



# Groundwater quality assessment in Anuradhapura district of the dry zone for domestic purposes and the effectiveness of laterite soil-based domestic water filter as an adsorbent for groundwater purification

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## Abstract

In the North Central province; Sri Lanka, high levels of hardness, Ca, Mg, NO<sub>3</sub><sup>-</sup>, PO<sub>4</sub><sup>3-</sup>, F<sup>-</sup> and, heavy metals in groundwater intake are turning into a severe health concern. The current study looked at the quality of groundwater in the Anuradhapura district, Padaviya, Medawachchiya, and Rajanganaya area, as well as the removal efficiencies of this groundwater by a laterite soil-based water purification cylinder. To determine the quality of groundwater, chemical parameters (hardness, Ca, Mg, NO<sub>3</sub><sup>-</sup>, PO<sub>4</sub><sup>3-</sup>, F<sup>-</sup>, Cr, Cd, and Pb) were examined. Hardness was 471 mg/L on average and ranged from (21-1730) mg/L. Ca and Mg levels were also found to be high in Anuradhapura, with an average of 122 mg/L and ranging starting (5-429) mg/L and 40 mg/L (2-160) mg/L, in that order. However, Phosphate, Nitrate and Fluoride concentrations ranged from 0.02 to 0.83 mg/L with an average of 0.08 mg/L, (0.05-6.5) mg/L with an average of 0.59 mg/L and (1.8-4.0) mg/L with the average of 2.3 mg/L, respectively. Heavy metal concentrations that were lower than the permissible levels, such as those of chromium, cadmium, and lead, had no noticeable impact. The average removal rates by a laterite soil-based water purification cylinder for hardness were 89.7%, Ca was 89.32%, Mg was 86.87% P was 100%, NO<sub>3</sub><sup>-</sup> was 92.6%, and F<sup>-</sup> was 81.6%. The findings showed that well water in the dry zone of Sri Lanka needs to be treated in advance so it can be used up. In terms of getting rid of high hardness, Ca, Mg, P, NO<sub>3</sub><sup>-</sup> and F<sup>-</sup>, the laterite soil-based water filter showed good performance.

**Keywords:** Groundwater quality, Laterite, Adsorption, Removal efficiency, Hardness, Fluoride

## Introduction

Groundwater is the most important supply of intake water for the majority of the Sri Lankan group of people, for the most part in the dry zone (Dissanayake, 2010). The use of groundwater has extended widely, mainly in arid regions. According to the National Water Supply and Drainage Board Annual Report 2017, for case in point, a remarkable percentage of the residents even now depend on tube wells (3.2%) and, dug wells (36.4%) as their prime water sources in Sri Lanka.

Groundwater quality and quantity are in general determined by environmental, geological, climatic, and anthropogenic features, which vary greatly across Sri Lanka (Panabokke &

Perera, 2005). The quality of groundwater in Sri Lanka is affected by anthropogenic activities like agrarian and sanitation practises as well as environmental aspects like lithology, land use, and climatic conditions (Jayasumana et al., 2015). The lithosphere of Sri Lanka contains a lot of underlying water storing or aquifer systems with a range of geological and geochemical properties (Indika et al., 2022). In Sri Lanka's dry zone, aquifers typically include alluvial aquifers, metameric hard rock aquifers (regolith) in the interior, northern coastal limestone karst aquifers, and coastal sandy aquifers. Groundwater in Sri Lanka North Central Province is frequently of Ca-Mg-HCO<sub>3</sub>, which is controlled by silicate weathering processes (Cooray et al., 2019). The effect of the climatic difference in groundwater all the way through

the year is significantly more in Sri Lanka's dry zone, which has a long dry season with considerably high temperatures and a short-wet season with too much rain (Indika et al., 2022). Higher dissolved constituent concentration levels in groundwater have been noticed due to greater evaporation and comparatively low rainfall in arid areas. The hardness of the groundwater in the Anuradhapura district ranged from hard (16.5%) to very hard (72.8%), greater than the Sri Lanka Standards Institution (SLS's) acceptable drinking-water hardness limit of 250 mg/L in both seasons (Indika et al., 2021). Fluoride and trace metals are frequent geogenic contaminants in shallow regolith aquifers in dry zone areas (Panabokke et al., 2007).

Raised up levels of total hardness, alkalinity, salinity and, fluoride have been described as important concerns in dry zone groundwater. A small number of areas in the country had greater amounts of trace elements including arsenic, cadmium, and lead in the groundwater, even though just about all of the regions had no dangerous drinking water. Fluoride in the groundwater is the key problem in the Anuradhapura district (Indika et al., 2022). The dry zone parts of this district are rich in fluoride minerals, especially apatite. In high-grade metamorphic terrains, the dissolution of minerals such as amphiboles, apatite and, biotite, leads to raised up quantities of fluoride in the groundwater in arid areas. Fluoride is an additional potential reason for Chronic Kidney Disease of unknown etiology (CKDu) (Nanayakkara et al., 2012). CKDu, skeleton fluorosis, and dental fluorosis are all tremendously common in dry zone Sri Lanka. The high concentration of fluoride has a direct impact on dental fluorosis and skeleton fluorosis; just about 80% of 15-year-old students in the Anuradhapura area were found to have dental fluorosis (Perera et al., 2013). The main sources of nitrate in groundwater are inorganic fertilisers, manure storage, septic systems and, spreading operations. Water readily dissolves nitrate, and as a result, getting rid of it is extremely challenging (Indika et al., 2022). Newborns who are exposed to nitrate in great quantities (greater than 50 mg/L) develop blue baby syndrome (Gutiérrez et al., 2014). For years, Sri Lanka has coped with key health emergencies as an end result of poor drinking water quality. Chronic kidney disease of unknown aetiology (CKDu) has received important consideration in current periods as its prevalence has been greater than before across the country (Cooray et al., 2019).

Managing groundwater quality, mainly in the dry zone, is necessary for long-term sustainability (Senarathne et al., 2021). As regards treatment ways and means, at present existing RO (Reverse Osmosis) units may deliver the population with safe and clean drinking water, but its applicability is still rather limited (Indika et al., 2022). Water treatment know-how at present available have strengths and limitations, and is costly, less in effect, and produces more byproducts. In addition, simple domestic treatment options for other pollutants, such as boiling, filtration, disinfection, and water softening, are ineffective for eliminating nitrates and fluorides (Gamage et al., 2021). There are still important gaps and technical hitches given that every person with the right to

use safe consumption water, mainly in rural societies in Sri Lanka (Indika et al., 2022). According to Indika et al. (2022), in Anuradhapura and the intermediate zones, well water from places with wide-ranging agrarian activity is not appropriate for drinking or domestic use. As a consequence, research and development of cost-effective water treatment know-how are essential to arrange for safe drinking water for people living in dry zone Sri Lanka. The adsorption method is normally regarded as superior in the treatment of water because of its practicality, easiness, and ease of use. Even though using tremendously basic technology, adsorption is more effective in getting rid of contaminants from water (Bhatnagar & Sillanpää, 2011). Laterite has been recognized as an effective adsorbent. The being there of  $\text{SiO}_2$ ,  $\text{Fe}_2\text{O}_3$ , and  $\text{Al}_2\text{O}_3$  in laterite soil, as well as its great permeability and the accessibility of anion exchange places, made laterite soil a brilliant adsorbent (Mitra et al., 2016). As laterite is plentiful in Sri Lanka (Dissanayake, 1980), its high availability and extensive distribution are also beneficial. Laterite has been revealed in studies to be effective at taking out anions such as fluoride (Vithanage et al., 2012), phosphate (Zhang et al., 2011), arsenite (Maiti et al., 2013), and heavy metals such as copper (Pham et al., 2017), lead, and chromium (Mitra et al., 2016). Hence, for developing nations like Sri Lanka, getting rid of pollutants through adsorption using a laterite-based filter may be practical, meaningful, and efficient.

The aims of this study are to evaluate the quality of the groundwater in the Anuradhapura district of the dry zone and to develop a laterite-based water purification device that could be used as a low-cost, environmentally friendly household water treatment solution to provide safe and clean consumption water to meet the criteria for drinking water quality in high-risk areas for ground water issues.

## **Methods and Material**

### **Sample and material preparation**

Laterite samples were gathered in southwestern Sri Lanka as composite samples and packed in ziplock polyethylene bags. The in-situ weathering of the wet zone laterite has been at length developed with less impurities. The soil samples were collected, gradually washed away with distilled water to take out contaminations, and then allowed to air dry for about 48 hours. The dried laterite soil was crushed and put through a sieve to produce fine particles.

### **Laterite soil based household water filter preparation**

Volume-wise, one portion of red clay, one portion of laterite soil, and two portions of rice husk were collected. All of the materials were thoroughly combined and ground with water. The mixture was shaped and dried in the sun around 10-15 days. Dried molds were burned for 8 to 10 hours at  $750^\circ\text{C}$  –  $850^\circ\text{C}$  (Ramprasad, 2016).

### Collection of groundwater samples and testing water quality parameters

Thirty-five groundwater samples were randomly collected from Anuradhapura (Padaviya, Medawachchiya and Rajanganaya). These samples were stored in plastic bottles, which were properly labeled until the laboratory analyses. The water samples were filtered through the developed Laterite soil-based household water filter. The total hardness as CaCO<sub>3</sub>, Ca, Mg, and total phosphorus as P, NO<sub>3</sub><sup>-</sup>, F<sup>-</sup>, Cr, Cd, and Pb of raw well water and strained well water were determined in the laboratory by the Central Environmental Authority, Battaramulla. Acid-base titration (APHA 2340 C) was used to determine the carbonate and bicarbonate content. EDTA titration with Eriochrome black T as an indicator (APHA 3500 Ca-B and APHA 3500 Mg-B) was used to determine the calcium and magnesium content. The Ascorbic technique (APHA 4500 P-B & E) was used to determine the total phosphorus as P. The Nitrate Electrode Method (APHA 4500 D) was used to measure nitrate. The colorimetric method (Hach DR 900) was used to measure the fluoride. The Direct Air-Acetylene Flame Method (APHA 3111 B) was used to measure Cr, Cd, and Pb.

### Physiochemical analysis for raw laterite soil samples

Using Scanning Electron Microscopy (SEM), the exterior arrangement and the morphology of the laterite soil sample were studied. The investigation was conducted using Hitachi S-4200 field emission SEM and, double-sided conductive carbon tape was used to mount gold-sputtered soil samples on the sample holder. At a constant current of 25 mA, crushed soil was successfully sputtered with gold (Mitra et al., 2016).

Using X-ray fluorescence spectrometry (RIX 2000), the National Gem and Jewelry Research and Training Institute in Sri Lanka investigated the chemical composition of the laterite soil sample. 200 kN of force was used to compress powdered samples into briquettes for 60 seconds (Nayanthika et al., 2018; Zhang et al., 2012) Then, the briquettes' most significant oxides and trace elements were examined. According to Jayawardana et al. (2014), For these components, the relative error was on average under 10%.

At the University of Sri Jayewardenepura; Sri Lanka, laterite soils were analysed using an X-Ray diffractometer Rigaku TTRAX III XRD apparatus. Cu K (alpha) radiation was utilized to investigate the powdered samples, and this radiation had a wavelength of 1.54 Å over 2 (theta) of 5-70° with a step size of 0.020/sec (Beauvais, 1999).

The behaviour of adsorption sites in laterite soils was examined with FT-IR analysis (Thermo Nicolet iS10). The soil samples are deposited on the ZnSe crystal of the instrument with 16 scans and 2 cm<sup>-1</sup> resolution in the 4000-400 cm<sup>-1</sup> spectral band (Mitra et al., 2016).

### Data and discussion

#### Characters of the raw laterite soil samples

The raw laterite soil samples were examined using X-ray diffraction (XRD), X-ray fluorescence (XRF), scanning electron microscope (SEM-EDX), and Fourier-transform infrared spectroscopy (FT-IR). In laterite XRD studies, clay minerals including gibbsite, goethite, hematite, kaolinite and quartz were found (Fig. 1). Prior research has found comparable results for laterite soil (Dissanayake, 1980; Nayanthika et al., 2018).

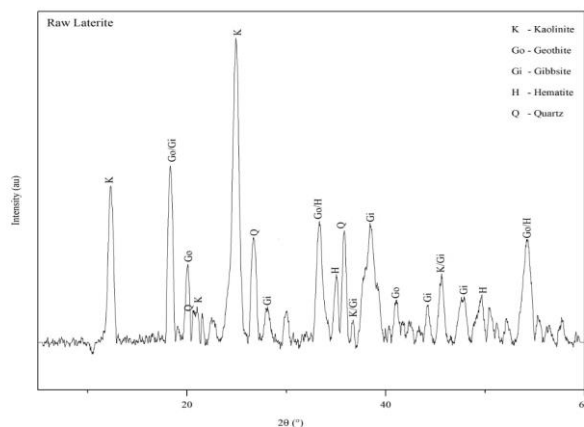


Fig. 1 XRD Patterns of Raw Laterite

XRF study was used to determine the raw laterite soil samples' composition, and Table 1 lists the most prevalent components. 33 elements and compounds were discovered to be present in laterite. The samples' most prevalent element was Fe (65.1%). Aside from that, Al (16.0%) and, Si (15.1%) were wealthy. There were also a lot of Al<sub>2</sub>O<sub>3</sub> (33.1%) and Fe<sub>2</sub>O<sub>3</sub> (19.0%). TiO<sub>2</sub> (2.32%), CaO (0.078%) and, K<sub>2</sub>O (0.167%) are other compounds that have been observed.

Table 1. X-ray fluorescence results of elements and minerals in raw laterite soil samples

| Minerals/wt %                  | Average | Min   | Max   | SD    |
|--------------------------------|---------|-------|-------|-------|
| SiO <sub>2</sub>               | 44.6    | 44.3  | 44.8  | 0.252 |
| Al <sub>2</sub> O <sub>3</sub> | 33.1    | 32.9  | 33.5  | 0.321 |
| Fe <sub>2</sub> O <sub>3</sub> | 19.0    | 18.8  | 19.3  | 0.265 |
| TiO <sub>2</sub>               | 2.32    | 2.31  | 2.34  | 0.015 |
| K <sub>2</sub> O               | 0.167   | 0.162 | 0.171 | 0.005 |
| CaO                            | 0.078   | 0.07  | 0.085 | 0.008 |
| Minerals/wt %                  |         |       |       |       |
| Fe                             | 65.1    | 64.6  | 65.8  | 0.643 |
| Al                             | 16.0    | 15.8  | 16.3  | 0.289 |
| Si                             | 15.1    | 14.7  | 15.6  | 0.473 |
| Ti                             | 1.9     | 1.87  | 1.91  | 0.023 |
| Zr                             | 1.0     | 0.984 | 1.00  | 0.009 |
| Tb                             | 0.3     | 0.196 | 0.347 | 0.076 |
| Co                             | 0.2     | 0.181 | 0.201 | 0.010 |
| Gd                             | 0.2     | 0.164 | 0.175 | 0.008 |
| K                              | 0.1     | 0.129 | 0.131 | 0.001 |
| V                              | 0.1     | 0.085 | 0.088 | 0.002 |

The adsorption surface of laterite soil is highly porous with a heterogeneous texture. The external morphology of laterite soil clearly shows a flaky-shaped constitutive part in SEM analyses. Usual laterite is consolidated clay that characteristically has blocky arrangements (Fig. 2).

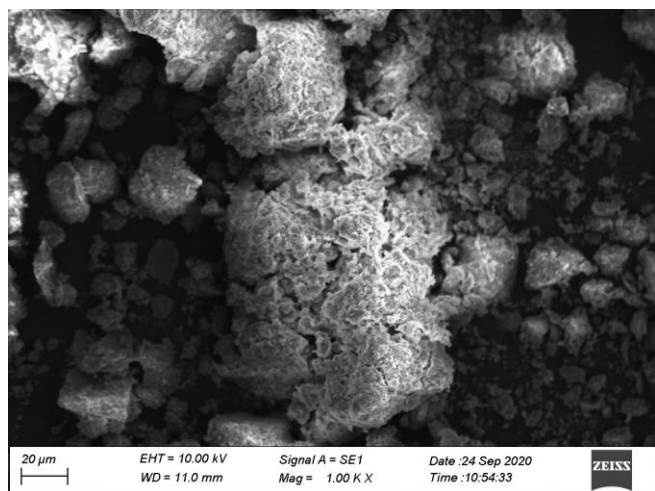


Fig. 2 Photomicrographs by SEM of Raw Laterite

The EDX analysis of laterite samples revealed minute organic matter and inorganic carbons. The samples were mostly made up of Al (20.32%), Si (18.78%) and, Fe which made up the largest portion of the total mass and the smallest amount of trace elements (Table 2). The findings are as good as to those of previous readings of Vithanage et al. (2012).

Table 2. EDX results of raw laterite

| Elements | Weight % |
|----------|----------|
| C        | 3.04     |
| O        | 55.01    |
| As       | 1.11     |
| Al       | 20.32    |
| Si       | 18.78    |
| Ti       | 0.59     |
| Fe       | 1.15     |

Three absorption bands (3688.97, 3619.38, and, 3419.16  $\text{cm}^{-1}$ ) are visible in the OH stretching vibration region (3700-3300  $\text{cm}^{-1}$ ) of the FTIR spectra (Fig. 3). Both the bending mode of the H-O-H band and the stretching modes of OH bands correlated to free water (around 3600  $\text{cm}^{-1}$ ) were discernible; inner layer water molecule (1645.28  $\text{cm}^{-1}$ ). Stretching vibrations of the outer hydroxyl groups in laterite's synchronised to its iron, aluminium, or silica can be the cause

of the band at 3688.97  $\text{cm}^{-1}$  (Maiti et al., 2013), on the other hand, the band at 3619.38  $\text{cm}^{-1}$  is explained by inner hydroxyl groups. The absorption band close to 3419.16  $\text{cm}^{-1}$  is characterised by the hydroxyl bonded to trivalent cations ( $\text{Al}^{3+}$  or  $\text{Fe}^{3+}$ ). As a result, the bands at 3419.16  $\text{cm}^{-1}$  suggest that the octahedral layer of the laterite contains  $\text{Al}^{3+}$  or  $\text{Fe}^{3+}$ . The Si-O-Fe, Al-OH, and Fe-OH vibrations are what cause the bands in the region of 1113.90, 1024.62, 998.76 and, 908.74  $\text{cm}^{-1}$  to exist. The Si-O bonds stretching associated with trivalent cations such as  $\text{Al}^{3+}$  and  $\text{Fe}^{3+}$  can be identified as the source of the bands at 788.68 and 908.74  $\text{cm}^{-1}$ . As a result, the presence of absorption bands at 788.68 and 908.74  $\text{cm}^{-1}$  shows that laterite contains tetrahedrally coordinated trivalent cations. The being there of Fe-O bond stretching is indicated by the band at 541.24  $\text{cm}^{-1}$  (Mitra et al., 2016).

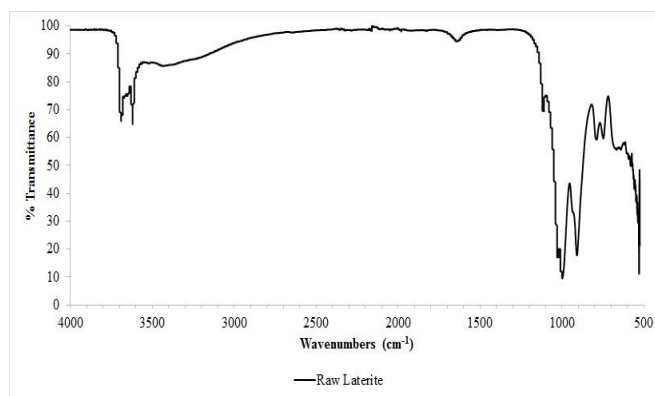
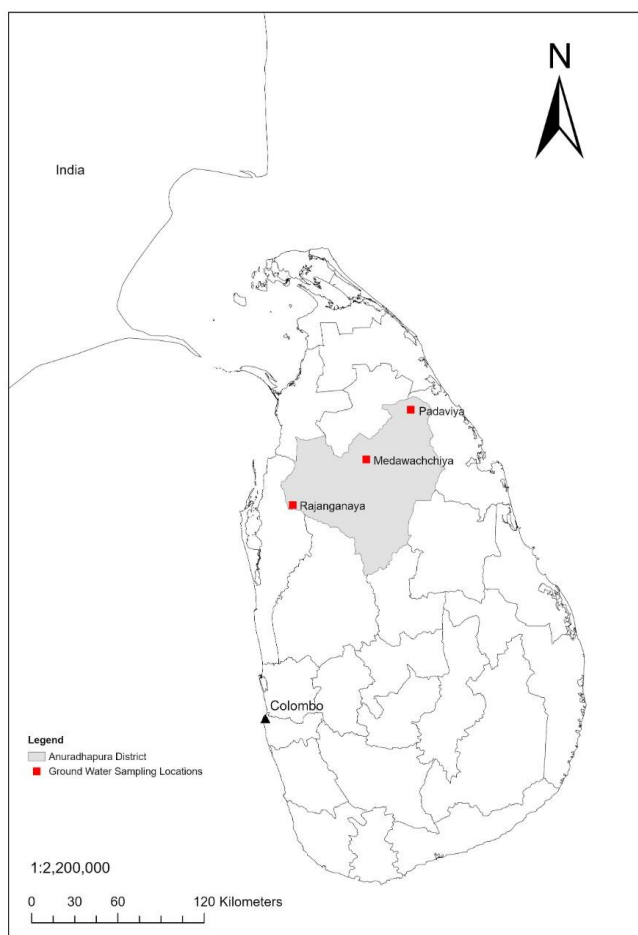


Fig. 3 FTIR Spectra of Raw Laterite

### Water quality parameters of well water

Well water samples were collected at random throughout the study areas during the dry season (Fig. 4). Water quality parameters were assessed before and after and, the developed laterite soil-based household water filter was used to filter the water samples (Fig. 5). Red clay and risehusk are typically used to make clay water filters (Ramprasad, 2016). Laterite soil was added as an active material to the recently developed domestic water purification system to improve the water quality. Table 3 summarizes the average water quality parameters and Table 4 shows the average cation and anion removal efficiencies in various water samples by the developed laterite soil-based household water filter. According to WHO and SLS standards, calcium carbonate concentrations ranging from 0 to 60 mg/L are classified as soft; 61 to 120 mg/L as moderately hard; 121 to 180 mg/L as hard; and greater than 180 mg/L as very hard. In the study areas, hardness in well water ranged from 21 to 1730 mg/L in well water samples (Fig. 6). Only one well in Anuradhapura district had soft water (21 mg/L), one had hard water (165 mg/L), and the rest were very hard. The mean hardness levels in the study area 471 mg/L. After the filtering through the developed laterite soil-based household water filter, the mean removal efficiency of hardness is 89.7%.





**Fig. 4** Water samples collected places in the Anuradhapura district

**Table 3.** Average water quality parameters in selected water samples

| Parameter                    | Mean Value (mg/L) |
|------------------------------|-------------------|
| Total Hardness               | 471               |
| Ca                           | 122               |
| Mg                           | 40                |
| Total P                      | 0.08              |
| NO <sub>3</sub> <sup>-</sup> | 0.59              |
| F <sup>-</sup>               | 2.3               |
| Cr                           | <0.05             |
| Cd                           | <0.01             |
| Pb                           | <0.05             |

Ca and Mg concentrations in water are 100 mg/L and 30 mg/L, respectively, as per WHO and SLS regulations. Ca levels in well water samples from Anuradhapura district ranged from 5 to 429 mg/L (Fig. 7), while Mg levels ranged from 2 to 160 mg/L (Fig. 8). Out of the all collected well water samples, 51.43 percent well water samples contain high

calcium amounts and 48.57% well water samples contain more magnesium. The mean Ca levels of the study areas is 122 mg/L, and the mean Mg levels in the study areas is 40 mg/L. After the filtration process, the mean removal efficiency of Ca is 89.32% and the mean removal efficiency of Mg is 86.67%.

**Table 4.** Average removal efficiencies in selected water samples

| Parameters                   | Removal Efficiency (%) |
|------------------------------|------------------------|
| Total Hardness               | 89.7                   |
| Ca                           | 89.32                  |
| Mg                           | 86.87                  |
| Total P                      | 100                    |
| NO <sub>3</sub> <sup>-</sup> | 92.6                   |
| F <sup>-</sup>               | 81.6                   |

Anuradhapura district has a mean total phosphorus content of 0.08 mg/L and range was <0.02-0.83mg/L (Fig. 9). After the filtration process, the mean removal efficiency of phosphorus is 92.46%.

According to the Sri Lankan Standard Institute guidelines, nitrate levels in drinking water in Sri Lanka must be less than 50 mg/L. In Anuradhapura district, nitrate concentrations in well water ranged from <0.05 to 6.5 mg/L (Fig. 10). The mean nitrate levels reported was 0.59 mg/L in Anuradhapura district. After the filtration the value of the water samples that exactly meets the Sri Lankan standards. The mean removal efficiency of nitrate is 92.6%.

The WHO recommended that, fluoride levels in consumption water be not as much of 1.5 mg/L, and Sri Lankan standard for fluoride in intake water is less than 1.0 mg/L. Fluoride levels in well water in Anuradhapura district varied from 1.8 to 4.0 mg/L (Fig. 11). The mean fluoride levels reported from study area was 2.3 mg/L. After the filtration through the laterite based water filter, fluoride removal efficiency was 81.6%.

Cr, Cd, and Pb concentrations in well water samples did not go beyond the Sri Lankan standard by 0.01, 0.003, or 0.01 mg/L, respectively.

From 2010 to 2014, Herath et al. (2017) collected water samples from wells in all districts of Sri Lanka. According to the data, the uppermost hardness value in Anuradhapura is 1,373 mg/L, with a mean of 283 mg/L. The Anuradhapura district had the highest fluoride concentration, 7.0 mg/L. Anuradhapura's fluoride concentration surpassed the national average of 1.0 mg/L. Fluoride levels in Anuradhapura groundwater range from 0.4 mg/L to 1.8 mg/L (Gamage et al., 2021). According to Cooray et al. (2019) fluoride concentrations in Anuradhapura range beginning from 0.2 mg/L to 6.0 mg/L.



Fig. 5 Laterite soil-based household water purification cylinder (Outside view and inside view)

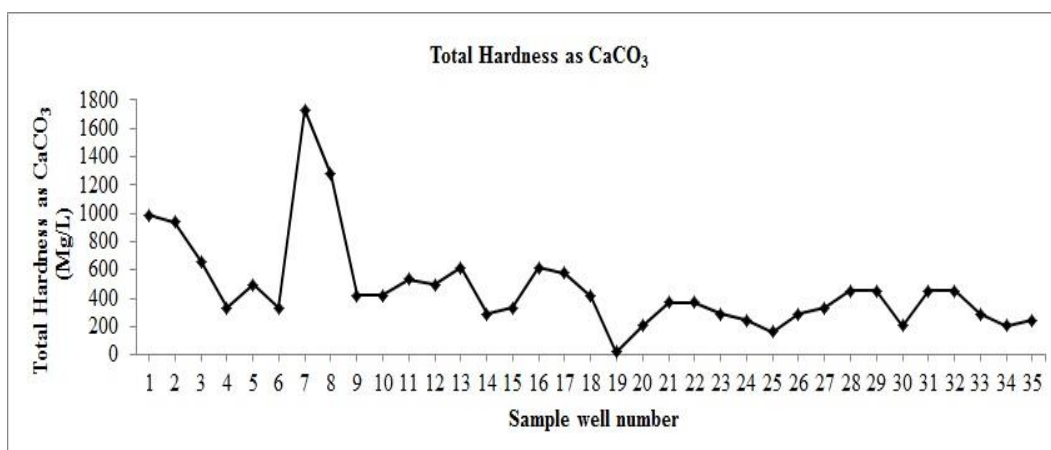


Fig. 6 Total hardness distribution pattern in selected water samples

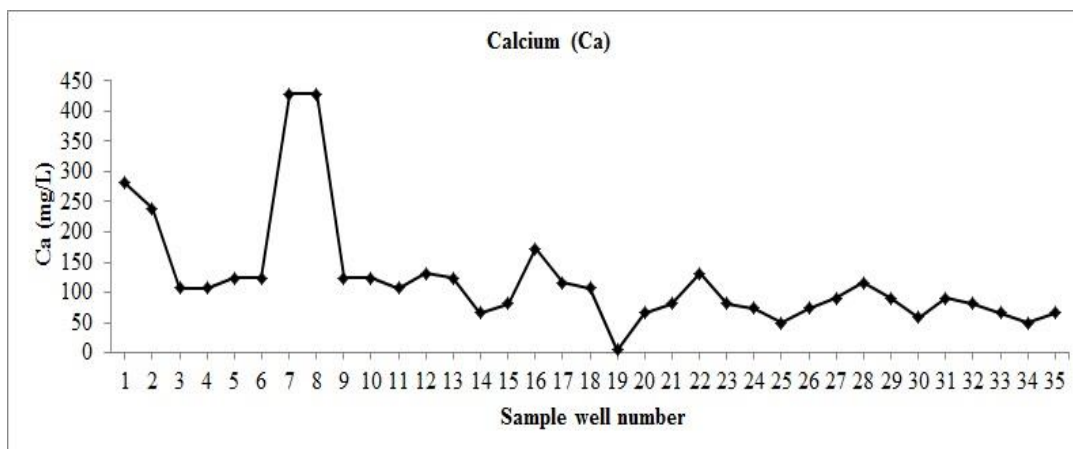


Fig. 7 Calcium distribution pattern in selected water samples

According to Gomoro et al. (2012), thermally treated lateritic soils have a great fluoride elimination by adsorption. According to Iriel et al. (2018), lateritic soils can be used to get rid of fluoride from consumption water on a domestic scale even when other ions like  $\text{Cl}^-$ ,  $\text{SO}_4^{2-}$ , and  $\text{NO}_3^-$  are present. According to Sarkar et al. (2006), laterite as an adsorbent for fluoride elimination is inexpensive, and as a

result, it can be considered a viable alternative to defluoridation. Laterite soil has a higher phosphate removal efficiency, according to Zhang et al. (2014) and Dissanayake et al. (2021). As an end result, laterite soil is a better soil type for getting rid of anions and cations from groundwater for the reason that it is a good adsorbent and adsorption is cost-effective and simple.

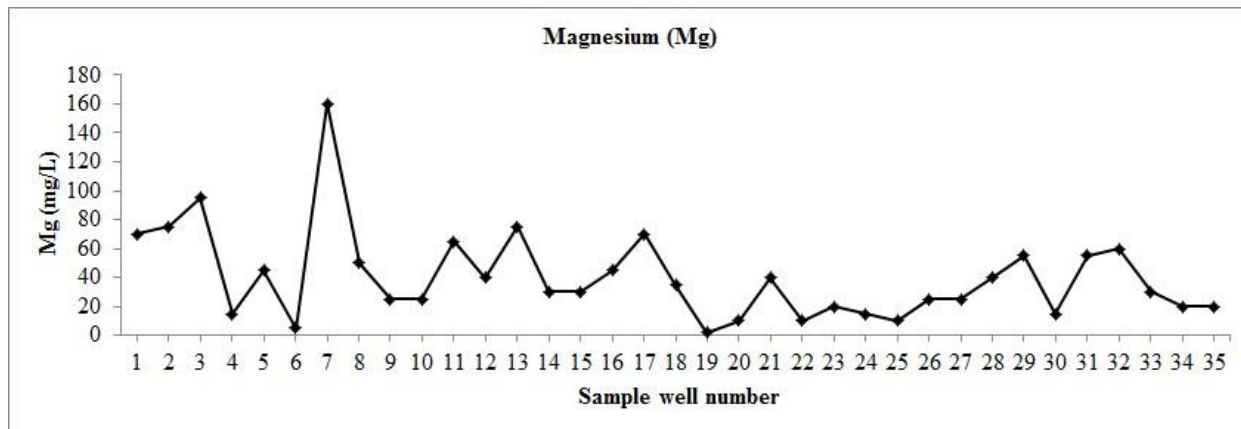


Fig. 8 Magnesium distribution pattern in selected water samples

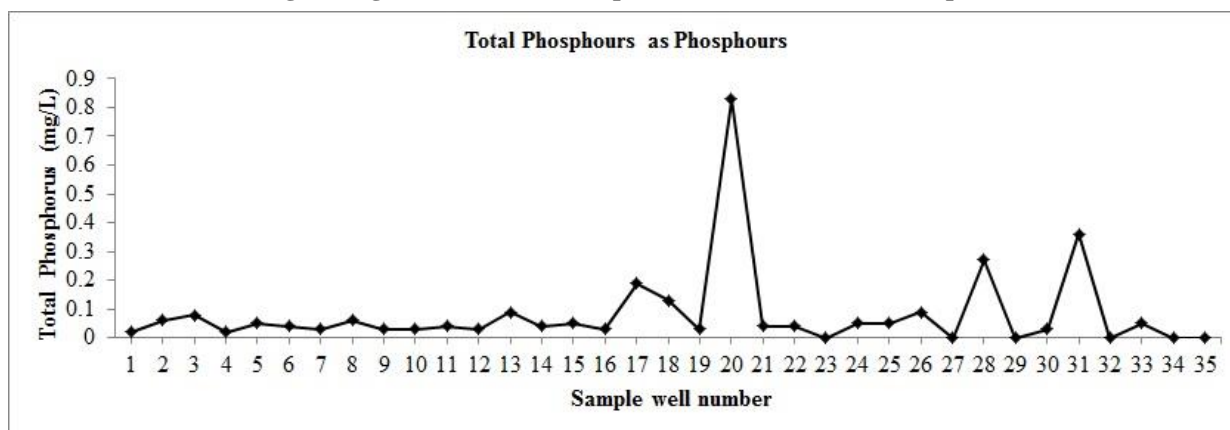


Fig. 9 Phosphorus pattern in selected water samples

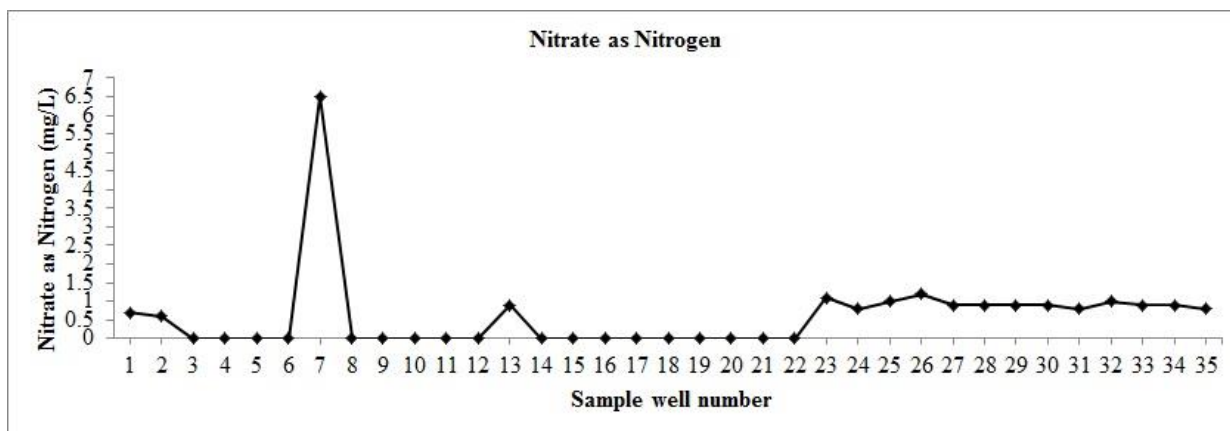


Fig. 10 Nitrate distribution pattern in selected water samples

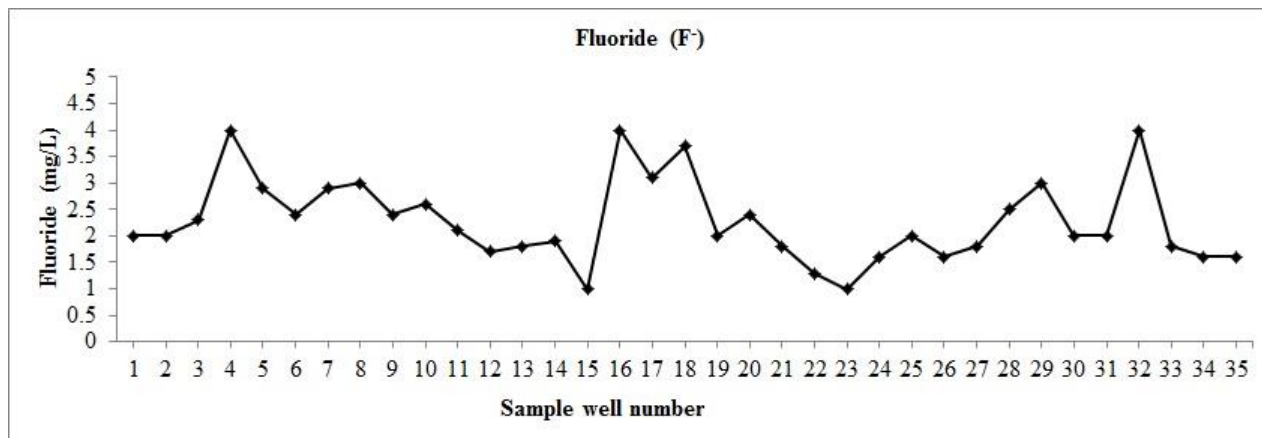


Fig. 11 Fluoride distribution pattern in selected water samples

Drinking water contamination should be reduced, and it is clear that, Sri Lankan well waters specially, Anuradhapura district like dry zone area have need of treatment for drinking purposes. The laterite soil based water filter showed a tremendous performance in terms of the removal of high hardness, Ca, Mg, P, and  $\text{NO}_3^-$  and  $\text{F}^-$  in all cases.

### Conclusion

The results revealed that the water is unfit for ingestion or domestic usage. The average hardness was 471 mg/L, with a range of (21-1730) mg/L. Ca and Mg intensities in Anuradhapura district were also found to be high, with an average of 122 mg/L and a range of (5-429) mg/L and 40 mg/L (2-160) mg/L, correspondingly. The concentrations of phosphate ranged from 0.02 to 0.83 mg/L, with an average of 0.08 mg/L. Nitrate concentrations ranged from (0.05-6.5) mg/L to 0.59 mg/L on average. Fluoride concentrations ranged from (1.8-4.0) mg/L and were on average 2.3 mg/L. Heavy metal concentrations below the allowable limit, such as chromium, cadmium, and lead, had no discernible effect. Hardness, Ca, and Mg are abundant in groundwater, particularly in the dry zone, according to the study. The value of the filtered water samples that exactly meets Sri Lankan standards. Hardness removal rates averaged 89.7 percent, Ca removal rates averaged 89.32 percent, P removal rates averaged 100 percent,  $\text{NO}_3^-$  removal rates averaged 92.6 percent, and fluoride removal efficiency was 81.6%. According to the findings, Sri Lankan dry zone well water specially Anuradhapura district must be treated before it can be consumed. The laterite soil-based water filter performed well in terms of removing high hardness, Ca, Mg, P, and  $\text{NO}_3^-$  and  $\text{F}^-$ .

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### Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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