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A Chemical and Statistical Analysis of Water Quality Assessment in Musiri Region

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Water quality is critical for both human consumption and agricultural activities. In this study, we analyze groundwater samples collected from various villages in the Musiri region. The Data contains multiple chemical and physical parameters, such as Total Dissolved Solids (TDS), pH, hardness, and other key ions like sodium (Na), calcium (Ca), and magnesium (Mg). These parameters are essential to determine water suitability for drinking and agricultural purposes.This article presents descriptive statistics, correlation analysis, and visual explorations to gain insights into the water quality in the Musiri region, identifying potential issues such as salinity, hardness, and sodium hazards.

Materials and Methods

Table: location of water quality samples

Village	Well	Latitude	Longitude
Alagarai	11019D	10Â°58'55"	78Â°23'25"
Devanur(puthur)	73039A	11Â°06'40"	78Â°25'45"
Ittayapatti	11063	11Â°01'21"	78Â°30'50"
Kalaravali{kottur}	73075A	10Â°55'10"	78Â°32'40"
Kattupputtur	11021	10Â°59'20"	78Â°13'15"
Kidaram	11020	11Â°02'20"	78Â°11'10"
Mahadevi	11023D	11Â°09'50"	78Â°23'50"
Pulivalam	11017D	11Â°00'50"	78Â°38'15"
Sittalarai	11022D	11Â°00'10"	78Â°25'40"
Thandalaiputur	11003D	10Â°59'50"	78Â°32'00"

The methodology for this study involved collecting water samples from 10 wells across various villages in the Musiri region, with each sample analyzed for physical and chemical parameters to assess water quality. Key physical parameters included Total Dissolved Solids (TDS), pH, and Electrical Conductivity (EC), which provide insights into the mineral content and alkalinity of the water. The chemical analysis focused on ions such as calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), chloride (Cl), sulfate (SO4), carbonate (CO3), bicarbonate (HCO3), and fluoride (F), alongside the measurement of nitrite and nitrate (NO2 + NO3). Additionally, critical water quality indicators such as Total Hardness (HAR_Total), Sodium Adsorption Ratio (SAR), and Sodium Percentage (Na%) were calculated to evaluate hardness levels and sodium hazards. Descriptive statistics and correlation analysis were employed to explore trends and relationships between parameters, while spatial patterns were visualized using bubble charts to map TDS distribution across the region. A heatmap was also generated to highlight correlations among variables, aiding in the identification of significant chemical interactions. Through this methodology, the study provides a comprehensive assessment of water quality, highlighting key areas for intervention based on salinity, hardness, and sodium content.

Results and Discussion

Descriptive Statistics

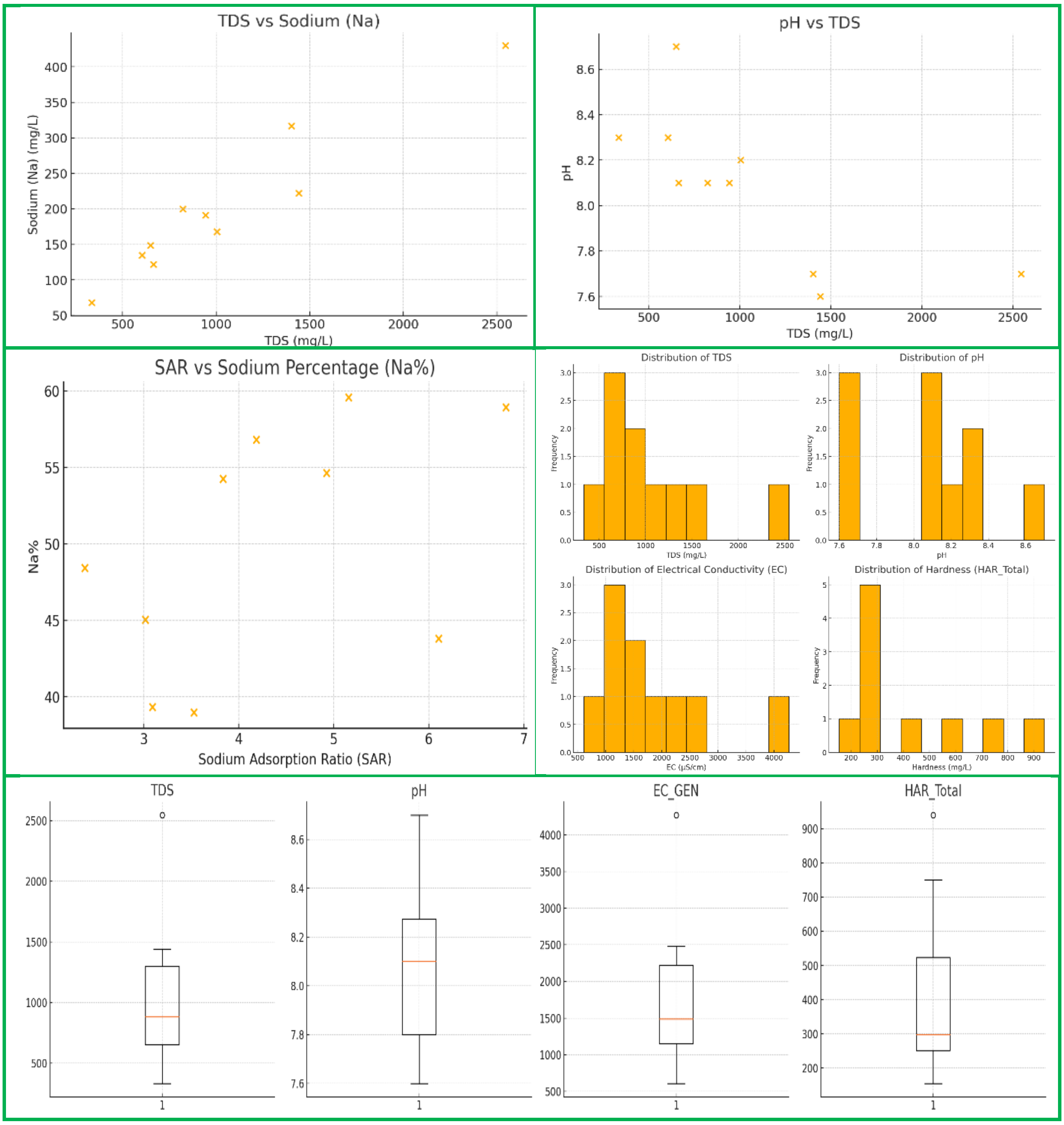
	TDS	NO_2+NO_3	Ca	Mg	Na	K	Cl	SO_4	CO_3	HCO_3	F	pH_GEN	EC_GEN	HAR_Total	SAR	RSC	Na%
Count	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Mean	1040.8	23.1	47	72.7785	200.2	34.9	331.8	96.7	2.075969	301.4141	0.802	8.08	1794	417	4.301762	0.190513	49.9856
std	632.1626	19.3933	24.40856	47.83614	104.6219	62.01335	270.4945	129.415	4.007208	133.1211	0.514518	0.335989	1043.852	254.8006	1.426851	0.407816	7.877746
min	335	3	24	19.44	68	2	99	10	0	134.2	0.11	7.6	610	155	2.377006	0	38.97635
25%	652.75	14.5	28.5	43.43625	138.5	5	183.5	39.25	0	208.925	0.41	7.8	1150	251.25	3.198627	0	44.1237
50%	882	17	37	54.0675	179.5	9	250	55	0	283.65	0.795	8.1	1490	297.5	4.008548	0	51.34649
75%	1302.5	26.25	64	88.0875	216.5	38	363.5	70.25	2.069768	384.3	0.96	8.275	2220	522.5	5.096661	0	56.27617
max	2545	59	96	170.1	430	203	993	451	12	512.4	1.62	8.7	4270	940	6.812292	1.102607	59.58262

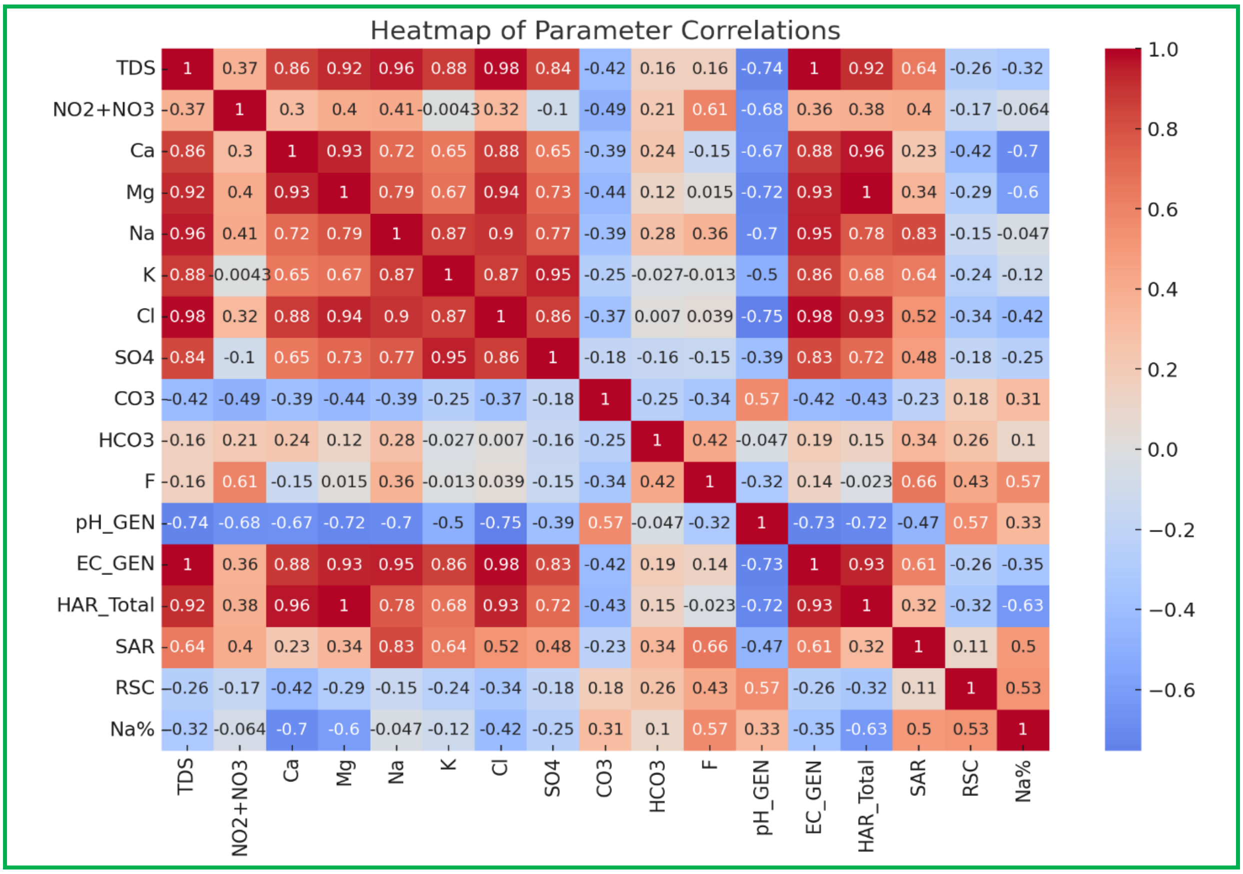
The TDS values range from 335 mg/L to 2340 mg/L, with an average of ~1041 mg/L. Higher TDS indicates potential salinity issues, particularly for agricultural use. Most water samples have a pH between 7.6 and 8.3, indicating neutral to slightly alkaline water, typical for groundwater. Electrical Conductivity (EC) values range widely, with a mean of 1794 µS/cm. High EC values suggest elevated mineral content. Hardness (HAR_Total) the water hardness ranges from 155 to 950 mg/L, suggesting the presence of both moderately hard and very hard water.Sodium Adsorption Ratio (SAR) the values range from 2.38 to 6.81, with an average SAR of 4.3. Higher SAR values indicate potential risks to soil quality in agricultural areas.

Correlation Analysis

	TDS	NO2+NO3	Ca	Mg	Na	K	Cl	SO4	CO3	HCO3	F	pH_GEN	EC_GEN	HAR_Total	SAR	RSC	Na%
TDS	1	0.374716	0.860435	0.919149	0.957639	0.875317	0.981114	0.84101	-0.41845	0.159905	0.158613	-0.73945	0.998325	0.916189	0.640096	-0.26186	-0.31676
NO2+NO3	0.374716	1	0.302564	0.403254	0.406053	-0.00433	0.317063	-0.10079	-0.48508	0.209283	0.605854	-0.68004	0.364535	0.38401	0.399447	-0.16748	-0.06429
Ca	0.860435	0.302564	1	0.934331	0.718705	0.647953	0.876418	0.648235	-0.38727	0.238616	-0.14563	-0.67471	0.881949	0.961342	0.23029	-0.42196	-0.69774
Mg	0.919149	0.403254	0.934331	1	0.787125	0.674841	0.938509	0.725529	-0.439	0.121051	0.015314	-0.72084	0.93288	0.996351	0.342548	-0.28592	-0.60117
Na	0.957639	0.406053	0.718705	0.787125	1	0.866892	0.898411	0.773085	-0.38547	0.275987	0.358818	-0.70475	0.948992	0.780245	0.829897	-0.14743	-0.04699
K	0.875317	-0.00433	0.647953	0.674841	0.866892	1	0.865464	0.951191	-0.25441	-0.02714	-0.01333	-0.49605	0.860296	0.676552	0.638962	-0.23969	-0.12076
Cl	0.981114	0.317063	0.876418	0.938509	0.898411	0.865464	1	0.863363	-0.37363	0.006993	0.039059	-0.75327	0.980136	0.934974	0.523336	-0.3366	-0.41507
SO4	0.84101	-0.10079	0.648235	0.725529	0.773085	0.951191	0.863363	1	-0.17737	-0.16234	-0.15403	-0.39265	0.831093	0.715781	0.477157	-0.17972	-0.24771
CO3	-0.41845	-0.48508	-0.38727	-0.439	-0.38547	-0.25441	-0.37363	-0.17737	1	-0.25057	-0.33766	0.574969	-0.41862	-0.43192	-0.22636	0.180901	0.309548
HCO3	0.159905	0.209283	0.238616	0.121051	0.275987	-0.02714	0.006993	-0.16234	-0.25057	1	0.418165	-0.04687	0.190323	0.150668	0.337506	0.260629	0.103616
F	0.158613	0.605854	-0.14563	0.015314	0.358818	-0.01333	0.039059	-0.15403	-0.33766	0.418165	1	-0.31854	0.143372	-0.02304	0.66118	0.431368	0.571024
pH_GEN	-0.73945	-0.68004	-0.67471	-0.72084	-0.70475	-0.49605	-0.75327	-0.39265	0.574969	-0.04687	-0.31854	1	-0.7341	-0.7185	-0.46525	0.56736	0.33443
EC_GEN	0.998325	0.364535	0.881949	0.93288	0.948992	0.860296	0.980136	0.831093	-0.41862	0.190323	0.143372	-0.7341	1	0.93195	0.614969	-0.25818	-0.34802
HAR_Total	0.916189	0.38401	0.961342	0.996351	0.780245	0.676552	0.934974	0.715781	-0.43192	0.150668	-0.02304	-0.7185	0.93195	1	0.319801	-0.32195	-0.63156
SAR	0.640096	0.399447	0.23029	0.342548	0.829897	0.638962	0.523336	0.477157	-0.22636	0.337506	0.66118	-0.46525	0.614969	0.319801	1	0.106119	0.498757
RSC	-0.26186	-0.16748	-0.42196	-0.28592	-0.14743	-0.23969	-0.3366	-0.17972	0.180901	0.260629	0.431368	0.56736	-0.25818	-0.32195	0.106119	1	0.527137
Na%	-0.31676	-0.06429	-0.69774	-0.60117	-0.04699	-0.12076	-0.41507	-0.24771	0.309548	0.103616	0.571024	0.33443	-0.34802	-0.63156	0.498757	0.527137	1

The correlation matrix revealed several significant relationships among the water quality parameters. Notably, **TDS and Sodium (Na)** exhibit a strong positive correlation (r = 0.96), indicating that sodium concentration is a major contributor to the total dissolved solids, directly influencing salinity levels. Similarly, the correlation between **SAR and Na%** (r = 0.83) suggests that higher sodium concentrations increase the sodium hazard, posing a risk for irrigation practices. Furthermore, **Total Hardness (HAR_Total) and Magnesium (Mg)** show an almost perfect positive correlation (r = 0.99), emphasizing that magnesium, alongside calcium, is a significant factor in water hardness. A negative correlation between **pH and TDS** (r = -0.74) reveals that as mineral content increases, pH tends to decline slightly, potentially reducing the water's alkalinity. These relationships highlight sodium's critical role in water quality, influencing both salinity (TDS) and sodium hazard (SAR). Additionally, the elevated magnesium and calcium levels contribute to water hardness, which can present challenges for both domestic consumption and industrial use.





Conclusion

The groundwater quality in the Musiri region shows significant variability, with elevated levels of **TDS**, **sodium**, and **hardness** in some areas. Key findings indicate the presence of **salinity concerns**, with high TDS and electrical conductivity (EC) values potentially affecting both drinking water and crop health. **Sodium hazard** is evident from the high SAR and sodium percentage (Na%), which may lead to soil degradation if not managed properly in agricultural applications. Additionally, many water samples exhibit **moderate to high hardness**, indicating the need for water softening for domestic use. This study emphasizes the importance of **regular monitoring** and the potential need for **water treatment interventions** to ensure safe and sustainable water usage in the region. For agricultural use, employing strategies to manage sodium levels will help mitigate risks to soil quality.

Recommendations

- **Water Treatment**: Implement water treatment technologies, such as **reverse osmosis or softening**, in areas with elevated TDS and hardness to ensure safe drinking water for households.
- **Monitoring Sodium Levels**: Regularly monitor **sodium concentrations** and **SAR** values to identify areas at risk of **soil degradation** and take appropriate preventive measures.
- **Blending Water Sources**: To reduce the impact of high SAR water on soil, farmers should consider **blending** it with lower SAR water sources, thereby maintaining soil productivity for agriculture.
- **Alkalinity and pH Management**: In areas with high TDS levels, pH monitoring is recommended to prevent water becoming too acidic or affecting crop growth.
- **Tailored Agricultural Use**: Farmers should select crops that are more **salinity-tolerant** or implement **irrigation strategies** that minimize the impact of high-sodium water on soil health.

This detailed analysis of water quality in the Musiri region, incorporating **statistical trends, correlations, and visual insights**, provides a framework for sustainable water management. Identifying the interplay between parameters such as **TDS, SAR, and sodium content** enables more informed decision-making and targeted interventions to mitigate risks. Ongoing **monitoring and proactive water management strategies** are essential to ensure the long-term availability of safe water for both domestic and agricultural use.

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Data Availability: Water quality Data collected from PWD Government of Tamilnadu