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A GIS approach to assess the distribution patterns of nephrotoxic constituents in a CKDu prevalent area, Badulla district, Sri Lanka

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Abstract

Chronic Kidney Disease of unknown etiology (CKDu) has been a major public health concern in Sri Lanka for two to three decades. Consumption of water with nephrotoxic constituents is one of the major risk factors for CKDu. Hence, this study was carried out to investigate the distribution of nephrotoxic elements; Cadmium (Cd), Lead (Pb), Chromium (Cr), Arsenic (As), Zinc (Zn), Manganese (Mn), and Aluminum (Al) in Rideemaliyadda-South Grama Niladhari Division (GND), Badulla District, Sri Lanka using Geographical Information System (GIS) techniques. A total of thirty drinking water samples were collected according to the Random Stratified Design method and the concentrations of selected nephrotoxic elements were analyzed by using Inductively Coupled Plasma Mass Spectrometry (ICP_MS_Agilent_7800). Each analysis was performed in triplicates. The spatial distribution patterns of Cd, Pb, Cr, As, Zn, Mn, and Al were interpolated by the Inverse Distance Weighted (IDW) tool and Moran's Index (MI) tools in ArcMap software. The mean concentrations of Cd, Pb, Cr, As, Zn, Mn, and Al were 0.158 ± 0.032 , 1.722 ± 0.29 , 3.312 ± 0.185 , 2.401 ± 0.248 , 165.429 ± 22.015 , 55.458 ± 8.460 , and 45.995 ± 6.026 in $\mu\text{g/L}$, respectively. According to the spatial distribution results interpolated using the IDW tool, the concentrations of Cd, Pb, Cr, As, Zn, Mn, and Al were ranged from 0.010-1.788, 0.412-7.949, 0.481-7.809, 0.030-11.637, 13.670-1032.963, 10.258-204.615, 7.179-129.896, respectively in $\mu\text{g/L}$. According to the Moran's Index values resulting from the spatial autocorrelation, Cd (0.1803), Pb (0.2504), As (0.5611), and Mn (0.3806) distributions showed the clustered pattern while the Cr (-0.1505), Zn (-0.0012), and Al (-0.2833) showed a random distribution pattern. The spatial distribution maps of nephrotoxic element concentration revealed that most contaminated waters existed close to agricultural areas. Further, the results concluded that the health of the residents is at risk due to the long-term exposure to the contaminated drinking water with nephrotoxic elements, although the mean concentrations of analyzed nephrotoxic elements were not exceeded the drinking water quality standards recommended by the WHO. The study results can be utilized to monitor and plan to reduce water pollution by assessing the polluted sources and sites efficiently. The study recommends using innovative agricultural practices with the minimum use of synthetic agrochemicals to minimize the health impacts of excessive and long-term exposure to nephrotoxicants.

Keywords: CKDu, IDW, Moran's index, Nephrotoxic elements, Spatial distribution

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