ENVIRONMENTAL CONCERNS CAUSED BY DRILLING AND PRODUCTION OPERATIONS IN PETROLEUM INDUSTRY (A CASE STUDY)

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ABSTRACT: *As we step into 21st century, the world is more concerned about environmental pollution. Petroleum industry is playing a major role in fulfilling the world energy demands and needs. But during the exploration and production phase of petroleum, a lot of waste is generated which is a source of environmental pollution and has adverse effects on the health of living organisms. Special attention is required both from the petroleum industry and environmental regulatory authorities to device means to effectively control pollution due to petroleum exploration and production. This paper highlights major environmental problems regarding petroleum industry and also provides possible solutions to address these issues effectively.*

Keywords: Environmental Pollution, Drilling, Production, Petroleum Industry.

INTRODUCTION

Oil and gas drilling is a subsurface operation in which a bore-hole is drilled to provide a conduit from surface to subsurface petroleum reservoir for hydrocarbon production.

A main point of concern has always been to protect the environmental pollution during drilling and production operations. For this concern, research has been undergoing since long, resulting into modifying the drilling procedure and chemicals which are used in such processes [1].

Environmental concerns are categorized mainly into two sections:

1. Environmental impacts during drilling and testing operations
2. Environmental impacts during production

During drilling and testing operations the major environmental impacts are related to:

- Land clearance/Providing road access to the rig-site
- Preparation of drilling-mud and cement slurry and their use in the well-bore
- Noise pollution during drilling and testing
- Air pollution during drilling and testing
- Water pollution during drilling

Before spudding the well, a proper-size and well managed well-site is needed. Most of the time drilling activity has been observed in remote areas. To access the well-site, road is the best and economical option to reach the site. Land clearance for the well-site and road construction would possibly impact the environment by changing the character of land from rural to developed setting. Existing land would be affected by the disturbing effects of noise pollution, increased traffic, dust, and human activity. Farmers in that area may be affected by the loss of their available crops land and vegetation. In areas where trees and plants are present, drilling activities can cause severe effect on vegetation with a very low degree of remediation [2].

Generally, these impacts are proportional to the number of wells to be drilled, i.e., higher the drilling activity; greater will be the damage on environment. Drilling-mud is a liquid composed of base liquid and different chemical additives to ensure its required properties for drilling oil and gas wells. It is used to contain formation pressure, to remove formation cuttings from the well-bore, to provide well-bore stability and to lubricate the drill-bit. The composition of drilling-mud is selected in such a way so that any discharge of whole mud, its base liquid or drilled cuttings have the least possible impacts on the environment. Additives and hazardous chemicals have been used in drilling-mud to have optimum mud design. Current drilling-mud research and development will lead to developing and modifying the mud composition which are lesser hazardous to vegetation and other environment related issues. The health of rig personnel is also important, and fluids to be used are selected to have minimal health risks.

The wrapping, transportation, and storage of drilling-mud additives and/or premixed material systems are closely inspected regarding health, safety and environment (HSE) issues. Workers who deal with drilling-mud handling and its preparation have to wear personal protective equipment (PPE) to avoid direct inhalation or other direct contact with potentially hazardous materials. Enhancement of people's efficiency in their respective working environment and risk assessment programs have been organized to lessen the potential for injuries during mud preparation and handling procedures [3].

Drilling-mud base liquids, additives, and whole mud are possibly transported in tanks or containers. These transportation practices help reduce packaging-related waste, and reduce the risk of harming workers and polluting the environment. Weighing materials such as barite, bentonite, salt, and base liquids are always provided in bulk to offshore platforms. Onshore locations might use both bulk and packaged-unit materials, depending on the well depth and complexity.

Mud engineer/specialist and operator representative at each location are responsible for ensuring that designed properties of the drilling-mud are in order to meet the immediate demands and have minimum environmental impacts.

SOURCES OF CONTAMINATION

Drilling-mud which is used during land and offshore drilling operations is the source of contamination such as:

- Drilling-mud in contact with fresh water table (drinking water)
- Disposal of whole mud after completion
- Disposal of drilled cuttings and other solids

Use of drilling-mud in the well-bore affects groundwater. Whenever, subsurface fresh water zone is drilled, water

contamination occurs due to either whole mud entry or due to filtrate (liquid phase of mud) invasion into the formation. Similarly, cement slurry is used to set the casing in-place and provides well-bore stability and isolation. During cementing operation, cement slurry has a contact with fresh water zone and may contaminate it as drilling-mud does [4].

In offshore drilling use of drilling-mud has adverse effect on marine life. To provide a passage for drilling-mud from offshore platform to the sea floor, a riser pipe is used which is set at the sea floor and through this pipe drilling-mud circulates. If any leakage takes place in this pipe, drilling-mud would mix with sea water and would cause harms to marine life.

EFFECTS ON SURFACE AND MARINE LIFE

Drilling-mud additives used in designing a mud compatible with the formation may have adverse effects as described below:

- Additives which are used to enhance or obtain certain properties of mud, which are required during drilling processes, can also result into decrease fertility rate and increasing mortality issues.
- A commonly used mud additive, ferro-chrome lignosulfonate can have negative effect on fish eggs.
- A pit is dug near shale shaker in which formations cuttings coming from the wellbore are kept. If the pit is not properly sealed or lined, the drilling mud with the cuttings may seep or leach to the underground water table and may contaminate it.
- Damaged sacks containing different chemicals including the hazardous compounds may pollute the environment and in turn are a risk to the health of workers.

SOLTEX, which is a common drilling-mud additive used worldwide to serve the purpose. Table 1 provides typical analysis for heavy metal content of SOLTEX:

Table 1: Major constituents of SOLTEX Composition [5,6]

SOLTEX Compounds	Concentration (mg/kg)
Nickel	11.0
Barium	16.0
Vanadium	16.0
Fluoride	200.0

Mercury, arsenic, cadmium etc. compounds contribute to a cumulative concentration of 17 mg/kg. Lead which is a major constituent of pipe dope is used in excessive quantity in making a connection has adverse effects on the environment. SOLTEX acts as an inhibitor in shale formations with water-base mud [6].

After completing the well, to dispose of drilling-mud and formation cuttings is the main concerns. Drilling-mud is generally disposed of at wastewater treatment plants. Oil-base mud is an expensive fluid used during drilling, so it is economical to reuse it, and due to this reason there is a decreasing trend for its disposal to public waste water treatment plants. Injection into disposal wells is another option to set out drilling waste liquids [7].

Disposing of mud wastes involves the burial method, because of one of the economically feasible way of dumping the waste. However, this method continuously adds into soil and environment pollution [7].

Major sources of noise pollution during drilling activity are the machinery and equipment used at well-site; bulldozers, cranes, drilling rig, mud pumps and diesel engines etc. Vehicular traffic to transport this machinery is also a source of noise in that area.

Noise pollution is also a point of concern during drilling and different testing operations. Drilling activities can generate a noise up to 115 dBA. Exposure to such high degree of noise can create certain issues (including retarding hearing efficiency and expression, etc.) in living organisms. Similarly after successfully hitting the reservoir, when the ells are put to production can cause continuous noise, which can have negative impact on surrounding environment.

Emissions generated during drilling activities, include transport vehicles emissions, diesel engines emissions, vaporization of stored fuels. Flaring of gas produces carbon monoxide and nitrogen oxide. During testing a well, hydrogen sulfide gas may come to the surface and its high concentration may cause casualties. Dust is produced during road construction and land clearance, increases in dust could cause lung and sinus diseases to workers and inhabitants of the area [2].

During drilling activity, drilling-mud remains in contact with groundwater as long as this zone completes its drilling. During this time period, drilling-mud contaminates groundwater and when this water is produced to the surface for domestic use and vegetation, its harmful effects have been observed in the form of different diseases.

ENVIRONMENTAL IMPACTS DURING PRODUCTION

1. Produced water
2. Oil spills
3. Gas flaring

Produced Water

Normally all petroleum reservoirs contain water beneath them as water is denser than oil and gas. The phenomenon to produce petroleum from deep down the earth is through pressure differential. As a pressure differential is applied at the face of wellbore, the petroleum from reservoir flows from the reservoir to wellbore and ultimately to the surface through production tubing. When petroleum is produced, the water-oil contact or gas-water contact rises owing to the amount of pressure differential applied. This contact keeps on rising until it reaches the perforation intervals. At this point the water from beneath the reservoir starts producing into the wellbore and is called water breakthrough. If the balance between gravitational forces and viscous forces is disturbed due to increased production rates, then a cone is developed near the wellbore zone and production of water starts earlier. This produced water is contaminated with hydrocarbons and should be treated before being disposed off. The produced water is treated to remove the hydrocarbons from it and then is either injected to injection well or is disposed off to open lands which pollute the environment. In case of offshore production is discharged to sea which is a source of environmental pollution and is deadly for marine life [8].

Oil Spills

Oil spills are the release of liquid petroleum into the environment and although includes onshore spills but is

mostly related to offshore production where these spills are a cause of great pollution to marine environment and a death warrant to marine life.

Gas Flaring

Hydrocarbon gases are an essential part of production in most cases. In case of gas condensate, wet gas and dry gas reservoirs, the main production is gas so all the facilities are installed for the proper refining and transportation of gas from the field to ultimate consumer. But in case of oil reservoirs, the production of gas is so less that it is uneconomical to install facilities for gas refining and transport, in such scenarios the produced gas is flared to the atmosphere thereby increasing the environmental pollution.

CONCLUSION AND RECOMMENDATIONS

- Oil and gas drilling in the need of the hour to fulfill today's energy requirement, but environmental concerns connected to drilling and testing operations must not be compromised at any cost.
- Use of drilling-mud in the well-bore is inevitable, so the best practice is to design a mud compatible with the formation with less harmful additives. This is possibly done with drilling-mud research and development (R&D).
- Filtration control additives must be used while drilling groundwater formation to keep its contamination at minimum level.
- When drilling activity is complete, drilling-mud and cuttings should be disposed of properly.
- All warning signs should be learned and handled properly and well-site drills should be performed on regular basis.
- The production of water should be stopped as it is not desirable from economics point of view and adds to environmental pollution.
- Oil spills especially in marine environments have been a source of detrimental effects to marine atmosphere and life.
- Gas flaring is a constant source of air pollution.

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