety of materials. This technique, which is non-contact and nonincineration, employs high heat to reclaim oil and other materials. Organic compounds, such as oil-bearing material from refineries, are often processed via thermal desorption.
- **Stabilization/ Solidification**: Any technique that alters the physical or chemical qualities of a waste to make it more suitable for land disposal or further treatment is known as stabilization.

  Solidification is one type of stabilization in which trash is physically or chemically linked or encapsulated in a stabilizing material to form a hardened block that reduces the likelihood of materials of concern (such as metals) being released or leached into the environment. Cement, clay, fly ash, and asphalt are common binding agents or stabilizing ingredients.
- **Container Cleaning**: The containers where waste is stored needs to be cleaned regularly after waste is removed for treatment so that there is no contamination between waste types.
- **Wastewater Treatment**: There are several types of industrial liquid waste treatment that can be used to eliminate harmful elements from liquid wastes, allowing them to be disposed of on land. For significant volumes of liquid waste, such as slops, oily water, or wash water from vessel tank cleanouts, a properly built treatment plant is the ideal management technique.

Waste Management Hierarchy

The WMP is underpinned by EEPGL's commitment to the waste management hierarchy, which is described below.

1. Generation of waste should be Avoided, Prevented, or Reduced at the source whenever feasible;

2. Wastes that are not Prevented should be Reused or Recycled in an environmentally safe manner, whenever feasible;
3. Wastes that are not Prevented or Recycled should be Treated in an environmentally safe manner, whenever feasible; and
4. Finally, Disposal should be employed as a last option and when employed, should be conducted in an environmentally responsible manner

Waste Storage

Waste can be treated immediately or can be stored for a period before it is treated. Exxon Mobil does its storage based on the characterization and classification of waste streams. Once these waste streams are determined the waste is placed into the appropriate containers based plainly on storage, transportation, or handling.

Waste Categories for the different wastes at Exxon Mobil during their operations

The classification of each waste is crucial for safe storage, transportation, and treatment/disposal planning, and it is the first step in proper waste management. This will be based on generator processes and knowledge, as well as a review of manufacturers' SDSs, product specifications, and select laboratory testing and analysis, as needed, to ensure that the hazards of each waste are known, including whether it is flammable, corrosive (acid or base), reactive (oxidizer, pyrophoric, reducer), and toxic.

Wastes Techniques used for the different Waste Types

Each waste is not the same, they are made up of different components or are presented in different forms such as liquid, solid or sludge that requires specific techniques to be used in order to dispose of them. Where such waste as hazardous wastes would require thermal treatment also known as incineration, to properly treat that type of ways because burning that wastes down to its lowest

form being ashes is environmentally friendly since the ashes can be used for land treatment. Management techniques I designed for this specific waste because it is the best methods to treat the ways so that it does not cause harm to the environment or the people around.

Waste Collection Process

The waste collection process is an important part of the waste management process. Knowledge of the process can help in making a smooth flow of wastes treatment. Once the process is determined this is where any problems that may arise can be fixed during, before or after to make sure the wastes is properly treated. The waste collection process will consist of all the operations from its collection to the separation of waste to determining the methods to the results.

Lab Testing

Lab testing is done on these vessels when samples of wastes are collected to determine if it is safe to be treated by analyzing the different components it is made up of. Lab testing is important when analyzing or breaking down the components of what it is made up of to determine whether the waste should be treated immediately or after a period, or if it should be treated on the vessel or onshore for safety reasons of the person who must handle it.

Report on Findings

Exxon Mobil is a globally recognized oil and gas company. Information is not always open for the public's eyes. Exxon Mobil representatives answered most of the questions which were still helpful despite not answering all. The main questions being based on the types of ways, methods of managing said wastes, storage and the laws or regulations used to govern how these methods are to be used or disclosed. The same was done with the Tiger Rentals Guyana representatives, due to confidentiality most questions were answered but not all.

The following are the results gathered from the questionnaires sent to both Exxon Mobil and tiger rentals Guyana representatives.

Discussion

This research study was developed with the aim to assess the methods used and challenges faced in waste management in the oil and gas industry in Guyana, which is generated during exploration and production activities. The objectives of this research were achieved with results from both Exxon Mobil and Tiger Rentals Guyana. The researchers received answers to the questions investigated on the current executive orders on waste management in this field. Also asked were the most accurate and effective waste management techniques for collecting and treating wastes, and some preventative measures that can be used to ensure waste does not cause harm to persons and the environment.

Exxon Mobil is the oil company responsible for the oil extraction along/outside the coast of Guyana. Waste that are generated over the course of E&P operations must be managed prior to disposal or reuse. There are a variety of options for onsite and offsite management available.

The oil and gas industry production activities can generate waste emissions in the form of unwanted material such as operational wastes that are discharged to sea under permit, and unwanted materials. The volume of waste depends on the level of production, drilling and managing activities within the industry. Exxon Mobil handles a number of wastes that are categorized based on the types of wastes. These categories include hazardous and non-hazardous wastes. They are controlled by numerous regulations and laws of Guyana as well as international regulations. These laws and regulations do not only guide Exxon Mobil on the waste management, but it also includes areas of public health, biological, physical and social/cultural resources. With such waste types there are treatment methods that are preferred for them based on the waste management hierarchy. Waste is isolated from each other based on properties. Based on the segregation methods the wastes

are stored in containers until treatment is ready to begin. These wastes are not all treated offshore, they are stored until they are ready to be transported onshore to a waste facility. Exxon Mobil uses Tiger Rentals Guyana for such a task.

Tiger Rentals has been doing waste management in the Caribbean for over 18 years and is in Guyana since 2011. In 2015 a contractual agreement between Tiger Rentals and Exxon mobile has been established although Tiger Rentals Guyana usually supports many other oil companies. The company usually follows all regulatory requirements from the Guyana EPA and international best practices where there is lacking. The categories of waste that are collected by this company from Exxon Mobile Offshore E&P activities are Hazardous Waste Solids, Hazardous Waste Liquids, General/Domestic Waste, Food Waste, Scrap Metal/Wood, and Plastic. Some of the techniques that are employed for the disposal of each category of waste are thermal treatment (Incineration) for Hazardous solids such as oily rags, filters, paint cans, rollers, brushes, bags, and chemical sacks. A vertical Infrared Technology for the treatment of drill cuttings and waste stabilization for centrifuge mud and wastewater is treated using oil-water separation and charcoal filters. There are safety measures implemented in place for each operation such as a Safe Operating Procedure, toolbox talks, and Job Safety Assessment before every job. Tiger Rentals has a storage facility to store waste. The storage time and condition for offshore waste depend on the type of waste. A manifest is received with a waste profile from the generator before waste can be collected. This is reviewed and once TRG can collect a scheduled delivery is made. Upon delivery, TRG verifies waste according to manifest and designate treatment. All discrepancies are documented to the client and a TRG signs receiving waste once it matches the manifest. Once collected TRG team identifies the appropriate treatment, and this is then staged for treatment and all internal waste movement forms are populated and destruction certificates are prepared after disposal.

The waste disposal methods used have been approved by the EPA and passed all local regulations. Medical waste is treated using the thermal treatment and all required PPE is used when handling. Once the waste collected is overly contaminated through the waste verification process all discrepancies are communicated to the client. No Greenhouse gasses are created and TRG does constant stakeholder engagement and feedback to identify any issues, which are logged, and corrective actions implemented**.**

Exxon Mobil's practice of using the waste management hierarchy is similar to the practice stated by the researchers in the literature review. Source reduction as seen in the figure is the most important and preferred method of waste management. Attacking waste when it is at its source is the best possible way of reducing ways before it builds up to a point where methods must be incorporated. An important note, every country or oil company would not use the same methods of waste management as seen with other studies.

Other countries use more advanced methods such as microwave, irradiation, ultrasonic irradiation, pyrolysis, etc. according to study conducted by [29].

CONCLUSION, IMPLICATIONS AND RECOMMENDATIONS

This chapter of the study concluded the investigation and make recommendations for improving waste management procedures in both onshore and offshore waste management in this industry.

Conclusion

This research was centered on the waste management practices of the oil and gas exploration and production waste discharges from the Exxon Mobil operation in Guyana. Onshore, Exxon Mobil uses various methods to discard their wastes, one being onshore treatment i.e. the use of Management Company. Other issues include discarding into the ocean, recycling, reusing, and so on. ExxonMobil considers risk at every stage of development, and they continuously work to manage environmental impacts. Conversely, offshore waste is discarded by waste company TRG, which uses various effective methods such as Waste Segregation, Waste Remediation (thermal), Waste Destruction (incineration), Landfilling, and Specialized Disposal. These methods provide sound environmental considerations.

These methods have been proven effective from the literature reviewed in this industry. Thus, despite the major effects that come with the industry of its advantages and disadvantages, it is also profitable to an economy. The main environmental impacts of the oil and gas industry throughout the stages of exploration and discovery of new deposits include oil spills, disposal of biodegradable and non-biodegradable waste materials, destruction of marine life, and the local fishing industries which creates an economic crisis. In addressing such issues, the industry uses methods that follow international and local standards that are safe for disposal of waste, and maintain a friendly environment. These include recycling, reusing, offshore disposal through landfills, etc.

It was noted that there are important developments regarding waste legislation around the world since industries such as this, pose threats in various ways that may affect the environment or the people who work or reside in it. Thus, it is necessary for these companies, Exxon Mobil and Tiger Rentals Guyana to i) increase the effectiveness of their environmental policies; ii) ensure that it obtains full results from their improved integration of environmental concerns into economic and social decisions, and iii) reinforce its international environmental co-operation comprehensive framework now exists for environmentally sound and economically efficient waste minimization and waste management.

Recommendations

Many organizations, including the Environmental Protection Agency (EPA), strongly encourage operators to follow best practices for preventing discharges throughout the development and treatment of exploration and production waste. Thus, to help improve these companies' efficacy, the researchers recommend the following:

1. Comprehensive surveys, including visual imaging, can be used to determine the locations, sizes, and types of Ecological and Biological Significant Areas (EBSA).
2. Have the boundaries of protected areas be set-back distances based on typical distances of impacts from installations:
    - No less than 200 kilometers from seafloor infrastructure, with no expected Discharge.
    - No less than 2 kilometers from any discharge points and surface infrastructure.
3. Strengthen implementation of environmental policies and legislation, with appropriate supervision of enforcement for both pollution alleviation and nature protection.

4. Conduct a cost-benefit analysis of material recovery schemes and compare their environmental advantages to other types of waste recovery and disposal.
5. Create strategies to guarantee that hazardous waste treatment and disposal are handled in an ecologically sound and economically effective way, as well as clearly define infrastructure needs.
6. Continue efforts to clean up closed landfills and other polluted areas.
7. Implement a thorough and rigorous monitoring program capable of detecting substantial changes inside existing MPAs as well as reference sites outside of MPAs and activity zones.

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Figure 1.1: The current waste management technologies currently employed at Exxon Mobil

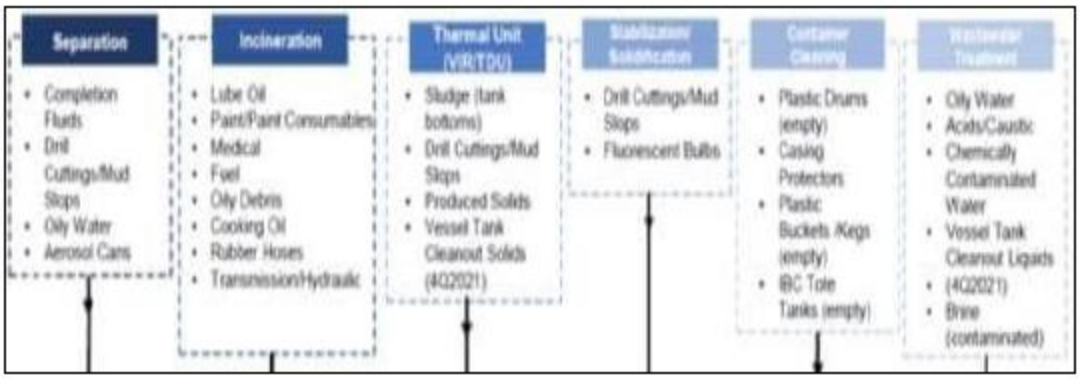
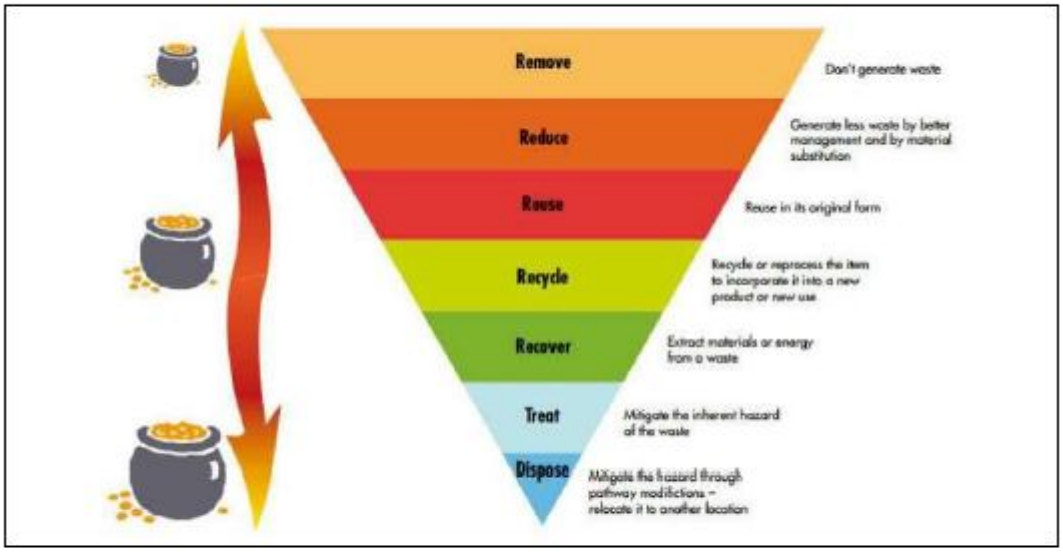


Figure 1.2: Waste Management Hierarchy



Source: OGP. (2009). Guidelines for waste management with special focus on areas with limited infrastructure. Accessed 26 September 2021 at http://www.ogp.org.uk/pubs/413.pdf.

List of Tables for Oil and Gas Waste Management Process

Table 1.1. Types of waste generation offshore at the Exxon Mobil base

Table 1.2. Waste Categories for the different wastes at Exxon Mobil during Operations

Table 1.3. Waste Techniques used for the different Waste Types

The typical Marine Vessel Wastes

Table 1.1. Types of waste generation offshore at the Exxon Mobil base

Type of Waste	Definition and Examples
Bilge Water	Not water but a mixture of a variety of substances. Examples are a mixture of freshwater sea water, oil, sludge, chemicals, and various other fluids.
Consumable Waste	Wastes that consumers' user recurrently. Examples: batteries, envelopes, calculators, computer cables, etc.
Deck & Equipment Area Drainage	Any spill, leak, or dirt on the deck is considered deck waste. To avoid endangering the environment, this sewage is emptied into a tank for further treatment. Fuel or parts of equipment that are no longer functional and must be disposed of are considered equipment waste.
Empty Packaging,	Any use industrial containers such as steel or plastic drum- whether whole, shredded or crushed- that is sent.

Food Waste	Food that completes the food supply chain to a final product, of good quality and fit for consumption, but still doesn't get consumed because it is discarded, whether after it is left spoiler expire. Examples: spoiled food, or peels.
Medical Waste	Medical waste is a subset of wastes generated at health care facilities, such as hospitals, physicians' offices, dental practices, blood banks, and veterinary hospitals/clinics, as well as medical research facilities

	and laboratories. Generally, medical waste is healthcare waste that that may be contaminated by blood, body fluids or other potentially infectious materials and is often referred to as regulated medical waste. Examples: Gauze, syringes, bandages or bandits, medication bottles, blood bags, etc.
Sanitary Waste	Wastes collected from toilets, showers, wash basins, sinks used for cleaning domestic areas, sinks used for food preparation, clothes washing operations, and sinks or washing machines where food and beverage serving dishes, glasses, and utensils are cleaned are all examples of liquid or solid wastes originating solely from humans and human activities.

Tank Cleaning Fluids and Sludges	Oil residues from oily water filtering or separating equipment, as well as purification of fuel and lubricating oils, are collected in a sludge tank. While hydrocarbons make up more than 90% of sludge, it is critical that staff cleaning the tanks spend as little time as possible cleaning inside the tank. There are three types of tank cleaning chemicals: strongly alkaline detergents, extremely acidic cleaners, and disinfectants. Proteinaceous, organic soils are removed by alkaline detergents. Inorganic soils, such asbeerstone or water stains, are best removed with acidic cleansers. Disinfectants kill bacteria and other germs.
Waste Oils / Fuels	Oil that has never been used because it has been tainted, usually by contamination, and is no longer fit for its intended use. Oil spill clean-
	up, bottom sediment from oil tankers after cleanout, and oil tainted by leaking containers are all examples of waste oil.

Tiger Rentals Guyana Results

Table 1.2: Waste Categories for the different wastes at Exxon Mobil during Operations

Waste Categories	Examples
Hazardous waste solids	Oily rags, filters, paint cans, rollers, brushes, bags and chem sacks
Hazardous Waste Liquids	Cleaning fluids, pesticides, or the by-products of manufacturing processes.
General/Domestic Waste	non-hazardous cleaning materials, paper towels, vacuum dust.
Food Waste	Leftovers from a meal, expired food, stale food, blemished fruits, and vegetables.
Scrap Metal/Wood	Appliances, Automobiles, Bed frames and mattress springs, Bicycles.
Plastic	Drink bottles, bottle caps, food wrappers, grocery bags, drink lids, straws.

Table 1.3: Waste Techniques used for the different Waste Types

Wastes	Waste Management Technique
Hazardous Waste Solids	Thermal Treatment (Incineration)
Drill Cuttings	Vertical Infrared Technology
Centrifuge Mud	Waste Stabilization
Wastewater	Oil Water Separation and Charcoal Filters