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Geogenic Pollution of Groundwater Quality in Gampaha District, Sri Lanka: A Case Study of Groundwater Acidification from Rathupaswala

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Abstract

Over recent decades, Gampaha district, Sri Lanka, has experienced significant urbanisation and industrial growth, increasing groundwater demand due to limited and polluted surface water resources. In 2013, a community uprising in Rathupaswala, a village in Gampaha district, accused a latex glove manufacturing factory of causing groundwater acidity ($pH < 4$). This study evaluates the spatial and temporal changes in geochemical parameters across three transects in the southern part of Gampaha district to 1) assess the impact of geological formations on groundwater; 2) compare temporal variations in groundwater; and 3) explain acidification via a geochemical model. Seventy-two sample locations were tested for pH, electrical conductivity (EC), and anion concentrations (sulphate, nitrate, chloride and fluoride). Depth to the water table and distance from the sea were measured to study variations across sandy, peaty, lateritic, and crystalline aquifers. Results showed pH readings around 7 for sandy and crystalline aquifers, below 7 for peaty aquifers, and below 5 for lateritic aquifers, with significant water table fluctuations near Rathupaswala area. Principal component analysis revealed three principal components (PCs) explaining 86.0% of the variance. PC1 (40.6%) correlated with pH, EC, and sulphate (saltwater intrusion), while PC2 (32.0%) correlated with nitrates and depth to the water table (anthropogenic nutrient pollution). A geochemical transport model indicated a cone of depression recharged by acidic groundwater from peat-soil aquifers, leading to acidic groundwater in Rathupaswala area. Previous attributions of acidic pH to the over-exploitation of groundwater by the latex factory have been reevaluated; the results suggest natural acidification from prolonged water-rock interactions with iron-rich lateritic aquifers. Groundwater pH is influenced by local climate, geology, topography, and drainage systems. It is recommended that similar water-rock interaction conditions may be present throughout the wet zone of Sri Lanka, warranting detailed studies to confirm this hypothesis.

Keywords

Groundwater Acidification, Acid Sulphate Soils (AAS), Ion Chromatography, Groundwater Quality

1. Introduction

Contamination of groundwater is a matter of serious concern in many parts of the world, particularly in South Asia including Sri Lanka [1]. Coastal sand aquifers, lateritic aquifers, and hard-rock aquifers are particularly vulnerable to quality issues that can adversely impact human health [2]. Access to safe drinking water is a fundamental human right and prolonged use of contaminated water can lead to severe health issues, with 80% of health risks linked to impure drinking water [3].

Numerous global studies have investigated the factors contributing to groundwater acidification, which can arise from both natural and anthropogenic sources. Natural causes include acid sulphate soils, geological weathering (such as lateritic soils and aquifers), climate influences, and anthropogenic activities such as acid loading and urban development [4] [5]. Research highlights the role of acid sulphate soils containing pyrite, which decompose under aerobic conditions to form sulphuric acid. For instance, in Perth, Western Australia, urban development has exacerbated acidity through the oxidation of sulphide minerals in peat soils. Extended periods of low rainfall increase the depth to the water table, while activities such as dewatering and excavation for suburban development further disturb sulphide peaty soils [4]. Similarly, in Denmark, groundwater acidification has been linked to pyrite oxidation triggered by carbonate dissolution in coastal sand aquifers [6]. Research in Gnangara Mound, Western Australia, has identified pyrite oxidation as a primary driver of groundwater acidification [7]. Tropical lateritic aquifers naturally contain acidic groundwater. Tropical laterite is composed of iron oxides, aluminium oxides, and silicon dioxides. Soils rich in alumina (Al_2O_3) and hematite (Fe_2O_3) can release hydrogen ions (H^+) into the soil and ultimately end up in groundwater in contact [8]. Research on the weathering processes, utilising the mineralogy and geochemistry of laterite and podsol gneiss in the upper Amazon basin, indicates that the water in the laterite soil of this region exhibits redox reactions and acidic conditions. Climate factors, such as their impact on groundwater redox processes, can contribute to the acidity of the soil solution [9]. Two studies conducted in parts of the Mamfe Basin, Cameroon, and the southern parts of the Abidjan district, West Africa, determined that groundwater ionic content was influenced by ion exchange resulting from prolonged rock-water interaction, which led to alterations in groundwater acidity [10] [11].

In July 2013, residents of Rathupaswala village (7.0466389˚N, 80.0299167˚E), Gampaha District, Sri Lanka, reported that their drinking water was contaminated with acidic effluents. Acidity in groundwater samples collected near the former latex glove manufacturing factory in Nedungamuwa was below pH 4, suggesting extreme acidity for drinking standards. Despite efforts, the scientific cause of this increased acidity remains unidentified. The latex factory, operating since 1997, was suspected of contributing to this issue [12] [13].

This paper aims to highlight the effects of groundwater disruptions, identify potential causes of groundwater acidification around the former latex factory, and discuss potential health risks in the Gampaha district, Sri Lanka. This study's findings provide a reference for improving and conserving groundwater resources in the western province of Sri Lanka and similar regions worldwide.

2. Study Area

Gampaha district is situated in the western province of Sri Lanka, covering an area of 1387 km^2 (**Figure 1**). It lies within the wet climate zone of the country. Southwest and Northeast monsoon winds are the main rainfall patterns in Sri Lanka. Gampaha district is obtaining uniform rainfall throughout the year from both monsoonal and conventional wind patterns. Most of the Gampaha district is receiving an annual rainfall between 2000 mm and 3500 mm. The drainage network is predominantly maintained by three major rivers: Maha Oya in the upper boundary, Attanagalu Oya in the middle, and the Kelani River in the lower boundary (**Figure 1**). Gampaha district is part of Sri Lanka's first peneplain, ranging from 0 m to 300 m in elevation. The western region exhibits a flat, undulating morphology, whereas the eastern boundary features a steep, rocky mountain series [14].

The soil types in the study area are diverse, including red-yellow podzolic soil (lateritic soil), latosols and regosols (red and yellow sandy soil), alluvial soil (clayey soil), and regosols (sandy soil). The geologic formation of the area belongs to the Wanni complex, predominantly underlain by Precambrian rocks. These lithologies include hornblende and hornblende-biotite gneiss, charnockitic gneiss (composed of hypersthene, diopside, biotite, hornblende, and garnet as major mineral assemblages), granitoids and granitic gneiss, quartz (in thin bands), cordierite-sillimanite garnet biotite gneiss, and laterite—*Cabook*. Laterites/*Cabook* predominantly occur in the wet zone where water table fluctuations are significant. The thickness, age, and composition of the lateritic cap vary across Gampaha district. Well-developed laterites form a belt extending 9 to 10 km inland from the coastal zone, reaching elevations up to 30 meters above mean sea level in the study area. Massive vesicular laterites are prominently exposed with thickness ranges from 5 to 25 meters [15].

Groundwater in Gampaha district is accessed through dug wells and boreholes, occurring in four major types of aquifers: coastal and sand aquifers (shallow unconfined), alluvial aquifers (shallow unconfined), laterite aquifers (vesicular semiconfined), and crystalline aquifers (regolith confined in the weathered rock zone). The western zone, closer to the sea, has a shallow groundwater table, while the eastern zone, characterised by elevated topography, exhibits a deeper groundwater table.

Land use in Gampaha district is varied and multifaceted. Agriculture plays a significant role in the district's economy, leading to the extensive use of agrochemicals to enhance soil permeability and increase crop yields. Gampaha district is also home to several major export processing and industrial zones. However, this industrial activity brings about considerable environmental challenges specifically to the groundwater system. These challenges include improper waste management, unplanned and leaky drainage systems, and the disposal of untreated sewage through septic tanks.

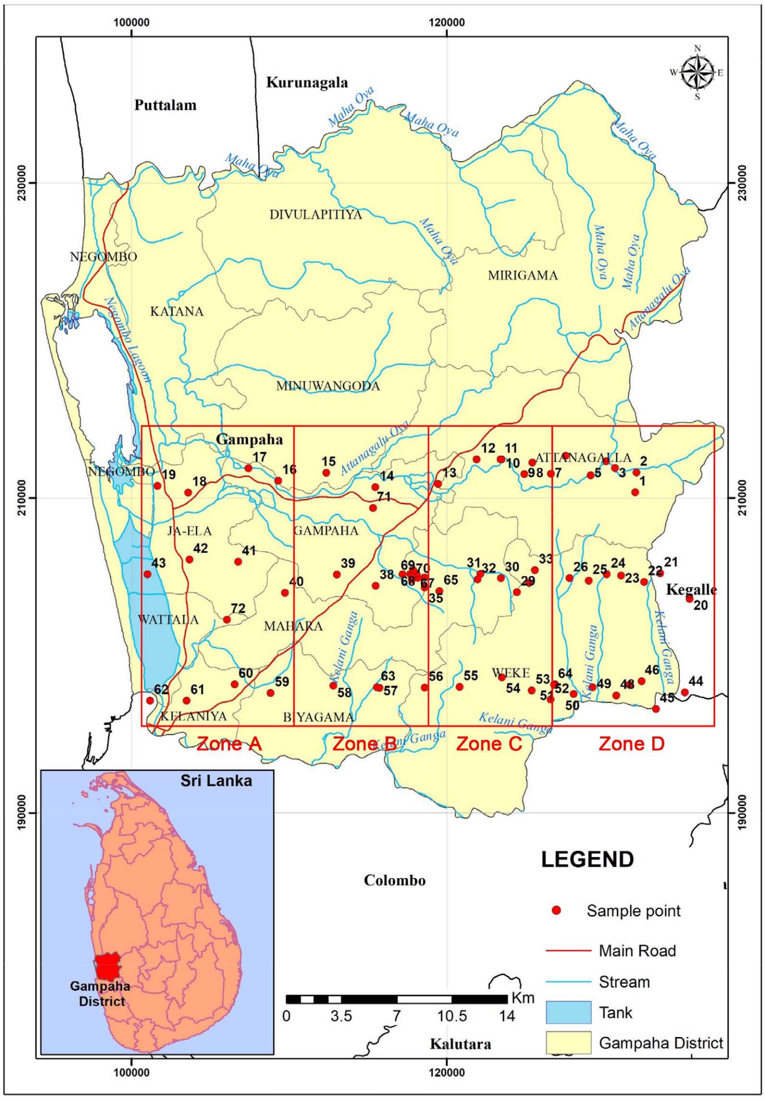


Figure 1. Map of Gampaha district, Sri Lanka, showing the sample points and zones. The map illustrates the locations of groundwater sampling sites used in the study, divided into distinct zones (A, B, C, and D).

3. Methodology

3.1. Sampling and Analysis

In August 2020, seventy-two water samples were collected from hand-dug wells in Gampaha District. The distribution of sample locations across the four zones is as follows: Zone A primarily consists of sandy aquifers with sandy soil as the predominant type, containing eight sample points. Zone B is characterised by lateritic aquifers and mostly lateritic soil, with eleven sample locations. Zone C marks the beginning of crystalline aquifers, moving inland, and is mainly composed of lateritic soil with clay, encompassing seventeen sample points. Zone D features aquifers of predominantly lateritic-crystalline origin, with clayey lateritic soil, and includes thirty-six sample locations (**Figure 1**).

These samples were gathered in 100 mL high-density linear polyethylene (HDPE) bottles, adhering strictly to the sampling protocol outlined by Classen (1982) for anion analysis [16]. To eliminate particulate matter, the samples were filtered using a syringe plunger and a Chrom Tech NYLON 0.22 µm syringe filter. Groundwater temperature and electrical conductivity of unfiltered samples were measured using a Thermo Scientific EUTECH con 450 conductivity meter. Water pH values were determined using a Hanna HI98103 Checker® portable pH meter. Additionally, parameters such as depth to the water table and soil type were recorded on-site.

The major anions, including nitrate (NO_3^-), sulphate (SO_4^{2-}), fluoride (F^-), and chloride (Cl^-), were analysed using Metrohm 930 Compact IC Flex Ion Chromatograph. For temporal comparisons, data from an initial study conducted in February 2015 [17], comprising sixty-two samples from the same study area, were obtained. This data included GPS locations of sample points, pH values, electrical conductivity (EC) values, the concentration of nitrate and sulphate ions, and the depth to the water table.

Secondary data relevant to the research, including pH values, EC values, and concentration of nitrate and sulphate ions were sourced from the Central Environmental Authority. These data pertained to the surrounding area of the formerly existing latex factory's industrial premises for the periods of July 2013 and October 2014.

Spatial variation maps of pH values, major anion concentrations in groundwater, EC, and depth to the water table were created using Inversely Distance Weighted (IDW) interpolation in Geographic Information Systems (GIS). Both primary and secondary data were analysed using GIS software (QGIS version 3.14.15). The application of GIS supports the classification of various combinations of soil type, weather, land, and water usage, enhancing the physical basis for recharge estimation in a more structured and systematic manner [18].

3.2. Statistical Analysis

Principal Component Analysis (PCA) is an essential statistical technique used to elucidate the variance among interrelated variables, thereby reducing the dimensionality of a data matrix [19] [20]. In this study, data on the depth to the water table and chemical parameters (pH, EC, nitrate, sulphate, chloride, and fluoride) from the Gampaha district were subjected to PCA using Minitab-19 software. PCA identified Principal Component 1 (PC1) with the largest eigenvalue, explaining the highest proportion of variance in the dataset. Subsequently, Principal Component 2 (PC2), which is uncorrelated with PC1, accounted for a smaller eigenvalue but contributed significantly to the remaining variance. PC loadings, derived from the multiplication of original correlated values, were utilised to assess the relative impact of chemical parameters on groundwater quality in Gampaha.

4. Results and Discussion

4.1. Hydrogeochemistry of Groundwater

Ensuring the quality of drinking water is crucial as it directly influences human health [21]. In Gampaha district, a significant proportion of residents depend on groundwater for their drinking water requirements, underscoring the critical importance of assessing groundwater quality. **Table 1** presents a summary of tested geochemical parameters. Except for pH, most parameters fell comfortably within the permissible limits set by the WHO and SLS for drinking water [3]. In 2020, the mean pH in the study area was 5.13, with values ranging from 4.24 to 6.52. Notably, all groundwater samples collected during 2015 and 2020 in this region were acidic, highlighting the pervasive nature of extremely low pH conditions for drinking purposes. The electrical conductivity of the studied samples ranged between 0.07 mS/cm and 0.49 mS/cm (median: 0.27 mS/cm) suggesting moderate mineralisation in groundwater indicating typical levels of dissolved ions that can originate from various sources such as mineral weathering agricultural activities or natural geogenic processes. In both 2015 and 2020, nearly all groundwater samples were within the WHO permissible levels for drinking water in terms of electrical conductivity.

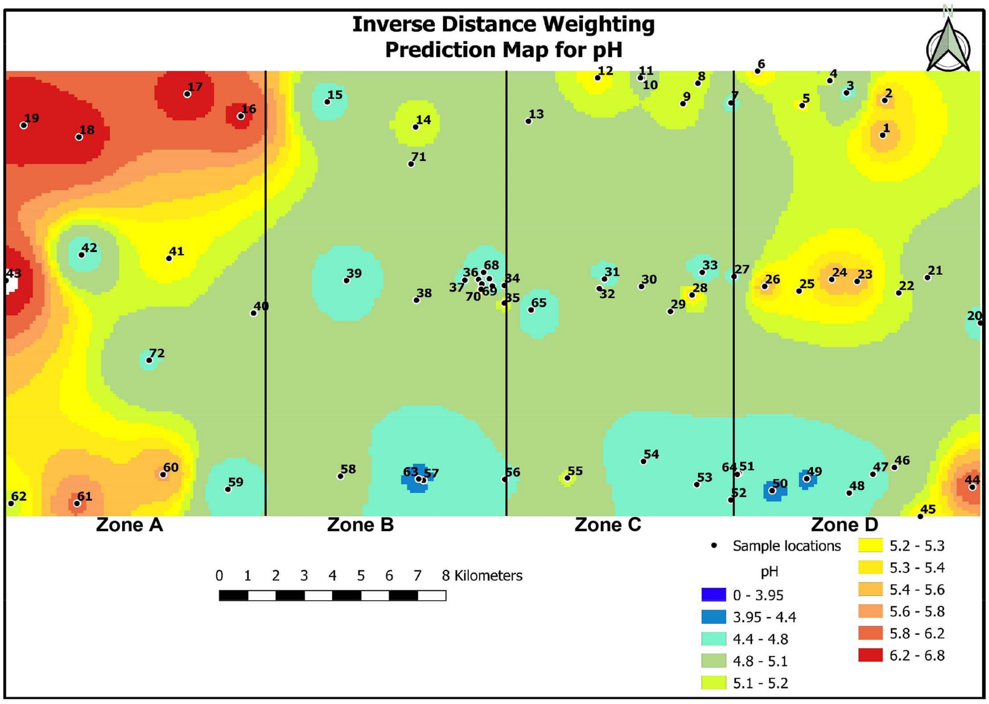
In 2020, the anion content of groundwater in the study region followed the order of chloride > nitrate > sulphate > fluoride. Among the major anionic constituents, chloride is particularly significant. Chloride concentrations in the studied samples ranged from 11.45 to 32.19 mg/L, with a mean of 16.37 mg/l, all of which were within the standard limits. Nitrate, another crucial water quality parameter, primarily originates from anthropogenic sources such as fertilizers. Remarkably low levels of nitrate-N were observed, indicating minimal contamination. The Main sources of nitrate in groundwater include the use of nitrogen fertilizers, leachates from septic tanks, and animal husbandry. However, the likelihood of deep groundwater contamination from these sources is considerably lower compared to surface water resources. The sulphate content in the water ranged from 1.0 to 19.46 mg/L and fluoride content exhibited extremely low values, with almost all samples falling within the lower limits of drinking water standards.

Table 1. Summary statistics of geochemical parameters determined in the Gampaha District, Sri Lanka (N1—Samples from 2015 [15] and 2020, N2—Samples from 2020, and N/A—Not analysed in 2015).

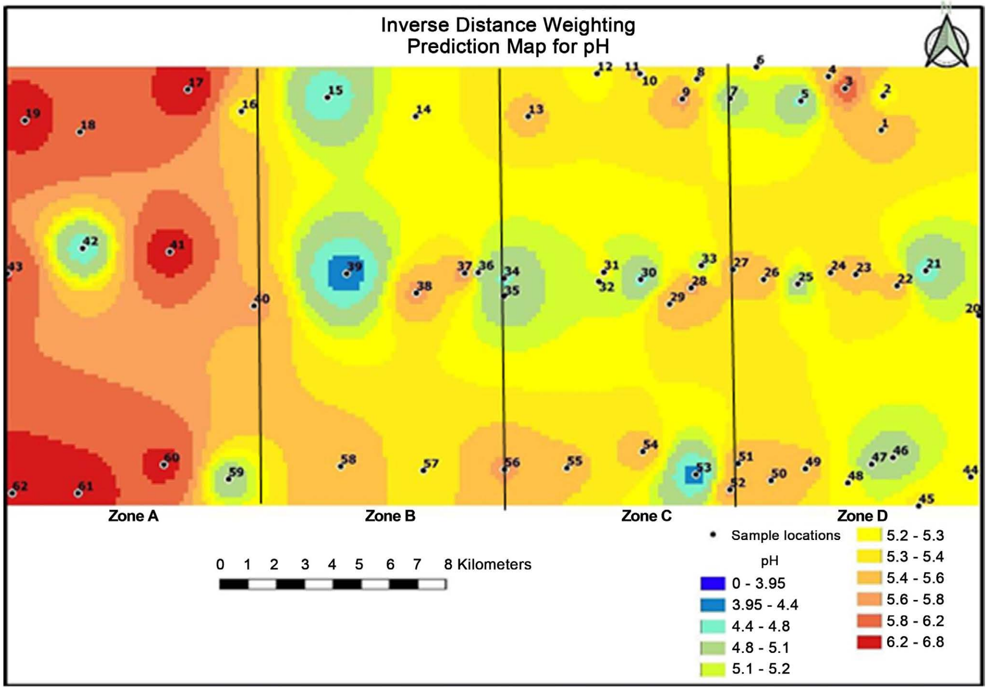
Observed parameters		pH	Depth to the water table (m)	EC (mS/cm)	Nitrate (mg/L)	Sulphate (mg/L)	Fluoride (mg/L)	Chloride (mg/L)
WHO Limits (2011)		6.50 - 8.50	-	1.00	45.00	250.00	0.6 - 1.50	200.00
SLS limits (2013)		6.50 - 8.50	-	0.75	50.00	250.00	0.6 - 1.00	250.00
Zone A (N_1 = 8, N_2 = 10)								
2015	Min - Max	4.61 - 6.69	1.15 - 5.45	0.5 - 2.64	0.56 - 8.38	1.89 - 59.50	N/A	N/A
	Mean	6.00	2.97	1.71	2.70	20.13	N/A	N/A
	SD	0.69	1.18	0.86	1.48	20.03	N/A	N/A
2020	Min - Max	4.73 - 6.52	0.40 - 4.25	0.23 - 0.49	<0.01 - 16.46	1.24 - 19.46	<0.01 - 0.07	12.08 - 27.6
	Mean	5.62	2.41	0.36	7.56	10.35	0.03	19.84
	SD	0.34	2.01	0.13	8.9	9.11	0.04	7.76
Zone B (N_1 = 10, N_2 = 11)								
2015	Min - Max	4.48 - 5.68	3.63 - 9.09	0.14 - 1.87	0.56 - 8.38	1.10 - 2.24	N/A	N/A
	Mean	5.19	6.53	0.66	2.72	1.58	N/A	N/A
	SD	0.62	1.60	0.55	2.32	0.53	N/A	N/A
2020	Min - Max	4.24 - 5.80	6.12 - 8.45	0.22 - 0.40	2.27 - 17.37	<0.01 - 3.10	0.01 - 0.09	11.45 - 32.19
	Mean	5.02	6.12	0.31	9.82	1.42	0.05	21.82
	SD	0.78	8.45	0.09	7.55	1.69	0.04	10.37
Zone C (N_1 = 15, N_2 = 22)								
2015	Min - Max	4.10 - 5.72	1.11 - 12.12	0.15 - 1.21	0.42 - 7.78	<0.01 - 2.37	N/A	N/A
	Mean	5.25	5.26	0.50	2.28	1.38	N/A	N/A
	SD	0.41	2.81	0.32	2.15	0.87	N/A	N/A
2020	Min - Max	4.51 - 5.23	2.74 - 7.49	0.07 - 0.41	2.56 - 11.68	<0.01 - 4.20	0.02 - 0.06	0.88 - 29.74
	Mean	4.87	5.11	0.24	7.12	1.56	0.04	15.31
	SD	0.36	2.37	0.17	4.56	2.65	0.02	14.43
Zone D (N_1 =8, N_2 =10)								
2015	Min - Max	4.61 - 6.11	1.21 - 9.09	0.18 - 0.53	0.57 - 5.48	<0.01 - 2.32	N/A	N/A
	Mean	5.30	3.45	0.31	2.02	1.43	N/A	N/A
	SD	0.34	2.08	0.10	1.28	1.11	N/A	N/A
2020	Min - Max	4.63 - 5.44	2.11 - 7.20	0.07 - 0.29	0.36 - 8.62	<0.01 - 2.93	0.00 - 0.10	0.21 - 16.83
	Mean	5.02	4.66	0.18	4.49	1.11	0.05	8.52
	SD	0.42	2.54	0.11	4.13	1.82	0.05	8.31

4.2. Acidity of Groundwater

The spatial distribution of pH in 2020 and 2015 [15] is depicted in **Figure 2(A)** and **Figure 2(B)** respectively. In 2020, the pH values of groundwater ranged from 4.15 to 6.95, indicating moderate to strong acidity in both periods. Within the acidic range, only 5.5% of the samples fell within the potable range as per the WHO recommendations. Zone A exhibited significantly higher pH values compared to other zones. Seawater is slightly alkaline due to its high salt concentration and the natural buffering capacity from carbonate and bicarbonate equilibria [22]. Zone A is characterised by sandy soil, whereas zones B, C, and D consist predominantly of lateritic soil. Most of the land area in Zones B, C, and D is underlain by the laterite/*Cabook* aquifer, which is formed from weathered bedrock such as sandstone, gneisses, granites, and migmatites. This weathered material contains acidic substances that dissolve into groundwater when it resides in the aquifer for extended periods, leading to increased acidity [23] [24]. Lateritic soil primarily comprises Al_2O_3, Fe_2O_3, SiO_2, and TiO_2 [15]. Groundwater interaction with various minerals results in diverse chemical compositions, which in turn influence the chemical parameters of the water. Increased soil acidity leads to the leaching of aluminium ions into streams and lakes, adversely affecting soil conditions for agriculture. Acidic groundwater also facilitates the leaching of metal ions, posing risks to dental health by weakening enamel and promoting cavities. Consuming acidic water has been associated with several other health issues such as nausea, vomiting, abdominal pain, internal organ damage, diarrhoea, etc. Children exposed to acidic water may exhibit behavioural disorders, growth delays, respiratory problems, and heart diseases [25].



(A)



(B)

Figure 2. Inverse distance weighted prediction maps for pH (A) 2020 and (B) 2015 [17].

4.3. Effect of the Latex Factory

The former latex glove manufacturing factory in Rathupaswala, established in 1995, was among the world's top five producers of non-surgical rubber gloves, accounting for 5% of global production. According to a Central Environmental Authority report (reference number 721/14/LS-727/14/LS), the factory utilised seven groundwater wells (one deep tube well and six shallow dug wells) on its premises, extracting nearly 60,000 Liters of water daily for manufacturing. This intensive groundwater exploitation caused a significant drop in the water table, creating a cone of depression that altered the natural percolation direction and led to the temporary drying of nearby dug wells. The overlapping cone of depression from multiple wells further resulted in 'well-interference'.

4.4. Principal Component Analysis (PCA)

The PCA for 2020 and 2015 [17] revealed three significant principal components (PCs) in both years, based on eigenvalues > 0.6. The analysis incorporated key chemical parameters (pH, nitrate, sulphate) and physical parameters (depth to the water table, EC).

In 2020 (Table 2), PCA explained 86.0% of the total variance in geochemical data. PC1 (40.6%) showed positive loadings for pH, EC, and sulphate, indicating saltwater intrusion. PC2 (32.0%) had positive loadings for nitrate and depth to the water table, suggesting nutrient pollution. PC3 (13.4%) highlighted groundwater over-exploitation and pH variations.

Table 2. Principal component loadings for 2020 eigenanalysis of the correlation matrix.

(a)

Eigenvalue	2.0301	1.6007	0.6689
Proportion	0.406	0.320	0.134
Cumulative	0.406	0.726	0.860

(b)

Variable	PC1	PC2	PC3
pH	0.429	−0.479	−0.477
EC (mS/cm)	0.515	0.387	−0.194
Nitrate (mg/L)	0.240	0.671	0.269
Sulfate (mg/L)	0.600	−0.006	−0.092
depth to water table (m)	−0.366	0.413	−0.809

Table 3. Principal component loadings for 2015 [17] eigenanalysis of the correlation Matrix.

(a)

Eigenvalue	2.1356	1.3083	0.7238
Proportion	0.427	0.262	0.145
Cumulative	0.427	0.689	0.834

(b)

Variable	PC1	PC2	PC3
pH	0.551	−0.098	−0.225
EC (mS/cm)	0.533	0.387	0.153
Nitrate (mg/L)	−0.019	0.792	0.374
Sulfate (mg/L)	0.540	0.041	−0.412
depth to water table (m)	−0.346	0.459	−0.785

In 2015 (**Table 3**) [17], PCA explained 83.4% of the total variance. PC1 (43.0%) had positive loadings for pH, EC, and sulphate, indicating seawater intrusion. PC2 (26.2%) showed a strong negative correlation for depth to the water table and a moderate negative correlation for sulphate.

Overall, PCA identified pH, EC, nitrate, sulphate, and depth to the water table as critical indicators of groundwater quality impairments, explaining over 70% of the total variance in both 2014 and 2020.

4.5. Geochemical Model to Explain the Acidification

Since 2013, the depth to the water table in the Rathupaswala area has exhibited unusual fluctuations. Between 2013 and 2015 [17], coinciding with the full operational capacity of the latex factory, there was a marked increase in the depth to the water table. following the cessation of the factory's operations, groundwater levels gradually normalised, with 2020 marking a return to typical levels. This normalisation has been confirmed through further observations. These long-term trends are attributed to the extensive groundwater extraction in the region. Seasonal variations in the water table depth depend on the discharge volume from the aquifer and the effective porosity of the groundwater aquifer. Zone C, in particular, experienced significant fluctuations due to high groundwater consumption for domestic and industrial purposes. Based on these observations, a geochemical predictive model has been proposed in **Figure 3**.

- Pre-2013 conditions: According to **Figure 3(A)**, the groundwater table and pH conditions were stable for many years before 2013. Natural acidification from existing laterite bodies rendered the groundwater slightly acidic, with average pH values ranging between 5.5. and 6.5.
- Post-2013 Urbanisation and Industrialisation: After 2013, rapid urbanisation and industrial development, particularly in the Gampaha district and around the Weliweriya-Rathupaswala area, led to increased demand for groundwater. **Figure 3(B)** illustrates the significant drawdown of the water table during 2013 extensive groundwater exploitation. Acidic waste from the latex factory exacerbated the natural acidity of groundwater from laterite aquifers, resulting in very low pH values in the Rathupaswala area.
- During 2015 Infiltration of water from surrounding peaty areas to recharge the water table: Peat soils contain continuous aquifers, while crystalline formations feature pockets or cascades of groundwater. Groundwater percolation from peat layers to recharge the water table is more efficient compared to crystalline terrains. **Figure 3(C)** presents the third model where acidic water from peat soil replenished the natural acidic laterite aquifer, contributing to low pH groundwater samples in Rathupaswala in 2015.
- Recent conditions 2020: Figure D depicts the current scenario. High consumption rates due to existing industries and population density lead to pronounced declines and recoveries in groundwater levels. Peat soil aquifers continue to replenish the water table, with natural acidification occurring due to the laterite ground conditions. These factors result in persistently low pH water samples in the Rathupaswala and Weliveriya areas.

The proposed geochemical model elucidates the complex interaction between groundwater exploitation, industrial activities, and natural geological processes, providing a comprehensive understanding of groundwater quality variation in the study area.

In addition to the parameters previously discussed (EC, pH, nitrate, sulfate, and depth to the water table), factors such as heavy metals, biological parameters (e.g., microbial activity), and land use patterns also play critical roles in affecting groundwater quality. The influence of these factors is complex; for example, pH affects the leaching and solubility of ions and minerals, which in turn influence the EC of groundwater. Similarly, sulphate concentrations can alter acidity through acid forming reactions. The depth to the water table impacts EC by

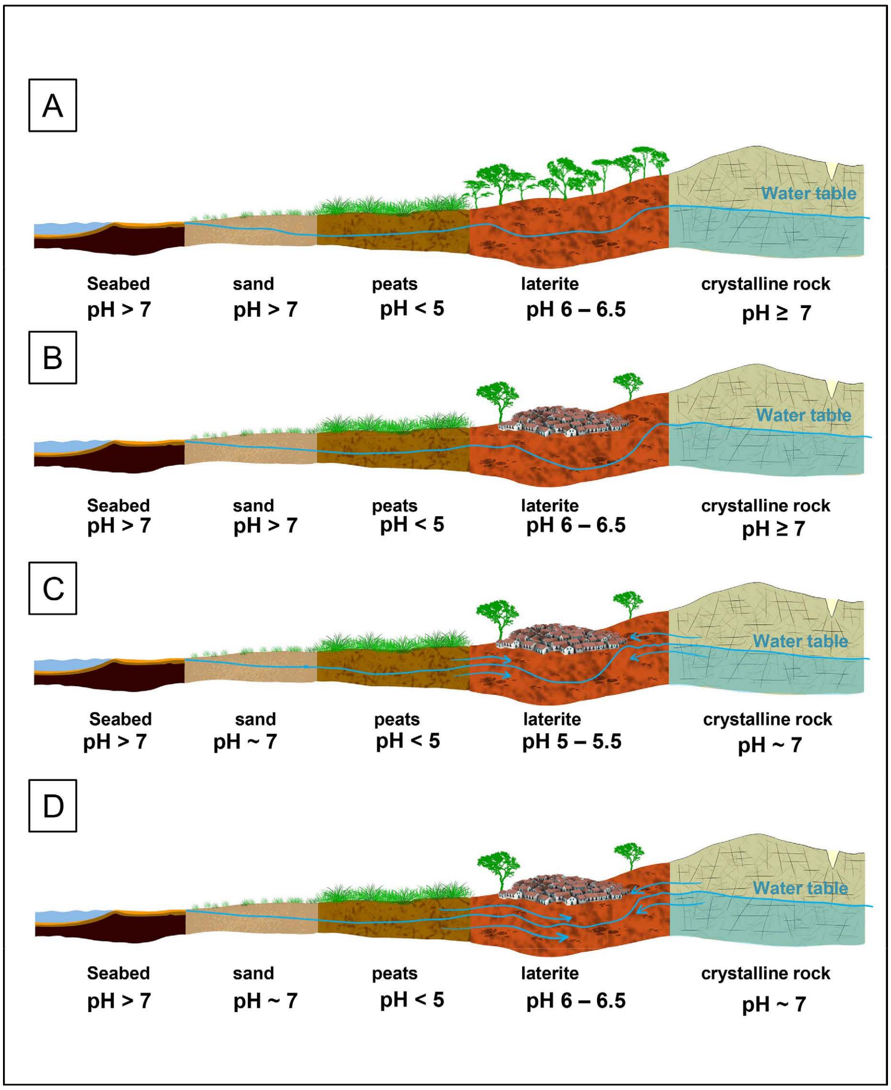


Figure 3. Prediction model of water quality variation along with the underlying geological conditions in Gampaha district. (A) Water acidity in normal condition before 2013; (B) Drawdown of the water table after extensive pumping in 2013 and acidity alteration; (C) Ground condition in 2015 during the initial study and change in the acidity due to infiltration of acidic water from peat soil; (D) Current scenario after 5 years, acidity change due to infiltration of acidic water from peat soil along with the natural acidification of groundwater due to the contact with laterite soils for a longer period.

determining the duration of contact between groundwater and rock within the aquifer, leading to subsequent ion dissolution. Understanding these interactions is essential for a comprehensive assessment of groundwater quality, as a change in a single parameter can trigger cascading effects on others. The current study acknowledges these complexities and aims to provide a thorough examination of these interdependencies within the specific context of the research objectives.

5. Conclusion

This study conducted in 2015 [17] and 2020 in Rathupaswala, Gampaha District, Sri Lanka, yielded the following conclusions: **Temporal Variations:** pH, EC, sulphate, nitrate, and depth to the water table were the most significant parameters affecting groundwater quality. Coastal groundwater was nearly neutral, while inland groundwater showed low pH values, particularly in areas with lateritic aquifers. A temporary decline in the water table from 2013 to 2015 was likely due to groundwater demand from a local glove manufacturing plant. However, by 2020, the water table has recharged to pre-2012 levels. Groundwater acidification in Rathupaswala-Weliveriya was primarily due to prolonged water-rock interactions, not factory operations. **Principal Component Analysis:** Saltwater intrusion, nutrient pollution, and water-rock interactions were identified as key factors influencing pH and other hydrogeochemical parameters. Nutrient pollution showed an increasing trend due to anthropogenic activities. **Hydro-Geochemical Influences:** The groundwater pH was influenced by local climate, lateritic formations, topography, and drainage. Prolonged water-rock interactions likely increased groundwater acidity, a phenomenon that may extend across similar geological settings in Sri Lanka. Given that groundwater is the main drinking water source in Gampaha district, the continuous utilisation of chemically degraded water poses significant health risks. This study provides critical insights for local authorities to implement immediate measures for groundwater preservation and management.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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