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Suitability of Clay Water Filter for the Removal of Nephrotoxic Constituents in CKDu Prevalent Areas

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Abstract

Consumption of water composed of different nephrotoxic constituents such as Hardness, Fluoride, Cadmium, and Aluminum has manifested to be triggering causal factors of Chronic Kidney Disease of unknown etiology (CKDu) and non-nephrotoxic health hazards. Hence, it is a prerequisite to remove these nephrotoxic constituents from water to levels less than the permissible drinking water guideline values. Thus, an introduction of clay water filters has been reckoned to be a solution, which will provide safe drinking water to people in CKDu prevalent areas. This filter media is composed of clay and shifted rice husk mixture. The suitability of the clay water filter unit to remove nephrotoxic constituents is, however, has not been comprehensively investigated. Therefore, the present study focuses on investigating the suitability of the clay water filter unit in the removal of nephrotoxic constituents effectively and efficiently from potable water. Feed water was, therefore, synthesized simulating wet (October & November) and extreme wet (December) seasons in the dry zone in Sri Lanka, in which the feed water constituted of Hardness of 350 and 150 mg/l, Fluoride of 3 and1 mg/l, Cadmium of 1 and 1 mg/l and Aluminum of 1 and 1 mg/l for both wet and extreme wet seasons respectively. With the assumption that four members of a family consume 8 l of water per day, samples were collected and analyzed. Average concentration values of the treated water were determined as Hardness of 340 and 148 mg/l, Fluoride of 0.92 and 0.87 mg/l, Cadmium of 0.69 and 0.58 mg/l, and Aluminum of 0.74 and 0.67 mg/l during wet and extreme wet seasons. Hardness values did not comply with drinking water guideline values of 250 mg/l (SLS- 613:2013) during the wet season and Cadmium of 0.003 mg/l (WHO Guideline) during both seasons. Aluminum and Fluoride values complied with WHO permissible drinking water guideline values of 0.9 mg/l and 0.6-1.5 mg/l respectively. The XRD, FTIR, ESEM-EDX analyses of filter media of the clay filter unit confirmed that the filter media composed of clay and non-clay minerals mainly, silicon oxide, quartz, albite, gottardiite and salicylic acid, with prominent elements of aluminum, calcium, magnesium, oxygen, silicon, and sodium. In such minerals, functional groups such as Si-O-Si, Si-O, -OH, -COOH and Si-OH were found to be the most dominant ligands that can form complexes with ions in water. Al^{3+}ions showed strong interactions with such functional groups more than Ca^{2+}, Mg^{2+} and Cd^{2+}ions did, resulting in a better removal of Aluminum through the formation of covalent bonds between Aluminum and ligands. Complexation of F^- with Al^{3+}, Ca^{2+}, and Mg^{2+}ions in clay minerals was too seen indicating an excessive removal of Fluoride in the water. However, Ca^{2+}, Mg^{2+},and Cd^{2+}showed poor interactions with ligands resulting in an ineffective and an inefficient removal of Ca^{2+}, $Mg^{2+}$and Cd^{2+} ions in water. Hence, it could be inferred that the use of the clay filter unit is not a promising solution to remove high concentrations of Ca^{2+}, $Mg^{2+}$and Cd^{2+}ions from water in CKDu prevalent areas.

Keywords: Aluminum, Cadmium, Drinking water, Fluoride, Hardness