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Comparative hydrochemical assessment of groundwater quality from different aquifers for irrigation purposes: Study area Armavir Region in Armenia

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Abstract. Groundwater quality is a key parameter in sustainable agriculture and water resource management. Poor groundwater quality directly affects soil properties and crop yields. This research aimed to study and assess the irrigation properties of groundwater in the Armavir region, one of Armenia's major agricultural centers. For the first time, groundwater irrigation suitability in this area has been evaluated using advanced methods, considering both the region's climatic conditions and the impact of anthropogenic factors. Sampling was conducted from 72 wells, 41 of which belonged to unconfined aquifers and 31 to confined aquifers. Often, the same groundwater with different indicators can have significantly different water quality, therefore, it is preferable to use the USSL and Wilcox plots, each of which includes two indicators and gives a more integral assessment. In this case, Electrical conductivity (EC) and various indices (SAR and Na%) were used in the graphical analysis. USSL plot analysis data showed that groundwater from wells in the unconfined aquifer has a high salt and low alkalinity hazard, while groundwater from the confined aquifer is suitable for almost all types of soils. According to Wilcox, most of the wells in both horizons fall into the "good to permissible" category. However, insufficient groundwater quality was observed at some monitoring wells, and long-term irrigation with such groundwater can lead to soil degradation and hinder the implementation of the SDGs.
Keywords: Groundwater quality, Hydrochemical property, Sustainable agriculture, USSL and Wilcox plots

1. Introduction

Groundwater constitutes one of the principal natural sources of freshwater globally. Its quality is increasingly compromised due to factors such as rapid urbanization, intensified agricultural practices, and industrial activities (Samtio et al., 2022). In the Republic of Armenia, groundwater holds particular importance, notably in the Armavir region, which serves as the area of this investigation. The Armavir region is distinguished by extensive agricultural activities and is recognized as a major agricultural center within the country. Given these circumstances, both the availability and quality of groundwater are critical. It is also noteworthy that the use of low-quality water for irrigation can alter the physical and chemical properties of the soil, thereby significantly impacting crop yield (Abdelkarim et al., 2022). Several indices, including the Permeability Index (PI), Sodium Percentage (Na%), Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC), and Magnesium Hazard (MH), are employed to assess the suitability of groundwater for irrigation. However, it is more appropriate to use methods that provide a more general assessment of groundwater quality, since the same groundwater may be of good quality by one index and unsuitable for irrigation by another. That is why graphical representation, such as United States Salinity Laboratory (USSL) and Wilcox plots, is more effective, as they give an assessment based on the consolidated values of various indicators.

2. Materials and methods

2.1. Study area

The Armavir region is situated within the Ararat Plain, a zone characterized by high agricultural utilization. It constitutes approximately 4.17% of Armenia's total land area. The agricultural irrigation in this region uses both surface and groundwater sources.

2.2. Sampling and laboratory measurements

Water samples were collected from 72 wells in the Armavir region, which were uniformly distributed across the study area. Of these, 41 wells were sourced from the unconfined aquifer, and 31 wells were from the confined aquifer. The groundwater samples were collected monthly, and the sampling and analysis were conducted between April and October 2022-2023. The electrical conductivity (EC) is measured using a conductivity meter (MAPK 603). Concentrations of K^+, Na^+, and Ca^{2+} ions were quantified using a flame photometer (Bioevopeak), whereas Mg^{2+} concentration was assessed using a laboratory ion meter (I-160 M).

2.3. Data processing and methods of hydrochemical classification

Two graphical methods were employed to assess the suitability of groundwater for irrigation purposes (USSL and Wilcox plots). For this purpose, we determined indices such as SAR and Na%, and hydrochemical parameters of groundwater, such as EC (Ghazaryan et al., 2020).

3. Results

During the evaluation of the irrigation properties of water using the USSL plot, important indicators such as SAR and EC were used, and in the case of Wilcox, Na% and EC. Analysis of USSL plot data showed that 4.9% of the groundwater in the unconfined aquifer has C2-S1 category, 73.2% - C3-S1, 9.7% - C3-S2, 4.9% - C4-S1, 4.9% - C4-S2, and 4.9% - C4-S4. And in the confined aquifer, 19.4% has C2-S1 category, 71% - C3-S1, 6.4% - C3-S2, and 3.2% - C4-S2. Analysis of Wilcox plot data showed that 14.6% of groundwater in unconfined aquifers was classified as "doubtful to unsuitable", 12.2% as "permissible to doubtful", 68.3% as "good to permissible", and 4.9% as "excellent to good", and 3.2% of groundwater in confined aquifers was classified as "doubtful to unsuitable", 6.4% as "permissible to doubtful", 67.8% as "good to permissible", and 22.6% as "excellent to good". In some areas, comparatively poor quality of groundwater in unconfined aquifers may be due to both natural (climatic and geological characteristics of the region) and anthropogenic (especially large-scale agricultural activities, use of traditional irrigation systems, over-use of groundwater, over-fertilization, etc.) processes.

4. Conclusion

Studying the irrigation properties of groundwater in the Armavir region using a graphical approach, which provides a more general assessment, reveals that groundwater in the unconfined aquifer is of lower quality compared to the confined aquifer.

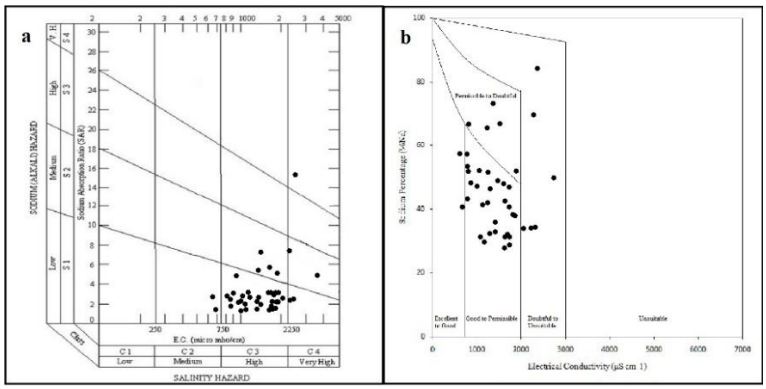

Figure 1. Classification of the groundwater from unconfined aquifer using USSL (a) and Wilcox (b) plots

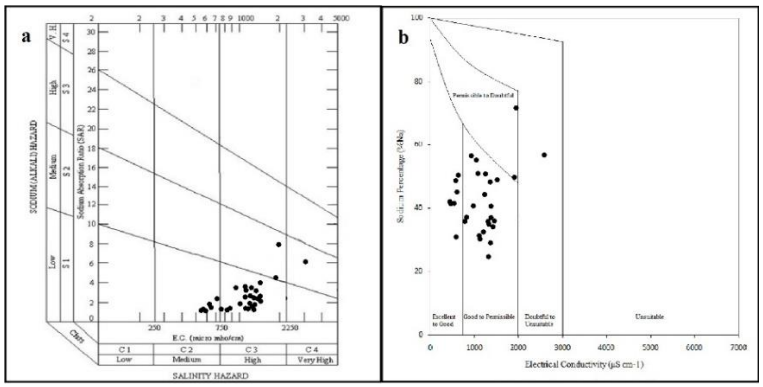

Figure 2. Classification of the groundwater from confined aquifer using USSL (a) and Wilcox (b) plots

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