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Sustainable Development and Waste Management in Offshore Oil and Gas Drilling and Production Industry

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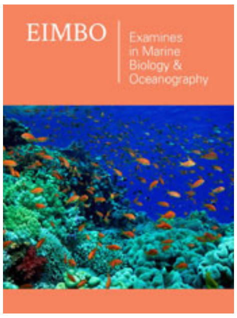

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Abstract

The present work summarizes and delineates the sources and types of wastes associated with oil and gas offshore drilling and production industry. The work is prepared using descriptive approach in addition to the information obtained from several site visits to different offshore rigs and platforms belonging to different oil and gas companies working in the Arabian Gulf area during the period from 2002 to 2010. It highlights the importance of developing and implementing waste management plans and actions to optimize the use of oil and gas offshore resources. It also demonstrates the waste management hierarchy which can be applied to minimize the negative impact of the offshore oil and gas industry to help in achieving environmental protection and sustainable development in this highly important economic sector

Introduction

Sustainable development is development that lasts. A specific concern is that those who enjoy the fruits of economic development today may be making future generations worse off by excessively degrading the earth's resources and polluting the earth's environment. The general principle of sustainable development adopted by the World Commission on Environment and Development-that current generation should "meet their needs without compromising the ability of future generations to meet their own needs"-has become widely accepted. In considering what we pass on to future generations, we must take account of the full range of physical, human, and natural capital that will determine their welfare and their bequests to their successors.

Offshore oil drilling and production industry wastes include petroleum hydrocarbons, salt, heavy metals, production chemicals, drilling fluids, produced water, nuclear radiation in addition to air pollutants and acoustic impacts [1]. These wastes have potential negative impact to present and future human welfare therefore they must be managed to achieve sustainable development in this economically important industry [2].

Objectives

The present work aims at summarizing and delineating

A. Sources of wastes associated with offshore oil and gas industry.

B. Waste management plans and actions.

C. Waste management hierarchy with special emphasis on waste treatment and disposal in offshore oil and gas drilling and production industry.

Methodology

This work is prepared using descriptive approach in addition to the writer knowledge and experience in the area of marine pollution and its control and also in view of the information gained during several site visits to rigs and platforms belonging to different oil companies working in the Arabian Gulf area during the period from 2002 to 2010.

Result and Discussion

Wastes are generated from a variety of activities associated with oil and gas offshore drilling and production industry. These wastes fall into the general categories of produced water, drilling wastes and associated wastes [2]. Produced water always contains impurities, and if present in sufficient concentrations, these impurities can adversely impact the environment. These impurities include dissolved solids, suspended and dissolved organic materials, formation solids, hydrogen sulphide, and carbon dioxide, and have a deficiency of oxygen. Produced water may also contain low levels of Naturally Occurring Radioactive Materials (NORM). In addition to naturally occurring impurities, chemical additives like coagulants, corrosion inhibitors, emulsion breakers, biocides, dispersants, paraffin control agents and scale inhibitors are often added to alter the chemistry of produced water.

Water produced from some projects may also contain acids, oxygen scavengers, surfactants, friction reducers and scale dissolvers that were initially injected into the formation. Drilling wastes include formation cuttings and drilling fluids, water-based drilling fluids may contain viscosity control agents such as clays, density control agents such as barium sulphate, deflocculants such as iron or calcium-lignosulphonate, caustic soda, corrosion inhibitors, biocides, lubricants, lost circulation materials and formation compatibility agents [3]. Oil-based drilling fluids also contain a base hydrocarbon and chemicals to maintain its water-in-oil emulsion. Drilling fluids typically contain heavy metals like barium, chromium, cadmium, mercury and lead. These metals can enter the system from materials added to the fluid or from naturally occurring minerals in the formation being drilled through. Associated wastes are those other than produced water and drilling wastes. Associated wastes include the sludge and solids that collect in surface equipment and tank bottoms, water softener wastes, scrubber wastes, stimulation wastes from fracturing and acidizing, and wastes from accidental spills and releases [4].

Another waste stream associated with the offshore oil and gas industry is air emissions. These emissions arise primarily from flaring, venting and purging gases and from the operation of internal combustion engines. These engines are used to power drilling rigs, pumps, compressors, and other equipment used for different purposes. Other emissions arise from the operations of boilers, steam generators, natural gas dehydrators, and separators. Fugitive emissions from leaking valves and fittings can also release unacceptable quantities of volatile pollutants [2].

Offshore oil and gas industry have the potential to impact the marine environment [5]. Therefore, comprehensive environmental protection plans, including waste management and contingency plans are needed to optimize the use of offshore oil and gas resources. It is of great importance in developing environmental protection plans to conduct an environmental audit to identify all of the waste streams at a particular site and to determine whether those waste streams are being handled in compliance with all applicable regulations [2]. Once an audit has been conducted, a written waste management plan for managing each waste stream should be developed. These plans identify how each waste stream is to be handled, stored, transported, treated, and disposed. The plan should also, indicate how records are to be kept [6]. Contingency plans are needed to minimize the impacts of accidental releases of materials and should incorporate relevant emergency responses.

Waste management plans identify exactly how each waste stream should be managed. They ensure that appropriate engineering controls, proper waste management options, adequate record keeping and reporting systems, and ongoing employee training are in place. One of the first steps in developing a waste management plan is to identify the region and cope to be covered. All materials generated within the region must be identified, quantified, and characterized. These data must include chemical, toxicological, health, fire, explosive, and reactivity information. They should also include first aid procedures to be used in the event of human exposure to the material. The potential for a material to migrate from a site must also be considered when determining the best way to manage it [7]. Factors like topography, water hydrodynamics, geology, sediment conditions, protected habitats and the presence of endangered species in the area must be evaluated. A critical factor that must also be considered in developing waste management plans is the regulatory status of each material at a site. Wastes may be classified as exempt and nonexempt. Nonexempt wastes can be further classified as hazardous, nonhazardous, or special wastes [8]. Exempt wastes are directly associated with offshore drilling of an oil or gas well or generated from the exploration and production of oil and gas. Most wastes in the offshore upstream petroleum industry fall into this classification. Nonexempt special wastes are covered under special status and regulations. Examples of wastes in this classification are asbestos, naturally occurring radioactive materials (NORM), polychlorinated biphenyls (PCBs), and pesticides [9].

A critical step in developing waste management plans is to identify a specific action plan handling each and every material at all sites covered by the waste management plan. The hierarchy of waste management principles defines the preferred order for action related to managing wastes. The first and most important action in the waste management hierarchy is to reduce the volume and /or toxicity of wastes generated. The next action is to reuse the wastes or materials in the wastes. Only after those actions have been completed should the remaining wastes be treated and disposed [10]. By following this hierarchy, both the volume of waste to be disposed and the ultimate disposal cost will be minimized. Possible actions for managing each material at a site can be identified by evaluating current practices in that area, current practices in other areas, current practices for other types of wastes, practices used by other companies or industries for similar wastes, and new practices that may be described in trade shows or in the literature.

Once a list of possible actions have been identified, those actions need to be evaluated and prioritized and a preferred action selected. Factors to be considered include cost, practicality, future liability, regulatory status, availability of resources and facilities, company policy, and local community concerns. This evaluation can include a risk assessment study to optimize the use of the available funds.

A critical aspect of good waste management plans is to develop and maintain good bookkeeping practices. This bookkeeping must include a waste tracking program which identifies where the waste was generated, the date the waste was generated. The type of waste and its volume, any needed transportation of the waste, the disposal method and location, and the contractor employed [6]. A waste management plan must also identify which personnel are responsible for the proper management of all wastes produced at the targeted facilities.

Environmental management encompasses a variety of strategies for dealing with waste [11]. The hierarchy which can be used to prioritize these strategies can be summarized as follows:

Prevention

The best waste reduction strategy is one that keeps waste from being formed in the first place. Waste prevention may in some cases require significant changes to process, but it provides the greatest environmental and economic rewards. Waste prevention strategy may include inventory management, improved operations, materials substitution and equipment modifications.

Recycling and reuse

If waste generation is unavoidable in a process, then strategies that minimize the waste to the greatest extent possible should be pursued, such as recycling and reuse. Many of the materials in offshore oil and gas drilling and production waste streams can be used more than once. If materials are intended for future use, they are not wastes. The following materials have a potential for reuse: acids, amines, antifreezes, batteries, catalysts, caustics, coolants, gases, glycols, metals, oils, plastics, solvents, water, wax, and some hazardous wastes. Material reuse can be facilitated by installing equipment that allows reuse, for example, closed-loop systems can be installed so that solvents and other materials can be collected and reused in plant process. Reusable lube oil filters can be installed in some applications instead of throwaway filters [7].

Flared natural gas can be re-injected for pressure control, or an alternate use for it can be found. Flaring should be restricted to emergency conditions only.

Treatment

When wastes cannot be prevented or minimized through reuse or recycling, strategies to reduce their volume or toxicity through treatment can be pursued. Treatment may be done by physical or chemical methods, photolytic reactions, thermal treatment methods, biodegradation, and land treatment and composting, based on the properties and behavior of the waste. The methods of physical treatment include phase separation: filtration, phase transition: distillation, evaporation and physical precipitation, phase transfer: extraction and sorption, and molecular separations: reverse osmosis, hyper- and ultra- filtration. The chemical treatment methods include acid/base neutralization, chemical precipitation, oxidation/reduction, electrolysis, hydrolysis and chemical extraction or leaching and ion exchange.

Disposal

The last strategy to consider is alternative disposal methods. Proper waste disposal is an essential component of an overall environmental management program; however, it is the least effective technique. Immobilization, stabilization, fixation, solidification, and chemical fixation are commonly used techniques whereby hazardous wastes are placed in a form suitable for long-term disposal. Solidification can be done through sorption to a solid matrix material, or thermoplastics and organic polymers, or vitrification, or solidification with cement, or solidification with silicate materials or encapsulation. There are several approaches to be applied for the ultimate disposal of ash, salts, liquids, solidified liquids and other residues that must be placed where their potential to do harm is minimized. These approaches implies on disposal aboveground, landfill, surface impoundment of liquids, and deep-well disposal of liquids.

During offshore oil and gas drilling and production activities, many wastes are generated that must be treated. The purpose of waste treatment is to lower the potential hazards associated with a waste by reducing its toxicity, minimizing its volume, and/or altering its state so that it is suitable for a particular disposal option. For many wastes, treatment is required prior to final disposal. The different treatment methods vary considerably in effectiveness and cost. Most waste treatment processes involve separating a waste stream into its individual compounds, e.g., removing dissolved or suspended hydrocarbons and solids from water or removing hydrocarbons from solids. In many cases, a series of methods may be needed to obtain the desired treatment levels. Removal of suspended hydrocarbons from water may be done by gravity separation or heat treaters or gas flotation or filtration or filtration coalescence or chemical coagulants or electric field separation or biological processes, while removal of dissolved hydrocarbons from water may be done by adsorption, volatilization, biological processes, precipitation, ultraviolet irradiation, and oxidation. Removal of suspended solids from water can be done by gravity separation, or filtration, or coagulation, while removal of dissolved solids may take place by ion exchange, or precipitation, or reverse osmosis, or evaporation/distillation, or biological processes, or neutralization.

During offshore oil and gas drilling and production activities, substantial contaminated cuttings, sediment, and produced solids are generated. The most common treatment method is to separate the solids from any contaminating water and/or hydrocarbons. A variety of methods are available to remove water from solids, including evaporation and filtration in addition to mechanical methods to dewater solids [2]. Varieties of methods are available to remove hydrocarbons from solids, such as drill cuttings, contaminated sediments, and produced sand. These methods include washing, adsorption, filtration, heating, solvent extraction, incineration, biological degradation, and mechanical filtration.

One way to treat contaminated solids is to solidify the mixture so that the contaminants become part of the solid. Solidification reduces pollutant mobility and improves handling characteristics. Two types of solidification have been used: adding materials to absorb free liquids and adding materials to chemically bind and encapsulate the contaminants [7]. During offshore oil and gas drilling and production activities, a substantial volume of air pollutants can be generated and emitted. These pollutants include hydrocarbons, Sulphur oxides, nitrogen oxides, carbon monoxide and dioxide, and particulates [2]. A variety of treatment methods are available, but their effectiveness varies considerably with the pollutant being treated.

The upstream offshore oil and gas industry generates a significant volume of wastes, primarily produced water and drill cuttings, no matter how effective a waste management plan or waste treatment program may be, wastes will remain that must be disposed of in offshore sites the wastes are commonly shipped for disposal off-site.

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