NORM, a Health concern to Personnel exposed to Formation Drill Cuttings – Regulation issue in Nigeria

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Abstract. During the drilling operations, formation rocks or shales drilled are removed from the wellbore as drill cuttings. These cuttings are real-time representative of the formation being drilled at that section of the wellbore, and it represents the formation of compositions and properties. Regulations for most oil well developments stipulate that the methods used for managing drill cuttings are dependent on the nature and type of drilling mud system used for the drilling operation. When the formation with these relatively high NORM contents is drilled using the drilling mud, these NORM traces are transported to the surface as drill cuttings; thus, exposing the personnel to health dangers and the immediate environment. The short and long-term health effects of NORM exposure include skin burns, harmful tissues reactions, increase the risk of lung cancer, mutation of somatic cells and leukemia. DPR has some standards and guidelines established to effectively police and regulate E&P industry activities in Nigeria. These guidelines and standards also take into consideration, the need for advanced pollution control strategies and technological treatments. However, the presence and harmful consequences of NORM in these drill cuttings are not considered in the current form of these regulations and guidelines. This study proposes the inclusion of NORM as a means of updating the already established guidelines and regulations for handling and treating these drill cuttings because they constitute the majority of the waste and toxic materials generated during drilling operations.

1. Introduction

Drilling fluid is a generic name for all compositions used to aid the production and removal of cuttings from a wellbore; this broad definition intentionally places no restriction on the objectives or type and source of the materials employed. The simplest drilling fluid is a dirty mixture of water, clay, and additives, often referred to as drilling mud. Drilling muds are fluids which are circulated through a well so as to remove formation drill-cuttings from the borehole. This definition is adopted in line with the objective of this research. These drilling muds are expected to perform some functions when in use during drilling operations, and for this purpose, some additives are added to optimize the drilling mud systems for effective suspension and transportation of formation drill-cuttings. B S Kinigoma [1] and E E Okoro et al., [2] conducted a study on the effects of these additives on field environments using Niger Delta as a case study. The soil, reserve pits in the field, plant growth and other biomasses were assessed. The study observed that the toxic effect of drilling fluids on the field environments contributed to poor plant growth. During the drilling operations, formation rocks or shales drilled are

removed from the wellbore as drill cuttings. These cuttings are products of real-time fragmentations of the formation being drilled at that section of the wellbore and are considered parts of the formation compositions and properties, although, they also contaminate the drilling mud system. Regulations for most oil well developments stipulate that the methods used for managing drill cuttings are dependent on the nature and type of drilling mud system used for the drilling operation. Example of a sample drilling operation waste is given in Table 1.

Table 1: Types of wastes generated during drilling operations

S/N	Types of Waste	Main Components	Constituents
1	Spacers	Base fluids (oil/water), surfactants	Aromatic hydrocarbons, salts, chemicals
2	Spent drilling fluids	Whole mud, base fluids (water/oil), biodegradable matters	Heavy metals, organic materials, inorganic salts, chemicals
3	Drill Cuttings	Formation solids, base fluids (water/oil)	Solids/cuttings, heavy metals, organic materials, inorganic salts, chemicals
4	Drilling fluid additives	Bentonite, barites, salts, synthetic chemicals	Heavy metals, hydrocarbons, organic materials, solids, chemicals

On-site burial of cuttings is deemed acceptable when water-based mud is used, however, cuttings generated from the use of oil-based mud system must be contained in a closed-loop system, after which they can be treated and disposed. The treatment usually does not consider the possibility of Naturally Occurring Radioactive Materials (NORM). This is a gap that should be captured and used to modify existing regulations for wastes generated during drilling operations. Over a century ago, J Elster and H Geitel [3] and, H F Burton [4] observed the presence of high concentrations of Naturally Occurring Radioactive Materials (NORM) in wastes obtained from drilling operations and crude oil. Currently, research has been focused on investigating the presence of NORM in the exploitation, exploration and production sectors of the petroleum industry [5]. This study identifies and proposes measures to remedy the lapses in the current regulations for handling drill cuttings and their possible health impacts to the personnel in contact with them.

2. Empirical Review

According to A M D Sharif et al. [6], virtually all oil and gas exploration, production and storage related activities involve the generation of one form of waste or the other, and majority of these wastes are associated with drill cuttings from the wellbore. They have the potential to harm personnel and environment when contact is made through accidental leaks from storage tanks, spills from the roll-off container and other drilling operations. Y Shen et al. [7] recorded the presence of high NORM content in mudstones, coals and sandstone reservoirs. These traces are considered to be a potential source of radioactive contamination. When a formation with these relatively high NORM content is drilled using drilling mud, the particulates are transported to the surface as drill cuttings; thus, exposing the personnel to health and environmental dangers. Their study also identified the uranium as a major contributor to waste generation/NORM that contaminates tapped hydrocarbons from source rocks. K Al-Nabhari et al. [5] noted the importance and need for further studies on NORM and Technically Enhanced Naturally Occurring-Nuclear Radioactive Materials (TENO-NRM) that have not been addressed in details. Their study was focused on identifying and examining the occurrence of radioactivity in the Exploration and Production (E&P) industry. The investigation can also be used to establish the potential health hazards of these materials to man and the environment. Literature has shown that during oil and gas production, some of the technical processes applied at different stages can enhance the production of these radioactive materials; they concluded that there is need to establish regulatory controls and quantitative risk assessments for occupational exposure pathways in E&P industry operations and waste management (Table 2). Uranium and thorium are radioactive

materials which are most likely associated with shale, sandstones, bentonites, carbonate rocks [8, 9]. Edmonson et al. [10] also affirmed that these NORMs can be technologically enhanced by E&P industry operations. A S Paschoa and J M Godoy [11] in their study identified areas that have a significant amount of NORM in the wastes generated during drilling operations. A study in Nigeria by G O Avwiri and C P Ononugbo [12] to ascertain the presence of NORM during hydrocarbon exploration and production in a field in Niger Delta affirmed the presence of NORM at the production site. They used samples of soil from the host community and field sediments for their analysis. The experimental results showed that the concentration of NORM in the field was higher than the control samples from a non-oil producing community. Furthermore, the result shows some potential health threats to the workers, public health, and the environment. Occupational Safety and Health Administration (United States Department of Labor) has identified sludge, drilling fluids and cuttings as potential sources of harm to E&P industry workers especially when they are contaminated with NORM. Improper handling and disposal of NORM from site to site can cause short and long-term health effects such as skin burns, tissue reactions, increased risk of lung cancer, mutation of somatic cells and leukemia; hence, there is a pressing need to consider the careful handling of NORM when handling and treating drill cuttings. In addition, during the treatment operations, emphasis should not only be placed largely on the type of drilling fluid used to generate these cuttings but also on the likelihood of the radioactive wastes that may result from the operations. Exposure of E & P workers and inspectors, the public, environment to NORM will have a significant deterministic and stochastic health impact.

Table 2: Uranium (U) and Thorium (Th) mean and range concentration in parts-per-million (ppm) present in some Formations and Bentonite

Rock/ Mineral	U Mean	U range	Th Mean	Th range
Average/ Common Shale	3.5 – 3.7	1 – 13	12	2 – 47
Sandstone	2.4 – 2.7	0.2 – 0.6	8 – 8.8	0.7 – 2.0
Bentonites	5	1 - 21	24	6 - 44

3. Petroleum (Drilling and Production Amendment) Regulations in Nigeria

Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN) is one of the statutory functions of the Department of Petroleum Resources (DPR). They ensure that the E&P industry operators do not degrade and pollute the environment in the course of their activities. DPR has some standards and guidelines established to effectively police and regulate E&P industry activities in Nigeria. These guidelines and standards cover is technically designed to incorporate recent advancements in pollution control technologies and treatments. The current list of qualified waste management companies provides information on the type of facility available in each company and their location within the country. For drilling fluids and associated-drill cuttings-waste treatments, the emphases have been on the drilling fluid constituents coating the cuttings. When coated with water-based drilling fluid, the cuttings can be treated on-site and disposed, but when these coatings are associated with oil-based drilling fluids, the cuttings are stored in a closed box and transported to treatment plants. DPR documentation requirements for the E&P industry operators have been limited to the presence and level of aromatic hydrocarbons, extractable acids, heavy metals and removable organics that may be toxic and hazardous to the environment after disposal. The possibility of NORM in these drill cuttings was not considered in the current form of the regulation and guidelines which is the reason behind this study. M I F Mkpaoro et al., [13] in their study reviewed the current DPR approved drill cuttings treatment and disposal techniques in Nigeria. The study outlined the inherent challenges encountered when utilizing these techniques, and they proposed the use of biochemical treatment as a solution because of its benefits. However, the analyses and discussion of the biochemical treatment technique mentioned in their study did not consider the possibility of NORM in the drill cuttings. The good news is that the DPR ECASPIN regulation and guidelines can be updated periodically with new knowledge. This study proposes that the knowledge of the harmful consequences of NORM be alarmed and used to review, update and establish an effective guideline

and regulation for handling and treating these drill cuttings that constitutes the majority of the waste generated during exploitation operations.

4. Conclusion

NORM has a significant deterministic and stochastic health impact to the E&P industry workers, regulation inspectors and the public when not properly handled. Current ECASPIN regulations and guidelines for treating drill cuttings are focused on the drilling fluid constituents, aromatic hydrocarbons, and heavy metals. This study is designed to highlight the risks associated with NORM and its possible impact on the drilling crew and the environment. The knowledge of NORM can help to inform the need for improved strategies by both regulators (DPR) and E&P industry operators for effective handling and treatment techniques for drill cuttings. Furthermore, the advocacy here is that drilling wastes should no longer be handled, transported from site to site and discharged on the ground without conducting appropriate NORM tests.

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