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THE USE OF THE ABANDONED FLOWING ARTESIAN WELL OF MONZOUNGOUDO IN BENIN AS A PIEZOMETER

L'UTILISATION DU FORAGE ARTESIEN JAILLISSANT ABANDONNE DE MONZOUNGOUDO AU BENIN COMME PIEZOMETRE

HOUNTONDJI B.[1], CODO F.P.[1], AINA M.P.[1]

[1] Laboratory of Water and Environmental Sciences and Techniques (LSTEE), University of Abomey-Calavi (UAC), Benin.

babilassrock@yahoo.fr

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ABSTRACT

The village of Monzoungoudo in Benin has an abandoned gushing artesian borehole located near the production well that feeds its mini drinking water distribution network. The problem that arises precisely here is the use of the abandoned artesian drilling of Monzoungoudo as a piezometer associated with its production well while removing all parasitic flows to allow to identify the variations of pressure at the head of drilling and to calculate the value of the average drawdown at the coordinate point (r =33.74m; h=286.65m) from which there is a decrease in the drawdown as the production flow increases with population growth. The function of Theis and the flow equations around the wells that are deduced from them, assuming simplifying equations, allow us to study these effects. This paper proposes the solution to this problem.

Keywords: Abandoned drilling, piezometer, production wells, drawdown, Monzoungoudo, Benin.

RESUME

Le village de Monzoungoudo au Bénin dispose d'un forage artésien jaillissant abandonné situé à proximité du puits de production qui alimente son mini réseau de distribution d'eau potable. Le problème qui se pose précisément ici est l'utilisation du forage artésien jaillissant abandonné de Monzoungoudo comme piézomètre associé à son puits de production tout supprimant tous les débits parasites pour permettre de relever les variations de pression en tête de forage et d'estimer la valeur du rabattement moyen au point de coordonnées (r=33,74m ; h=286,65m) à partir duquel on assiste à une diminution du rabattement lors que le débit production augmente avec l'accroissement de la population. La fonction de Theis et les équations d'écoulements autour des puits qui en sont déduites en supposant des équations simplificatrices permettent d'étudier ces effets. Le présent papier propose la solution à ce problème.

Mots clés : Forage abandonné, piézomètre, puits de production, rabattement, Monzoungoudo, Bénin.

INTRODUCTION

Groundwater is essentially below the earth's surface. In many regions, it is an important source of water. In understanding a hydrological system in its entirety, it is necessary to understand the groundwater system (Fetter 1994; Freeze and Cherry, 1979).

In village hydraulics, pressurized groundwater reservoirs are often encountered, exploited by gushing artesian boreholes. In these cases, groundwater rises to the surface of the ground, due to the difference in pressure between the drill foot in the reservoir and the head of the borehole; it's the phenomenon of artesianism. Figure 1 next shows a gushing artesian drilling. The porous aquifer in the village of Monzoungoudo is starting from this type of reservoir. This village has two gushing artesian boreholes, one of which is abandoned and the other functional one is used as a production well for the supply of its mini drinking water distribution network. The water gushing from the abandoned artesian borehole is not without effect on the reactions of the aquifer system, i.e. the Monzoungoudo groundwater reservoir. By switching from a closed circuit to an open circuit (artesianism gushing), man damaged the environment. This phenomenon leads to rising water and drainage problems (Remini and Souaci, 2019). Also, the supply of water to the captive water table becomes alarming and therefore leads to the flooding of the village and the destruction of crops (Remini, 2006).

The problems created by the overexploitation of the village's groundwater resource due to gushing artesianism, have motivated our interest in analyzing the drying up of this system in the study region (Boutadara et al., 2020).

The objective of this work is to be able to keep closed the monzoungodo gushing artesian drilling located near its production well so that it can act as a piezometer to allow to identify the variations in pressure at the drill head and to calculate the value of the average drawdown at the coordinate point (r =33.74m; h =286.65m) from which there is a decrease in the drawdown as the production flow increases with population growth.

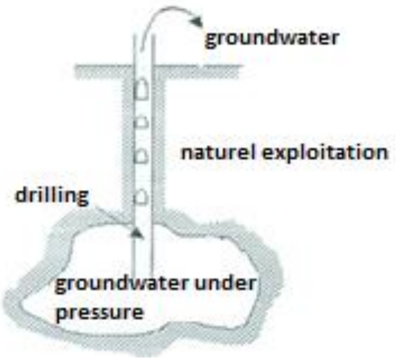

Figure 1 : Existing artesian drilling (Ben Lahbib, 2002)

DESCRIPTION OF THE PROBLEM

The model studied (Fig. 2 and Fig. 3) consists of a captive-slick natural groundwater reservoir with a waterproof roof and wall, and a production-flowing artesian well that allows groundwater to be operated. There is also the presence of an abandoned artesian drilling in the reservoir, which is used as an observation well (piezometer) and which allows the study of the behaviour of the slick during production.

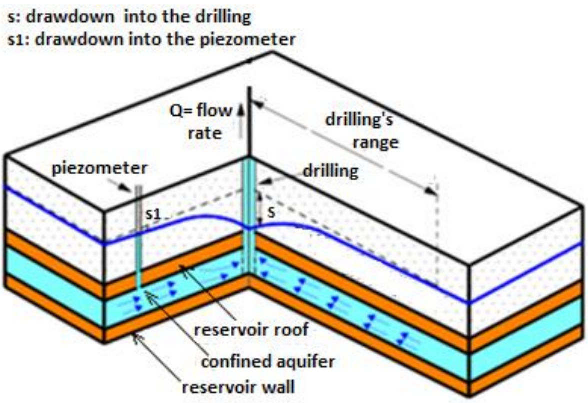

Figure 2 : Model structure (Hountondji, 2019)

MATERIAL AND METHOD

The following sections describe the material and methodology adopted in this study.

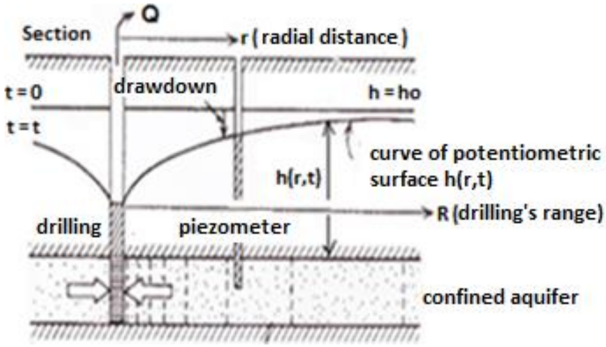

Figure 3 : Radial flow in confined aquifer (Freeze and Cherry, 1979)

METHOD

Drilling-piezometer maintained at constant flow

The abandoned existing artesian drilling (piezometer) of Monzoungoudo is at a stable initial regime (DGEau, Benin, 2012). It has the equipment in front of the clock Figure 4. It is possible to adjust the V valve so that the gushing flow remains constant when the effects of the nearby production well are felt. This drilling will not bring parasitic disturbances and production-induced flaps will be directly measured at the M gauge. In fact, the increasing loss of load due to lower slick levels will be compensated for by opening the valve.

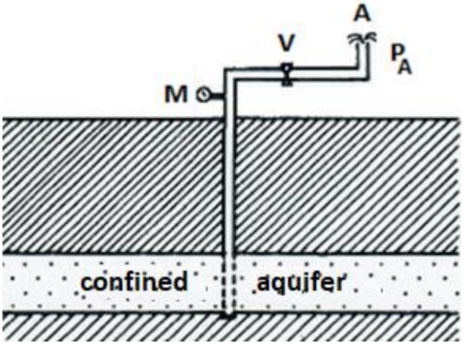

Figure 4 : Trapping in confined aquifer (Forkasiewicz. J et al, 1976). M = Pressure gauge; V= vandal body; P_A= atmospheric pressure

Analysis of the decrease in flow after drilling has opened abandoned

The closure of the abandoned Monzoungoudo drilling for a long time will note that the pressure on its cover corresponds to the static load Hst that is, the height of a column of water reaching the piezometric surface at the drilling site (Fig. 5).

As soon as the Monzoungoudo well goes into production, the load drops instantly and stabilizes at the value corresponding to the water output level of the production well. The difference between the static level Hst and the free flow level of the drilling is noted sp. This is a constant for the gushing production well whose knowledge is necessary for any interpretation of the variation in the flow.

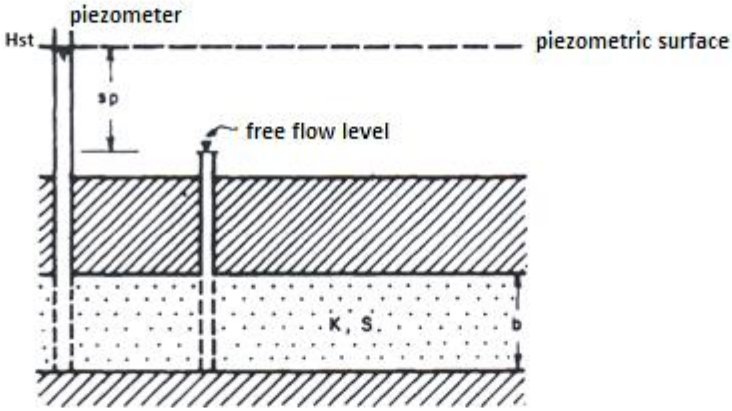

Figure 5 : Pedestrian and production wells in confined aquifer (Forkasiewicz. J and al, 1976)

MATERIAL

Solving this problem uses Theis function and flow equations around wells that are deduced from it by assuming simplifying equations.

Boundary conditions

The boundary conditions are:

Initial condition: constant potential across the field;
Well condition ($r = r_p$): constant flow for t >0

$$2\pi T\left(\frac{\partial h}{\partial r}\right)_{r_p} = Q_0$$

Condition to infinity: h = h0

Where:

r = radial distance; r_p= radius of the well; T = transmissivity; t = time

Q_0 = production flow; h = hydraulic head; h_0 = initial head

Monzoungoudo Reservoir Data

For the Monzoungoudo reservoir (DGEau, Benin), hydraulic conductivity is constant with depth and is K= 2.28×10^{-4} m/s in the model. Porosity is constant with depth and is 30 %. The storage coefficient is 0.933.

Map of water level in Monzoungoudo reservoir-piezometric map

To organize and order water level measurements from the Monzoungoudo observation well, it is interesting to use the piezometric map of the study area. It is a map of water levels based on the altitude of the water level in the wells measured against a common marker such as sea level (figure 6). The main interest of this map is to be able, to be used to determine the direction of the underground flow (Majdoub and al, 2014).

Technical data from abandoned drilling and Monzoungoudo production well

Technical data from the abandoned drilling and the Monzoungoudo production well are grouped in Table 1.

Table 1: Geometric features and hydrodynamic parameters of abandoned drilling and Monzoungoudo production well

Geometric features and hydrodynamic parameters Monzoungoudo drilling (source: DGEau Benin, 2012)		
Parameters	**Abandoned drilling**	**Production well**
Drilling depth H (m)	247	244.18
Drilling Diameter D (m)	0.126	0.126
Flow rate Q (cm^3 /s)	2000	2000
Acceleration of gravity g (m/s^2 ou N/kg)	9.81	9.81
Pressure at the head of drilling p_2 (bars)	4.16	4.16
Drilling depth H’ at the roof of the reservoir (m)	201	201

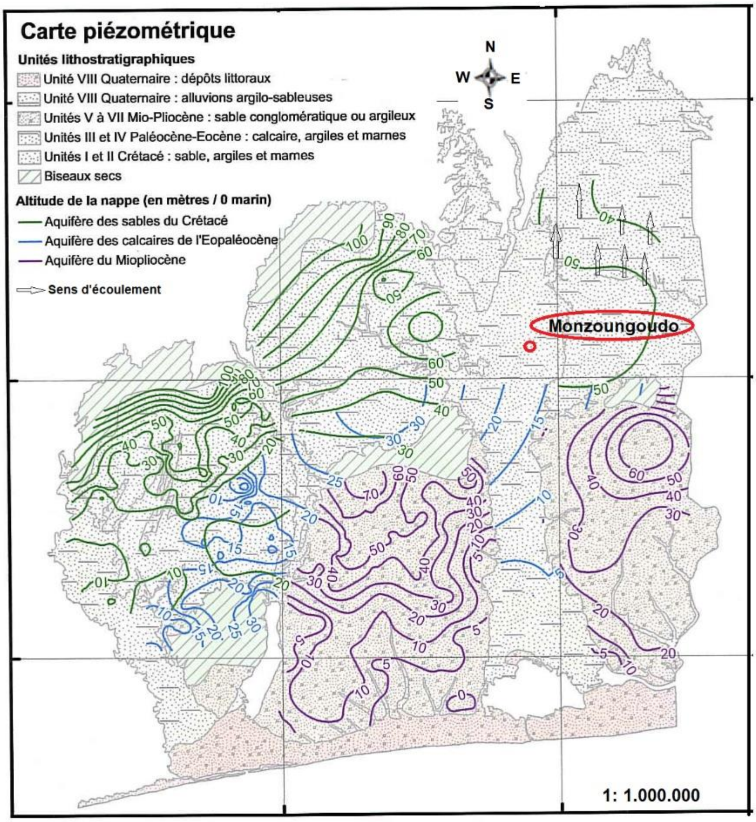

Figure 6: Piezometric map of the coastal sedimentary basin (DGEau, Benin, 2012)

RESULTS AND DISCUSSIONS

Calculating parameters by analyzing the increase in pressure after the closure of the abandoned artesian drilling from Monzoungoudo

Figure 7 presents the results that could be obtained following the closure of the abandoned artesian drilling in Monzoungoudo.

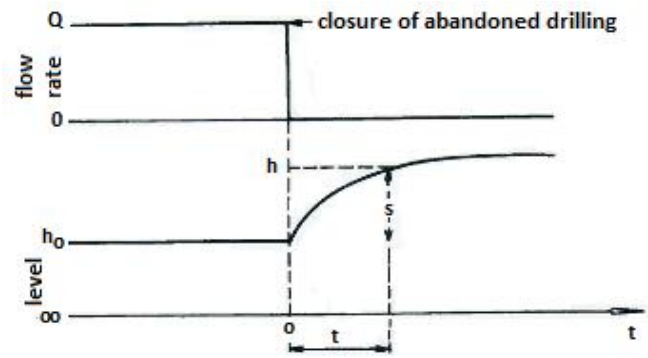

Figure 7: Flow and folding curves over time following the closure of abandoned drilling (Forkasiewicz. et al., 1976)

The abandoned artesian drilling from Monzoungoudo is flowing freely since the end date of drilling which is January 06, 2000, i.e. from a very long time; it can be considered that the range of action has had time to reach the feeding limits and that the flow regime is permanent. By abruptly stopping the flow by closing the abandoned gushing artesian drilling, the deformation of the piezometric surface will be the same as that produced by an injection of water into the constant flow drilling.

The interpretation of the increase in loads following the closure of the drilling is treated as a classic descent caused by the production, the difference of head ($H - H_0$) is the drawdown for drilling.

Calculating static head H_{st} closure of abandoned drilling and average drawdown

Static pressure Pst in the reservoir can be written as (Hountondji, 2019):

$$P_{st} = P_2 + \rho_w gH + \frac{\mu Q}{ek} + 0.06642\rho_w \frac{H}{D^{4.8}} Q^{1.8} V^{0.2} \qquad (1)$$

Where:

ρ_w = water density;

V = Darcy velocity;

e = productive thickness of sheet;

μ = dynamic viscosity of the fluid;

k = intrinsic permeability of the medium

Using the geometric and hydrodynamic data from the production well in the previous formula, we've got:

P_{st} = 28.14 bars

The static head in the drilling H_{st} is related to static pressure in the reservoir P_{st} by the relationship:

$$H_{st} = \frac{P_{st}}{\rho_w g} + e \qquad (2)$$

Using geometric and hydrodynamic data from the production well in the previous formula, we've got:

H_{st} = 330.03m

The chart below (Figure 8) is obtained from the function of Theis and the resolution of flow equations around the well that are deduced from it assuming simplifying equations. The different flows used take into account population growth, resulting in an increase in water demand, which could lead to a shortfall in drinking water supplies in the future.

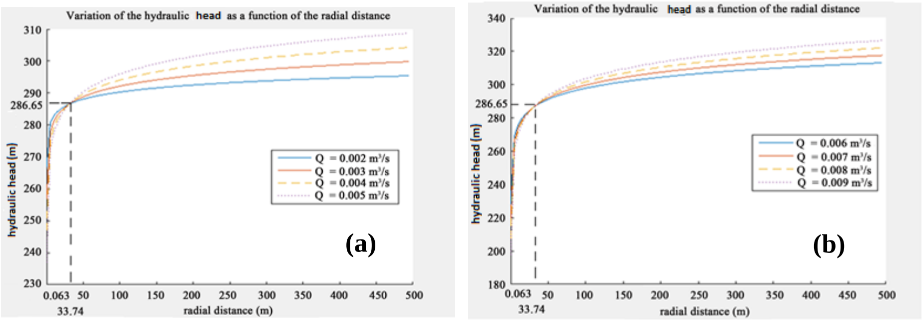

Figure 8: variation of hydraulic head with radial distance

The average drawdown S_{av} at the coordinate point (r = 33.74m; h = 286.65m) which is the difference between static head H_{st} and the head h in r =33.74 m is S_{av} = 43.38 m. The average drawdown is equal to the thickness of the reservoir.

CONCLUSIONS

The old hydraulic drilling of Monzoungoudo not being abandoned completely can be used as a piezometer for certain specific needs (piezometric level, point quality levy ...).

The abandonment and closure of this old hydraulic drilling is therefore an aspect in its own right in protecting the environment and in particular in the protection of groundwater resources.

The techniques involved in these actions require a detailed analysis of the hydrogeological context and the conditions of construction of the work to respond to this particular case.

In all cases, it is useful that the wellhead development ensures the safety of the point. To do this, it is advisable to set up a cemented steel casing, styling the drilling equipment casing and padlocked. This protective steel casing will protrude from the ground or may be located under a sewer-type plate.

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