ASSESSMENT AND MAPPING OF GROUNDWATER QUALITY FOR DRINKING PURPOSES: A CASE STUDY ON VALLIPURAM COASTAL AREA, JAFFNA PENINSULA, SRI LANKA

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The people of the Jaffna Peninsula completely rely on groundwater for all of their water requirements. The Vallipuram water supply scheme has been started by National Water Supply & Drainage Board (NWS&DB) with the construction of four groundwater wells in the Vadamarachchi sand dune aquifer. However, due to the over-extraction of groundwater from these wells, there could be a severe groundwater imbalance in the area, where aquifers are depleting and the water table is lowering. Therefore, the present study was designed to identify the availability and quality of the well water surrounding a 1.5 km radius from the four NWS&DB dug wells, and 120 domestic wells were selected for the study. This study aims at the assessment and mapping of groundwater quality parameters and assessing the Water Quality Index (WQI) to determine the potability of groundwater. Sample collection and water quality analyses were conducted according to using standard procedures. The coordinates of each sampling location were established using Global Navigation Satellite System (GNSS) RTK Receivers at the site and an interpolation technique was used to analyze the spatial patterns of drinking water quality parameters in the case study area. The Weighted Arithmetic Water Quality Index method was used to find the suitability of water for drinking purposes. The test results revealed that turbidity, colour, TDS, total hardness, total alkalinity, Chloride, Fluoride, Total Iron, Calcium, and Sulphate concentrations exceeded the Sri Lankan drinking water quality standards values. Further, pH, nitrate, nitrite, and total phosphates are within the Sri Lankan Standards for all 120 wells. Heavy metals such as Arsenic and cadmium were not detected in any of the samples but lead contamination was detected in six samples. The microbiological results indicate that the entire study area was contaminated with total coliform and *E.coli* bacteria. According to the physical and chemical parameters, the WQI value varies from 4.5 to 287.2 and 72 wells are suitable for drinking purposes. When microbiological parameters were incorporated, a mere 3 wells were deemed suitable for drinking purposes. Therefore, it is highly recommended to conduct regular chlorination or disinfection of the wells.

Keywords: Groundwater, Jaffna peninsula, Water quality, Water quality index

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Introduction

The people of the Jaffna Peninsula completely rely on groundwater resources for all of their water requirements. The Vadamarachchi aquifer is a sand dune aquifer that is distributed in coastal areas of the northeast side of the peninsula, located between the coastlines and the north shore of Vadamarachchi Lagoon (Suntharalingam et al., 2021). In the Jaffna Region, there are 18 Water Supply Schemes (WSS) functioning under the National Water Supply and Drainage Board (NWS&DB). Accordingly, Point Pedro Water Supply Scheme (WSS) has been started with the construction of four supply wells as a water source in Vallipuram areas. The excessive extraction of groundwater from these four wells in Vallipuram area using high-capacity pumps for prolonged periods has caused a reduction in groundwater elevations (Kapilan et al., 2015). It was revealed that the extraction of groundwater from these four wells, causing severe groundwater imbalance in the area's aquifers and lowering the water table, may result in saltwater intrusion in groundwater and decline the freshwater layer. Therefore, the National Water Supply and Drainage Board decided to analyze the water quality of the domestic wells and give recommendations on whether this water can be used for human consumption. The domestic wells in this study area were particularly selected as no such studies were made previously to assess the quality of drinking water in this region. This study was conducted to assess and map the distribution of drinking water quality parameters in the Vallipuram region of northern Sri Lanka and to determine the suitability of the water for drinking purposes.

Materials and Methodology

The study area was the Vallipuram coastal area. It is a village in Vadamarachchi, close to Point Pedro in the Northern Province of Sri Lanka, and domestic wells that are situated within a 1.5 km radius from the four NWS&DB dug wells in the Vadamarachchi sand dune aquifer were selected for the study. Water samples were collected randomly from 120 domestic wells from October to November 2022 (the Second Inter-monsoon) which is the driest period in the northern region of Jaffna. Stainless steel round vertical standard water sampler was used to collect samples from the middle of each well. All water samples were collected, preserved, and transported to the laboratory according to the American Public Health Association (APHA) guidelines.

All the samples were analysed for colour, turbidity, EC, pH, TDS, nitrates, nitrite, total Iron, total hardness, total alkalinity, Chloride, Fluoride, total Iron, total alkalinity, total hardness, Calcium, Sulphate, Total coliform, E.coli*,* Cadmium, Arsenic, and lead analyses. All testing procedures were based on Sri Lankan standards SLS 614:2013 and APHA guidelines. The coordinates of each sampling location were established using Global Navigation Satellite System (GNSS) RTK Receivers at the site. The coordinates were analyzed using ArcGIS 10.8 package and Microsoft Excel. An interpolation technique (Inverse Distance Weighted - IDW) was used to analyze the spatial patterns of drinking water quality parameters in the case study area. Weighted Arithmetic Water Quality Index Method was used to find the suitability of physical, chemical, and biological parameters of drinking water, and Metal Index was used to find the suitability of heavy metals in drinking water.

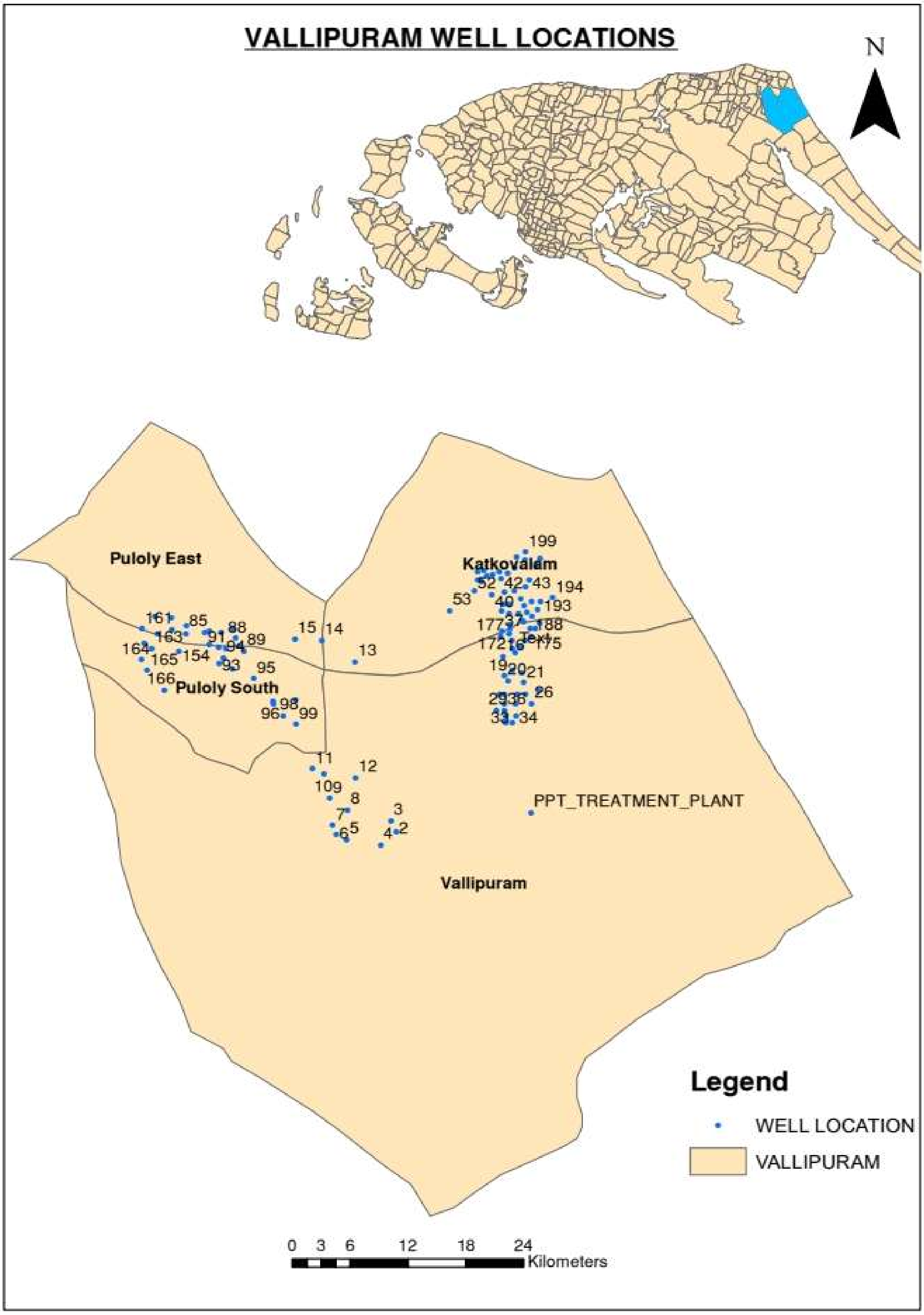

Figure 1: Ground water sampling locations in the study area

Results and Discussion

Physical, chemical, and microbiological parameters and heavy metal contamination.

pH is a key parameter in evaluating the acid–base balance of water. SLS recommended permissible limits of pH from 6.5 to 8.5 for drinking purposes. All well water samples were within the acceptable pH values for drinking. The colour and turbidity of drinking water are aesthetically unacceptable, which makes the water look unappetizing. During the analysis of groundwater, Turbidity (30.8%) and Colour (18.3%) are above the SLS 614:2013. Water with a high total dissolved solid (TDS) can cause a mineral-like taste in drinking water. High TDS values increase the electrical conductivity (EC) of the water and are not acceptable for drinking purposes, and Jeevaratnam et al., (2018) recorded similar information. Chloride is not considered a health risk but a higher chloride level increases the TDS thereby increasing the EC of water. According to the groundwater distribution map, the highest TDS values and chloride concentrations were recorded in Puloly East Grama Niladhari Division compared to the other Grama Niladhari Division. Because those areas are near the coastal region, and the depth of the wells is relatively high. Furthermore, the samples are taken during the driest period. It causes fresh water evaporates and saltwater intrusion in the fresh water layer and Ehanathan et al., (2020) recorded similar information. High levels of sulphate can give water a bitter taste and can have laxative effects. Groundwater near the coastal areas was having a high sulphate content due to the seawater intrusion. Some of the domestic wells exceed the permissible limit because of their high well depth and nearby sea areas.

Nitrates can reach groundwater as a consequence of agricultural activity. In the study area, there are sand dunes as well as coastal areas and less agricultural activities. Therefore, the nitrate contamination level is very low. All well water samples were within the acceptable nitrate and nitrite range for drinking. Fluoride intake plays a beneficial role in dental health and the optimal drinking water concentration of fluoride for dental health is generally between 0.5 to 1.0 mg/L. Iron can give water an unpleasant taste, odour, and colour. It is not hazardous to health, but it is considered an aesthetic contaminant and similar results were recorded by Kapilan et al., (2015). The alkalinity of the drinking water is too high. This could give the water a salty taste. All the wells were showing an increasing trend of alkalinity. The alkalinity and hardness of the Puloly Grama Niladhari division were comparatively higher than other Grama Niladhari divisions. The flavour of water can be changed by an overabundance of calcium. The results show that the Calcium of the groundwater was in a range of 26-360mg/L and 54.2% of the samples are below 100mg/L.

Table 01: Chemical parameters of groundwater samples

Parameters	Range	SLS 614: 2013 Permissible level	Unit	Percentage complying with SLS
Electrical Conductivity	394 - 8120	-	μScm^{-1}	-
Total Dissolved Solids	252 - 5197	500	mg/L	31.7%
Total Iron	0.00 -1.32	0.3	mg/L	92.5%
Nitrate (as NO_3^-)	0.00 - 12.40	50	mg/L	100%
Nitrite (as NO_2^{-})	0.000 - 0.032	3	mg/L	100%
Fluoride (as F^-)	0.00 - 2.70	1	mg/L	85.8%
Total phosphate (as PO_4^{3-})	0.00 - 1.46	2	mg/L	100%
Sulphate (as SO_4^{2-})	20 - 2750	250	mg/L	57.5%
Total Hardness (as $CaCO_3$)	150 - 2362	250	mg/L	36.7%
Total Alkalinity (as $CaCO_3$)	136 - 562	200	mg/L	26%
Chloride (as Cl)	20 - 2877	250	mg/L	72.5%
Calcium (as Ca)	32 - 360	100	mg/L	54.2%

Electrical conductivity, Total Dissolved Solids, Total iron, Nitrate, Nitrite, Fluoride, Total phosphate, Sulphate, Total hardness, Total alkalinity, Chloride, and Calcium variation of groundwater are summarized in Table No 01.

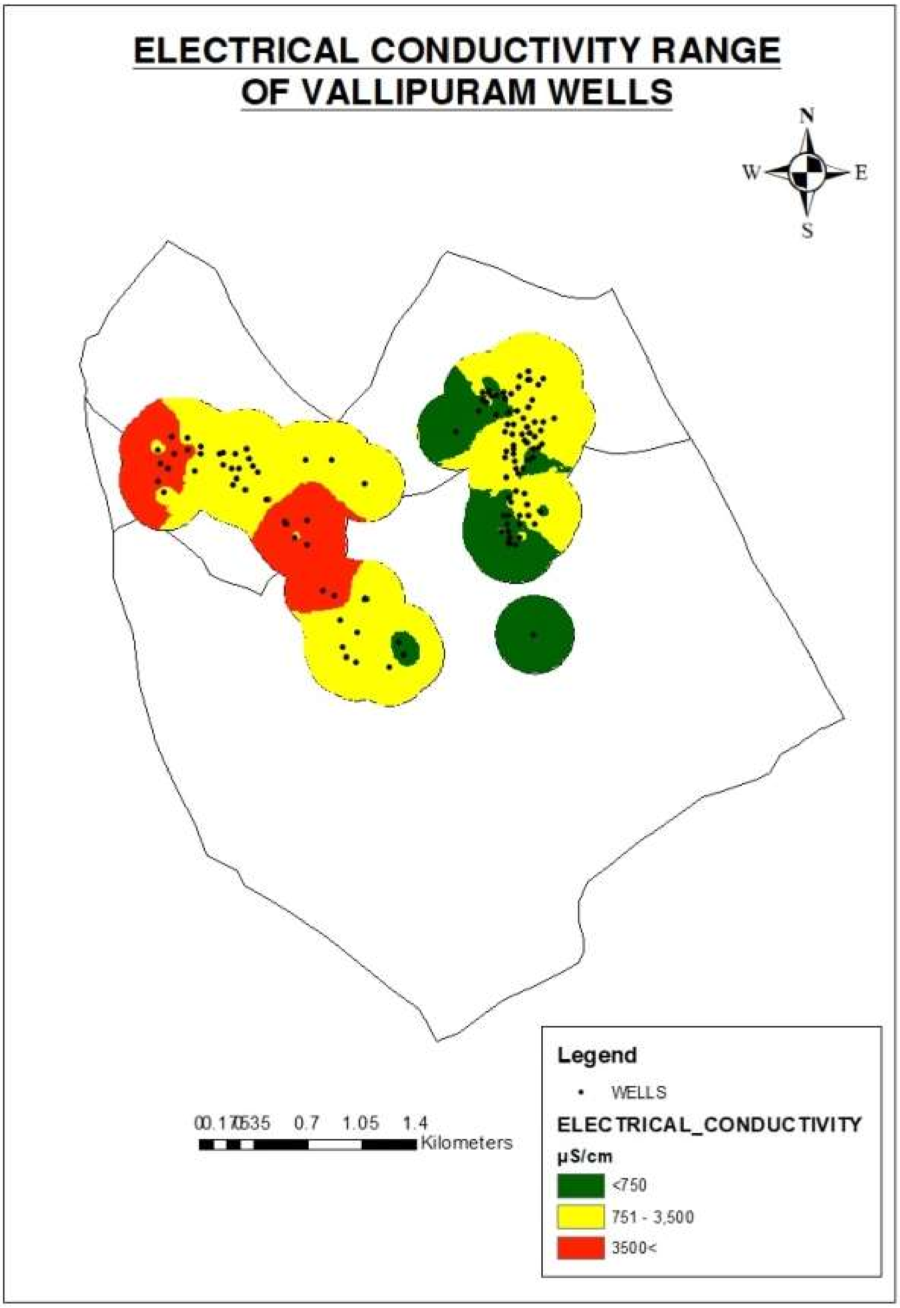

Figure 2: Spatial of Electrical Conductivity distribution

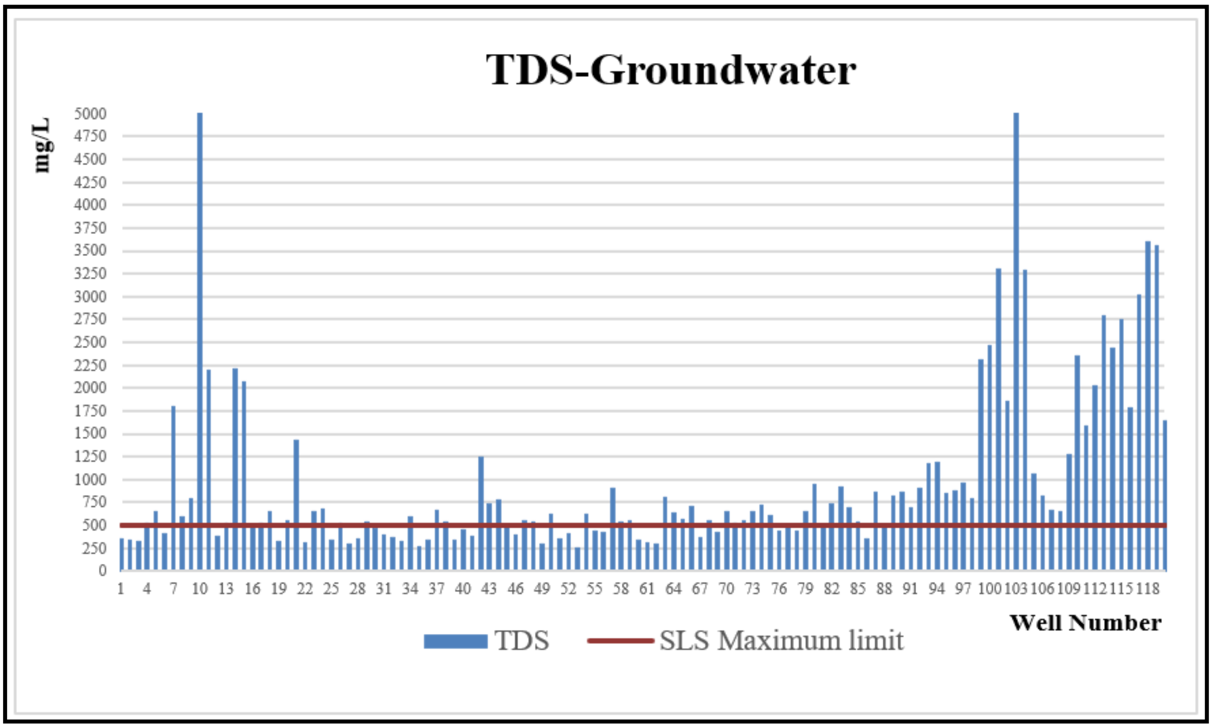

Figure 3: Variation of TDS of Groundwater

Total coliform and *E.coli* contaminations were not within the Sri Lankan Standards for drinking water (SLS 614:2013). The primary issue is the excess fecal coliform seen in well water. It was observed that the appropriate distance between the septic tank and the groundwater source was not maintained and similar results were recorded by Mahagamage et al., (2019).

All the water samples have not contained cadmium and arsenic at detectable levels. Out of 120 wells, only 6 wells were detected for lead above the SLS limit.

Water Quality Index (WQI) and Metal Index (MI)

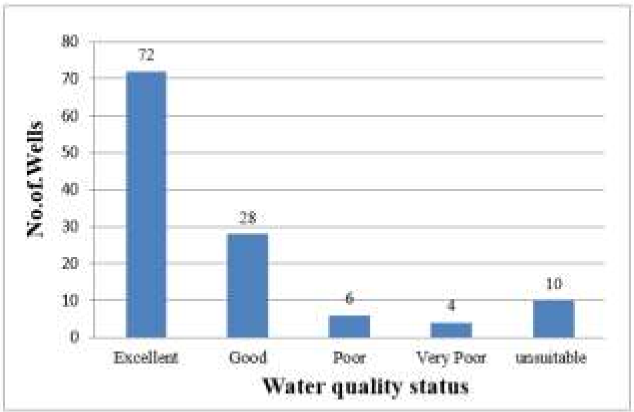

Figure 4: WQI Range of Physical and chemical parameters.

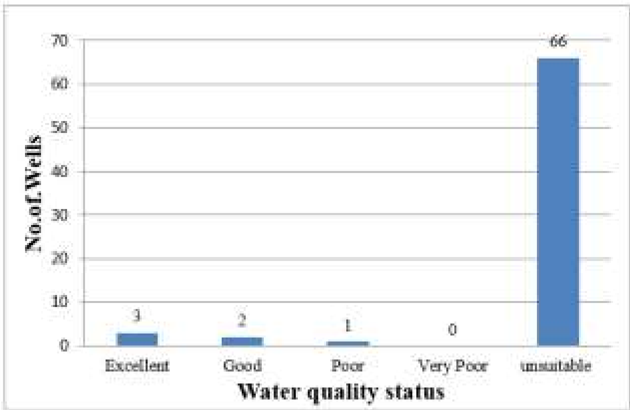

Figure 5: WQI Range of Physical, chemical and microbiological parameters

According to the Water Quality Index by considering physical and chemical quality, there were seventy-two (72) domestic wells showed excellent water quality and ten (10) wells were unsuitable for drinking purposes. When microbiological parameters were incorporated, a mere 3 wells were deemed suitable for consumption. The excess Total coliform and *E.coli* found in the well water is the main factor reducing its quality. It was found that recommended level distance was not maintained between the septic tank and the wells. Metal Index (MI) results showed that heavy metal pollution was very low. This could be due to the fact that there are not many industrial activities in the study area.

Conclusion

When considering the quality of groundwater in the Vallipuram study area, the physical parameters such as turbidity (30.8%) and colour (18.3%) are above the SLS standard. Regarding chemical quality: TDS (68.3%), Total hardness (63.3%), Total Alkalinity (75%), Chloride (27.5), Fluoride (15%), and Total iron (8.3%), Calcium (45.8%) and Sulphate (42.5%) were above the Sri Lankan Standards (SLS) limit. On the other hand pH, Nitrate, Nitrite, and Total phosphates are within the Sri Lankan Standards (SLS) limit. The results indicate that the entire study area was contaminated with total coliform and *E.coli*. All the water samples collected from domestic drinking water systems have not contained heavy metals at detectable levels. According to the Physical and chemical water quality index, seventy-two 72 domestic wells are suitable for drinking purposes. When microbiological parameters were incorporated, a mere 3 wells were deemed suitable for suitable for drinking purposes.

Recommendation

It is recommended to introduce well cleaning and disinfection using chlorine regularly before consume. Furthermore, for regular usage the water should be boiled and a suitable filtration mechanism should be used for drinking purposes, improve the well structures and implementation of sealed type septic tanks; educate villages to raise awareness regarding proper household water treatment *viz;* boiling and storage. And it is recommended to construct a rainwater recharging pond to improve the chemical quality of the groundwater. The dry period of the year was used for sampling. Therefore, it is advised to conduct ongoing monitoring to discover the seasonal variations of groundwater quality.

Acknowledgment

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