A SOCIO-TECHNICAL HAZARD ANALYSIS OF EMERGING ORGANIC CONTAMINANTS IN PERI-URBAN SHALLOW GROUNDWATER IN UGANDA[1]

ABSTRACT

Anthropogenic groundwater contamination in Sub-Saharan Africa (SSA) has increased due to high urbanisation, especially by on-site sanitation (OSS) practices. Emerging organic contaminants (EOCs) have been reported in groundwater; however, knowledge on their distribution and hazards in the context of SA is still limited. This study aimed to enhance the understanding of socio-technical factors influencing the distribution of EOCs and the associated hazards in peri-urban shallow groundwater in Uganda. The study adopted an exploratory embedded case study design, focusing on Bwaise and Wobulenzi areas. Through a critical review, the socio-technical management frameworks influencing peri-urban groundwater contamination were analysed. The distribution and seasonal variation of EOCs was studied using high-performance liquid and gas chromatography coupled with triple quadrupole mass spectrometry (LC/MS/MS and GC/MS/MS). In order to assess the influence of OSS practices, the study employed *in-situ* and laboratory analyses for antibiotics, microbial and physico-chemical parameters. The socio-institutional factors were studied through key informant interviews and transition arenas.

The findings showed that the existing management framework has had a limited impact on mitigating peri-urban shallow groundwater contamination in SSA. Microbial (*E. coli*) and nutrient (NO_3^-) contamination are still predominant hazards. Antibiotics were detected in both Bwaise and Wobulenzi, up to total concentration of 3,720 ng/L, depicting a high risk for antibiotic resistance in 65% of the sources in Bwaise. Furthermore, the antibiotics showed significant correlations with physico-chemical and microbial parameters associated with OSS practices. Pesticides were detected, predominantly in Wobulenzi due to higher agricultural land use, exceeding the European Commission parametric value of 500 ng/L. Hydrocarbon compounds were detected in both areas, however, at low concentrations to cause adverse health impacts at long term exposure (up to total concentration of 2,535 ng/L). Seasonal variations showed lower concentrations during the wet season for antibiotics and pesticides due to dilution, but higher for hydrocarbons due to run-off infiltration. The key socio-institutional drivers of groundwater contamination were land-use management, user attributes, governance, infrastructure management, groundwater valuation, and the operating environment. These findings imply that peri-urban communities in Uganda are exposed to high health risks from antibiotics and pesticides. Improved monitoring and regulation of EOCs and the associated hazardous events is recommended through a systemic socio-technical approach.

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