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EDITORIAL

Challenges Ahead in Groundwater of Sri Lanka

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ABSTRACT

Groundwater has been a safe water storage in Sri Lanka throughout history and the unique characteristics of different aquifers impact variation of the water quality. However, due to population growth, unplanned urbanization, intensive agriculture, improper waste management, etc., the groundwater quality is considered unsafe. Therefore, it is important to refer to the available data related to the groundwater quality of Sri Lanka. Saltwater intrusion is a considerable factor in shallow karstic aquifers and as a result, relatively higher electrical conductivity, water hardness, total alkalinity, and higher anions concentrations (chloride, sulfate) were observed in the Jaffna area. The dry zone including Padaviya and Hambanthota shows relatively higher water hardness and fluoride in groundwater. Nitrate concentration is also a considerable factor, especially in the Jaffna and Padaviya areas may be due to intensive agriculture. Identification of groundwater recharge zones, recharge estimates, continuous monitoring of groundwater quality, vulnerability mapping of aquifers, and proper planning of urbanization have been identified as challenges ahead in groundwater of Sri Lanka and it is essential to include those items in the National Water Policy in Sri Lanka.

Key Words: Aquifer, groundwater, national water policy, saltwater intrusion

Introduction

Water trapped in underground rock and soil pore spaces and in the fractures of rock formations is termed groundwater. Groundwater is a part of the water cycle and is recharged either by rainwater and snowmelt or from water that leaks through the bottom of some lakes and rivers. These water-bearing soil layers are known as aquifers. Sri Lankan ground waters mainly distributed in six types of aquifers, namely shallow karstic aquifers, deep confined aquifers, coastal sand aquifers, alluvial aquifers, deeper fracture zones, and shallow regolith aquifers, which are mainly distributed in the North-Central and North-Western provinces of Sri Lanka (Panabokke and Perera 2005). The Jaffna peninsula is unique with shallow karstic and coastal sand aquifers, while the deep confined aquifer is unique to the North-Western coast of Sri Lanka. Groundwater is an important resource as it meets more than 70% of the rural and urban drinking water requirements of Sri Lanka. For instance, more than 85% of the drinking water requirements for the rural communities in Jaffna, Vavuniya, Batticaloa, Mannar, and Puttalam are obtained from shallow and deep wells (Perera et al. 2008). According to the available data, there are 5000 tube wells distributed in Anuradhapura district. In addition, approximately 3000 tube wells have been found in Kurunegala, Hambanthota, and Puttalam districts. Therefore, much attention needs to be paid to groundwater dynamics, groundwater quality, and awareness of the society for sustainable utilization of Sri Lankan groundwater. On the other hand, this information will benefit achieving the SDG 6 of the United Nations; "Ensure availability and sustainable management of water and sanitation for all". Therefore, the objective of this article is to explore the

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dynamics, water quality, and challenges ahead for the management of groundwater in Sri Lanka.

Groundwater dynamics

Information on groundwater dynamics is important for quantifying groundwater extraction, determining the interference of other borehole/ pumping wells in the same aquifer, determining the fluctuations of the groundwater table, and changes in groundwater recharge, etc. Shallow groundwater available under the small tank cascade systems in the dry zone of Sri Lanka is now being subjected to severe stress of over-extraction. It is mainly due to the use of large-diameter dug wells or agro-wells constructed to irrigate agricultural fields of high-value cash crops. The overexploitation of shallow groundwater could lead to long-term desertification, and it would result in disastrous ecological consequences in the area (Dissanayake, 2005). Similarly, groundwater dynamics largely depended upon climatic factors. For instance, groundwater recharge is a function of precipitation (Kovalevskii 2007; Haidu and Nistor 2020) while global warming depletes the groundwater level (Dehghani et al. 2022). During July and August of the year 2023, there was a severe drought in the dry zone of Sri Lanka and this drought drastically reduced the water level of water bodies. Specifically, the water level of Udawalawe Reservoir dropped to 2 percent of its capacity due to severe drought conditions. During this severe drought, the villages faced a lot of difficulties in searching for water from the wells for their daily needs. Just after one month, a severe flood was reported in the wet zone in Sri Lanka. Flood is an important factor behind the chemical dynamics (Sánchez-Pérez and Trémolières 2003), quality, and quantity (Ghazavi et al. 2012). A case study in the Jaffna peninsula showed a significant influence of rainfall on temporal variation of groundwater quality; electrical conductivity, chloride, nitrate-N, alkalinity, and total hardness due to the leaching of ions from surrounding fields to the groundwater during the rainy season (Gunalan et al. 2011).

Groundwater quality

Groundwater quality refers to the state of water that is located beneath the Earth’s surface, and it is decided by a combination of factors including chemical, physical, and biological aspects of the ground waters. Specifically, the geology of the aquifer system which largely depends upon the length of the flow path, residence time with the aquifer base materials, and geochemistry are particularly important to decide their water quality (Indika et al. 2022). However, the quality of groundwater is a function of both natural and anthropogenic impacts (Xiao et al. 2021). Under this context, urbanization, saltwater intrusion, and contamination of both chemical and biological agents have been identified as promising factors behind groundwater quality.

Urbanization

Urbanization has been identified as one of the major processes that impact groundwater recharge in both quantity and quality in urban cities where the groundwater flows beneath. Further, extensive use of ground for effluent discharge, and waste disposal in urban areas largely deteriorates groundwater quality. For instance, urban non-point sources are contributing to groundwater recharge and adversely affecting its water quality (Carlson et al. 2011). The alteration of natural infiltration systems and changes in natural drainage in urban areas further affect groundwater recharge. Leakage of waste including hazardous chemicals and pathogens from nearby open dumping sites to the groundwater wells has been reported in Sri Lanka (unpublished data). Insufficient sewage and waste disposal infrastructure on a local basis adversely affects groundwater quality. A recent water quality monitoring program conducted at the area near the University of Ruhuna showed unacceptable coliform contamination in the wells (unpublished data), and most probably this observation is due to bacterial pollution from pit latrine soak-ways. National Policy on Protection and Conservation of Water Sources, their Catchments and Reservations in Sri Lanka in 2014 highlighted under section 1.9 that soil pollution affects water used for drinking purposes.

Saltwater intrusion

Saltwater intrusion compromised the quality of ground waters specifically in the coastal aquifers. Ebrahimi et al. (2016) observed the unsuitability of groundwater for agricultural applications due to high salinity levels in the Damghan basin, Iran. The leaching of salts increases the electrical conductivity (EC) of well water located in a deep confined limestone aquifer which has been intensively used for irrigated agriculture. One of our previous studies (Gunaalan et al. 2015) analyzed water samples collected from sixty wells in Jaffna (Table 1).

Table 1. Water quality parameters of wells in Jaffna

Region	Min-Max range of water hardness (mgL^{-1})	Reference
Dry Zone	250 - 500	Dissanayake (2005)
Padaviya	40 - 645	Dhanapala et al. (2016)
Bandagiriya in Hambanthota	9 -42	Premarathne et al. (2018)
Tangalle	5.5 – 13.6	Perera et al. (2014)
Angunakolapallassa	2.4 – 8.8	
Beliatta	5.6 – 21.2	
Balangoda	0.02 – 0.052	
Padalangala	20 - 400	Abdul et al. (2015)
Jaffna	72-862	Gunaalan et al. (2015)

(Source: Gunaalan et al. 2015)

Table 2. The hardness of Sri Lankan groundwater

Parameter	Range
pH	6.62 – 8.20
Electrical Conductivity (μScm^{-1})	260 - 9700
Turbidity (NTU)	0.19 – 3.86
Total alkalinity (mgL^{-1})	80 - 880
Chloride (mgL^{-1})	46 - 1725
Nitrate (mgL^{-1})	0 - 19
Sulfate (mgL^{-1})	4 - 532
Phosphate (mgL^{-1})	0 – 2.56

However, except for the northern region and small areas near Hambantota and Puttalam, the rest of the country did not experience a significant problem caused by the elevated level of salinity in the well water.

Water hardness

The total calcium and magnesium ion concentration in a water sample is referred to as water hardness and is expressed as the concentration of calcium carbonate (Ansell 2005). There is a spatial variation in hardness in Sri Lanka (Table 2), where a comparatively high level of hardness was observed for the Northern Sedimentary formation (850 ppm). Hardness of water is an issue in most parts of the country, especially in the dry zone associated with the reddish-brown earth soils.

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Other contaminants

Apart from the above-mentioned locations, some other water quality parameters including some heavy metals were recorded in different areas (Table 3).

Challenges ahead

Ancient people of the country paid their honor to the wells at the auspicious time and practiced traditional methods to maintain the quality of water as remediation techniques (ref). The use of *Igini (Strychnos potatorum)* seeds and coconut charcoal are traditional methods to maintain the quality of groundwater while planting *Kubuk* (*Terminalia arjuna*) trees near the wells is also one of their traditional phytoremediation technique. The experiment of Nijakini et al (2022) showed the possibility of using a blend of coconut shell charcoal and eggshell powder to remove fluoride from portable water. However, with time people shifted to pipe-borne water and as a result, groundwater wells are mostly located in rural areas where pipe-borne water distribution facility is not available. Or else, in recent times the initial cost and water bill are unbearable for the rural community.

Table 3. Water quality of Sri Lankan well water

Area	**Parameter**	**Min-Max range of water quality**	**Reference**
Padaviya (30 wells)	Nitrate (mgL^{-1})	1.01 - 23.4	Dhanapala et al. (2015)
	Fluoride ($mg\ L^{-1}$)	0.47 – 1.92	
	Organic phosphorous ($mg\ L^{-1}$)	0.1 - 0.39	
	Copper ($mg\ L^{-1}$)	0.001 - 0.002	
	Iron ($mg\ L^{-1}$)	0.0011 - 0.0084	
	Total dissolved solids ($mg\ L^{-1}$)	6.3 – 378	
	Electrical Conductivity (μScm^{-1})	16.25 – 755.0	
Moneragala (25 wells)	Electrical Conductivity (μScm^{-1})	150 - 2150	Subashini et al. (2013)
	Fluoride ($mg\ L^{-1}$)	0.1 - 1.5	
Hambanthota (15 wells)	Nitrate ($mg\ L^{-1}$)	0.57 - 2.39	Perera et al. (2014)
	Orthophosphate ($mg\ L^{-1}$)	0.67 – 1.20	
	Fluoride ($mg\ L^{-1}$)	1.28 – 1.58	
	Mercury ($mg\ L^{-1}$)	0.000 – 0.005	
	Manganese ($mg\ L^{-1}$)	0.000 – 0.65	
Balangoda (6 wells)	Nitrate ($mg\ L^{-1}$)	0.28 – 0.50	
	Orthophosphate ($mg\ L^{-1}$)	0.05 – 0.27	
	Fluoride ($mg\ L^{-1}$)	0.91 - 1.070	
	Mercury ($mg\ L^{-1}$)	Not Detected	
	Manganese ($mg\ L^{-1}$)	Not Detected	

Awareness of the stakeholders who are responsible for the management of groundwater in Sri Lanka including the public is a challenge. In this regard, conducting community-based approaches on the key components of sustainability of groundwater usage as groundwater recharge, aquifer drainage, and pollution is important. Further, continuous monitoring of groundwater quality is a big challenge because still no authority has been established. Section 2.5 of the National Policy on Protection and Conservation of Water Sources, their Catchments and Reservations in Sri Lanka in 2014 mentioned eight main issues for conserving and protecting water sources such as lack of public participation in protecting the areas related to the water sources, issues in the present laws, rules, and regulations, institutional problems regarding the conservation of water sources, etc. National Water Supply and Drainage Board, Department of Agrarian Development, Divisional Secretary, and other agencies concerned have been identified as responsible agencies for the use of ground or surface water resources springs and sprouts for drinking water projects and/or agricultural purposes. Identification of groundwater recharge zones, recharge estimates, vulnerability mapping of aquifers, and land use planning for deciding which type of development activities would be accepted in different areas of the country are specific needs to be included in the National Water Policy in Sri Lanka.

Conclusion

Sri Lanka is not a country with water scarcity, but several natural and anthropogenic factors; population growth, agricultural land-use practices, rapid industrialization unplanned urbanization, and climate change are putting groundwater resources under pressure. Several studies have already been carried out on the quality and chemical characteristics of groundwater in Sri Lanka. Some of the water quality parameters in the groundwater of the country exceeded the permissible levels for drinking water. For instance, based on the previous studies considered, fluoride concentration in Padaviya, Moneragala, and Hambanthota exceeded the maximum permitted level (1.5 mgL^{-1}), nitrate concentration in Jaffna and Padaviya area also exceeded the maximum permitted level (10 mgL^{-1}). Other than those values manganese concentration in well water in the Hambanthota area exceeded the level of the permitted value (0.5 mgL^{-1}). Therefore, further studies are recommended on the assessment of the chemistry of groundwater systems the effect of climatic factors, and the identification of the soil-water interactions in the groundwater of Sri Lanka.

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