Environmental Impacts of Drilling Operations and their Mitigation Measures

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Abstract

With the rise of the environmental protection movements, the petroleum industry has placed greater emphasis on minimizing the environmental impact of its operations. In the upstream petroleum industry, there are two major operations that can potentially impact the environment i.e. Drilling and Production. Both operations generate a significant volume of wastes. Because of the high costs of non-compliance with the numerous regulations governing the industry and the high costs associated with the loss of public trust for damaging the environment, substantial resources must be dedicated to minimizing environmental impact. As the authors are engaged in drilling operations at the well-site, environmental impacts during drilling operations are only discussed here with their mitigation measures.

Introduction

Drilling is the process in which a hole is made in the ground to allow sub-surface hydrocarbons to flow to the surface. During drilling, fluid is injected down the drill string and through small holes in the drill bit. The drill bit and holes are designed to allow the fluid to clean the cuttings away from the bit. The fluid, with suspended cuttings, then flows back to the surface in the annulus between the drill string and formation. At the surface, the cuttings are separated from the fluid; the cuttings, with some retained fluid, are then placed in pits for later treatment and disposal. The separated fluid is then re-injected down the drill string to lift more cuttings. The base fluid most commonly used in the drilling process is water, followed by oil, air, natural gas, and foam. When a liquid is used as the base fluid, either oil-based or water-based, it is called "mud." Water-based drilling fluids are used in about 85% of the wells drilled worldwide. Oil-based fluids are used for virtually all of the remaining wells.

The process of drilling oil and gas wells generates a variety of different types of wastes. Some of these wastes are natural by-products of drilling through the earth, e.g., drill cuttings, and some come from materials used to drill the well, e.g., drilling fluid and its associated additives. During drilling activities, a variety of air pollutants are emitted. The primary source of air pollutants are the emissions from internal combustion engines, with lesser amounts from other operations, fugitive emissions, and site remediation activities.

The construction and operation phases of drilling involve various activities which have potential impact on drainage and topography of the area, Land use pattern, Regional climate, Air environment, Noise environment, Water environment, Soil environment, Biological environment, Socio-economic environment and Occupational Health and Safety.

Environmental Impacts and their Mitigation

The environmental impacts can be categorized as either primary or secondary. Primary impacts are those which are attributed directly by the construction and operation of the project, secondary impacts are those which are indirectly induced and typically include the associated investment and changed patterns of social and economic activities by the construction and operation. The impact matrix of different drilling activities is given in the table 1.

Many of the materials and wastes associated with drilling activities have the potential to impact the environment. The potential impact depends primarily on the material, its concentration after release, and the biotic community that is exposed. Some environmental risks may be significant, while others are very low. Toxicity occurs when a material causes a deleterious effect on an organism, population, or

Table 1: Impact Matrix for Drilling Activities

Activities	Environmental Attributes						
	Air	Noise	Water	Land & Soil	Ecology	Socio-economics	Aesthetics
Drilling & Testing activities							
Well site & access road construction	Y	Y	Y	Y	Y		Y
Site preparation and cleaning	Y	Y		Y	Y		Y
Storage and handling of construction waste	Y		Y	Y		Y	Y
Transportation of drilling rig and ancillaries	Y	Y		Y		Y	Y
Generation of waste water & discharge from construction activity & labor			Y	Y	Y		Y
Operation of DG sets and machinery	Y	Y				Y	
Operation of drilling rig		Y		Y			
Storage and disposal of drill cuttings and mud			Y	Y			Y
Flaring during testing and process upset	Y					Y	
Blow out	Y					Y	
Spillage of chemical & Oil	Y		Y	Y	Y	Y	
Decommissioning and aftercare		Y		Y		Y	
Removal of well site construction materials & disposal		Y		Y		Y	
Site restoration				Y		Y	

Source: ABC Techno Labs India Pvt. Ltd.

community. These effects can range from temporary disorientation to lethality. The toxicity of a substance is a measure of how it impairs the life and health of living organisms following exposure to the substance. In most cases, the effects of the substance on human life and health are of primary importance. So the planning for drilling should include environmental considerations. Environmental management at the

well site must involve thoughtful planning at the onset of exploration or development. Some of the Environmental impacts of drilling activities with their mitigation measures are given below:

1) Impact on Topography

Potential impact on drainage and topography viz. alternation of drainage pattern and water logging are observed during well site preparation, widening/strengthening of access roads and restoration of exploratory well facilities. There may be minor changes in the natural drainage pattern at immediate vicinity of the well site. Unplanned restoration may lead to the long term disruption in natural drainage pattern and water logging in neighboring agricultural land abutting the site.

Mitigation measures:

- Disruption/alteration of micro-watershed drainage pattern is minimized to the extent possible.
- Levelling and grading operations must be undertaken with minimal disturbance to the existing contour, thereby maintaining the general slope of site.
- Loss of micro-watershed drainage, if any, is so to be compensated through provision of alternate drainage.

2) Land Use Pattern

The land used to construct an approach road from the road head to drill site results in disturbance and compaction of soils around the drilling rig due to equipment, vehicles. Access road to the drill sites also impacts top soils.

Mitigation measures:

- Adequate compensation to landowners against loss of standing crops in accordance to regulatory requirements viz. Land Acquisition Act, 1894 (amended in 1984).

3) Impact on Air Environment

During drilling activities, the potential sources of air emissions during the drilling operation are DG sets, Test flaring and Vehicles movement. During the short period of site preparation, mechanical shovels and earthmovers are used for vegetation clearance, cut and fill and other site leveling activities. These activities generate dust particles which are mobilized by wind, and deteriorate the ambient air conditions. All air emissions other than dust arise from combustion of hydrocarbons. The pollutants of concerns are NOx, SO_2, CO, Particulate, and unburnt hydrocarbons.

Mitigation measures:

- Water spraying should be done on the access roads to control re-entrained dust during dry season.
- All vehicles used for transportation of loose and friable materials should not be loaded over the freeboard limit and will be covered.
- All the vehicles must be PUC certified.
- Engines and exhaust systems of all vehicles and equipment used for the project must be maintained so that exhaust emissions are low and do not breach statutory limits set for that vehicle/equipment type.
- DG set with appropriate stack height should be utilized.
- Providing Personnel Protective Equipments (PPEs) like mask to workers at site.

4) Impact on Noise Environment:

Potential impact on noise quality is from noise vehicular movement, operation of construction machinery during well site preparation and access road strengthening and operation of drilling rig. However, these noise sources are temporary in nature and operated mostly during daytime and for short duration.

During drilling, equipment/machinery, identified as important sources that may have adverse impact on the existing noise level within the blocks are: Drilling Machines, Compressor Pumps, DG set etc. Operational phase noise impacts are from operation of drilling rig and ancillary equipment viz. Shale Shakers, Mud Pumps and Diesel Generators.

Mitigation measures:

- Installation of sufficient engineering control on equipment and machinery (like mufflers & noise enclosures for DG sets and PC pumps) to reduce noise and vibration emission levels at source, carrying out proper maintenance and subjecting them to rigid noise and vibration control procedures.
- Providing Personnel Protective Equipments (PPEs) like ear plugs/muffs to workers at site.
- Undertaking preventive maintenance of vehicles and machinery to reduce noise levels.

5) Impact on Water Environment:

Potential impact on lakes and canal systems and river bodies may arise if the well site lies in proximity to these water bodies. Impact on surface water quality of natural drainage channels and community water bodies arise from the discharge of contaminated surface run-off, sewage and process waste water generated during various phases of the drilling project. Potential wastewater discharges may arise from the following sources during drilling:

- Spent drilling muds, cuttings and completion fluids disposal.
- Treated domestic effluent (sewage and kitchen waste).
- Any produced water and liquid hydrocarbon fractions collected in the test separator during well testing.
- Potential contaminated storm water drainage from the derrick floor and other systems.

Mitigation measures:

- Water drainage outlet, to prevent discharge of contaminated run-off.
- Drainage and sediment control system at the well site should be efficiently designed.
- Proper treatment of all wastewater must be made to ensure that they comply with criteria set by the regulatory body (MoEF&CC and HPPCB).
- All chemical and fuel storage areas, process areas should have proper bunds so that contaminated run-off cannot escape into the storm-water drainage system.
- Construction activities viz. stripping, excavation etc. during monsoon season should be restricted to the extent possible.

6) Impact on Soil Environment

Potential impact on soil quality is envisaged in the form of increase in soil erosion and loss of soil fertility resulting site clearance and top soil stripping due to well site preparation. Accidental spillage resulting from storage and handling of mud chemicals is potential soil abuser.

During construction the major impacts on soil occurs due to excavation, compaction due to movement of heavy equipment and leveling as well as pollution due to addition of moorum. Site preparation will entail stripping and removal of the topsoil which contains most of the nutrients and organisms that give soil a living character and productivity. This will in turn result in minor changes in soil hydrology and small changes in the topsoil structure.

The hazardous wastes generated from the drilling operations include drill cuttings, drilling fluid, spent lube oil and waste oil. Apart from the above, packaging wastes, used containers, and any contaminated soil arising out of any accidental oil spillage during the drill rig movements and operations etc. are also generated from exploratory drilling activities.

During drilling, the chances of soil contamination increases from the storage practices of chemicals and fuels surface runoff carrying contaminated substances. Drilling wastes generated during drilling operation through various geological formations might hold hydrocarbons reach to the nearby water reservoir results in its deterioration. The mud used, brings the rock cuttings (generated from drilling) to the surface, along with the mud are called drilling wastes. Drilling operations are typically associated

with a range of wastes such as drilling mud, used oils, hydraulic fluids and various discarded chemicals products, empty drums and sacks, acids, surfactants, cement, biocides, solvents, and camp wastes. The drilling mud and cuttings also add to the subsurface contamination if not handled appropriately.

Mitigation measures:

- The topsoil should be stored in mound form; the height of the mound should not be more than two meters and the slope angle should not be more than 30 degree.
- A jute mat should be overlayed on the mound to contain the erosion of topsoil.
- Carrying out restoration of soil to its earlier conditions, to the extent possible.
- Ensuring proper storage of fuels and chemicals to prevent any potential contamination from spillage.
- Implementing appropriate spill prevention and control measures.
- Implementing adequate sediment control measures to prevent discharge of untreated surface run-off characterized by increased sediment load to adjoining agricultural land.

7) Impact on Socio-Economic Environment

During site construction, dust is generated from transportation of construction material, machinery and personnel, irregular dumping of construction wastes, domestic wastes from labor camp. These may cause visual and aesthetic impacts. Such impacts are likely to be experienced by communities residing in the vicinity of exploratory well.

The construction of drill pad, drilling of exploratory wells and decommissioning involve a continuous day and night process, hence the high power lighting (halogen) at night may cause a visual discomfort to the residents of nearby settlements. Other than that light generated from flaring events might also be visually discomforting at night. However flaring is likely to be of intermittent in nature, to occur only during testing. It is likely that ploughing and sowing activities in and around drilling site and road may be affected during cultivation season. The land acquired for drilling site and road would not be available for agriculture for the period of the project.

Mitigation measures:

- All the construction activities should be restricted within the designated site.
- Dust nuisance from construction site should be suppressed through periodical water spraying at high dust laden area due to construction of wells.
- On completion of work all temporary structures, surplus materials and wastes must be completely removed from the site and disposed at a designated area.
- Construction wastes and municipal solid waste temporarily stored at the sites must be transported to the designated disposal site/facility at regular intervals.
- Care should be taken to orient the halogens at the construction facility. Excess lighting should not be used. After decommissioning of rig and associated facilities, drill sites must be restored-drill platform will be removed, pits & garland drains must be filled up, and construction material should be buried in the pit.
- Site must be restored through lying of topsoil.

8) Impact on Occupational Health and Safety

Occupational injuries and ill-health have huge socio-economic implications on individuals, their families and communities. They also have economic impacts in the form of direct and indirect costs for society as a whole. Major occupational health risks encountered in drilling activities include noise from drilling activity, operation of heavy vehicles and machinery, handling of chemicals.

Community health and safety of inhabitants residing close to the drilling site stands to get affected from frequent heavy vehicular movement along village access roads and due to noise from drilling rig operations. Health and safety impact arising from technological emergencies viz. well blow outs, explosions will be dealt with utmost importance.

Mitigation measures:

- All activities should be under proper fencing.
- Proper hoardings in English and Hindi language should be displayed during construction to prevent people from encroaching the fenced area or to make them aware of the danger associated with the construction.
- Pipes should kept in level ground within proper barricade.

Environmental Impact Assessment (EIA)

Environmental Impact Assessment is the assessment of the environmental consequences of a plan, policy, program, or actual projects prior to the decision to move forward with the proposed action. A comprehensive EIA survey must be carried out before the commencement of drilling project. The environmental and social impacts whether attributed directly or indirectly must be considered and analyzed in terms of key potential environmental impacts. Any sensitive location of ecological, historical or strategic importance around the area of concern during various activities of the project both short-term or long-term must be identified and where adverse impacts have been identified the extent to which these impacts would be mitigated through the adoption of industry standard practices and guidelines and following local legislative requirements.

The Environmental Management Plan (EMP) must be prepared which can provides a delivery mechanism to address potential adverse impacts, to instruct consultant and to introduce standards of good practice to be adopted for all project work. The EMP can be developed into a standalone document covering each stage of the drilling activity. For each stage of the activity, the EMP lists all the requirements to ensure effective mitigation of every potential biophysical and socio-economic impact identified. For each action, or operation, which could otherwise give rise to impact, the following information is prescribed:

- A comprehensive listing of the mitigation measures
- The parameters that will be monitored to ensure effective implementation of the action
- The timing for implementation of the action to ensure that the objective of the mitigation are fully met

The EMP also comprises a series of components covering direct mitigation and environmental monitoring, an outline waste management plan and restoration plan.

Conclusion

Improved environmental protection requires better education and training of industry personnel. The most important steps in minimizing adverse environmental impact are for the industry to take a proactive approach to managing operations and become educated about those activities that can potentially harm the environment. The proactive approach involves adopting an attitude of environmental responsibility-not just to comply with regulations but to actually protect the environment while doing business. Environmentally responsible actions require an understanding of these wastes and how they are generated. From this understanding, improved operations that minimize or eliminate any adverse environmental impacts can be developed.

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References

1) Reis, John C. Environmental control in petroleum engineering
2) Lyons C. William, A Working Guide to Drilling Equipment and Operations
3) IADC HSE Case Guidelines for Land Drilling Contractors, Issue 1.0.1, 27 July 2009