

MACHINE LEARNING-BASED WATER QUALITY ASSESSMENT OF GROUND WATER IN NANJIKOTTAI, THANJAVUR

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ABSTRACT

This project presents a Machine Learning (ML)-based approach to assess the groundwater quality in the Nanjikottai region of Thanjavur, Tamil Nadu. Groundwater is a primary source for both domestic and agricultural needs in this area; however, increasing urbanization and agricultural runoff pose significant threats to its chemical integrity. Traditional water quality indexing methods often involve complex manual calculations and may struggle with large-scale, non-linear environmental data. To address this, we developed a predictive framework utilizing various ML algorithms to classify water samples based on key physicochemical parameters such as pH, Total Dissolved Solids (TDS), Electrical Conductivity (EC), Chlorides, and Nitrates.

KEYWORDS

Water quality prediction, machine learning algorithm, spatial mapping

INTRODUCTION

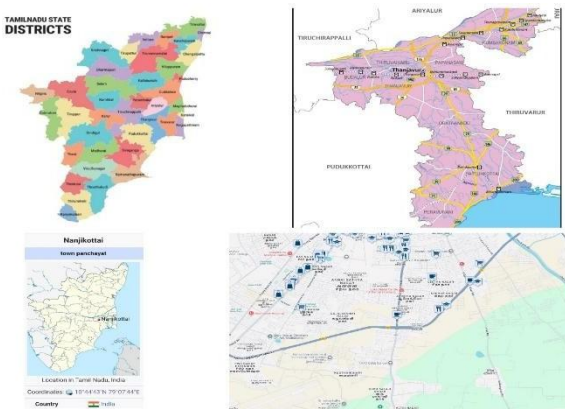
In India, especially in agrarian belts like Nanjikottai in Thanjavur district, groundwater and surface water are primary sources for drinking, domestic, and irrigation purposes. Traditional methods of water quality assessment involve periodic sampling and laboratory analysis, which, although accurate, can be time-consuming, labor-intensive and expensive. Increasing availability of data science, environmental data, machine learning (ML) techniques offer a powerful alternative for rapid,

predictive, and scalable water quality monitoring and management. This study explores the integration of machine learning algorithms to assess, classify, and predict the water quality status in the Nanjikottai region, using measured parameters such as pH, Total Dissolved Solids (TDS), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), turbidity, and nitrate levels. The approach not only aims to enhance the efficiency of water monitoring but also seeks to provide early warnings for contamination, assist in sustainable water

resource management, and support informed policy decisions.

STUDY AREA

- Location-1 = Irudaya Samy Nadar mandapam
- Location-2 = Govt. (A.D.W) Primary School Water Tank
- Location-3 =Veterinary hospital water tank
- Location-4 = TAAC School
- Location-5 = Tamil Nadu sericulture training institute.



PROBLEM DEFINITION

High Salinity (TDS): Total Dissolved Solid soften exceed 1,000 mg/L, making the water taste salty and unsuitable for sensitive uses.
Excessive Hardness: High levels of Calcium and Magnesium cause & leading to pipe scaling and health concerns like kidney stones over long-term consumption

Nitrate & Sewage Seepage: Fertilizer runoff and leaking septic tanks have increased nitrate levels, which is a major risk for infants. Chlorine

Deficiency:

While water is often safe at the source, about 65% of tap samples lack residual chlorine, leaving it vulnerable to bacteria as it travels through pipes Industrial Runoff: Proximity to rice mill and small industries contributes to localized chemical imbalances (alkalinity and iron). Total Hardness: The presence of high calcium and magnesium concentrations is a frequent issue, leading to & hard water“ that causes scaling in pipes and appliances and is less effective for domestic use.

To assess the physical-chemical characteristics of groundwater and surface water in Nanjikottai region by collecting and analyzing water samples from selected locations. To compute the Water Quality Index (WQI) based on parameters such as pH, TDS, BOD, COD, nitrate, turbidity,

etc., and classify water into quality categories (e.g., excellent, good ,poor).To apply machine learning algorithms (e.g., Decision Trees, Random Forest, SVM, etc.)to Predict key water quality parameters, Classify water as potable or non-potable, Identify pollution patterns and critical zone.

S.N O	PARAMETER	UNIT	TEST METHOD
1.	pH@25*c	--	IS 3025 part 11-2022
2.	Total Alkalinity as CaCO3	mg/L	IS 3025-part 23-1986
3.	Total Hardness as CaCO3	mg/L	IS 3025-part 21-2003
4.	Nitrate as NO3	mg/L	APHA 23 rd Edition 2017-4500-NO3 B
5.	Chloride as Cl	mg/L	IS 3025-part 32-1988
6.	Fluoride as F	mg/L	APHA 23 rd Edition 2017-4500-F-D
7.	Sulphate as SO4	mg/L	IS 3025-part 24-secl-2022
8.	Appearance	--	Visual observation

provided which can be changed according to the need.

S.N O	PARAMETER	UNIT	TEST METHOD
17.	Potassium as K	mg/L	APHA 23 rd Edition 2017-3500 K B
18.	Iron as Fe	mg/L	APHA 23 rd Edition 2017-3500 Fe B
19.	Manganese as Mn	mg/L	APHA 23 rd Edition 2017-3500 Mn B
20.	Ammonia as NH3	mg/L	APHA 23 rd Edition 1989-4500 NH3C
21.	Nitrite as NO2	mg/L	APHA 23 rd Edition 2017-4500-NO2 B
22.	Total Phosphate as PO4	mg/L	APHA 23 rd Edition 2017-4500 P-D
23.	Tidy's as O2	mg/L	APHA 23 rd Edition 2017-4500 O-B
24.	Residual Chlorine as Cl2	mg/L	APHA 23 rd Edition 2017-4500 CL-B

PARAMETERS AND TESTED METHODS

S.N O	PARAMETER	UNIT	TEST METHOD
9.	Odour	--	IS 3025 part 5:1983
10.	Turbidity	NTU	APHA 23 rd Edition 2017-2130 B
11.	Total Dissolved Solids	mg/L	APHA 23 rd Edition 2017-2540 C
12.	Conductivity	μ mho/cm	APHA 23 rd Edition 2017-2510 B
13.	P- Alkalinity	mg/L	IS 3025-part 23-1983
14.	Calcium as Ca	mg/L	APHA 23 rd Edition 2017-3500 Ca B
15.	Magnesium as Mg	mg/L	APHA 23 rd Edition 2017-3500 Mg B
16.	Sodium as Na	mg/L	APHA 23 rd Edition 2017-3500 Na B

This all are following parameters and tested methods to be conducted.

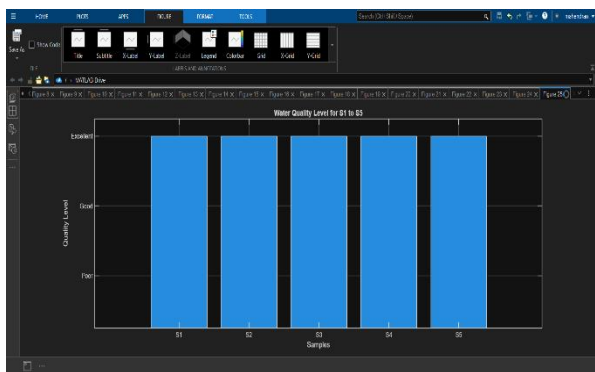
RESULT&DISCUSSIONS

S.N O	PARAMETER	UNIT	TEST METHOD	RESULT	REMARK	SPECIFICATION AS PER IS 10500:2012	
						Acceptable Limit	Permissible Limit
1.	pH@25*c	--	IS 3025 part 11-2022	6.57	Good	≤6.5-8.5	≤6.5-8.5
2.	Total Alkalinity as CaCO3	mg/L	IS 3025-part 23-1986	100	Excellent	≤200	≤600
3.	Total Hardness as CaCO3	mg/L	IS 3025-part 21-2003	160	Poor	≤200	≤600
4.	Nitrate as NO3	mg/L	APHA 23 rd Edition 2017-4500-NO3 B	14	Poor	≤45	≤45
5.	Chloride as Cl	mg/L	IS 3025-part 32-1988	75	Excellent	≤250	≤1000
6.	Fluoride as F	mg/L	APHA 23 rd Edition 2017-4500-F-D	0.40	Excellent	≤1.0	≤1.5
7.	Sulphate as SO4	mg/L	IS 3025-part 24-secl-2022	11	Excellent	≤200	≤400
8.	Appearance	--	Visual observation	Clear	Excellent	Clear	Clear

VALIDATION & CONCLUSION

APPLICATIONS

Public Health Safety: By identifying the concentration of physical and chemical parameters, the study determines the suitability of groundwater for drinking



purposes based on IS 10500 standards, helping to prevent waterborne diseases and long-term health issues like fluorosis or kidney stones.

S.N O	PARAMETER	UNIT	TEST METHOD	RESULT	REMARK	SPECIFICATION AS PER IS 10500:2012	
						Acceptable Limit	Permissible Limit
9.	Odour	--	IS 3025 part 5:1983	Agreeable	Excellent	Agreeable	Agreeable
10.	Turbidity	NTU	APHA 23 rd Edition 2017-2130 B	0.1	Excellent	≤1	≤1
11.	Total Dissolved Solids	mg/L	APHA 23 rd Edition 2017-2540 C	349	Excellent	≤500	≤2000
12.	Conductivity	μ mho/cm	APHA 23 rd Edition 2017-2510 B	499	Good	≤750	≤2250
13.	P- Alkalinity	mg/L	IS 3025-part 23-1983	0	Excellent	≤200	≤600
14.	Calcium as Ca	mg/L	APHA 23 rd Edition 2017-3500 Ca B	42	Excellent	≤75	≤200
15.	Magnesium as Mg	mg/L	APHA 23 rd Edition 2017-3500 Mg B	13	Excellent	≤30	≤100
16.	Sodium as Na	mg/L	APHA 23 rd Edition 2017-3500 Na B	48	Excellent	≤50	≤200

S.N O	PARAMETER	UNIT	TEST METHOD	RESULT	REMARK	SPECIFICATION AS PER IS 10500:2012	
						Acceptable Limit	Permissible Limit
17.	Potassium as K	mg/L	APHA 23 rd Edition 2017-3500 K B	4	Excellent	≤10	≤12
18.	Iron as Fe	mg/L	APHA 23 rd Edition 2017-3500 Fe B	0.00	Excellent	≤0.3	≤1.0
19.	Manganese as Mn	mg/L	APHA 23 rd Edition 2017-3500 Mn B	0.00	Excellent	≤0.1	≤0.3
20.	Ammonia as NH3	mg/L	APHA 23 rd Edition 1989-4500 NH3C	0.00	Excellent	≤0.5	≤0.5
21.	<input type="checkbox"/> Nitrite as NO2	mg/L	APHA 23 rd Edition 2017-4500-NO2 B	0.00	Excellent	≤0	≤0.1
22.	Total Phosphate as PO4	mg/L	APHA 23 rd Edition 2017-4500 P-D	0	Excellent	≤0.1	≤1.5
23.	Tidy's as O2	mg/L	APHA 23 rd Edition 2017-4500 O-B	0.20	Excellent	≤1.0	≤3.0
24.	Residual Chlorine as Cl2	mg/L	APHA 23 rd Edition 2017-4500 CL-B	0.0	Excellent	≤0.2	≤1.0

Planning: The results provide a baseline for local authorities to design appropriate filtration or treatment systems (such as RO plants or Ion-exchange units) specifically tailored to the contaminants found in the Nanjikottai region.

Agricultural Management: Since many groundwater sources are used for irrigation, this assessment helps farmers understand if the water's salinity or mineral content is suitable for local crops, preventing soil degradation and ensuring better yields.

Environmental Monitoring & Mapping: The data can be used to create water quality maps of the Thanjavur district. This helps in tracking the movement of pollutants and identifying areas where groundwater is being over-exploited or contaminated by external runoff.

□ **Policy Support:** This report can act as a technical reference for government bodies and NGOs to implement sustainable water management strategies, such as rainwater harvesting or artificial recharge zones, to improve the local water table quality.

FUTURE SCOPE

Real-Time IoT Integration: Deploying low-cost sensors in Nanjikottai wells for live data streaming. Transitioning from static datasets to a Real-Time Water Quality Index (RWQI).

Spatio-Temporal Forecasting: Using LSTM (Long Short-Term Memory) networks to predict quality trends across different seasons in Thanjavur. Analyzing the long-term impact of agricultural runoff on groundwater.

Mobile Application Development: A user-friendly app for local residents to check potability based on their GPS location

CONCLUSION

EFFECTIVE ASSESSMENT: Successfully integrated Machine learning algorithms to assess groundwater quality in the Nanjikottai, Thanjavur region with high accuracy.

WQI PREDICTION: The model effectively predicts the water quality index (WQI), reducing the needs for expensive and time-consuming manual laboratory testing.

SPATIAL INSIGHTS: Identified critical zones of groundwater contamination, providing a clear map for local authorities to prioritize water treatment.

DATA DRIVEN DECISIONS: Proved that AI/ML tools are essential for modern civil engineering projects in managing sustainable water resources.

CUMMUNITY IMPACT: This research offers a scalable framework to ensure safe drinking water for the growing population in the Thanjavur districts.

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[7] Spatio-Temporal Forecasting: Using LSTM (Long Short-Term Memory) networks to predict quality trends across different seasons in Thanjavur. Analyzing the long-term impact of agricultural runoff on groundwater.

[8] Mobile Application Development: A

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[9] Spatio-Temporal Forecasting: Using LSTM (Long Short-Term Memory) networks to predict quality trends across different seasons in Thanjavur. Analyzing the long-term impact of agricultural runoff on groundwater.

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