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Toxicology of Heavy Metals to Subsurface Lithofacies and Drillers during Drilling of Hydrocarbon Wells

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This study investigates the toxicological effects of heavy metals on lithofacies of the subsurface in a drilled hydrocarbon well as well as, to the drilling crew and people in an environment. The pollution levels of selected heavy metals were considered alongside their ecological effects during dry and wet seasons. The health hazard potential of human exposures to the metals, were estimated in terms of intensity and time using the USEPA recommended model. The heavy metal concentration for each layer decreased across the lithofacies as follows; Layer 5 > Layer 4 > Layer 3 > Layer 2 > Layer 1. 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 highest concentration of Al, Cu, and Zn in this present study were within the maximum allowable limits whereas, those of As, Cd, Hg and Ni were all above their maximum allowable limits. Among the transition metals analysed, the maximum mean daily dose of Pb (9.18×10^{-6} mg/kg/d) and Cr (1.42×10^{-6} mg/kg/d) were confirmed susceptible to human carcinogens and environmental toxins. The estimated hazard quotient shows that the dermal pathway is the most likely route via which the drilling crew and people in the environment can get contaminated. The cancer risk values for the Pb (7.72×10^{-4}), Cd (1.35×10^{-1}), Ni (9.97×10^{-3}), As (1.50×10^{-1}) and Cr (3.16×10^{-3}) are all above the acceptable values. The cancer risk contribution for each metal was in the order of As > Cd > Ni > Cr > Pb. Layer 5 had the maximum Geo-accumulation index for the heavy metals considered. This higher Geo-accumulation index noted at the depth in Layer 5 may be attributed to the effect of water basin with turbidity currents, deltas, and shallow marine sediment deposits with storm impacted conditions. Also, the pollution from lead (Pb) in the dry season was maximum with an I_{geo} value > 5 for all the lithofacies considered because of the low background concentration of the metal. During the wet season, the heavy metal pollution rate was moderate for Zn whereas, it was extremely polluted with respect to Pb. The ecological risk potential of Pb shows that the associated ecological risks range from 536 – 664 in the wet season (i.e. extremely strong) and 2810 – 3480 in dry season (extremely strong). The high level of Pb pollution found in the area at such shallow depth may be due to the sedimentary folds possibly caused by the full spectrum of metamorphic rocks and primary flow structures at shallow depths. This was used to identify the environmental sensitivities of the heavy metals during the dry and wet seasons.

Hydrocarbon reservoirs can only be accessed through drilling of the subsurface rocks/ formations. Rotary drilling technique has been currently employed in drilling of hydrocarbon wells which run into thousands of feet below the ground surface[1]. A hydrocarbon well is drilled by rotating a drill-bit attached to the lower end of the drill-string (drill-pipe). Cuttings which are the true representations of subsurface lithofacies are being generated during drilling, and are removed by continuous circulation of the drilling fluid in the annular space between the wellbore and the drill string[2,3]. At the surface, settling pits and mechanical equipment (shale shaker) extract the cuttings (pieces of lithofacies drilled), and allow the clean drilling fluid to be re-circulated downhole in the closed loop drilling setup.

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