Hydrodynamic characterization of the Tamanrasset aquifer (Central Hoggar-South Algeria)

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Abstract— In the region of Hoggar, the alluvial aquifers superimposed on a crystalline basement presents the essential water resource for the population of the region. The aquifers contain reserves fed by the flood waters. This recharge depends on several factors, including the hydrodynamic parameters of the surface layer.

The hydrodynamic parameters (K) of an alluvial system in a Tamanrasset region were studied from grain size analysis of soil samples extracted from traditional wells, and pumping tests from wells in the same area. The geometric mean permeability (K) for the alluvial layer (9.31E-04 ms-1), determined by particle size analysis, was 90 times higher than the geometric mean obtained during the pumping tests (1.02E-05 ms-1).

Key-Words— Tamanrasset *area, alluvial aquifer, grain size analysis, pumping test, permeability.*

I. INTRODUCTION :

The region of tamanrasset which is part of the algerian Sahara whose geological formations are crystallophylic and volcanic. The region subjected to the influence of two climatic regimes, the mediterranean diet (the harmattan) and the tropical regime (monsoon). Mean annual rainfall is about (55) mm at Tamanrasset station and 140 mm at Assekrem, of which about 90% during the monsoon period from June to September. Water supply is dependent on monsoon rains, streams and groundwater systems fed by this rainfall. Surface runoff is generated during this period and recharge to aquifers occurs primarily from the infiltration of these waters.

The objective of this study is to evaluate the hydraulic conductivity of aquifers in the Tamanrasset region using statistical methods of granulometry and pumping tests. The results of this study will contribute to improving the development of groundwater resources and their subsequent management.

II. CONTEXT OF THE STUDY AREA :

The wilaya of Tamanrasset, located at the extreme Algerian more than 2000 km from Algiers in the Hoggar massif, It covers an area of 619 360 km².The watershed of the wadi Tamanrasset extends over a area of approximately 42,000 km². The study area (Figure 1) between 1,300 and 1,400 m altitude, it is part of the basin located upstream of the agglomeration of Tamanrasset

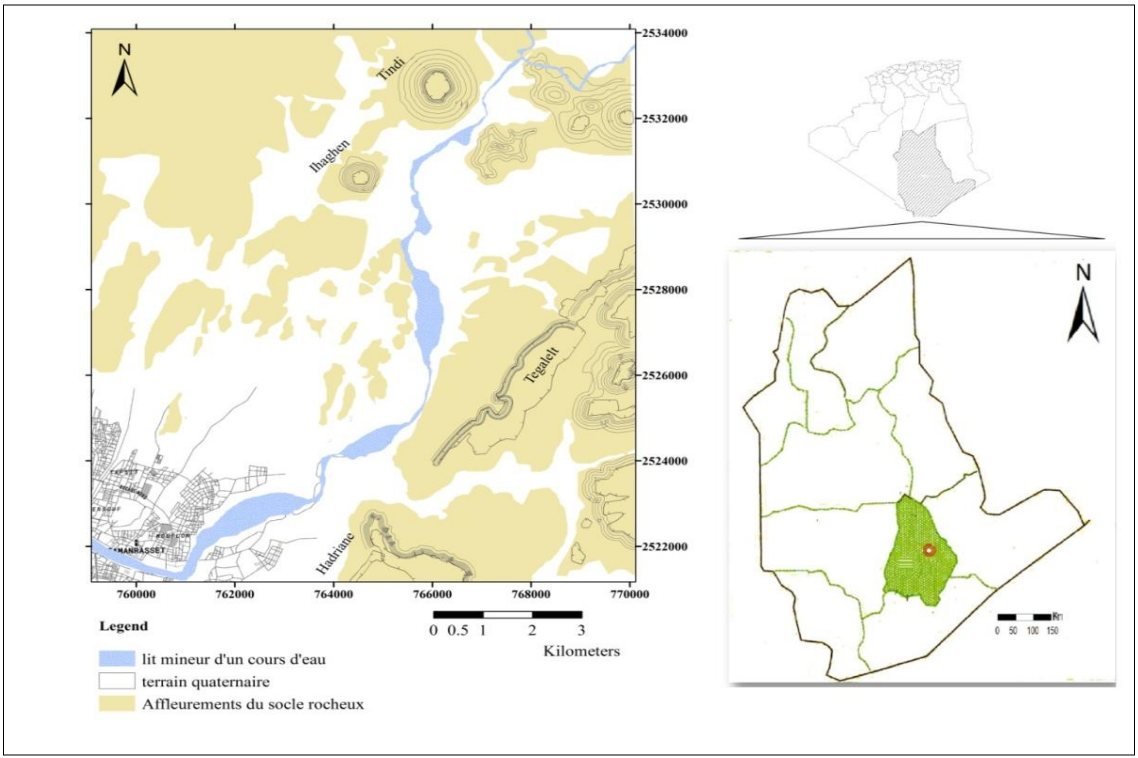

Figure 1: location map of the study area

III. MATERIAL AND METHODS :

Grain size analysis, which includes the study of soil sample size and pumping tests, were used to determine the hydraulic parameter of the aquifer in some wells. The hydraulic parameters of the aquifer include porosity and hydraulic conductivity and transmissivity.

Permeability estimation formulas from grain size analysis have been identified by several researchers (Alyamani and Şen[1],Barnes and Allison[2], Barr[3], Beyer[4], Carman[5], Chapuis[6], Cirpka[7], Kozeny[8], Krumbein and Monk[9], Terzaghi and Peck[10]).

Soil samples were collected from the wells, from the surface of the wells to the bottom, dried and analyzed for determine the size distribution by sieving method using nine (9) sieves, from 0.125 mm to 8 mm, in order to construct grain size distribution curves and determine diameters d10, d20 , d30, d50 and d60 of each sample. Statistical methods of grain size were then used to determine the hydraulic conductivity values. Estimation of hydrodynamic parameters were done by the methods of (Hazen 1892)[11] , Kozeny-Carmen (1953) and Beyer (1964) [4], as follows:

Hazen 1892 :

$$K = \frac{g}{v} \times 6 \times 10^{-4} \left[1 + 10(n - 0.26)\right] d_{10}^{2}$$

Kozeny-Carmen (1953) :

$$K = \frac{g}{v} \times 8.3 \times 10^{-3} \left[\frac{n^{3}}{(1-n)^{2}}\right] d_{10}^{2}$$

Beyer 1964 :

$$K = \frac{g}{v} \times 6 \times 10^{-4} \log \frac{500}{U} d_{10}^{2}$$

Where :

K = hydraulic conductivity

g = acceleration due to gravity

d_{10} = effective grain diameter

v = The kinematic viscosity

n = porosity

Observing the effects of pumping on the underground environment is one of the best methods of study to estimate various hydraulic properties of aquifer systems, the tests also provide to get to know the behavior of the aquifer[12]–[15].

The pumping tests were carried out in three (3) wells near the soil sampling sites in order to determine the hydrodynamic parameters (permeability and transmissivity). for this purpose, Monitoring well type Micro-Diver were used. thye are stand-alone data loggers that have been installed in wells using a cable at a given depth. They were programmed at an acquisition time interval of 15 seconds. The data will transfer to a computer for processing (Figure 2).

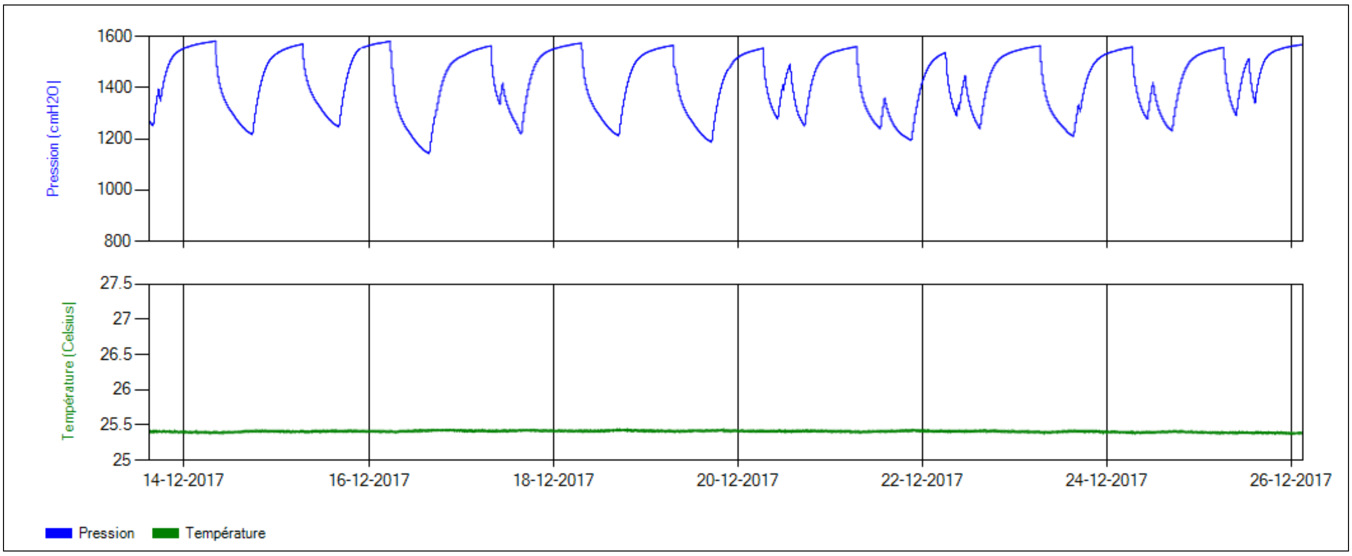

Figure 2: variations in piezometric levels as a function of time registered by data loggers during pumping test

The duration of the pumping tests averaged 10 hours with a 12-hour recovery time and the pumping were constant from (1, 4) to (4.2) m3 min-1 for different wells. Residual drawdowns are measured at the level of the boreholes themselves.

IV. RESULT AND DISCISION:

After the analysis of the grain size analysis data to calculate the hydrodynamic parameter, the overall results showed that the hydraulic conductivities calculated by the Kozeny-Carmen (1953) method between 1.58E-04 $m.s^{-1}$ and 7.24E-03 $m.s^{-1}$ with a means of 1.16E-03 $m.s^{-1}$, while the permeability calculated by the method of (Hazen, 1892) between 4.55E-05 $m.s^{-1}$ and 5.88E-03 ms^{-1} with a means of 8.98E-04 $m.s^{-1}$, and for the method of (Beyer, 1964) the hydraulic conductivity between 5.29E-05 $m.s^{-1}$ and 6.04E-03 $m.s^{-1}$ with a means of 7.35E-04 $m.s^{-1}$.

The pumping tests carried out to determine the hydraulic parameters, in particular the transmissivity (T) and the permeability coefficient (K) of the alluvial layers, gave the transmissivity values (T) calculated by the Cooper Jacob method. The transmissivity (T) ranged from 5.55 × 10-3 to 2.38 × 10-2 $m.s^{-1}$ .the permeability (K) was calculated by dividing (T) by the thickness of the water table at the pumping wells. Estimates calculated for permeability (K) ranged from 8.87E-07 to 2.00E-05 $m.s^{-1}$ with an average of 1.02E-05 $m.s^{-1}$.

Comparative results of the hydraulic conductivities measured from the defective methods show that the mean permeability values (K) estimated from the pumping tests were slightly different to those estimated from the grain size analyzes.

The mean permeability values (K) obtained from the grain size analyzes were 90 times higher than the permeability value (K) obtained from the pumping tests.

V. CONCLUSION :

Observing the results of pumping tests on the porous medium is one of the best methods for determining hydrodynamic parameters in hydrogeology. The permeability values (k) determined using the Hazen, Beyer and Kozeny-Carmen methods are significantly higher for all the test sites compared to the K values determined from the pumping tests.K values, derived from the Kozeny-Carmen methods remain the highest in most tests. These differences suggest that permeability estimation methods from grain size analyzes can not be used directly to estimate the permeability of a grandwater .

VI. REFERENCES :

[1] M. S. Alyamani et Z. Şen, « Determination of hydraulic conductivity from complete grain- size distribution curves », *Groundwater*, vol. 31, nº 4, p. 551-555, 1993.

[2] C. Barnes et G. Allison, « The distribution of deuterium and 18O in dry soils: 1. Theory », *Journal of Hydrology*, vol. 60, nº 1-4, p. 141-156, 1983.

[3] D. W. Barr, « Coefficient of permeability determined by measurable parameters », *Groundwater*, vol. 39, nº 3, p. 356-361, 2001.

[4] W. Beyer, « Zur bestimmung der wasserdurchlässigkeit von kiesen und sanden aus der kornverteilungskurve », *WWT*, vol. 14, nº 6, p. 165-168, 1964.

[5] P. C. Carman, « Flow of gases through porous media », 1956.

[6] R. P. Chapuis, « Predicting the saturated hydraulic conductivity of sand and gravel using effective diameter and void ratio », *Canadian geotechnical journal*, vol. 41, nº 5, p. 787-795, 2004.

[7] O. Cirpka, « Environmental Fluid Mechanics I: Flow in Natural Hydrosystems », 2003.

[8] J. Kozeny, « Uber kapillare leitung der wasser in boden », *Royal Academy of Science, Vienna, Proc. Class I*, vol. 136, p. 271-306, 1927.

[9] W. Krumbein et G. Monk, « Permeability as a function of the size parameters of unconsolidated sand », *Transactions of the AIME*, vol. 151, nº 01, p. 153-163, 1943.

[10] K. Terzaghi et R. B. Peck, « Soil mechanics in engineering pratice », 1967.

[11] A. Hazen, « Some physical properties of sands and gravels. Mass. State Board of Health », *24th Annual Report*, p. 539-556, 1892.

[12] J. Bruin et H. E. Hudson, « Selected methods for pumping test analysis », Illinois State Water Survey, 1955.
[13] V. T. Chow, « On the determination of transmissibility and storage coefficients from pumping test data », *Eos, Transactions American Geophysical Union*, vol. 33, nº 3, p. 397-404, 1952.
[14] G. P. Kruseman, N. A. De Ridder, et J. M. Verweij, *Analysis and evaluation of pumping test data*, vol. 11. International institute for land reclamation and improvement The Netherlands, 1970.
[15] M. P. Samuel et M. K. Jha, « Estimation of aquifer parameters from pumping test data by genetic algorithm optimization technique », *Journal of irrigation and drainage engineering*, vol. 129, nº 5, p. 348-359, 2003.