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Review Article

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A Review in Oil Exploration and Production Waste Discharges According to Legislative and Waste Management Practices Perspective in Malaysia

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Abstract

The core frame of research is dominated by the waste management practice of the oil exploration and production waste discharges from Malaysia's petroleum industry related to legislation. As the waste harms the environment, the composition and possible environmental impact of the waste produced from the offshore drilling process activities are studied. This research will lead to a better waste management practices framework which comply Malaysia's legislation and regulation act. In this study, the biggest issues that limits the waste management practices in petroleum industry in Malaysia is lacking of practices on petroleum waste management. The main difference between waste management practices between Asian and African countries is the African country has more utilization of waste into useful product but has non-modification of the conventional disposal of waste and the Asia country has less utilization of waste but has modification of the conventional disposal of waste. In order to accept the challenge towards sustainable development, this study is very useful for a responsible party as it endow precious Malaysia's asset and promoting a comprehensive efficacy of petroleum refining industry waste controlling practices.

Keywords: Drilling waste; Waste management; Environmental impact; Legislation; Petroleum

Abbreviations: ALARP: As Low As Reasonably Practicable; ASEAN: Association of Southeast Asian Nation; ASP: Alkaline-Surfactant Flooding; CMC: Carboxylmethly Cellulose; CSG: Coal Seam Gas; EIA: Environmental impact Assessment; EPA: Environmental Protection Agency; FME: Federal Ministry of Environment; MLR: Ministry of Land and Resources; MOFCOM: Ministry of Commerce; NCNB: Nigerian Content Monitoring Board; NCS: Norwegian Continental Shelf; NDRC: National Development and Reform Commission; NESREA: National Environmental Standard and Regulation Enforcement Regulation; NHRF: National Harmonized Regulatory Frame Work; NOSDRA: National Oil Spill Detection and Response Agency; NS: North Sea

OBM: Oil Based Drilling Mud; OSPAR: Oil Spill Prevention, Administration and Response Fund; PAC-LV: Low Viscosity Polyanionic Cellulose; PAH: Polycyclic Aromatic Hydrocarbon; PDO: Petroleum Development Oman; PFW: Produced Formation Water; PHPA: Partially Hydolyzed Polycrylamide; PW: Produced Water

Introduction

Oil and gas are one of the most important resources in the world and it plays a role in the global economy. However, the activities of oil and gas from most of companies in the world have many negative impacts on the environment. One of the reasons is due to the waste production from the oil and gas industry. According to 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. The exploration and extraction of oil and gas processes produce the waste materials such as used drilling fluids and drilling cuttings like complex mixtures of clays and chemicals. Usually the waste is discharged directly from the platforms into the surrounding marine water.

Based on the standard procedure, the waste has to clean first before discharge the waste into the marine water by various physical means and the company has to follow the limits on levels of contaminants based on the regulations and legislations. If the disposal of these wastes is not regulated, the resulting environmental pollution may lead to radiation exposure, whether for people directly involved in oil and gas operations, the general public, animals and plants. There are several potential adverse impacts to the marine water due to disposal of wastes. For example is it can pollute of the marine environment, surface soil and water degradation and groundwater contamination?

In general, this paper provides an overview on the oil exploration and production waste discharges according to legislative and waste management practices perspective in Malaysia and the study of the effect of the waste produced from the oil and gas industry to the environment. The scopes of the study are covered by several sections as follows: the oil exploration and production waste discharges, waste management in oil and gas waste products, the regulations and legislations act related to oil and gas in Malaysia and the possible environment impact due to disposal of wastes to marine water.

Literature Review

Oil exploration and production waste discharges

Most of drilling wastes discharge in offshore and onshore is essentially similar. Offshore petroleum drilling waste comprises drilling fluids and drill solid cuttings [1]. Drilling fluids consist of remnants of drill mud. Meanwhile drilling cuttings materials consists of the

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crushed rock cuttings from borehole and returned to the surface with drilling fluid [2]. According to Elnenay [3] drilling muds comprise base fluid and various solid and liquid additives to allow for a good drilling performance. The major components of drill muds are a liquid (such as water, oil, or another organic fluid) and a weighting material (typically bentonite and barite, $BaSO_4$). Several additives are also used to improve the technical performance of the mud. Among these are viscosifiers (e.g. polyacrylates, and other organic polymers), emulsifiers (e.g. alkylacrylate sulphonate and polyethylene oxide), pH and shale control agents, and deflocculants [4]. Some of these additives introduce potentially toxic compounds into the fluids, which must be considered when the resulting wastes are managed. Due to depletion of reserves in numerous onshore locations, the exploration process in Malaysia is expanded to offshore deeper water [5]. Because of these, drilling waste from oil and gas exploration activities has led to a serious environmental issue that need to be considered and managed according to Malaysia's legislation act.

Drilling fluids: The fundamental of drilling mud in oil and gas drilling process are for (1) remove and carry drill cuttings to the surface, (2) control subsurface pressures, (3) lubricate and cool the drill bit, (4) provide borehole stability [6]. Instead of drilling mud, produced water from oily wastewater treatment in oil and gas refining process also included in drilling fluid discharges [4]. This produced water sometimes contains the injection of water and condensation water. Nowadays, in onshore oily wastewater treatment technology has been used successfully in the ASEAN oilfield, but the produced water is more difficult to treat than that from water flooding and polymer flooding [7]. Moreover, has stated that the produced water is more difficult to treat than water flooding since the water produced from Alkaline-Surfactant-Flooding (ASP) flooding has chemical complex substances and stable emulsion system [8]. Besides, some other different additives composition were used green starch, low viscosity polyanionic cellulose (PAC-LV), xanthan gum (XC-Polymer), partially hydrolyzed polyacrylamide (PHPA), potassium chloride (Merck, 99.5%), sodium chloride (Merck, 99.5%), barite, caustic soda, and clouding glycol [9].

Drilling solids: Khondaker [2] found that drilling solids includes inert solids such as barites, active solids such as bentonite, attipulgite and carbonates, thinners such as lignosulfonates, lignites, tannins, surfactants used as emulsifiers, viscosifiers such as starches and CMC bacteriacides, polyacrylamide flocculants and inorganic salts such as $CaCl_2$ and KCl. Other than that, clays, shales, anhydrites, empty bags, pallets and other miscellaneous disposable items are also comprised in solid waste discharges. According to Sadiq [10], one of the most important additives to drilling fluids is barite. It is naturally occurring barium sulphate ore which is a high-density material used to control down hole pressure during the exploration and development phases of offshore well drilling. Besides, Bakke [4] stated barite also used as a weighting agent in drilling muds as it is a primary source of toxic heavy metals in drilling waste discharges. Based on [11] there is a statistical analysis where researcher found some correlation between cadmium (Cd) and mercury (Hg) concentrations, and the concentrations of some other trace metals in the barite.

Waste management in oil and gas waste products

In any given industry, including oil and gas, it is their responsibility to manufacture useful products from raw materials to be used by the consumers but the manufacturing of this useful product comes with a disadvantage, which is the production of waste during the process. There are many sorts of waste that is produced in an industry such as industrial waste, process waste, associated waste etc. It is important that we can manage all of these types of because it can cause harmful effects towards the environment and its surroundings.

There are two types of solid waste that is produced in the process of manufacturing useful products from hydrocarbon. The first type of solid waste is the drilling waste. Drilling waste is when exploration drilling is conducted to obtain crude oil and the waste generated during the exploratory drillings is mostly domestic and non-hazardous. It is composed of drill cuttings and discarded drilling fluids or muds. The next and the most common solid waste that all the oil and gas industry have to overcome is the process waste. Process waste is composed mainly of produced water which is a mixture of oil and water and also oily sludge. Most of this waste can be recycled or disposed in industrial or municipal waste treatment facilities. In the past, various types of sludge were generated in refinery operations and they require handling using alternative thickening, stabilization, and dewatering process prior to final disposal. Final disposal practices might include landfilling, lagooning, land farming, or incineration of the sludge. The predominance if each disposal methods as it existed in 1973 for an estimate of 1983 conditions is presented in (Table 1).

Solid waste management of petroleum

Common and alternative methods of the disposal of petroleum waste: The production of oily sludge not only happens after the production of oil products but it could also happen during in storage tanks. Each year Petroleum Development Oman (PDO) generates approximately 18000 tonnes of oily tank bottom sludge, 53000 tonnes of petroleum contaminated soil, and 1000 tonnes of mud cuttings [12]. However, land-farming is a frequently chosen treatment method for petroleum hydrocarbon-contaminated soils because containment which have a relatively low cost and high potential for success (Table 2). It involves the use of the natural biological, chemical, and physical processes in the petroleum-contaminated soil to transform the organic contaminants of concern [13].

Utilization of the petroleum solid waste into useful product (Table 3)

Recycling and reusing petroleum solid waste in enhancing energy recovery (Table 4)

Solid waste management of drilling waste: The adverse effect

Method	Distribution (%)	
	1973	1983
Landfill	50	44
Lagooning	40	19
Land Farming	9	34
Incineration	1	3
On-site Disposal	44	73
Off-site Disposal	56	27

Table 1: Refining industry sludge disposal practice [46].

Author	Method
Al-Futaisi et al. [12]	Manages oil sludge from bottom of the tank by transferring it into a receiver pit, remaining sludge is mixed with land-farming strips where biodegradation is stimulated with watering and tiling
Hu G et al. [46]	Land-farming, incineration, solidification, solvent extraction, ultrasonic treatment, pyrolysis, photocatalysts, chemical treatment, and biodegradation

Table 2: Methods of the disposal of petroleum waste.

from this course of action causes a concern in the areas of petroleum exploration and development. Proper disposal practices are required to prevent any further marine pollution. Drilling fluids and cuttings are complex mixtures of clays and chemicals and if it is dispose of into water it can cause pollution of marine environment, surface and soil water degradation and groundwater contamination. The method used for the disposal of drilling waste either offshore or onshore depends on many factors including the type of drilling fluid used, type of drilling waste generated and location of drilling operations. For example, the usage of oil based muds for offshore drilling have two ways of disposing which is brought ashore for reconditioning or brought ashore to specific sites for washing [2] (Table 5).

Liquid waste management of petroleum waste

Off-shore and on-shore produced water waste management: With limited volumes and increasing costs of fresh water resources, the search for a more sustainable management practices is crucial for the treatment of and reuse of PW and FFB [14]. Offshore production accounts for 30% of the world's oil and gas production and is expected to increase in the future and it is further moving to deeper waters and harsher environments such as the Artic which is a lot more challenging for a safe and environmentally sound operations. Produced water is the largest waste stream from oil and gas production [15]. Pollutants such as petroleum hydrocarbons, metals, heavy metals, and toxic treatment chemicals and all of this is the composition of the effluent (Table 6).

The negative effect towards the environment caused by the contaminants in the effluent has become a major concern for the oil and gas industry and government which later promotes the significance of offshore produce waste water management. However, due to the harsh environment of the arctic, the applicability of waste water management technology is limited. The differences in managing produced water offshore and onshore are a result of space and motion on off-shore platforms. Factors such as different regulations, produced water volume, and alternative sources of water-flooding also lead to different options for onshore and offshore produced water management [15].

Liquid petroleum waste for contaminated soil management (Table 7)

Regulation and legislation act

In oil and gas industry, the production processes tend to contribute large volume of waste either in solid, liquid or gaseous form [16]. Oil and gas industry is essentially divided into two sectors which are upstream and downstream. The upstream segment explores and produces crude sources from onshore and offshore reserves, while the downstream segment develops crude and natural gas into various refined products and derivatives [17]. The increase in consumption of petroleum product has obvious implications for the operations of the petroleum industry in the country in both upstream and downstream including the risks posed to the natural environment and human safety [18]. Any of the activities either in upstream or downstream sectors pose human health, safety and environmental risk is balancing these

Author	Method
Pinheiro et al. [47]	Oily sludge in Brazil is being treated with bentonite clay which is converted into solid petroleum waste. This solid petroleum waste is disposed into sanitary landfills. Ceramic industry uses a huge amount of natural raw materials and there is an obvious interest in solid wastes as a source of low-cost material
Kuriakose et al. [48]	Purified refinery can be a substitute for processing oil in natural as well as synthetic rubber compounding. It also found that 17% of lighter oil can be recovered from the oily sludge. After the removal of lighter oil, the residue was converted to industrial grade bitumen which is an important component in making paint
Souza et al. [49]	Development of new technologies for petroleum waste recycling, which are consistent with the current needs is of high economics and environmental interest. In previous works, it has been shown that petroleum waste-clay mixtures have potential application in clay-based products

Table 3: Utilization of the petroleum solid waste

Author	Method
Xu M et al. [50]	A new concurrent disposal method for oily sludge is by preparing coal-oily-sludge slurry by adding oily sludge to coal-water slurry is a simple and cheap technology to address issues associated with using organic waste as direct fuel
Shen et al. [51]	Recovery of oil is enhanced by thermal disposal method, which is incineration and pyrolysis but incineration is limited due to existence of secondary pollution and high viscosity of fuels while pyrolysis is more preferable because it is able to separate the stable emulsion of oily sludge into oil, water and residue fraction efficiently
Liu et al. [52]	Incineration has been proven to be an alternative to dispose of many kinds of wasted such as municipal sludge, biomass waste, and industrial waste and this can not only minimize the solid waste but also to recover energy
Ramaswamy et al. [53]	Froth flotation is widely used in technique mining, metallurgical and mineral industries, owing to its very high throughput and efficiency. Flotation is also successfully used to clean up oily waste water and it is an active area research. Present work involves the use of induced air flotation to recover oil from sludge containing oil

Table 4: Recycling and reusing petroleum solid waste.

Author	Method
Khondaker [2]	The process of drilling and extracting oil and gas beneath the ocean floor often require disposal of waste materials such as spent drilling fluids (also called drilling mud) and solid and these materials are often discharged from drilling platforms into the surrounding marine water

Table 5: Solid waste management of drilling waste.

Research	Method
Al-Hubail and El-Dash [54]	In Kuwait, the four technologies that exists in the industry for the disposal of produced is seepage pits, sealed pits, underground effluent injection to recover reservoir pressure. Disposal of produced waste have never been a problem for the petroleum industry in Kuwait as there are large areas surrounding the oil field
Kose et al. [55]	There are two main approaches recommended for the management of PW: reinjection to the discharged wells and treatment for reuse. The types of method applied for treatment of PWs up to date are dissolved air flocculation, gravity separation and skimming, coagulation and flocculation and de-emulsification

Table 6: Off-shore and on-shore produced water waste management.

Author	Method
Wang et al. [56]	Bioremediation, which uses microorganism for pollutant degradation, has been applied for petroleum-hydrocarbon polluted site remediation and most of the petroleum hydrocarbons are comparatively biodegradable. Bioremediation would be a feasible technology for petroleum-hydrocarbon polluted soil remediation
Guo et al. [57]	Another study which is the application of electrokinetics are used to improve the conventional bioremediation. The efficiency of bioremediation strongly depends on the type of contaminant, the availability of nutrient and contaminants, as well as soil conditions, such as soil pH, temperature and moisture content

Table 7: Liquid petroleum waste for contaminated soil management.

concerns with national economic development. This is done through the establishment of an adequate regulatory framework consisting of laws and regulations setting out rights, obligations, procedures and standards, and regulatory institutions charged with responsibility for monitoring compliances [18].

All the waste produced is indeed inevitable, but there is a proper action that can be taken to manage the waste produced. The action taken must be complying with the regulation and legislation act according to the regulation and legislation act. Dealing with municipal waste, commercial and industrial waste in a sustainable way presents significant difficulties [19]. Stringent and periodic iteration of regulations related to the monitoring of chemical releases from the offshore oil and gas industry requires the use of ever changing, rapidly developing and technologically advancing techniques [20]. The primary petroleum industry law in Malaysia is as shown below:

I. Petroleum Development Act 1974

II. Petroleum Regulation 1974

III. Gas Supply Act 1993

IV. Environmental Quality Act 1974

Aside from these, there are a number of other statutes, ordinances and regulations applicable to the industry including and not only limited to the listed Acts. A case study will be discussed on the next sub-topic to give clearer image on how this regulation played an important role to ensure the environment is kept protected from the pollution done by human being.

Case study of AGL's camden gas project-Foam and water emission: AGL's Camden Gas Project is located 60 km south west of Sydney, in the Southern Coalfields of the Sydney Basin. Commercial gas production began in 2001 and currently the Camden Gas Project is NSW's only commercial CSG operation. The Camden Gas Project consists of 144 gas wells and of these 89 is currently producing gas (including 31 horizontal wells). In February 2013, plans to drill another 66 wells to the north were suspended following strong community and government opposition.

In this case study, it is focus on the Camden Gas Project routine maintenance activity at its Sugarloaf 3 well, located near Campbeltown, approximately 1km away from residential area [21]. The cleaning method apply by the maintenance team is just a simple procedure which is, using water, soap, and air to clean sand and coal debris from the well. In this core, the amount of produced water detected by the worker is beyond their expectation. Hence, in order to bring the water to the surface, the amount of soap used in cleaning process is increased as well. The degasser choke was fully open and this resulted in excessive foaming. A visible white plume of foam shot upward for 2-5 minutes and dispersed within 40m of the well. By making quick assumption, the worker assured and convinced that the foam was harmless and did not attempt to adjust the operation of the degasser.

According to North Sea Water Code of Practice for Coal Steam Gas (CSG) Fracture Stimulation Activities, any gas companies are required to prepare a Fracture Stimulation Management Plan for any activity that is conducted at the gas production well including the cleaning and maintenance and from the case, AGL have failed to provide such plan. The Office of Environment and Heritage found that the worker failed to operate the degasser in a proper and efficient manner, in breach of AGL's environmental protection licence (pollution licence) and determined that a formal warning was the appropriate regulatory response given AGL's cooperation and corrective action to reduce the likelihood of this type of incident reoccurring [22].

AGL Company should follow the National Harmonised Regulatory Framework (NHRF) as it is a fundamental guidance and references tool regulator for the CSG industry on how to manage their activity in site. The objective of this regulation is to provide suite of national and global practices to implement in the assessment and on-going regulation of proposed projects for CSG exploration and production. The draft NHRF identifies a series of 'leading practices' aimed at ensuring that CSG activities are undertaken in an acceptable manner based on environmental and social concerns. The first four leading practices are identified as being 'overarching leading practices apply equally to each of the four core areas of well integrity, water management and monitoring, hydraulic fracturing and chemical use. These are:

- Undertake a comprehensive environmental impact assessment, including but not limited to, rigorous chemical, health and safety and water risk assessments;
- Develop and implement comprehensive environmental management plans which demonstrate that environmental impacts and risks will be as low as reasonably practicable (ALARP);
- Apply a hierarchy of risk control measures to all aspects of the CSG project;
- Verify key system elements, including well design, water management and hydraulic fracturing processes, by a suitably qualified and authorised person.

These practices are clearly well aligned with the risk assessment and risk management practices prescribed by Australian water quality guidelines. However, the specific guidance level of detail provided is small compared to what is currently referred to and used by the Australian water industry. There is no apparent cross-referencing to the existing water quality guidelines and hence no obvious attempt to ensure that the approaches adopted for CSG risk management are, in practice, consistent with established practices for water quality management in Australia [23].

Case study of produced water and drilling waste discharges from Norwegian Offshore petroleum industry: Offshore oil and gas activities have been established on the Norwegian Continental Shelf (NCS) over the past 40 years. About 65 oil and gas producing fields are operating and the numbers are increasing [4]. It shows that in 2012, the total production of Norwegian oil and gas production were about 226 million standard cubic meters of oil equivalents [24]. North Sea (NS) has one of the greatest environmental pressures from offshore oil and gas operations, but the highest activities are in Norwegian Sea and Barents Sea. The major contaminants entering the sea from their regular operations are formation water and rock cuttings from drilling. Various physical means are carried out and regulations with strict limits on levels of contaminants on drilling waste and produced water are introduced before it can be discharged to the sea. There are chances of accidental spills of oil and chemicals that can arise during operation. In 2012 totally 122 small incidents were reported with a total oil discharge of 16 m^3. Acute spills of chemicals have been stable at 100e150 incidents per year on the NCS over the past decade [24]. Large chemical spills in 2007, 2009 and 2010 came from leakages from injection wells. No leakage has occurred after that due to technical improvements [24].

Besides oil spillage, until the mid-1990's the discharge of cuttings with oil based drilling mud (OBM cuttings) was the main source of oil hydrocarbons entering the marine environment from the offshore petroleum industry in the NS [4]. The average annual discharge of oil on cuttings to the NCS for the period 1981e1986 was 1940 tons [25]. This source was gradually eliminated by regulation, in 1993 in Norway and in 1996 and 2000 within the OSPAR region [26]. Stricter discharge legislation has been introduced after detection of unexpected ecological effect from sediment monitoring that has been done on NCS. The most conspicuous example is the identification in the early 1990's of much larger areas with fauna effects from OBM cuttings discharges than previously known [27], leading to the prohibition of such discharges by OSPAR in 1996 [28].

Environmental impact from petroleum waste in Malaysia

There are a variety of wastes produced or associated with offshore and onshore petroleum production. The type of waste from oil and gas industry are produced formation water (PFW), drilling fluid chemicals; oil and water based drilling muds and cuttings, crude oil from extraction process, drilling muds (sludge) and the toxic gas released from the manufacturing [29]. Operational discharges of these wastes are continuous source of contaminants to continental shelf ecosystem. Until the mid-1990 the discharge of cuttings with oil based drilling mud (OBM cuttings) was the main source of oil hydrocarbons entering the marine environment from the offshore petroleum industry [4]. The amount of waste produced from an oil industry depends on the geological location, formation conditions, type of production operations and the age of production well.

Produced formation water (PFW): Produced formation water (PFW) is oily water discharged from a platform after separated from oil. The radioactivity level in produced water from unconventional drilling can be significant and the volumes are large. The ratio of produced water to oil in conventional well is approximately 10 barrels of produced water per barrel of oil and accounts for more than 98% of the exploration and production waste. PFW majorly impacts the surface micro layer surrounding hydrocarbon production platforms. In marine systems, many planktonic larval organisms and early developmental stages could potentially be exposed to plumes of PFWs and there is some evidence that exposure of early life stages to low concentrations of PFWs can cause a developmental response at a later stage in sea urchins [30].

Drilling fluids and chemicals: Drilling fluids and chemicals are used to remove cuttings from the hole, prevent blowouts by controlling the back pressure, maintaining the integrity of the hole to permit the installation of a casing and to cool and lubricate the drill bit. There are three types of drilling fluids: water-based, oil-based and synthetic-based. Water-based drilling fluids are the most common and consist of variety of chemicals [30]. The response of benthic organisms has been either a reduced number of individuals with few species close to drilling installations (smothering or toxic effect) or an increased abundance of few species close to source of contamination (organic enrichment effect). Diversity shows a similar pattern to species richness with low diversity near installations and background levels being achieved by 2 km [31,32].

Crude oil: Crude oil produced from the extraction process. Pollution of the seas by oil has become a matter of widespread concern, attracting attention of politicians, environmentalists and scientists [33]. Recent studies have also confirmed that metals can be an important issue of environmental concern owing their presence in crude oil [34] and in marine sediments around oil and gas production facilities. It shows an increasing sub-lethal and chronic effect of crude oil on aquatic organisms, but it is still uncertain of the long term impact on the oil spills. Oil pollution damages property, marine flora and fauna. Pollution from the oil fields usually takes the form of oil spills which affect sources of drinking water and contaminate fishing creeks with mass destruction of fish and other marine life [35]. The beaches have been polluted with tarballs and the chemicals derived from the crude oil which has reduced the beaches potential for recreational purposes [36]. Most of the navigable waters have been seriously affected by discharges of oil from ships and other related facilities in that particular area.

Drilling muds (sludge): Drilling muds consist of certain metal that has potential impact on both temperate and tropical marine ecological process. Their ability to bio-accumulate in tissues and in some cases, bio-magnify up food webs makes them potential contaminants of significance [37-40]. The most obvious metal that appears around drilling platforms is barium (Ba). Barium concentrations in the sediment have thus been frequently used as a tracer to monitor offshore oil and gas discharges [41,42]. According to United Scales Environment Protection Agency, although the concentration of radiation is lower in sludge, they are more soluble and therefore more readily released to the environment, resulting in higher risk of exposure.

Toxic gas: Petroleum industries have greatly affected the air quality by the toxic gas released from both offshore and onshore petroleum industry. These toxic gases are mainly produced when the natural gas produced from the petroleum fractions are flared to convert methane to carbon dioxide since methane gas is four times more dangerous than carbon dioxide. The flaring of the associated natural gas [43] since 1958 currently put at a rate of over one million m3 per day has created serious air pollution problems [44,45]. Besides that, sulphur and nitrogen oxides, ammonia, acid mist and fluorine compounds are also in a form of gas emissions emitted from production and refining plants operations.

Discussion

Issues that limit the practices and evaluation of onshore and offshore waste management in Malaysia

According to our review in petroleum waste management, there a few limitation that are encountered in conducting the practices that are with respect to the law and legislation act set in Malaysia. These complies the lacking of knowledge on petroleum waste management, less encouragement from agencies that manage petroleum wastes, deficit of petroleum waste management technology in Malaysia, inferiority of commitments from petroleum waste management party and finally the cost of managing the petroleum wastes. The results and analysis on the issues that limits the practices and evaluation of onshore and offshore waste management in Malaysia are shown in the figure below. From the result, it is quite obvious that all the issues are essential because all of them have the mean value of importance the average. Lacking of knowledge on petroleum waste management has the highest rank compared to other issues and deficit of petroleum waste management technology in Malaysia is the lowest rank (Figure 1 and Table 8).

Comparison between waste management practices between Asian and African countries

Aside Malaysia, Nigeria is another country that its economy is mainly depends on the petroleum industry. However, the petroleum is industry has been associated with major issues incident and disaster

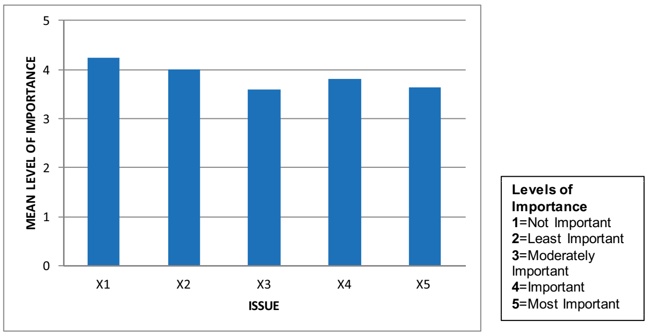

Figure 1: Issues that limit the practices and evaluation of onshore and offshore waste management in Malaysia.

which have contributed to vast safety and environmental problems [18]. The social and environmental costs of oil production have been extensive. They include destruction of wildlife and biodiversity, loss of fertile soil, pollution of air and drinking water, degradation of farmland and damage to aquatic ecosystems, all of which have caused serious health problems for the inhabitants of areas surrounding oil production. Pollution is caused by gas flaring, above ground pipeline leakage; oil waste dumping and oil spills. The authorities that regulate the extraction of oil and gas in Nigeria has been mentioned in Table 9.

In China petroleum industry, basically the crude oil output reached 1.5 billion barrels, 3.42 billion barrels for refined oil, and more than 117.1 billion cubic metres for natural gas (of which 14.1 billion cubic metres is unconventional CBM). China imported 53 billion cubic metres of LNG in 2013, and exported 2.4 billion cubic meters of LNG in 2013. Following is the authorities regulate extraction of oil and gas in China (Table 10).

In Asian countries, there is less utilization of the waste and converting into useful product. This is probably because Asian countries have enough raw materials for the production of products without needing to rely on the usage of waste a substitute. However, Asian countries prefers the conventional practices in disposal of waste such as land farming or land filling but with a slight modification so that they can improve the management of the disposal of waste and to ensure that environment is unharmed. For example, is the co-firing of oil sludge which is associated with coal-slurry although the conventional way of this the incineration but it is already modified to improve waste reducing and improve energy recovery (Figure 2).

As for African countries, they are experiencing problem in obtaining raw material to produce certain type of products due to unavailability

Issues	Description
X1	Lacking of practices on petroleum waste management
X2	Less encouragement from agencies that manage petroleum wastes
X3	Deficit of petroleum waste management technology in Malaysia
X4	Inferiority of commitments from petroleum waste management party
X5	Cost of managing the petroleum wastes

Table 8: List of issues indicated in the chart.

Authorities	Work Description
National Environmental Standards and Regulations Enforcement Agency (NESREA)	Responsibility for enforcing compliance with the provisions of international agreements, protocols, conventions and treaties on the environment
Nigerian Content Monitoring Board (NCMB)	Responsible for supervising, co-ordinating, monitoring and managing the development of Nigerian content in the Nigerian oil and gas sector in accordance with the requirements and prescriptions of the NCDA
Federal Ministry of Environment (FME)	Responsible for administering environmental impact assessments (EIAs) relating to public and private projects, including oil and gas projects
National Oil Spill Detection and Response Agency (NOSDRA)	Responsible for preparing, detecting and responding to oil spillages

Table 9: The authorities regulate extraction of oil and gas in Nigeria [58].

Authorities	Work description
National Development and Reform Commission (NDRC)	General authority to regulate all projects in China, including oil and gas projects. It examines and approves oil blocks available for Sino-foreign co-operation and development plans
Ministry of Land and Resources (MLR)	Primarily charged with regulating oil and gas resources within China. It awards oil exploration/exploitation licences, regulates the transfer of licences and supervises compliance by licensors. It also approves geological survey qualifications and resources/ reserves reports
Ministry of Commerce (MOFCOM)	Authority to approve business structures and M&A transactions
Ministry of Environmental Protection	Charged with administering environmental policy and legislation in China
State Administration of Work Safety	Separate regulatory authority regulating occupational health and safety matters

Table 10: The authorities regulate extraction of oil and gas in China [58].

or shortage of supplies. But they can manage to overcome this problem by utilizing the waste as a substitute. For example is the making of porcelain stoneware tile and ceramic clay because the constituent of the waste which is not hazardous is somewhat suitable for certain products. As for the disposal of waste, usually African countries just follow the conventional method because they probably have many and large suitable places for disposal. Below are the chemical discharge limitation published in Malaysia and Nigeria (Tables 11 and 12).

Conclusion

In conclusion, the waste management practice of the oil exploration and production waste discharges from Malaysia's petroleum industry related to legislation act has been discussed accordingly. The foremost issue that limits the waste management practices in petroleum industry is lacking of practices on petroleum waste management. Moreover, it is notoriously difficult to study and compare the oil exploration and production specific volumes waste discharges by Malaysia petroleum companies as there are limited sources on findings. The comparison studies have been conducted based on other relevant country such as China represents Asian continental and Nigeria represent African continental. This results the African country has more utilization of waste into useful product but has non-modification of the conventional disposal of waste and the Asia country has less utilization of waste into something useful but has modification of the conventional disposal of waste.

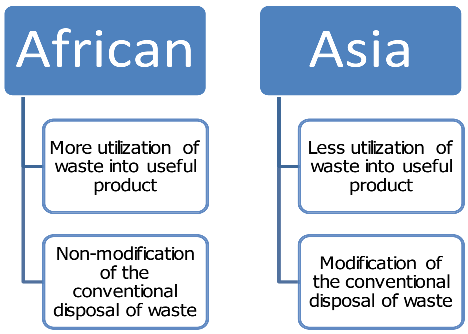

Figure 2: Waste management practices between Asian and African countries.

Parameter	Class 3 (Ports, Oil & Gas Fields)
Temperature (°C)	≤ 2°C increase over maximum ambient
Dissolved oxygen (mg/L)	3
Total suspended solid (mg/L)	100 mg/L or ≤ 10% increase in seasonal average, whichever is lower
Oil and grease (mg/L)	5
Mercury* (µg/L)	50
Cadmium (µg/L)	10
Chromium (VI) (µg/L)	48
Copper (µg/L)	10
Arsenic (III)* (µg/L)	50
Lead (µg/L)	50
Zinc (µg/L)	100
Cyanide (µg/L)	20
Ammonia (unionized) (µg/L)	320
Nitrite (NO2) (µg/L)	1000
Nitrate (NO3) (µg/L)	1000
Phosphate (µg/L)	670
Phenol (µg/L)	100
Tributyltin (TBT) (µg/L)	0.05
Faecal coliform (Human health protection for seafood consumption)	200 faecal coliform 100 mL^{-1}
Polycyclic Aromatic Hydrocarbon (PAHs) ng/g	1000

Table 11: Malaysia marine water quality criteria and standard.

Parameter	Nearshore	Offshore
pH	6.5-8.5	No Limit
Temperature (°C)	30	-
Total Suspended Solid	>50	-
Oil and grease (mg/L)	20	40
Chemical Oxygen Demand	125	-
Biological Oxygen Demand	125	-
Mercury (mg/L)	-	-
Chromium (VI) (µg/L)	0.05	-
Copper (mg/L)	No limit	-
Sulphide (mg/L)	0.2	0.2
Lead (mg/L)	No limit	-
Zinc (mg/L)	5	-
Sulphate (mg/L)	200	300

Table 12: Nigerian effluent discharged limits, Isehunwa and Onovae [59].

Oil and gas industry is indeed having given a great impact to development in Malaysia as well continued to serve as one of the major source of income for the government. Despite the challenges that the oil and gas industry is currently facing, the focus on oil and gas projects arising from Economic Transformation Program will create a more dynamic and progressive oil and gas industry in Malaysia with various market opportunity and potential jobs.

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