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ORIGINAL ARTICLE

Efficacy of *Terminalia arjuna* mature leaf powder and *Phyllanthus emblica* bark powder to reduce nitrate: N and total hardness in groundwater in karstified limestone aquifer

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Abstract
Groundwater is a vital resource in the northern region of Sri Lanka, as it is the only water resource used for domestic, agricultural and industrial activities in that area. However, due to excessive usage of synthetic fertilizer, the groundwater in this part of the country is highly contaminated with nitrates. In addition, due to the effect of underlain limestone aquifer, water hardness is also high. The present study aimed to study the effect of filtration through *Terminalia arjuna* mature leaf powder and *Phyllanthus emblica* bark powder on reducing nitrate concentration and hardness. The results indicated that 21.4% reduction of nitrate concentration can be achieved by filtration through *Terminalia arjuna* mature leaf powder and 9.3% reduction of total hardness by filtration through *Phyllanthus emblica* bark powder. Therefore, further research is recommended on testing the potential and side effects of using *Terminalia arjuna* mature leaf powder and *Phyllanthus emblica* bark powder as a combined home remedial treatment technique for treating nitrate contaminated hard water.

Keywords Home remedial techniques · Groundwater · Drinking water pollution · Water purification

Introduction

The Jaffna peninsula, Sri Lanka, is underlain by 100–150-m-thick Miocene limestone formation which is uniquely bedded and well established and highly karstified. The unique geological features of this part of the country include lagoonal and estuarine deposits, unconsolidated brownish grey coastal sands, highly karstified Miocene sedimentary limestone formations, red beds and dune sands (Kumara et al. 2013). The whole population in Jaffna Peninsula is primarily dependent on groundwater resources to meet the domestic, agricultural and industrial water requirements (Wijeyaratne and Suvendran 2017).

The groundwater aquifers in Jaffna peninsula are shallow karstic-type aquifers and are recharged only by infiltration of rainfall. This shallow groundwater aquifers form mounds or complexes of freshwater lenses of up to 25 m thickness that floats over the saline water and reach their peak during the monsoon rains in November and December (Panabokke and Perera 2005; Vijakanth et al. 2017). Jaffna peninsula receives an average approximate annual rainfall of 1200 mm per 1000 km^2 area. However, after all the natural losses of precipitation, approximately 5–50% of rainwater is lost to sea as subsurface flow thereby leaving approximately 450 million m^3 water annually to fulfil the requirements of the residing population in the peninsula. According to the Falkenmark indicator, this amount of annual water availability indicates that this region is facing water scarcity (Vijakanth et al. 2017). For more than five decades, the groundwater resources in Jaffna peninsula were sustainably extracted due to less population resided in the area during that period. However, the recent new developmental activities in the peninsula, the resettlement of population and rapid industrial and agricultural expansion have resulted in extensive use of groundwater resources leading to unsustainable groundwater extraction.

Increased concentration of nitrates and nitrites in some aquifer systems in Jaffna peninsula is identified as a significant issue over the decades. The high nitrate and nitrite

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