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Risk assessment of toxic metal contamination in groundwater and paddy soil; A study in CKDu affected Maradankulama area in Anuradhapura, Sri Lanka

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Chronic Kidney Disease of Unknown Etiology (CKDu) has emerged as a serious public health concern in Sri Lanka. The North Central Region (NCR) has the highest CKDu prevalence in the country, and the disease is more prevalent among farming communities and people who rely on groundwater as their primary source of drinking water. Meanwhile, heavy metal/metalloids exposure and accumulation are recognized as the causative agent of many acute and chronic diseases in certain vulnerable human tissues, including the kidneys. This study assesses the level of contamination of heavy metals/metalloids in drinking water and agricultural soil in a CKDu endemic area in NCR, Sri Lanka. Fifteen groundwater samples collected from wells were analyzed for pH, EC, hardness, heavy metals, and anion concentration using potentiometric, conductometric, titrimetric, inductively coupled plasma mass spectrometric, and ion chromatographic methods, respectively. From six sampling sites in a paddy field, composite soil samples were collected from the surface, and two depths (30 cm and 60 cm). Soil samples were analyzed for pH, EC, organic matter, potassium, phosphate, and heavy metals using potentiometric, conductometric, titrimetric, flame photometric, colorimetric, and inductively coupled plasma mass spectrometric methods respectively. Accordingly, the mean pH of groundwater is 7.25 and this lies within the guideline values. Mean EC is 662.4 $\mu\text{S}/\text{cm}$ and mean hardness is 287.0 mg CaCO_3/L . Among fifteen samples, four and five water samples have exceeded the health guideline values for EC and hardness, respectively. Metal content varies in the following order, $\text{Cd} < \text{As} < \text{Cr} < \text{Cu} < \text{Co} < \text{Fe} < \text{Ni} < \text{Mn} < \text{Zn}$. Pb was not detected in any of the water samples and other metals were found in concentrations well below the standard guideline values. Only one sample and three samples exceeded the guideline value for fluoride and nitrite, respectively. Mean pH, EC, organic matter, potassium, and phosphate in paddy soil is 7.57, 101.8 $\mu\text{S}/\text{cm}$, 1.34%, 148.9 mg/kg, and 24.05 mg/kg respectively. Heavy metal content in soil varies in the following order, $\text{Cd} < \text{As} < \text{Pb} < \text{Co} < \text{Ni} < \text{Cu} < \text{Zn} < \text{Cr} < \text{Mn} < \text{Fe}$. Paddy soil from the very bottom showed the highest pH, Pb, Cd, As, Zn, Ni, Mn, Cr, and Fe content while the highest EC, organic matter and potassium content was detected in topsoil. EC, organic matter, and potassium content decreased with the depth of the soil, and the concentration of Pb, As, Zn, Mn, and Fe increased with the depth. This study reveals the dependence of some soil quality parameters on the depth of the soil profile. Monitoring the soil quality is important to minimize the possibility of heavy metal uptake by rice plants. Low heavy metal concentration in groundwater may not have an acute health effect on humans. But long-term chronic exposure to toxic heavy metals together with high EC, hardness, and fluoride would be a reason to trigger the prevalence of CKDu in Maradankulama area.

Keywords: Anuradhapura, CKDu, Drinking water, Paddy soil, Toxic metals.