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Impact of Radioactivity and Heavy Metal Concentrations from subsurface formation cuttings on the Environment

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Abstract

An assessment of Naturally occurring Radioactive Materials (NORM) and heavy metals (Al, Cr, As, Hg, Ni, Cd, Pb, Cu and Zn) from drill cuttings of six different layers in the subsurface of an oil well in the Niger-Delta was carried out. The assessment was carried out to estimate the radionuclides and heavy metals in the drill cuttings and as well determine, the radiological risks posed by the radionuclides and heavy metals to operators and nearby-inhabitants. The radionuclide activities and heavy metal concentrations of the samples were analyzed. The health hazard potential of human exposures to the metals, were estimated in terms of intensity and time using the USEPA recommended model. The average concentrations of the heavy metals present in the samples obtained from the formation zone, varied significantly and decreased in the order of Al > Zn > Ni > Pb > Cr > Cu > Cd > As > Hg. The mean activity concentration for the different radionuclides are ^{238}U, ^{232}TH and ^{40}K were 3.9, 17.5 and 221.2 $Bqkg^{-1}$ respectively. Comparing the results from this study with those of a previous study, shows that for sandstone formations, the uranium (^{238}U) concentration was greater in the current study than what was obtained in the previous study while the ^{232}TH and ^{40}K concentrations were lesser in the former than the latter. A similar observation was made for a shale formation whereas, for a sandstone shale formation, the estimated ^{238}U, ^{232}TH and ^{40}K concentrations are less than those of the previous study. The radionuclide activities decreased in the order of Layer 2 > Layer 1 > Layer 4 > Layer 5 > Layer 3 > Layer 6 whereas, for the heavy metal concentration obeyed this trend: Layer 5 > Layer 4 > Layer 3 > Layer 2 > Layer 1 > Layer 6. The risk assessment for the Annual Effective Dose Rate was

greater than the allowable limit; while the exposure factor for heavy metal was within the allowable limit.

Keywords: Drill-cuttings; Formation; Health and radiological risk; Heavy metals; Radionuclides

1. Introduction

NORM waste such as drill cuttings are brought to the surface by drilling operations, which are then examined to make a record of subsurface materials that had penetrated various depths; these drill cuttings result in environmental contamination (Mkpaora, 2015). Due to the increasing demand for oil and gas, the technology to handle the process has become more advanced, and this has led to the need to develop requirements necessary for the management and control of the potential hazards of NORM to humans and the environment (Levinthal et al., 2017; Okoro et al., 2019a).

Sub-surface lithology data plays an important role in rock properties and reservoir characterization as it is impossible to determine fluid content of any geological bed without first knowing the lithology with which the fluid is associated with (Nton and Esan, 2010). Drill cuttings are also rock samples; they are tiny bits of rocks from the wellbore that are brought to the surface via the help of drilling mud. They are usually by-products of drilling activities and represent pieces of components that are returned to the surface with the drilling fluid (Okoro et al., 2019b). Drill cuttings are separated from the drilling mud at the surface by shale shakers. Drill cuttings are usually analyzed for further interpretation of the formation, the different rock formations include sandstone, limestone, dolomite, claystone, chert, coal, shale and so on. The size of the individual rock samples examined at the surface is usually small because it is limited by the size of drill cutting and rock strength which led to the desire to obtain larger unbroken pieces of formation rocks and subsequent development of coring techniques/operations.

Natural Radioactive elements are present in very low concentrations in the Earth's crust and are brought to the surface through human activities such as oil and gas exploration (Taheri et al., 2019). Removing drill cuttings from tanks and pits, may expose employees to particles containing increased levels of alpha emitting radionuclides that could pose health risks if inhaled or ingested. Various researches and studies have been carried out, and it has been discovered that exposure to NORM during Exploration and Production of oil and gas has significant effect on the health and