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# Environmental and Safety Aspects of Drilling Waste Disposal

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## ABSTRACT

**Muds and fluids are frequently used in the drilling of petroleum exploration and production wells. The basic purpose of these fluids is to remove cuttings from hole and carry them to coal and lubricate the bit and the drill string. The down hole pressure is controlled through the use of muds and the use of mud system depends upon anticipated problems.**

**Ground water contamination is a major environmental concern. Base metals in drilling fluids causes damages to both living organisms and fresh water aquifers. Toxins which exist in drilling fluid once introduced into the soil, it causes widespread growth and development problems to all associated systems. Though guideline and regulator provisions exist but no elaborate audit programmes are available to promote and check the compliance.**

**This paper has been prepared with an aim to in-depth review of environmental impact of drilling activities and its likely impact on environment.**

## INTRODUCTION

This paper describes impact of drilling operation on environment. Various drilling system have been discussed. The consequence of possible environmental hazards and remedial measures to check the pollution have been suggested.

Pakistan Government is giving high priority to the energy sector and is making an all out efforts to increase the production. Currently the country is producing 57000 bb of oil/per day and 2400 million cu.ft. of gas/day which is insufficient to meet the requirements. Pakistan's commercial energy demand doubles every ten years. Despite very encouraging gas discoveries, the energy shortfall will double by 2007-8 (Pakistan Energy Year Book 2001).

Since its inception till July 2001, it has drilled 526 exploratory well and 679 development wells. As a result of this exploration activities 142 discoveries have been made. Fifty seven (57) were oil discoveries and 85 were gas discoveries. In fact one well per 1573 sq.km. was drilled, which is very low compared to the international standard.

Drilling is the most important link in the entire process of exploration discovery and production (Deshpande, 1992). The major by-products of oil field operations are oil field brine, oil bearing water and oil drilled mud. All these by-products need adequate treatment in order to prevent environment damage. The disposal of these effluents to natural drainage system will adversely affect the flora, vegetation and animals by polluting fresh water sources (Reinder & Zahid, 1998).

The utilization of new techniques such as acidization for fracturing has further added to the problem, making it more imperative for careful handling of drilling fluids.

## DRILLING FLUID MANAGEMENT PROGRAMME

The drilling fluid management programme can be divided into two segments (Chilingarian & Vorabutr, 1983). The first segment covers the planning and policies prior to drilling and the second segment pertain to drilling and post drilling operations. These are:

### Pre-drilling Activities

1. Planning to undertake activities as per existing regulations.
2. Preparation of written procedures/instructions.
3. Communication of policy to all concerned.
4. Sufficient training arrangements to ensure the compliance with the written procedures.

All these actions are important and must be carried out prior to drilling operations. The effectiveness of the programme depends upon the commitment of the management and the preparation of clear-cut written procedures. It may be ensured that every one, who is involved in the programme understand the significance and importance of each operation and is properly trained to conduct the activities as planned. The availability of required resource is another critical step and it is essential that all required resources are arranged in time to avoid any problem, which may occur due to lack of resources. The importance and benefits of the programme are communicated to all concerned and their commitment to the programme is ensured.

### Drilling Activities

The rotary system of drilling requires the circulation of a drilling fluid in order to remove the drilled cuttings from the bottom of the hole and thus keep the bit and bottom of the hole clean. Drilling fluids are usually pumped from the surface down through a hollow drill pipe to the bit and the bottom of the hole and returned to the surface through the annular space outside the drill pipe. Any cavings from the formations already drilled and exposed in the bore-hole must be raised to the surface by mud circulation. The cavings and drill cuttings are separated from the mud at the surface by flowing the mud through the moving screen of shale shaker and by settling in mud pits.

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All the fluids used in a well bore during drilling operations may be classified as drilling fluids. Fluid employed for this purpose include:

**1) Oil Based Fluids (OBFs):** Crude oil and diesel oil are commonly used for their high performance drilling characteristics. However, these have a poor performance in terms of their ecotoxicity and their tendency to persist. Oil Based fluids having aromatic hydrocarbons >1% is not accepted because of the high potential of adverse environmental impacts.

**2) Synthetic Based Fluids (SBFs):** Synthetic based fluids olefins, polyalpha olefins, linear alpha olefins, acetates and ester base fluids. These have recently been developed to provide similar drilling performance as OBFs but improved toxicity and biodegradatian characteristics.

**3) Water Base Fluids:** Water based fluids are not generally giving optimal performance in a more challenging drilling conditions, provide the best environmental performance in terms of their non-toxic nature and enhanced ability to degrade rapidly.

## DRILLING MUD TYPES

There are three major drilling mud system:

### Fresh Water - Base Muds

Fresh water base-muds consists basically of (1) a liquid phase, fresh water or emulsion (2) a colloidal phase, principally clays (3) inert phase, principally barite weight material and fine sand; and (4) a chemical phase to control the behavior of colloidal material such as clays.

### Salt Water - Base Muds

Salt water base-muds consists basically of (1) a liquid phase, salt water or emulsion (2) a colloidal phase, principally clays (3) inert phase, principally barite weight material and fine sand; and (4) a chemical phase to control the behavior of colloidal material such as clays.

### Oil-Base Muds

Oil-base muds are suspensions of solids in oil. Crude oil and diesel oils are commonly used as a liquid phase and the necessary finely dispersed solid is obtained by adding oxidized asphalt. Common weighting agates are used to increase the density. Several types of oil-base muds are commercially available.

Oil-emulsion muds are commonly of the oil-in-water type of emulsions in which small droplets of oils are dispersed in continuous water phase.

The choice of a particular mud system depends upon the anticipated problems which may be encountered in drilling anticipated formations. The budgetary constrains is also a major factor in the selection of mud system.

## CHEMICALS AND ADDITIVES USED IN DRILLING MUD

Each of the muds contains different additives/chemicals which pose a variety of environmental concerns. Some of these are summarized as under:

1. Ligno-sulfonates base muds which may be used in deep wells.
2. Calcium treated muds which may contain hydrated lime, gypsum and calcium chloride.
3. Polymers as flocculating agents which may enhance viscosity.
4. Salt or saturated salt mud systems which may have a chloride concentration between 5000 and 190000 PPM.
5. Nacl or KCl which is used in salt base muds. Diammonium phosphate is also used in salt base mud systems.
6. Asphaltines, oxidized asphalts, organic acids and diesel fuel which is used in emulsion system.

## ENVIRONMENTAL MANAGEMENT

The use of all these variety of chemicals and additives poses a serious threat to the environment (Wahi, 1992 and Chhatwal, 1998). The various concerns arise are:

1. Ground water contamination
2. Base metals contaminations which may affect vegetation and living organisms. Potential metals found in drilling waste are barite, copper, Iron, zinc, vanadium and chromium.
3. High salt may cause growth problems in living organisms.
4. Soil contaminations due to high toxin contents such as chlorine etc.

It is therefore, utmost necessary that muds are properly treated prior to disposal.

## DISPOSAL AND TREATMENT OF DRILLING MUDS

The drilling muds can be treated in a number of ways either to recondition them or render them harmless to the environment. Before, selecting the method of reconditioning, it is necessary that the analysis of drill mud may be carried out. The analysis is also necessary before disposal of mud.

### Chemical Analysis

The liquid portion is checked for the following:

1. PH
2. Specific conductance
3. Suspended solids
4. Nitrogenous compounds (nitrate and ammonia) and
5. Major ions.

After analysis, the fluid can be regenerated through following process:

### Solid Control

1. Solid control removes drill cuttings from the system, keeping the mud clean of unwanted particles and fines.
2. May yield a clean effluent that is re-introduced to the mud system.
3. Allow the segregation of drill cuttings from the mud, which may be stored in separate pit.
4. Drilling fluid passes over a series of graduated mesh shakers, desitters and centrifuges which effectively separate the drill cuttings from the mud.
5. The process not only recycles drilling fluid but also reduces expense

### Toxicity Analysis

The fluid waste is assessed through toxicity testing and for verifying that toxins such a bactericides, corrosion inhibitors, emulsifiers and forming agents are absent. There are various tests which must be performed on drilled fluids before disposal. These are:

1. Ecotoxicity test: Ecotoxicity test of drilling fluid provides information on the possible effects of the fluids on biota and therefore from a basis on which to assess its environmental acceptability.
2. Biodegration: Biodegradability is an important characteristics of drilling fluids to ensure that the fluids do not persist in the environment for a long period.
3. Bioaccumulation / Bioconcentration: Bioaccumulation typically refers to the uptake and retention of a contaminant by an organism and biocontcentration refers to the net accumulation of a contaminant resulting from simultances uptake and release. Rapid depuration may reduce the potential for bioaccumentation where there is potential for the accumulation of heavy metals that may be contained in drilling fluids. Therefore bioavailability of heavy metals in these compounds should be considered.

## SOLID WASTE MANAGEMENT

### Waste Characterization

Waste characterization is the assessment of the physical, chemical and toxicological characteristics of a waste (Guid 58, 1996). There are two primary reasons for characterization:

i. To determine the danger relating to road transportation.
ii. To determine environmental consequences of a waste.

To classify the waste as dangerous or non-dangerous, the following properties are evaluated:

1. Flammability: Waste has an flash point of less than 61 $^{o}$C.
2. Toxicity: Waste has no oral, dermal and inhalation toxicity.
3. Corrosive: Waste has PH value of less than 2 or greater than 12.5.
4. PCB Content: Waste has PCB contents of less then 50 mg./kg.
5. Oxidization Potential: Waste has a minimum oxidizing potential.

### Waste Management

The main solids waste generated during drilling are drill cuttings of various sizes from mixture of rock formations, sand and clay. Besides that, solid spills from the base drilling fluid material such as bentonite, baryte, polymers etc are also generated.

Therefore on the basis of estimated waste generated, solid holding pit has to be made. The strategic location of the holding pit should come mainly in the area, where drill cuttings are collected.

It is extremely important that the settlelates discharge lead to solid holding pit, thus collecting majority solid at one point of the location. When solid comes along with liquid, settling tanks should be used.

The following methods may be used for the disposal of waste:

- The collected solids can be effectively used for land filing.
- They can be used as filling material, whenever it is required.
- Drilling fluid base materials contain heavy metals such as Cr, Cd, As, Hg, Zinc and these metals if exceed in concentration can lead to undesirable results. Therefore, it is utmost important to take care in handing to prevent leaking of these metals and other toxic compounds into water stream.
- Standard practice and procedures should be followed for land reclamation to maintain the environment and life supporting system.

## SAFETY OPERATION

Management of safety is the direct responsibility of the operator and it has to prove to the regulator that it is controlling the risk properly. The concept requires the operator to formally document how risk will be managed in its operations and across its facilities, to demonstrate that the major hazards of operation have been identified and appropriate control is provided. The operator should ensure that the operations are safe (Gray, 1986).

## SAFETY GUIDELINES

All operating companies must develop a system to monitor and evaluate the followings:

1. Ensure that all operations are planned and are being executed as per safety requirements.
2. Audit and implement well site and operational safety on on-going basis.
3. Conduct training and awareness programmes to train the personnels.
4. Ensure that adequate safety equipment are at site.
5. All workers including drivers comply with the laid down safety instructions.
6. All procedures/plans such as emergency plans, evacuation procedures and location of fire fighting

equipment should be worked out and displayed at prominent locations for the knowledge of employees.
7. Good house keeping practice must be maintained.
8. All equipment must be maintained and inspected on on-going basis.
9. Safety meeting should be held and documented regularly.

## CONCLUSION

In essence, there are six basic program elements which must be followed and implemented. These are:

### Management and Leadership

The basic issues such as environmental policy statement, responsibilities and accountability and performance recognition, should be clearly spelled out to all concerned.

### Environmental Protection

All necessary details of every step from site selection to waste disposal may be worked out, insuring that all work is performed in an environment friendly manner.

### Regularity Compliance

All existing rules/regulations are adhered to while carrying out necessary work. Inspection and audit is carried out to insure compliance.

### Emergency Plan

Corporate emergency response is worked out and properly documented and communicated to all concerned for insuring the safety of operations.

### Employee Training and Awareness

Training program may be conducted for the awareness of employees to make it certain that methods/procedures are properly understood by the all concerned.

### Stake Holder Involvement and Reporting

Environmental reporting / complained response system is elaborately worked out and implemented.

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