

Evaluation of Physical and Chemical Characteristics of Groundwater in the Northern Region - A Case of the Savelugu/Nanton District

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ABSTRACT

The Northern Region is characterised with semi-arid climate. Due to insufficient and polluted surface water resources, groundwater is increasingly gaining significance as the main solution to the water supply problems in the region, especially in the rural areas such as the Savelugu/Nanton district. However, identifying high yielding wells is a major problem for most of the organisations involved in the provision of water in the district. The District is underlain by rocks belonging to both the upper and middle Voltaian Palaeozoic rocks which are predominantly sandstones, mudstones and siltstones.

This study focuses first and foremost, on the assessment of the hydraulic properties of the major aquifers in order to identify the most productive ones, which is necessary for future tasks regarding their management. Secondly, the study also aims at determining the factors that play significant roles in the hydrochemistry of the groundwater and to evaluate the suitability of the groundwater for drinking, domestic and irrigation purposes.

Pumping test data have been interpreted to determine aquifer parameters. Linear regression analysis was used to design a model to determine the relationship between these aquifer parameters. The model had yield as a dependent variable against depth and static water level (both as separate independent variables). Transmissivity was also used as a dependent variable against specific capacity and yield (both were also independent variables). Conventional graphical, mathematical, multivariate statistical methods such as Hierarchical Cluster Analysis (HCA) and Principal Component Analysis (PCA) were also employed with Water Quality Indices (WQI) on the water quality data to characterize the hydrochemistry of the groundwater and to assess its suitability for different uses. Interpolation maps were created using GS⁺, ArcView 3.3 software and GIS based techniques to show the distribution of the parameters in the district.

The sandstones aquifers are the most variable aquifers in the area in terms of transmissivity and specific capacity. The highest yielding wells in the area are completed in sandstone aquifers followed by mudstone with siltstone having the least.

Results of the regression analysis for yield as a dependent variable and depth as an independent variable reveals the coefficient of determination, R^2 to be 0.025. A similar

analysis for yield as a dependent variable and static water level as the independent variable also showed $R^2 = 0.09$. In addition, R^2 of 0.982 was obtained for transmissivity as the dependent variable and specific capacity, the independent variable. Another analysis for transmissivity as a dependent variable and yield as an independent also revealed $R^2 = 0.855$. The low value of R^2 means that the independent variable cannot predict the dependent variable and also the high R^2 value means that the dependent variable can be predicted by the independent variable using the model.

The study indicates that Na^+ and HCO_3^- are the dominant cation and anion respectively and they are the only ions that exceeded the 50% of the total cations or anion in most boreholes in the area. Most of the chemical parameters were within the WHO recommended values except for few occasions where there were slight deviations.

HCA and PCA analysis that were carried out indicate that the chemistry of groundwater in the area is largely controlled by the weathering and leaching of rocks and minerals in the area. Unhygienic conditions and the application of certain type of manure during farming were the other source of the chemistry of groundwater in the area.

Based on WQI analysis and other parameter such as EC, percent sodium, magnesium hazard, sodium adsorption ratio (SAR) and Residual Sodium Carbonate (RSC), the quality of the groundwater in the study area is good based on inferences made though some of the boreholes have issues of concern.

This research has offered a much better understanding of the hydraulic properties of the major aquifers and also the general quality and suitability of the groundwater of the study area. Some of the major findings include regression models for the aquifer parameters, prediction maps for the aquifer parameters and water quality parameters. The GIS predictive maps of the aquifer parameters would be useful for groundwater exploration and aquifer management within the study area and the Voltaian basin in particular.

To meet the present and future challenges of the population growth with regards to water demand, it is necessary to delineate areas of recharge and subsequently protect them from activities that may affect their state. Moreover continuous water quality monitoring by the Community Water and Sanitation Agency (CWSA) should be encouraged to ensure early intervention in the communities with water quality problems.

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