



Assessment of Groundwater Quality Using Physicochemical Parameters in Hodan District, Mogadishu, Somalia

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Abstract

Groundwater is the principal source of domestic water supply in Hodan District, Mogadishu, Somalia, yet rapid urbanization, unplanned settlement growth, and inadequate sanitation infrastructure have raised concerns over its quality and safety for human consumption. This study evaluated groundwater quality in Hodan District using seven physicochemical parameters: pH, electrical conductivity (EC), total dissolved solids (TDS), total hardness (TH), chloride (Cl^-), nitrate (NO_3^-), and fluoride (F^-) obtained from eight boreholes (Heydar, Buruj Tower, Rer M. Shekh, Gorgor, Umu Batula, Ciise Qodax, Soonikia/Digfer, and Tarabuuna/Umu Caisha) distributed across the district. Laboratory-derived hydrochemical data were compiled, statistically summarized, and compared against World Health Organization (WHO) drinking-water guideline values, while spatial distribution patterns were mapped using Geographic Information System (GIS)-based Inverse Distance Weighting (IDW) interpolation. Results show that the groundwater is alkaline (pH 7.6–8.9) and very hard, with mean EC (2.42 mS/cm), TDS (2274.0 mg/L), and chloride (526.6 mg/L) values exceeding WHO permissible limits at most or all sampling points, indicating pervasive salinization consistent with seawater intrusion in this coastal aquifer. Nitrate concentrations were highly variable (4.3–146.6 mg/L), with three boreholes exceeding the WHO limit of 50 mg/L, pointing to localized anthropogenic contamination from onsite sanitation systems. Fluoride was the only parameter within safe limits at every borehole (0.28–0.60 mg/L). The findings indicate that groundwater in Hodan District is largely unsuitable for direct consumption without treatment, primarily due to salinity and localized nitrate pollution, and highlight the need for routine water-quality monitoring, sanitary protection of wellheads, and appropriate household-level treatment.

Keywords: Groundwater quality, Physicochemical parameters, Hodan District, Mogadishu, Somalia, Seawater intrusion

1. Introduction

Groundwater is the primary source of domestic water in Somalia, as perennial surface water is largely limited to the Juba and Shabelle river basins (Basnyat, 2007; World Bank, 2021). In Mogadishu, and particularly in Hodan District, the absence of a functioning piped municipal network means that households depend almost entirely on shallow and deep boreholes for drinking, cooking, and other domestic needs. This dependence has intensified as the city's population has grown rapidly and settlement has expanded without corresponding investment in sanitation infrastructure.

Naturally, groundwater is never chemically pure: as water percolates through soil, sediment, and rock it dissolves mineral ions that determine its physicochemical character (Harter, 2003). Where this natural mineralization is compounded by coastal seawater intrusion, evaporative concentration, or the infiltration of contaminants from pit latrines, septic tanks, and uncontrolled waste disposal, groundwater quality can deteriorate to the point of posing a direct risk to public health. National assessments indicate that a large proportion of Somali water points already exceed WHO and national salinity guidelines, and that nitrate and bacteriological contamination of shallow water sources is widespread (World Bank, 2021). A recent city-wide assessment by Omar et al. (2025) demonstrated that drinking-water quality varies across Mogadishu and identified widespread bacteriological and physicochemical concerns, including particularly poor conditions in Hodan District. However, that study evaluated water at the household point of consumption and focused primarily on temperature, turbidity, pH, free residual chlorine, iron, and bacteriological indicators. More importantly, it did not directly assess groundwater salinity using electrical conductivity (EC), total dissolved solids (TDS), or chloride, and the study explicitly noted that salinity was not tested. Consequently, the hydrochemical characteristics of groundwater sources within individual urban districts remain insufficiently documented, particularly with respect to salinity, hardness, nitrate, and fluoride.

Accordingly, this study aims to (i) characterize the groundwater quality of Hodan District using seven key physicochemical parameters: pH, electrical conductivity (EC), total dissolved solids (TDS), total hardness (TH), chloride (Cl^-), nitrate (NO_3^-), and fluoride (F^-); (ii) quantify the borehole-level variability and spatial distribution of these parameters using GIS-based analysis; and (iii) compare the measured concentrations with WHO (2017) drinking-water guideline values to evaluate groundwater suitability for domestic consumption and identify the principal water-quality concerns within the district.

2. Study Area

Hodan District is located in the western part of Mogadishu, within the Banadir Administrative Region of Somalia. It forms part of the densely populated urban area of Mogadishu and is situated within the central-western part of the city as shown in Figure 1. The district is bordered by Wadajir District to the south, Dharkenley District to the southwest, Howl-Wadag District to the northeast, and Waberi District to the east, and Dayniile District to the northwest. Mogadishu has a population ranging from approximately 1.7 to 2.6 million people (World Bank, 2021). The district has no perennial surface-water bodies, so groundwater is the sole dependable water source for domestic use, small-scale irrigation, and livestock watering; its hydrology is shaped by the interaction of an arid-to-semi-arid climate, coastal sedimentary geology, and intensive human activity typical of a densely populated urban center (Basnyat, 2007).

Geologically, the Banadir Region is predominantly underlain by Quaternary sediments, consisting mainly of sands, gravels, and beach deposits (Ali Kassim & Chorowicz, 2001). These unconsolidated coastal sediments provide permeable materials that can facilitate groundwater storage and movement, making them important to the hydrogeological characteristics of the region.

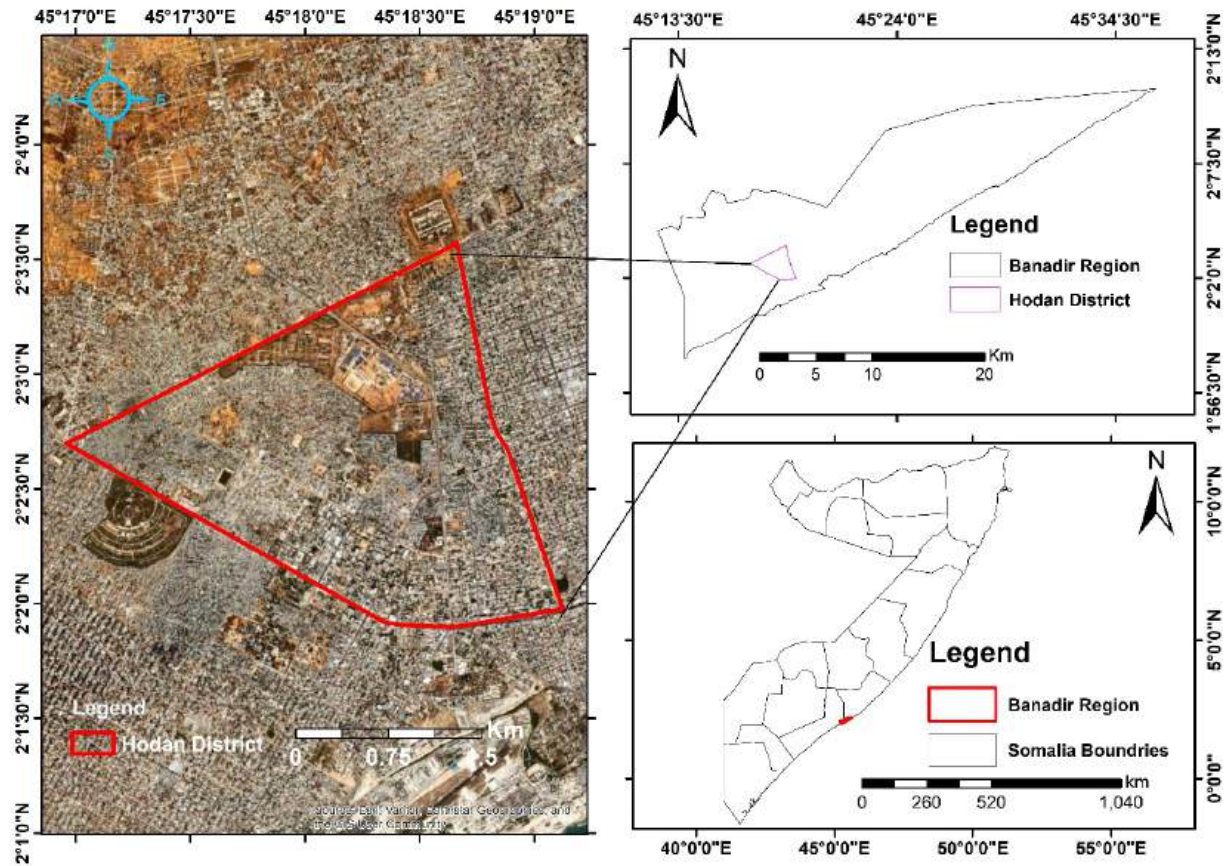


Figure 1. Study area map showing Hodan District

3. Materials and Methods

3.1 Research Design and Data Sources

This study adopted a quantitative, descriptive-analytical design combining secondary hydrochemical data synthesis, comparative benchmarking against WHO drinking-water guidelines, and GIS-based spatial visualization. Given the absence of a continuous field-monitoring programme in the district, the analysis relied on secondary data — validated laboratory reports for eight purposively selected boreholes — supplemented by a review of the hydrogeological literature on Somalia and the Banadir coastal aquifer. This approach allowed the study to combine numerical rigor with spatial interpretation while acknowledging that the dataset represents a single-round snapshot rather than continuous field monitoring, a limitation discussed further in Section 5.

3.2 Sampling Locations

Eight boreholes distributed across Hodan District were selected as sampling points based on their accessibility, spatial coverage, and importance as active sources of domestic water for local residents: Heydar, Buruj Tower, Rer M. Shekh, Gorgor, Umu Batula, Ciise Qodax, Soonikia (Digfer), and Tarabuuna (Umu Caisha). Geographic coordinates and depths of the boreholes are given in Table 1.

Table 1. Location and depth of the sampled boreholes in Hodan District.

No.	Borehole Name	Latitude / Longitude	Depth (m)
1	Heydar	2.034343, 45.30478	96.75
2	Buruj Tower	2.033060, 45.30944	138
3	Rer M. Shekh	2.045000, 45.28639	43
4	Gorgor	2.050556, 45.30194	86
5	Umu Batula	2.035278, 45.30944	85
6	Ciise Qodax	2.034444, 45.31472	90
7	Soonikia (Digfer)	2.047778, 45.29806	90
8	Tarabuuna (Umu Caisha)	2.042778, 45.31000	93

3.3 Parameters and Analytical Methods

Seven physicochemical parameters were analyzed: pH, electrical conductivity (EC), total dissolved solids (TDS), total hardness (TH), chloride (Cl^-), nitrate (NO_3^-), and fluoride (F^-). These parameters were selected because of their established relevance to the suitability of groundwater for drinking and domestic use (Bajpai, 2021; Kumar, 2016). pH, EC, and TDS were determined using calibrated digital meters; chloride and total hardness were determined by standard titrimetric methods; and fluoride and nitrate concentrations were determined spectrophotometrically. All analyses followed standard, internationally recognized laboratory protocols to ensure accuracy, consistency, and comparability of results with WHO (2017) guideline values for pH (6.5–8.5), EC (1.5 mS/cm), TDS (1000 mg/L), total hardness (500 mg/L), chloride (250 mg/L), nitrate (50 mg/L), and fluoride (1.5 mg/L).

3.4 Data Analysis and Spatial Mapping

Laboratory results for all eight boreholes were tabulated and analyzed descriptively (minimum, maximum, mean, and standard deviation) in Microsoft Excel, and the resulting values were compared against WHO drinking-water quality standards. Spatial distribution maps for each parameter were produced in ArcGIS (v10.8) using the geographic coordinates of the boreholes, with Inverse Distance Weighting (IDW) interpolation applied to estimate values at unsampled locations and to visualize district-wide contamination patterns and hotspots.

4. Results and Discussion

4.1 Descriptive Statistics of Physicochemical Parameters

Table 2 summarizes the descriptive statistics for the seven parameters across the eight boreholes, alongside the corresponding WHO (2017) guideline values.

Table 2. Statistical summary of groundwater quality parameters in Hodan District, compared with WHO drinking-water guideline values.

Parameter	Unit	Min	Max	Mean	SD	WHO Limit
pH	—	7.6	8.9	8.22	0.43	6.5–8.5
EC	mS/cm	1.43	3.60	2.42	0.87	1.5
TDS	mg/L	1325	3428	2274.0	818.4	1000
Total Hardness	mg/L	229.3	501.8	348.0	103.4	500
Chloride	mg/L	279.6	888.9	526.6	237.9	250
Nitrate	mg/L	4.27	146.6	52.5	57.5	50
Fluoride	mg/L	0.28	0.60	0.39	0.12	1.5

The mean pH of 8.22 indicates that the groundwater is predominantly alkaline, with the single exceedance of the WHO upper limit (8.5) occurring at Ciise Qodax (8.9). By contrast, the mean EC (2.42 mS/cm), TDS (2274.0 mg/L), and chloride (526.6 mg/L) values all substantially exceed WHO guideline values, reflecting a high degree of mineralization across the district. Total hardness averaged 348.0 mg/L, placing the water in the “very hard” category, with the maximum value (501.8 mg/L at Gorgor) marginally exceeding the WHO limit. Nitrate showed the largest relative variability (SD 57.5 mg/L against a mean of 52.5 mg/L, which itself slightly exceeds the WHO limit), reflecting sharply localized contamination rather than a district-wide trend. Fluoride was the only parameter for which all eight boreholes complied with the WHO limit.

4.2 Borehole-Level Results and Spatial Distribution

Table 3 presents the measured concentrations of all seven parameters at each borehole. To complement the tabulated borehole values, GIS-based Inverse Distance Weighting (IDW) interpolation was used to generate continuous spatial distribution surfaces for each parameter across Hodan District (Figures 3, 5, 7, 9, 11, 13 and 15). These maps reveal a general gradient of increasing salinity toward the western and south-central parts of the district, consistent with a coastal seawater-intrusion signature, while nitrate hotspots are concentrated at Rer M. Shekh and Heydar in the western and south-central sectors.

Table 3. Physicochemical parameter concentrations at each sampled borehole compared with WHO drinking-water limits.

Borehole	pH	EC (mS/cm)	TDS (mg/L)	Hardness (mg/L)	Chloride (mg/L)	Nitrate (mg/L)	Fluoride (mg/L)
Heydar	7.6	3.60	2570	440.00	740.00	135.30	0.520
Buruj Tower	7.7	2.65	1325	280.10	340.00	30.40	0.350
Rer M. Shekh	8.2	3.28	3177	435.12	725.62	146.60	0.596
Gorgor	8.1	3.04	3428	501.76	888.92	14.05	0.289

Borehole	pH	EC (mS/cm)	TDS (mg/L)	Hardness (mg/L)	Chloride (mg/L)	Nitrate (mg/L)	Fluoride (mg/L)
Umu Batula	8.4	2.33	2315	377.30	585.75	60.92	0.299
Ciise Qodax	8.9	1.47	1340	229.32	279.57	4.27	0.420
Soonikia (Digfer)	8.5	1.43	2542	268.52	314.52	6.79	0.349
Tarabuuna (Umu Caisha)	8.4	1.52	1495	251.86	338.08	21.70	0.284
WHO Limit	6.5–8.5	1.5	1000	500	250	50	1.5

4.2.1 pH and Alkalinity

Measured pH values ranged from 7.6 (Heydar) to 8.9 (Ciise Qodax), with seven of the eight boreholes falling within, or at, the WHO (2017) range of 6.5–8.5 (Figure 2); only Ciise Qodax exceeded the upper limit. The generally alkaline character of the water is consistent with interaction between infiltrating water and carbonate-bearing minerals in the limestone-dominated local aquifer, and pH has previously been shown to correlate positively with electrical conductance and total alkalinity in comparable groundwater settings (Kumar, 2016). Elevated pH at Ciise Qodax may contribute to a bitter taste and to scaling within distribution pipework over time.

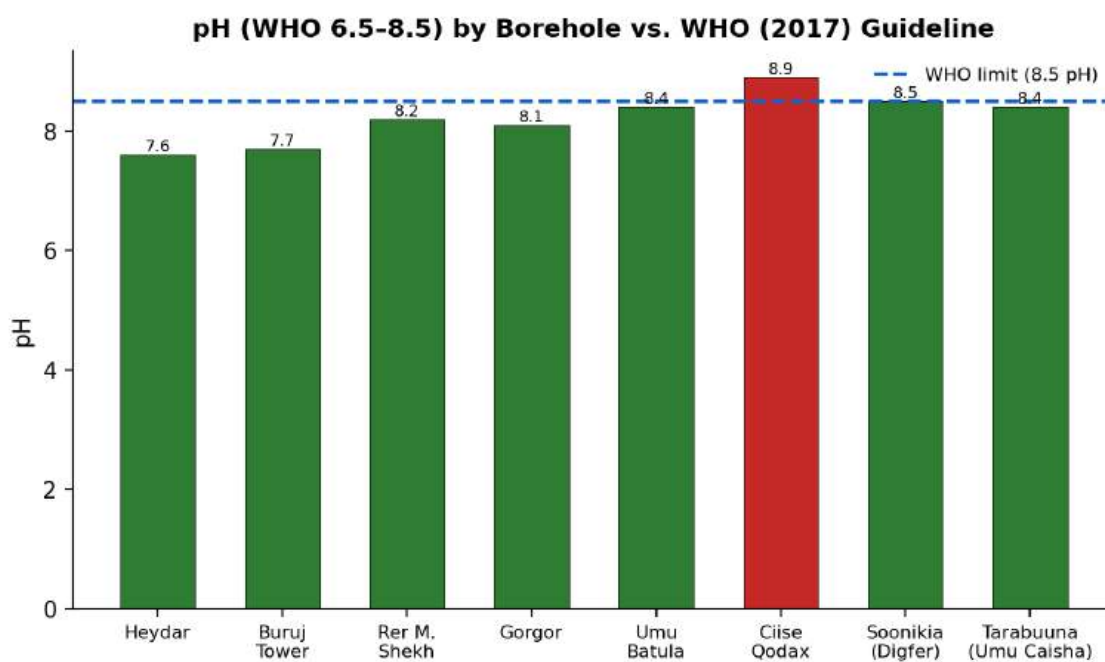


Figure 2. pH concentrations across the eight sampled boreholes relative to the WHO (2017) guideline range.

The pH distribution varies spatially across the study area (Figure 3), with most central and western areas showing values of 8.12–8.38, indicating generally alkaline groundwater. Lower values (7.60–8.12) are concentrated in the south-central area, while the highest values (8.64–8.90) occur in isolated zones in the far north and near the eastern boundary.

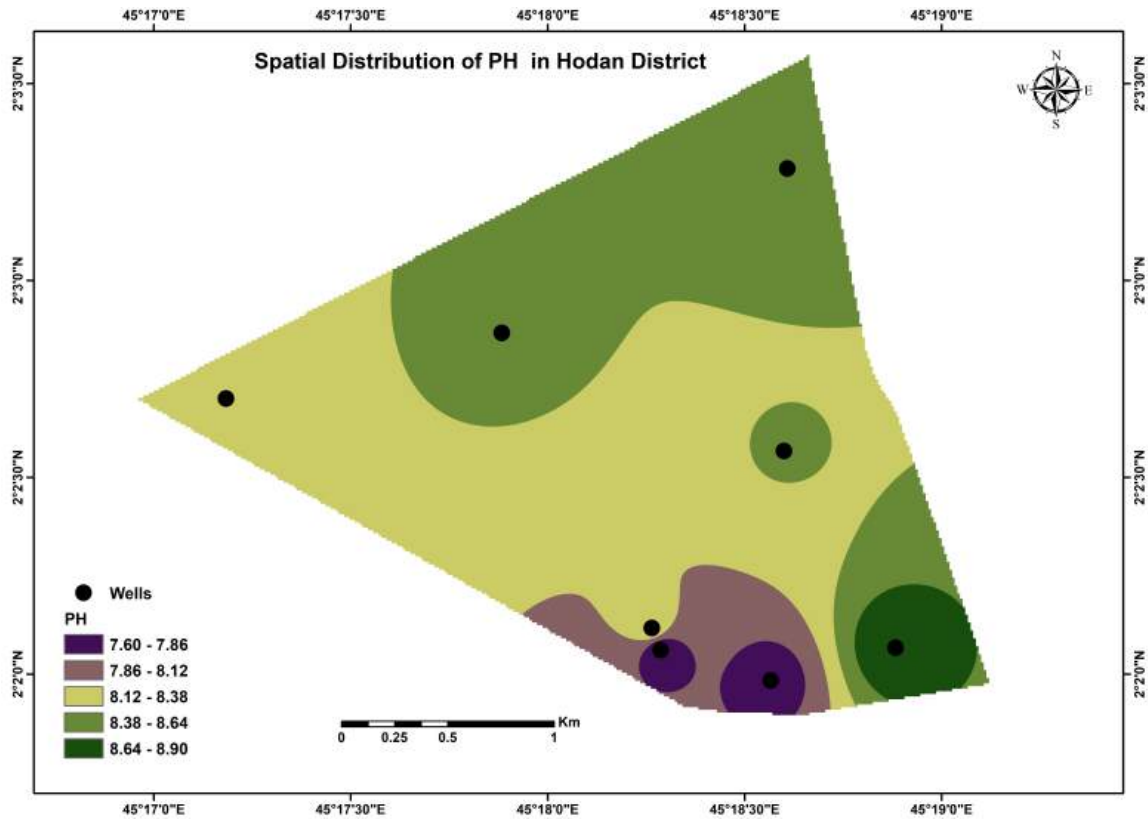


Figure 3. Spatial distribution of pH in Hodan District (IDW interpolation).

4.2.2 Electrical Conductivity

Electrical conductivity exceeded the WHO (2017) limit of 1.5 mS/cm at six of the eight boreholes, ranging from 1.43 mS/cm at Soonikia (Digfer) to 3.60 mS/cm at Heydar (**Figure 4**). The spatial pattern indicates the highest conductivity along the western edge and south-central portion of the district, coinciding with areas most vulnerable to coastal seawater intrusion (World Bank, 2021). Elevated EC of this magnitude is consistent with a substantial dissolved-salt load and indicates that the water in much of the district is already, or is becoming, brackish.

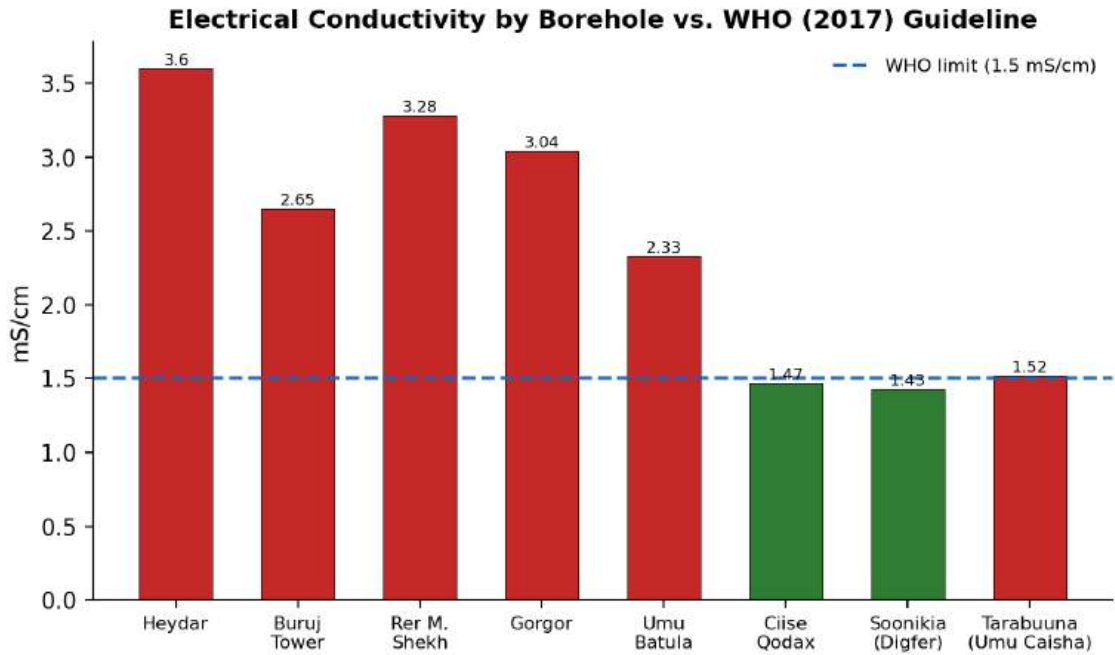


Figure 4. Electrical conductivity by borehole relative to the WHO (2017) guideline limit. Electrical conductivity (EC) varies spatially across the study area (**Figure 5**), with the highest values (3.16–3.60 mS/cm) concentrated in the west and lower values (1.43–1.86 mS/cm) toward the north and east. A moderate EC zone (2.73–3.16 mS/cm) occurs in the south-central area. The west-to-east decline suggests increased salinity and a possible influence of coastal seawater intrusion in the western part of the district.

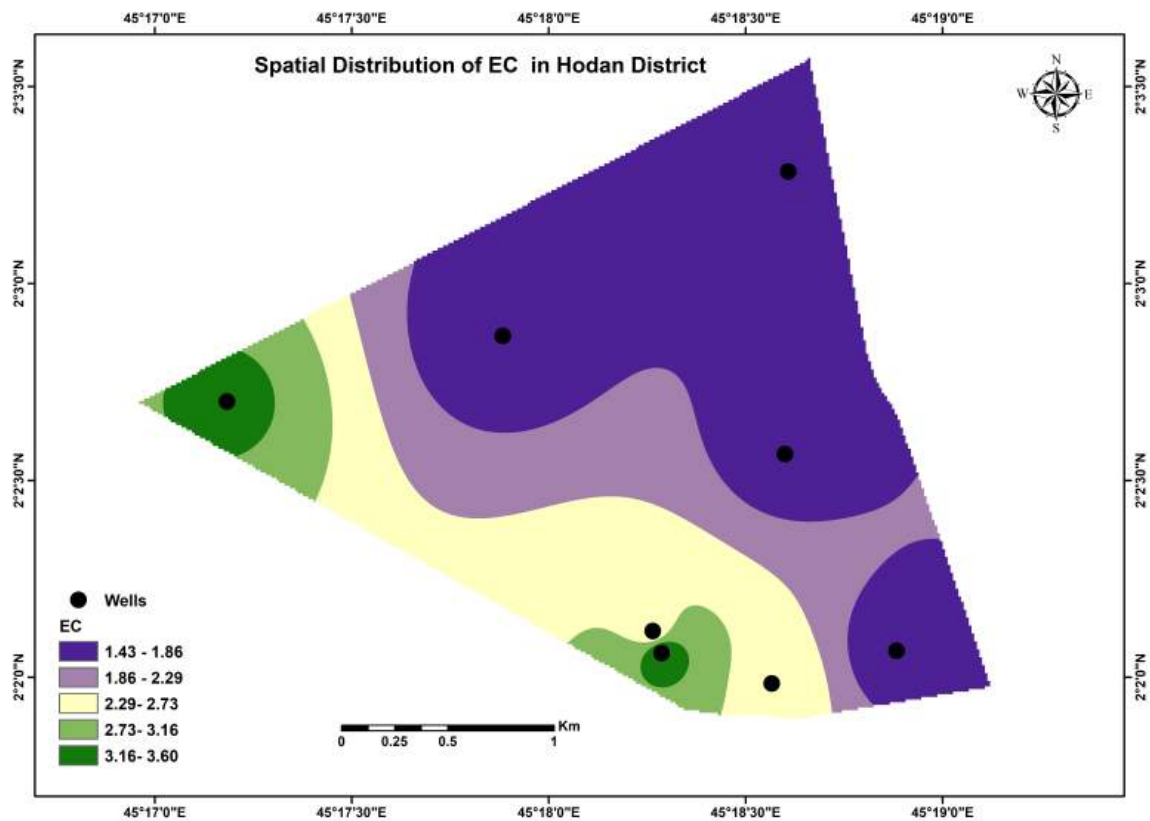


Figure 5. Spatial distribution of electrical conductivity (EC, mS/cm) in Hodan District (IDW interpolation).

4.2.3 Total Dissolved Solids

TDS exceeded the WHO (2017) limit of 1000 mg/L at every sampled borehole, ranging from 1325 mg/L at Buruj Tower to 3428 mg/L at Gorgor (**Figure 6**). This universal exceedance, mirrored by the EC results, reinforces the interpretation that salinization is a district-wide phenomenon rather than an isolated, localized issue, a pattern also reported in integrated assessments of anthropogenic and geogenic influences on groundwater quality in comparable urban coastal settings (Egbueri & Unigwe, 2023).

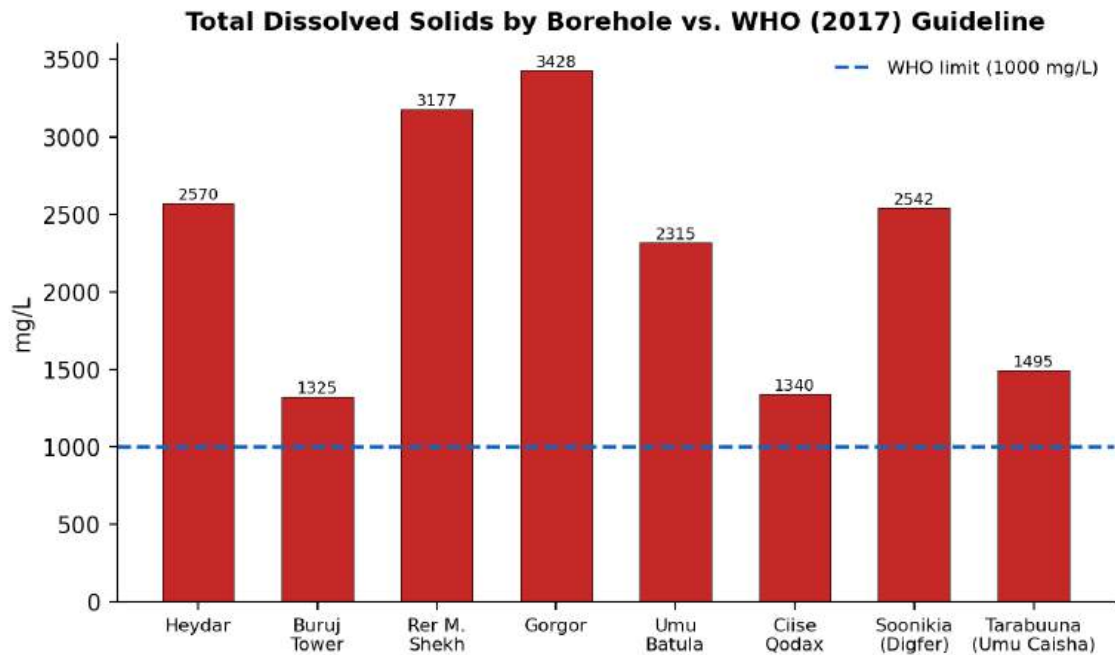


Figure 6. Total dissolved solids (TDS) by borehole relative to the WHO (2017) guideline limit. The IDW-interpolated surface for total dissolved solids (TDS) shows that the highest TDS values (2,806–3,177 mg/L) occur at the western tip of the district and along a band in the north (2,436–2,806 mg/L), while the south-eastern part of the district shows comparatively lower TDS values (1,325–2,066 mg/L). As shown in Figure 7, a small, localized zone of elevated TDS also appears in the south-central part of the district. This west/north-to-south-east gradient mirrors the EC pattern and reinforces the interpretation of a coastal salinization signature affecting the western and northern parts of the district.

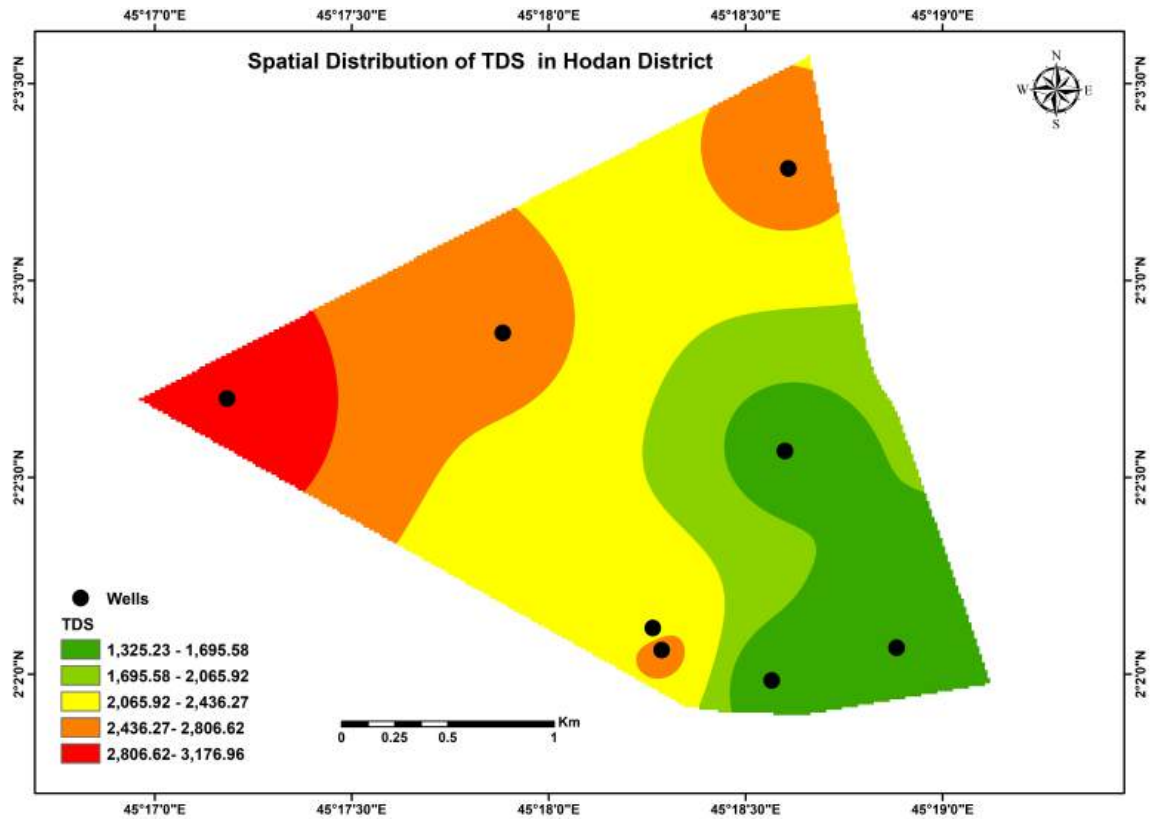


Figure 7. Spatial distribution of total dissolved solids (TDS, mg/L) in Hodan District (IDW interpolation).

4.2.4 Total Hardness

Total hardness ranged from 229.3 mg/L (Ciise Qodax) to 501.8 mg/L (Gorgor), classifying the groundwater as very hard throughout the district (Figure 8); only Gorgor marginally exceeded the WHO (2017) limit of 500 mg/L. This pattern parallels the salinity results and is consistent with dissolution of calcium- and magnesium-bearing limestone and gypsum within the aquifer, a mechanism similarly implicated in hardness patterns observed in other carbonate-hosted groundwater systems (Ackah & Osei, 2011). While hardness poses no direct health hazard, very hard water at Gorgor and Heydar is likely to cause scaling in pipes and water heaters, elevated soap and detergent consumption, and aesthetic (taste) complaints.

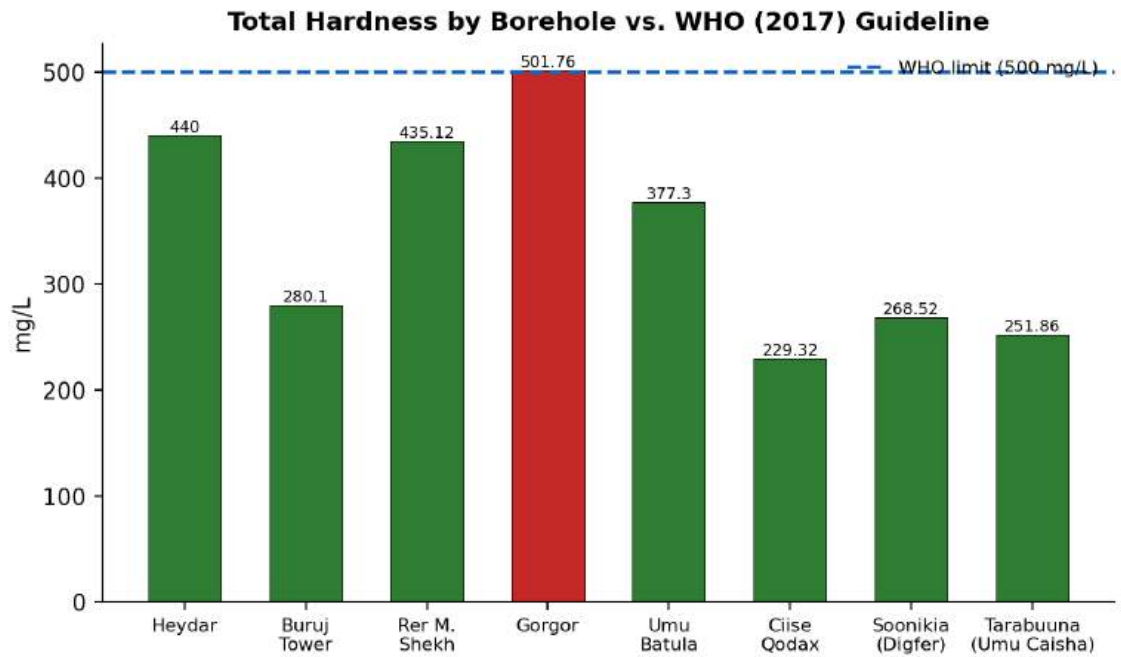


Figure 8. Total hardness by borehole relative to the WHO (2017) guideline limit.

The spatial distribution of total hardness shows that the highest hardness values (397.8–439.9 mg/L) are found at the western tip of the district, while isolated pockets of comparatively lower hardness (229.3–271.4 mg/L) occur in the north and in the south-eastern corner (Figure 9). Most of the remaining area falls within the intermediate-to-high classes (271–356 mg/L), consistent with the very hard character of the groundwater described above and broadly paralleling the spatial patterns of TDS and chloride.

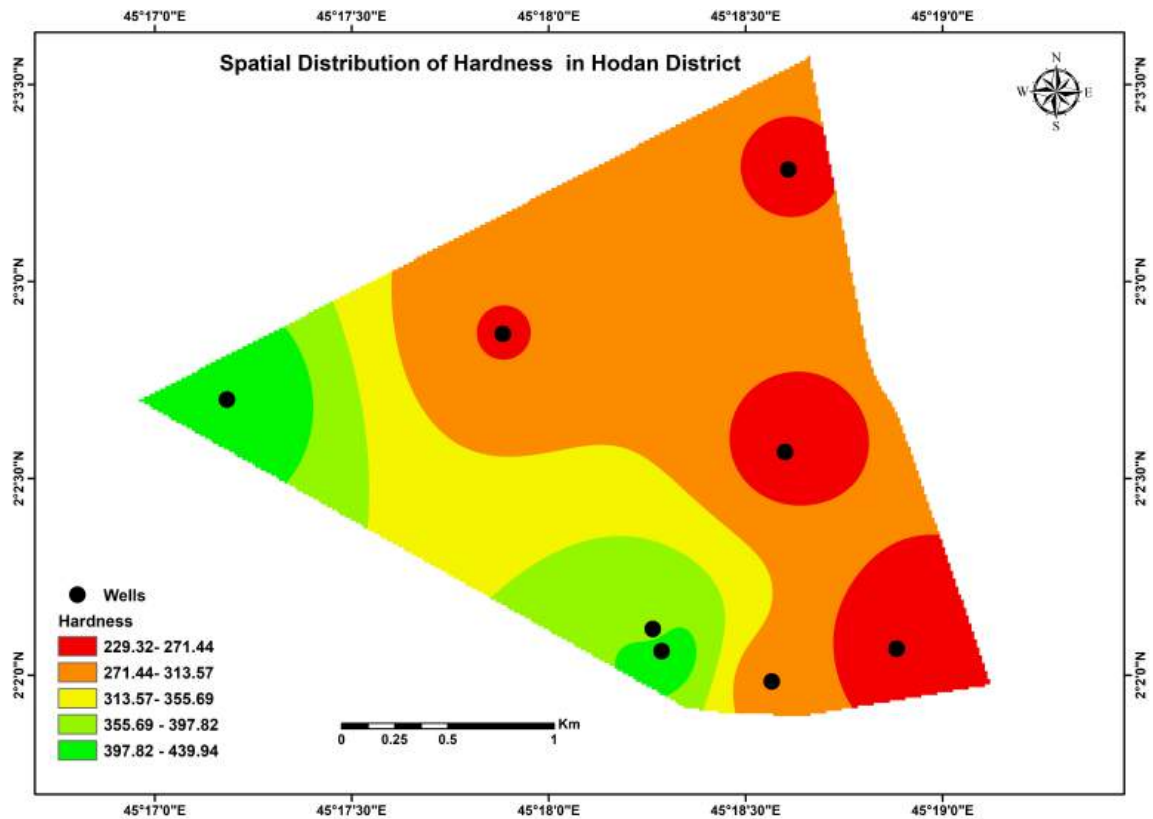


Figure 9. Spatial distribution of total hardness (mg/L) in Hodan District (IDW interpolation).

4.2.5 Chloride

Chloride exceeded the WHO (2017) limit of 250 mg/L at all eight boreholes, ranging from 279.6 mg/L at Ciise Qodax to 888.9 mg/L at Gorgor — nearly 3.6 times the guideline value (Figure 10). The close spatial correspondence among chloride, EC, and TDS points to a common driver, most plausibly seawater intrusion into the shallow coastal aquifer, compounded by mineral dissolution from the surrounding carbonate geology (World Bank, 2021). Water with chloride at these levels is likely to have a salty taste, to accelerate corrosion of metal plumbing, and to require treatment such as reverse osmosis before use for drinking.

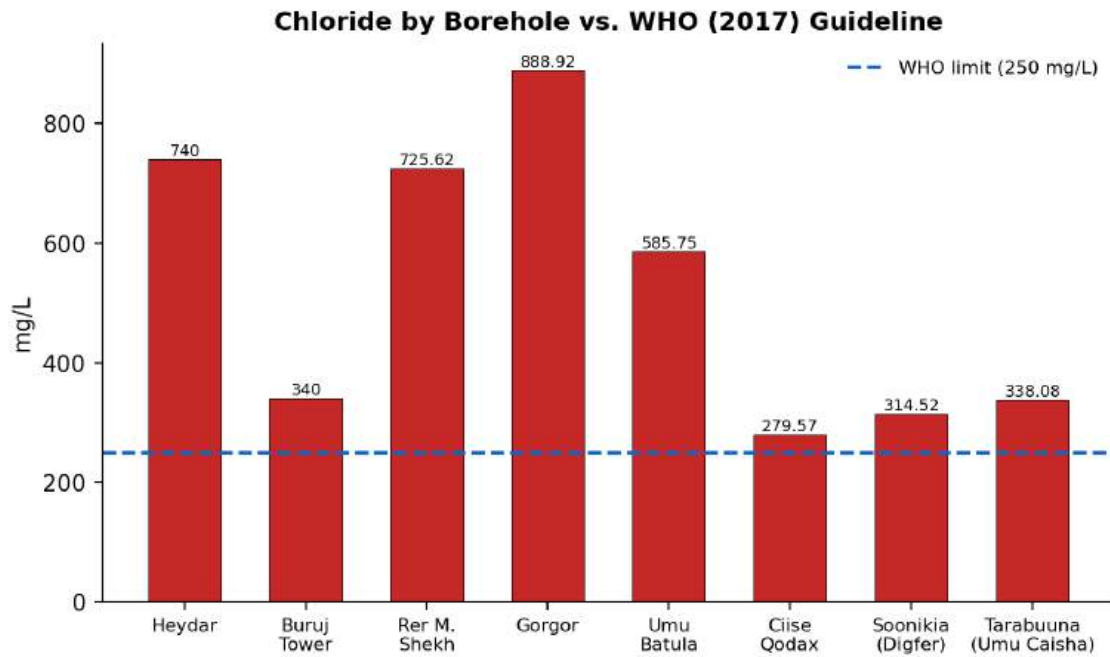


Figure 10. Chloride concentrations by borehole relative to the WHO (2017) guideline limit. The spatial distribution of chloride concentrations shows that the highest chloride values (647.8–739.9 mg/L) are concentrated at the western tip of the district and in a small south-central pocket, while the northern and eastern parts of the district, covering the largest share of the study area, show comparatively lower chloride levels (279.6–371.6 mg/L) (Figure 11). A transitional band of moderate chloride concentrations (371.6–555.8 mg/L) occupies the central part of the district. This pattern reinforces the district-wide exceedance of the WHO chloride limit discussed above, with the western and south-central zones most severely affected.

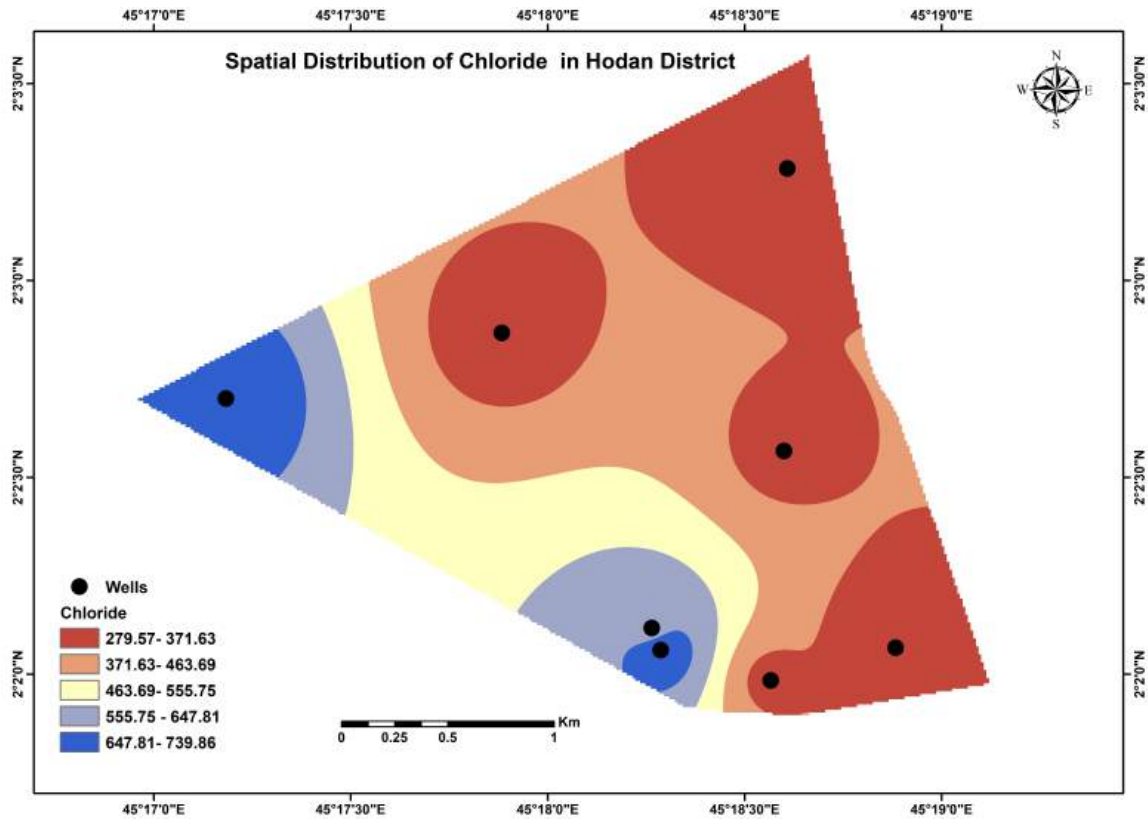


Figure 11. Spatial distribution of chloride (mg/L) in Hodan District (IDW interpolation).

4.2.6 Nitrate

Nitrate showed the widest relative range of any parameter, from 4.27 mg/L at Ciise Qodax to 146.6 mg/L at Rer M. Shekh (Figure 12). Three boreholes — Umu Batula (60.9 mg/L), Heydar (135.3 mg/L), and Rer M. Shekh (146.6 mg/L) — exceeded the WHO (2017) limit of 50 mg/L, with the latter two representing critical exceedances nearly three times the guideline value. Unlike the salinity parameters, nitrate was only moderately associated with TDS and chloride ($r \approx 0.44\text{--}0.57$); its closer association with EC ($r \approx 0.77$) arises mainly because the two highest-nitrate boreholes also have high EC, while the borehole with the highest TDS and chloride (Gorgor) has low nitrate, suggesting a distinct, localized anthropogenic source rather than a geogenic or seawater-intrusion origin, consistent with patterns of septic-derived nitrate contamination documented elsewhere in Somalia (World Bank, 2021) and in other rapidly urbanizing settings with poor sanitation infrastructure (Qureshi et al., 2021). The most plausible explanation is infiltration of effluent from nearby pit latrines, septic tanks, or soak-away pits into the shallow aquifer. Because nitrate at these concentrations carries a direct risk of infant methemoglobinemia (“blue baby syndrome”), the affected boreholes should be regarded as unsafe for infant feeding without treatment or an alternative source.

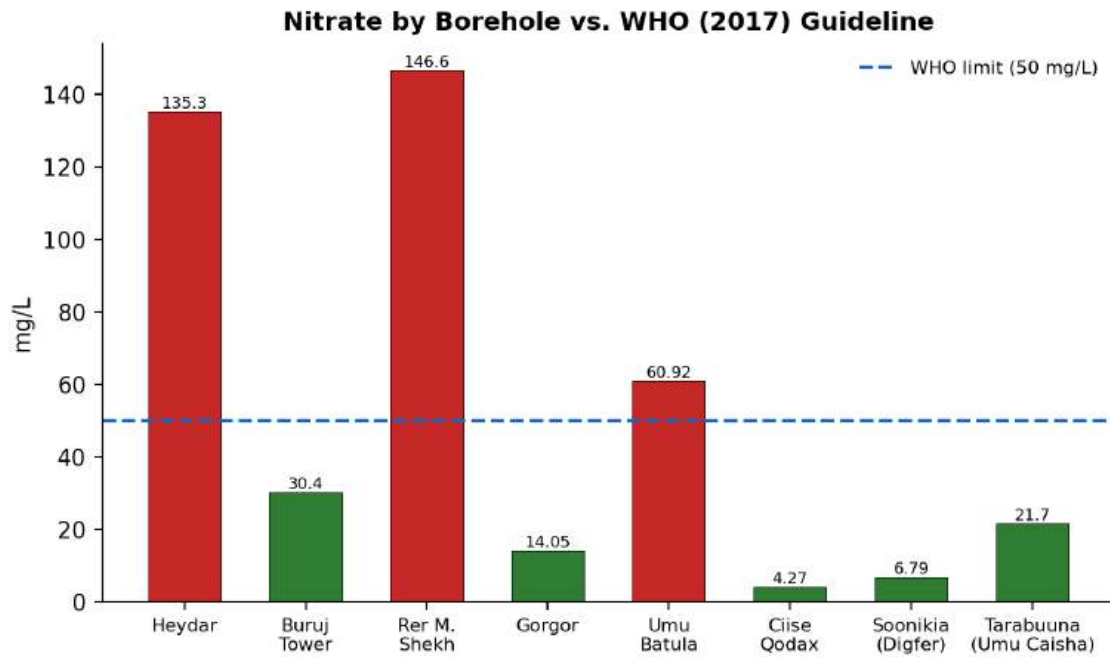


Figure 12. Nitrate concentrations by borehole relative to the WHO (2017) guideline limit.

The spatial distribution of nitrate concentrations shows a highly patchy pattern. The highest concentrations (118.1–146.6 mg/L) are confined to the western tip of the district, with a secondary elevated zone (61.2–118.1 mg/L) in the south-central area near two closely spaced boreholes. As shown in Figure 13, most of the northern, central, and eastern parts of the district fall within the lowest nitrate class (4.3–32.7 mg/L). This markedly localized pattern, which differs from the smoother salinity gradients observed for EC, TDS, and chloride, supports the interpretation that nitrate contamination originates from discrete anthropogenic sources, such as septic systems and pit latrines, rather than from a district-wide geogenic process.

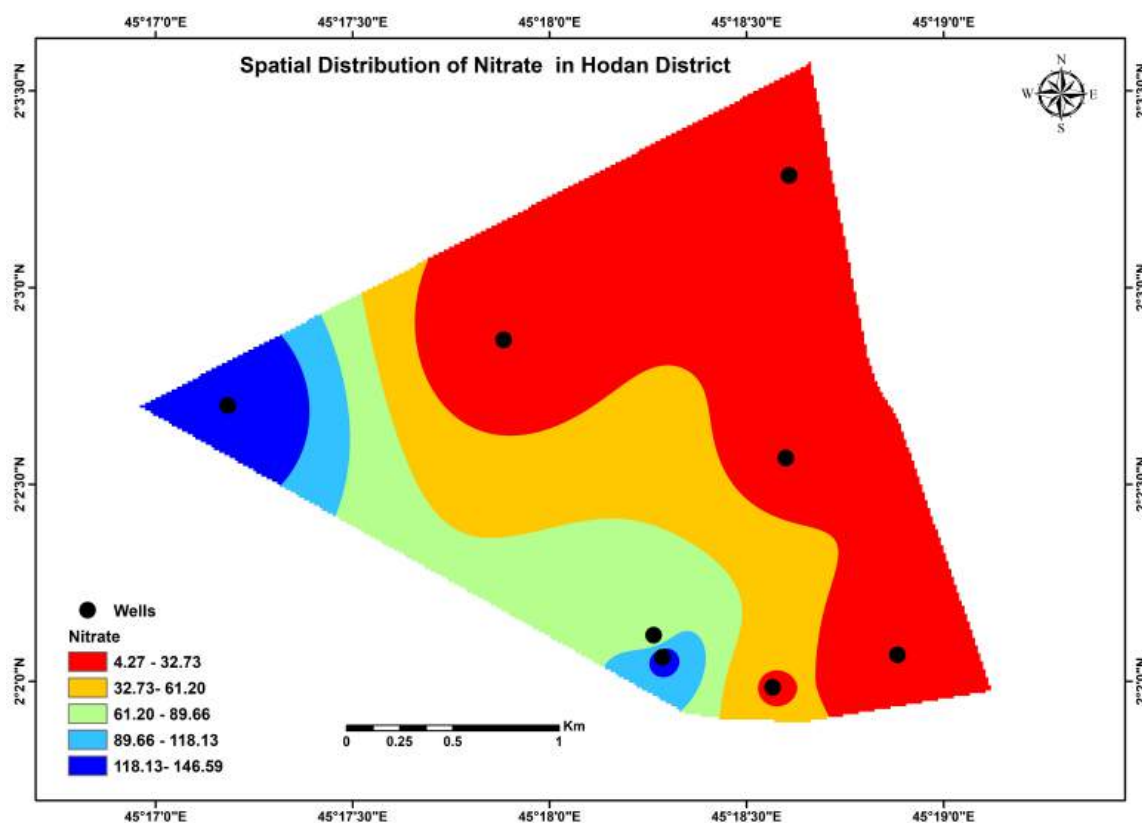


Figure 13. Spatial distribution of nitrate (mg/L) in Hodan District (IDW interpolation).

4.2.7 Fluoride

Fluoride concentrations ranged from only 0.284 mg/L (Tarabuuna) to 0.596 mg/L (Rer M. Shekh), remaining well within the WHO (2017) limit of 1.5 mg/L at every borehole (Figure 14). This indicates a low abundance of fluoride-bearing minerals in the local aquifer and poses no risk of dental or skeletal fluorosis; conversely, the lowest values, recorded in the northern part of the district, are below the level generally considered protective against dental caries, so fluoride was the only parameter identified as uniformly safe, though not necessarily optimal, across the study area.

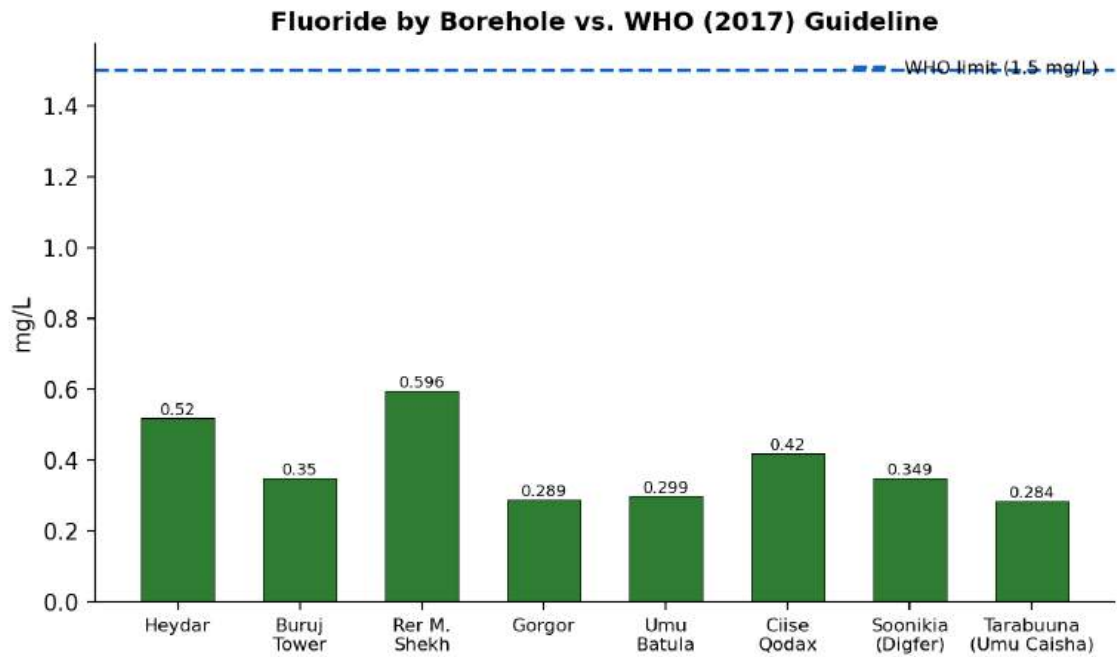


Figure 14. Fluoride concentrations by borehole relative to the WHO (2017) guideline limit. The highest fluoride values (0.53–0.59 mg/L) occur at the western tip of the district, while most of the remaining area falls within the low-to-moderate 0.34–0.40 mg/L class (Figure 15). Two localized pockets of the lowest fluoride values (0.28–0.34 mg/L) occur near the centre-east of the district and in a small area to the south. Even the highest recorded value remains far below the WHO guideline of 1.5 mg/L, confirming that fluoride is uniformly safe across Hodan District, though the low-value zones fall below levels generally considered protective against dental caries.

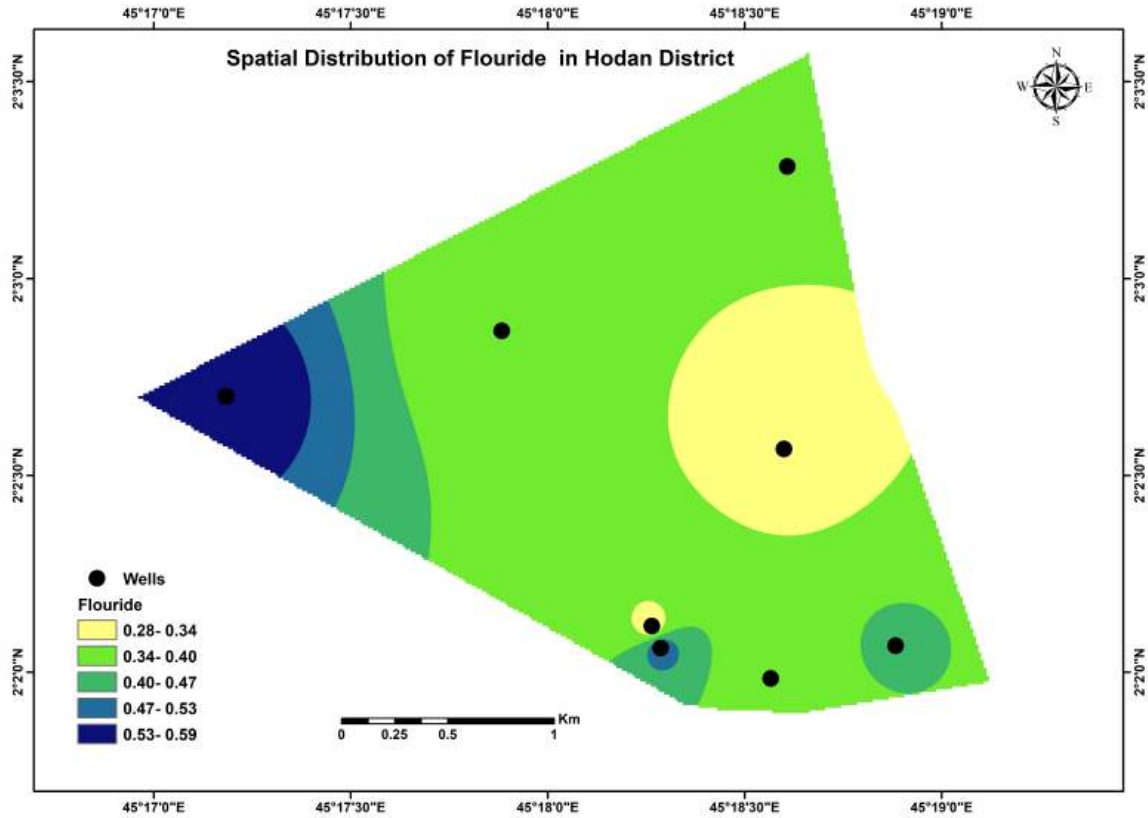


Figure 15. Spatial distribution of fluoride (mg/L) in Hodan District (IDW interpolation).

4.3 Inter-Parameter Relationships

Comparison of the parameter patterns across boreholes indicates a strong positive association among EC, TDS, and chloride, consistent with a shared salinity-driven origin most likely linked to seawater intrusion in this coastal district, a co-variation pattern widely reported in similar physicochemical assessments of coastal and semi-arid aquifers (Aboll et al., 2022; Debassi et al., 2025). The close co-variation of total hardness with chloride and TDS ($r \geq 0.87$) further points to mineral dissolution from the carbonate-rich local geology accompanying salinization, whereas pH was inversely related to EC in this dataset ($r \approx -0.79$). Nitrate, in contrast, varied independently of the salinity parameters: the borehole with the highest TDS and chloride (Gorgor) recorded low nitrate, and the highest-nitrate boreholes (Rer M. Shekh, Heydar) were not those with the highest TDS or chloride, supporting the interpretation that nitrate contamination originates from localized anthropogenic sources such as septic-system leakage rather than from the same processes controlling salinity.

4.4 Overall Groundwater Suitability

Taken together, the results indicate that groundwater in Hodan District is characterized by high alkalinity, very hard water, and elevated salinity, with all eight boreholes exceeding WHO (2017) limits for chloride and TDS, and six of eight exceeding the EC limit. Superimposed on this district-wide salinity signature are critical, spatially concentrated nitrate hotspots in the western and south-central parts of the district, echoing the localized, sanitation-linked nitrate contamination patterns documented across Somalia more broadly (World Bank, 2021). Fluoride was the only parameter compliant with WHO guidelines at every location, and pH was compliant at all boreholes except Ciise Qodax. On balance, the groundwater of Hodan District is generally unsuitable for direct human consumption without treatment, primarily because of salinity, and locally because of nitrate contamination.

5. Conclusions and Recommendations

This study assessed the physicochemical quality of groundwater from eight boreholes in Hodan District, Mogadishu, and compared the results with WHO drinking-water guidelines. The groundwater was found to be alkaline and very hard, with electrical conductivity, total dissolved solids, and chloride exceeding WHO limits at most or all sampling points — a pattern consistent with seawater intrusion into this coastal aquifer, compounded by dissolution of carbonate host rocks. Fluoride was the only parameter within safe limits throughout the district. Overall, the groundwater of Hodan District is generally unsuitable for direct consumption without treatment.

Based on these findings, several measures are recommended. First, local authorities and the Ministry of Energy and Water Resources should establish and enforce minimum safe separation distances between boreholes and septic tanks or latrines to reduce nitrate infiltration. Second, a routine groundwater-monitoring network should be established to track salinity trends and detect the advance of seawater intrusion, and private water suppliers should be required to report water-quality data regularly against WHO and national standards. Third, at the household level, reverse-osmosis or ion-exchange treatment is recommended to address hardness and salinity, and community awareness campaigns should highlight the risks of nitrate exposure, particularly for pregnant women and infants. Boreholes with extreme contamination, such as Rer M. Shekh, may warrant professional rehabilitation or deepening to access less contaminated aquifer horizons.

This study is limited by its reliance on a single round of secondary laboratory data for eight boreholes, without direct field sampling, seasonal replication, or microbiological or heavy-metal analysis. Future research should therefore incorporate bacteriological testing (e.g., *E. coli* and total coliforms), assess seasonal variation between dry and rainy periods, screen for heavy metals such as lead, arsenic, and mercury as recommended for comparable groundwater systems in East Africa (Mkelemia & Nnko, 2024), and develop three-dimensional hydrogeological models of the Mogadishu aquifer to better predict the progression of seawater intrusion and to guide sustainable groundwater abstraction.

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Conflict of Interest

The authors declare no conflict of interest.

Data Availability Statement

The datasets analyzed during the current study are available from the corresponding author on reasonable request.

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