Study of the impact of land use and hydrogeological settings on the shallow groundwater quality in a peri-urban area of Kampala, Uganda

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Abstract

A study to assess the impacts of land use and hydrogeological characteristics on the shallow groundwater in one of Kampala's peri-urban areas (Bwaise III Parish) was undertaken for a period of 19 months. Water quality monitoring was carried out for 16 installed wells and one operational protected spring to ascertain the seasonal variation. The aspects of hydrogeological setting investigated in the study were the subsurface unconsolidated material characteristics (stratigraphy, lithology, hydraulic conductivity, porosity and chemical content), seasonal groundwater depths and spring discharge, topography and rainfall of the area. Both laboratory and field measurements were carried out to determine the soil and water characteristics. Field surveys were also undertaken to identify and locate the various land use activities that may potentially pollute. The results demonstrate that the water table in the area responds rapidly to short rains (48 h) due to the pervious (10−5−10−3 ms−1) and shallow (b1 mbgl) vadose zone, which consists of foreign material (due to reclamation). This anthropogenically influenced vadose zone has a limited contaminant attenuation capacity resulting in water quality deterioration following the rains. There is widespread contamination of the groundwater with high organic (up to 370 mgTKN/l and 779 mgNO−3/l), thermotolerant coliforms (TTCs) and faecal streptococci (FS) (median values as high as 126E3 cfu/100 ml and 154E3 cfu/100 ml respectively) and total phosphorus (up to 13 mg/l) levels originating from multiple sources of contamination. These include animal rearing, solid waste dumping, pit latrine construction and greywater/stormwater disposal in unlined channels leading to increased localised microbial (faecal) and organic (TKN/NO−3) contamination during the rains. The spring discharge (range 1.22–1.48 m3/h) with high nitrate levels (median values of 117 and 129 mg/l in the wet and dry seasons) did not vary significantly with season (p=0.087) suggesting that this source is fed by regional base flow. However, the microbial quality deterioration observed in the spring discharge after a rain event (median values of 815TTCs cfu /100 ml and 433 FS cfu/100 ml) was attributed to the poor maintenance of the protection structure. Identification and selection of appropriate management solutions for the protection of shallow groundwater in informal settlements should not only be based on water quality problems and the causal physical characteristics as demonstrated by this study, but also institutional and socio-economic factors.

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