**From Assessment to Implementation: Core Messages and Outcomes of the Groundwater Quality Study in the Nineveh Plain and Their Implications for Sustainable Groundwater Management**

**Introduction**:

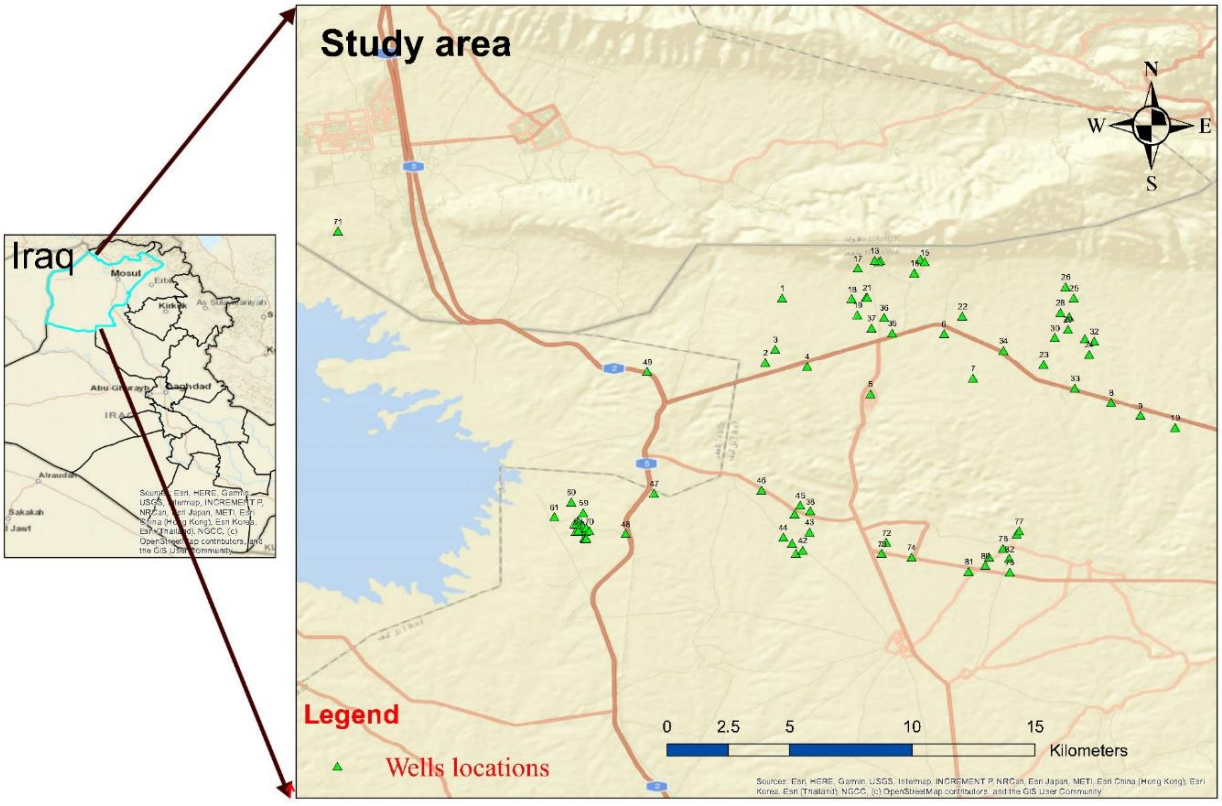
Groundwater is the main source of domestic and agricultural water in the Nineveh Plain, Iraq, where growing population, expanded farming, climate variability, and reduced surface water have placed increasing pressure on this vital resource. This study evaluated groundwater quality in the AlQosh–Tel-Kif area during summer 2025 through hydrochemical, irrigation, trace metal, and microbiological analyses following WHO standard methods.

Results indicate neutral to slightly alkaline groundwater, ranging from fresh to moderately mineralized, mainly controlled by water–rock interaction and limited human influence. Most samples are suitable for irrigation with proper management, while drinking-water quality generally meets standards; however, localized contamination by arsenic, lead, uranium, and microbial indicators highlights the urgent need for monitoring, well protection, and sustainable groundwater management.

**Research Methodology**:

A total of 82 groundwater samples were collected from wells during the period from July to August 2025. Samples were obtained using 0.5-liter plastic bottles commonly used for drinking water, which were thoroughly cleaned and rinsed with deionized water, then air-dried at room temperature prior to sampling. To ensure representative samples, each bottle was rinsed several times with groundwater from the source, and samples were collected after pumping the well for at least three cycles to allow adequate flushing.

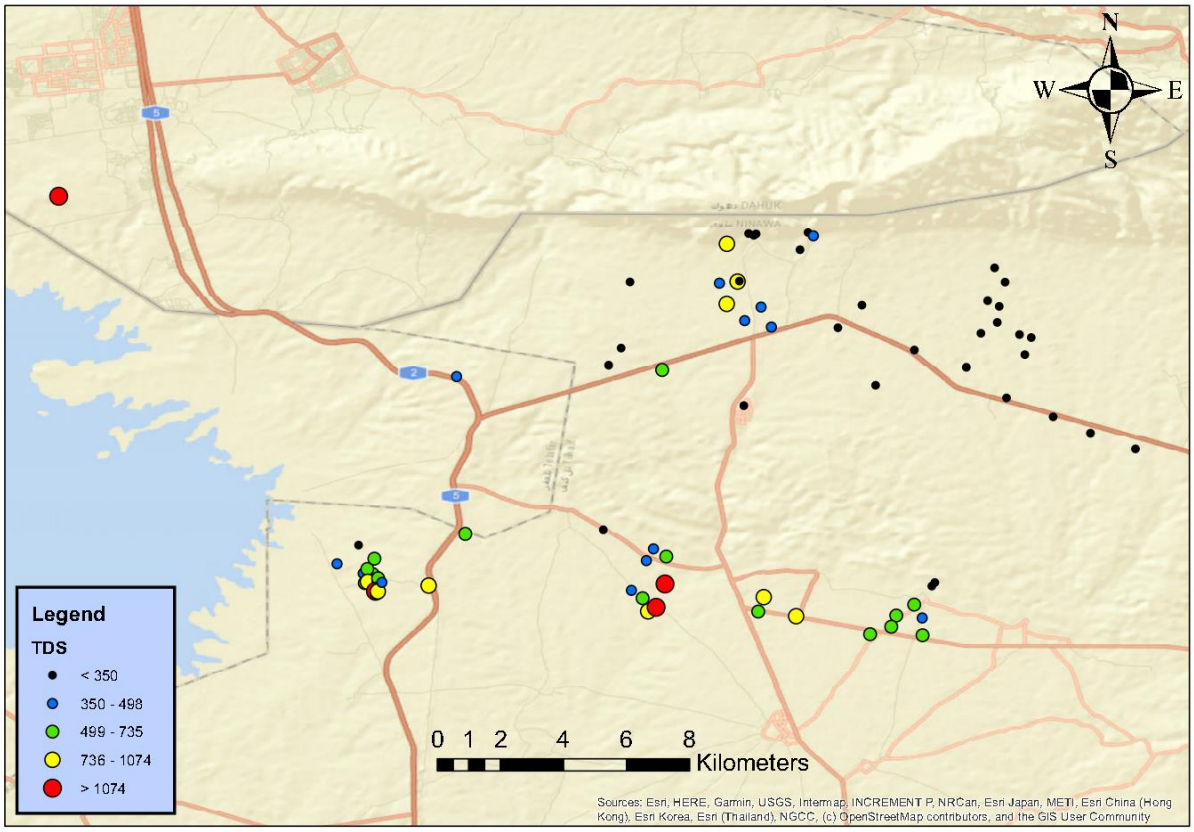
Immediately after collection, samples were placed in icebox containers to preserve their quality and minimize temperature fluctuations, in accordance with U.S. Environmental Protection Agency guidelines (2016). All samples were subsequently stored at 4 °C in a laboratory refrigerator before being transported to the Atmospheric Laboratory in Erbil for further analysis.

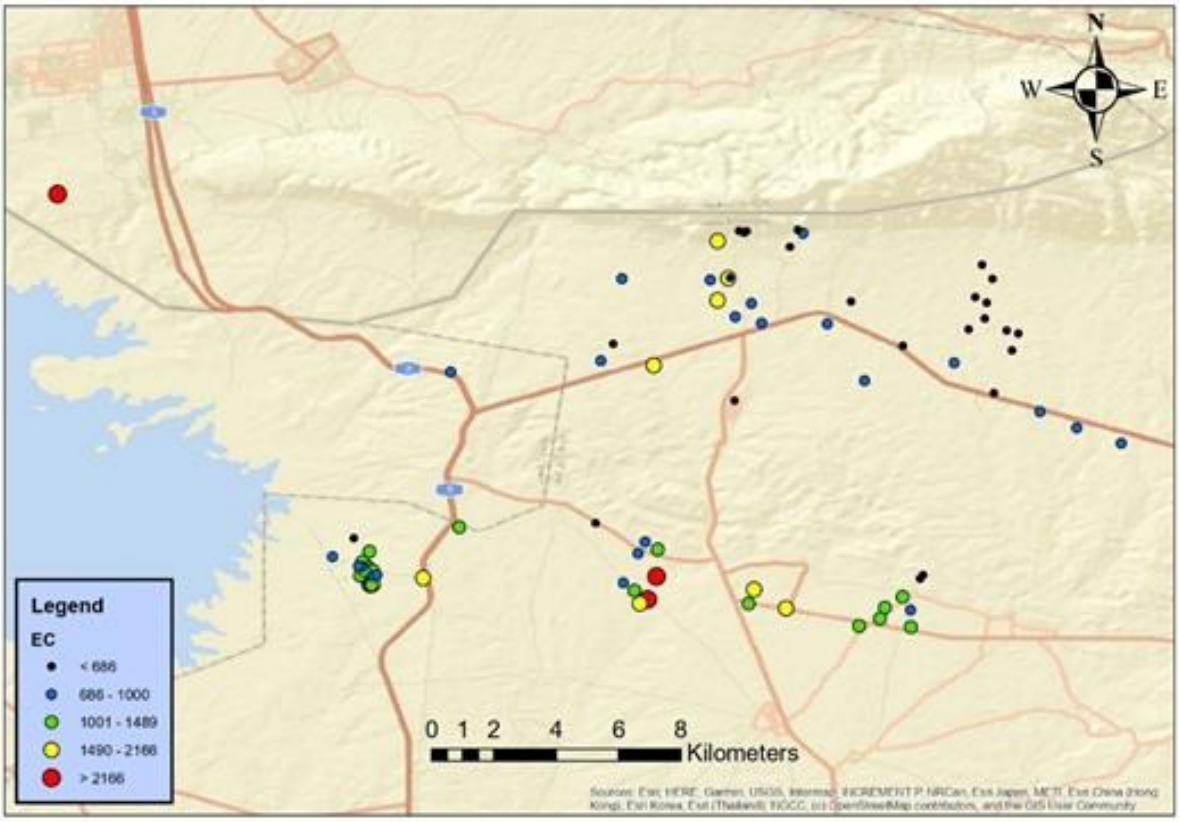


**From Wells to lap: Understanding Groundwater Dynamics in Nineveh plain:**

The concentrations of total dissolved solids (TDS) varied from 160 to 1990 mg/L, with an average value of 525 mg/L; thus, mostly fresh to moderately mineralized groundwater. Thirty-four samples exceeded the WHO aesthetic guideline for drinking water (500 mg/L), whereas only one sample was above the limit set by Iraq of 1500 mg/L for potable water.

The electrical Conductivity (EC) values, denoting wide variability in mineralization the aquifer system, ranged between 325 and 4000 µS/cm, with a mean of 1077.97 µS/cm.






## Recommendations:

1. Implementation of a long-term groundwater monitoring program that includes monthly or, at a minimum, seasonal measurements. Emphasis should be placed on cooperation and coordination among groundwater users, academic research teams, governmental institutions, and non-governmental organizations to ensure data accuracy and continuity of monitoring.

2. Reduction of negative anthropogenic impacts on groundwater quality by maintaining a minimum distance of 500 meters between wells and potential sources of contamination, particularly livestock facilities, solid waste disposal sites, and wastewater discharge areas.

3. Rationalization of agricultural fertilizer and pesticide use through strict adherence to the quantities and types recommended by agricultural authorities and relevant agencies, thereby minimizing nitrate leaching and the infiltration of chemical compounds into the aquifer.

4. Promotion of modern irrigation techniques, such as drip and sprinkler irrigation, due to their effectiveness in reducing water losses and limiting the leaching of salts and contaminants into groundwater.

5. The study results indicate that groundwater quality in the study area is generally suitable for agricultural use. Nevertheless, it is recommended to regulate the exploitation of this resource by prioritizing rain-fed agriculture or cultivating summer crops with low water requirements, in order to preserve the long-term sustainability of the aquifer.

6. Prohibition of groundwater use for drinking purposes without prior treatment, and the necessity of subjecting well water to disinfection and filtration processes (chlorination and filtration) in accordance with World Health Organization (WHO) guidelines, given the detection of certain biological indicators that may pose health risks to consumers.

7. Regular and systematic monitoring of groundwater levels and well productivity rates, including both existing wells and those proposed for future drilling, to assess the impacts of climate change, declining precipitation, and increasing groundwater demand for agricultural and domestic purposes on aquifer storage, and to ensure its sustainability in the medium and long term.

8. Call upon local governments, agricultural departments, groundwater authorities, and relevant stakeholders to organize awareness programs and training workshops aimed at enhancing public understanding of the importance of groundwater, as well as promoting safe and sustainable extraction and use practices across various sectors.

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