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Potential Reserves and Demands of Water of Conceição De Coité Municipality, State of Bahia, Brazil's Ne.

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ABSTRACT: *The Conceição of the Coité municipality is located in the part eastern center-north of the Bahia state and is situated in the dries polygon of northeast Brazilian, presents a rain regimen marked by extreme irregularity and water scarcity. Geologically is inserted in San Francisco Craton in its terrains of sequence to volcanics and sedimentary rocks associated witch granitoides of the Itapicuru greenstone belt and orthognaiss and migimatites rocks of Caraíba basement complex. The net of superficial waters is constituted by rivers and pertaining intermittent streams belonging to the basin of the river Paraguaçu and Itapicuru. The watery dams are frequently affect by salinization. The groundwaters are contained solely in the water-bearing fissural of the crystalline substratum. The calculation of the hydrics reserves of Conceição de Coité is esteem in this work as being possessing of the hydric potential of the order of 4,784 x 10^6 m^3 for a total population demand of the order of 2,050 x 10^6 m^3/year, that is 0.47% of permanent reserves and 42.06% of the regulating reserves of the city.*

Keywords: *Conceição de Coité, Dries Polygon, Hydrics Reserves*.

I. INTRODUCTION

This article presents an overview of studies engendered to quantify the potential and water demand of Conceição do Coité municipality and from this, provide managers, subsidies for better planning of the development of this Bahia municipal unit. In the state of Bahia, whose length is 564,693 km^2, the area of crystalline rocks occupies the largest space with 201,688 km^2, representing 35.5% of its area (BAHIA, 2003). Most is located in the semiarid region, whose water needs are most critical. The municipality of Conceição do Coité is located in the eastern north-central part of Bahia State, Brazil The municipal seat with area is 832 km^2, an altitude of 440 meters is located in the following geographical coordinates: 11º33'00" South latitude and 39º17'00" West longitude (Figure 1).

Being located in the polygon of drought in northeastern Brazil, Conceição do Coité features a precipitation regime marked by extreme irregularity of rainfall where water scarcity is a strong barrier to their socio-economic development and even the survival of the population. According to the census data for the year 2010, the IBGE (Brazilian Institute of Geography and Statistics), the municipality has a total population estimated in 2015 of 68,146 inhabitants, divided as follows in the urban and area in the countryside, with a population density 51.64 inhabitants/km^2.

The water supply from the municipal headquarters and several villages is done by EMBASA (Bahian Company of Water and Sanitation), in an integrated system with tube well water captured in Biritinga municipality situated at a distance of approximately 60km, placed in the Tucano Sedimentary Basin. the sewerage system partially meets the city and the urban waste collected is transported in trucks and deposited in open dumps.

The characteristic climate is Aw according to KÖPPEN classification with poorly distributed rainfall, rare concentrated between the periods from November to April and winter rainfall (July) and high evaporation rates. The average annual rainfall ranges from 600 to 700mm/y. The annual average temperature is 23.4ºC with maximum and minimum 28,3ºC 19,4ºC respectivily. The risk of drought is high for the area to be 100% inserted in the Braziian polygon of droughts.

Influenced by climatic, morphological and pedological factors the vegetation that grows prominently in the region is the savanna, consisting of groups of xeromorphic and woody plants. This scrub can be identified two subsets, open and dense, organized into three plant strata: arboreal, shrubby and grasses.

The predominant soils in the area are of three types: a) neosols eutrophic litholic occupying the northeastern part of the municipality; b) neosols eutrophic regolith that are distributed in the northernmost portions, Northeast and South Central; c) Planosols eutrophic solodics, which are the most abundant and are prepared for almost all perimeter of the municipal territory (BAHIA, 2003).

The municipality of Conceição do Coité is located in the watershed of two rivers catchments the Itapicuru and Paraguaçu. The drainage system is essentially formed by rivers and intermittent streams forming a dendritic pattern. The flow of water in their beds is checked only at times of heavy thunderstorms and an

association with the zones of fracturing the rocks and openings providing conditions required for infiltration and accumulation of water in the aquifer fissure.

According PEREIRA (1992), the area is fully embedded in the regional geomorphological unit called *Pediplano* Country. This vast flat land, structured ganitoides and dominant high-grade metamorphic rocks of Archean and Eoproterozoic ages. Features flat terrain, with gently undulating forms, flattened and ramps, altitudes ranging from 240 to spread 560m, waste elevations mark unevenness up 300m, showing intense denudation processes and planning which underwent region. The flat terrain is continuous and monotonous in almost any municipality and near the border with Serrinha city is observed residual relief in the form of ridges separated by valleys or structural furrows oriented to NE-SW direction.

Trying to establish a correlation with the geomorphological cycles defined by KING (1956), the surface formed by the bas-reliefs, softly curled and flattened, which emerge the residual elevations, would be correlated to the surface/Old Higher Tertiary cycle.

The notching of flat country linearly along the current drainage network, would be referred to the Paraguaçu cycle started in the Pleistocene and still active.

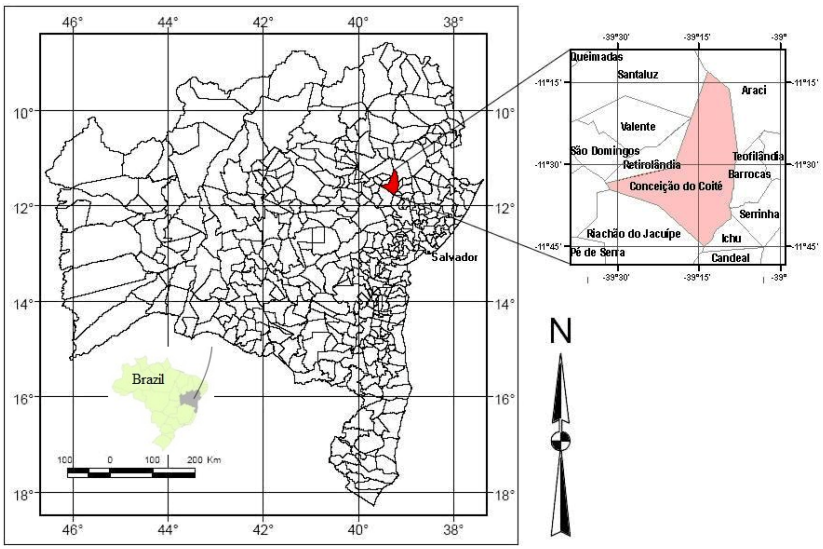


Figure 1 - Location of the municipality in the state of Bahia (adapted from CPRM, 2005)

Geological Situation

Regionally the area is part of the San Francisco craton (ALMEIDA, 1977). According to Pereira (1992) the geology of the municipality is basically composed of two sequences of metamorphic rocks of the crystalline basement, one of them, by the volcano/sedimentary sequence and granitoids that form the greenstone belt of Itapicuru River of age between the Archean and Proterozoic Superior, while the other, the orthognaisses and migimatites constituting the Caraíba Complex, belong to the Proterozoic Lower. The unconsolidated Quaternary coverage has negligible representation.

Surface Water

The main surface water reserve Conceição do Coité municipality consists of the network of rivers and intermittent streams existing in the southern portion of the area are owned by the Paraguaçu river basin, while the northern region belong to the Itapicuru basin. The municipal office is located in a watershed point of the two basins.

Other important water reserves are the various existing public and private dams and waterholes. These sources are often salinated due to the semi-arid climate, its small size, the lack of a bottom outlet and the type of hydraulic basins in which they were erected, usually shallow and wide, which contributes decisively to salt concentration.

The qualities of these waters also reflect the environments where they circulate the drainage network of their river basins, keeping a close relationship with the types of drained rocks and the products of human activities acquired along its path (LIMA JR., 2007).

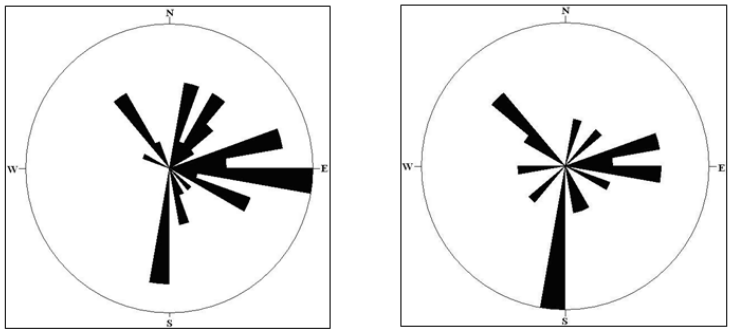
Groundwater

The municipality is located on the hydrogeological field of crystalline rocks, which are fissural aquifers. As there is basically a primary porosity in these types of rocks, the occurrence of groundwater depends on the existence of fractures and cracks that generate a secondary porosity, resulting in the formation of random

reservoirs and discontinuous small extent. The hydrogeological potential of these rocks accumulate and produce water is related to the existence, openness, density and intercommunication of fractures. In the study area, in general, the flow produced by the wells are small, with the arithmetic mean of 3.33 m^3/h (LIMA JR., 2007). The function of lack of water underground movement, the effects of the semi-arid climate and the type of rock is in most cases salinated (mean STD 9,349 mg/L). These define a low potential for aquifer without however, diminish its importance as an alternative in the supply of small communities and rural properties or as a strategic reserve in periods of prolonged droughts.

Corroborating the assertion that rocks fissured raise random and discontinuous reservoirs and the density, openness and interconnection fractures are determining factors in the movement of groundwater were found in examples of events area in which two wells located in Alto Bonito resort a distance of 600m from each other produce very different water flows and qualities. There is a well with a flow rate of 1.69 m^3/h, 11,548 TDS mg/L hardness 4336.67 mg/L as $CaCO_3$, chlorides 4859.97 mg/L Cl and a second well with flow 6 33 m^3/h; 19300,00 STD mg/L; hardness 6575.58 mg/L CaCO3; chlorides 8630.10 mg/L Cl.

The rosette diagrams (Figures 2a and 2b) indicate that the NE-SW directions represent the brittle faulting, according PEREIRA (1992) may be related to the last stage of the strike-slip deformation phase of the Serrinha domain (crustal block craton of San Francisco). The NW-SE direction coincides with the shear zone contractional that occurs in the southeastern portion of the city dominated two distinct geological areas: orthogneisses monzonitic range and sienegranitic and migmatitic and paragneiss gneisses. Under the hydrogeological point of view these fracture patterns presented themselves as very important, since they are coinciding with the preferred directions of the streams and valleys.



(a) (b)

Figure 2 - Rosette diagrams: (a) attitudes of fractures measures in the field; (B) direction of the valleys where there are wells.

The arithmetic average found to the main hydrodynamic parameters of the wells of Conceição de Coité area are depth 64.77m; level static 7.83m; dynamic level 42.16m, flow 3.32 m^3/h. Demonstrating that the level of groundwater is not very deep, the most common type of funding is always the tube well, with an average depth of 60 meters. A proof of this statement we see through the photos 01 and 02 timely occupation by a phreatophyte plant (Pseudopiptadenia contorta) in open sub-vertical fractures, with direction E-W in the town board.

Photos 01 and 02 - Pseudopiptadenia contorta growing in open fractures in gneiss with direction E-W.

II. ASPECTS QUANTITATIVE

In the State Water Resources Plan - PERH (BAHIA, 2003), the Office of Water Resources (SRH) proposed a subdivision in the field of crystalline rocks, based on weather conditions, separating it into two domains: sub-domain of precipitations below 800 mm/year, typical of semi-arid regions of the state (where is located the municipality of Conceição do Coité) and the sub-domain with rainfall above 800 mm/year, characteristic of humid regions.

According to PERH (BAHIA, 2003), the level of commitment of the reserves, the crystalline domain was 17.4% and 5.95%, for precipitation sub-domains larger and smaller than 800 mm/year, respectively. The municipality of Conceição do Coité lies on crystalline rocks (a free aquifer secondary porosity), with rainfall ranging between 600 and 700mm/year, where the underground water potential is directly conditioned by index fracturing, degree of opening of the slits and the interconnection of fractures. In the municipal perimeter were considered 51 wells between public and private that had an average depth of 64.77 m, with an average flow of 3.32m^3 / h and specific discharge (Sy) average of 0.0596 m^3/h per meter drawdown (LIMA JR. 2007).

The methodology used to calculate the total annual water supply in Conceição do Coité considered a total area of 832 km^2, an average rainfall of 700mm/year, an average annual temperature of 23.6°C and a value of minimum average effective porosity 1%, with a view that does not have concrete elements to their exact determination. According WAR (2003), the typical rocks of the crystalline basement as granites, gneisses and migmatites generally have an average porosity of between 1% to 3%. This calculation results in rainfall volume in the municipality of 5.824x108 m^3/year (832 million m^2 x 0.7m = 58.2400.000 m^3/year).

Being fractured aquifers through a heterogeneous, discontinuous and anisotropic, the permeability within the system presents quite sharp variations, and most often do not obey Darcy's law (HAUSMAN, 1982), demonstrating peculiarities not well studied. Given these conditions, the permeability varies with the extent of the fracture and variation of its relative roughness discontinuity along its plane in both horizontal and vertical hydraulic and their parameters are more determined by the nature of the rupture which the lithologic characteristics. The variation in yield and storage potential of a fractured aquifer mainly depend on the intensity of the forces that determine the volume of disjunction. The joints are discontinuous surfaces, through which the water circulates, and if not present the same opening over its entire surface, and its walls do not have the same roughness, these facts will vary the conditions of hydraulic conductivity, both along the horizontal and vertical streams. This difference of the effective aperture is due both to the geometric variation of the opening, as the secondary mineralization fractures.

The water flow in fractured system has peculiarities arising from its natural condition and displays the variations linked to the geometry of the discontinuity surfaces (LOUIS, 1974). According Haussman (1984), some of these reflexes in the middle fissural can be summarized in the following aspects: a) The flow is linear and non-radial type;b) The passage of a laminar flow to a turbulent, and vice versa, is possible at different speeds because of the great variability of the geometric characteristics of the fracture;c) In a continuous flow system is three-dimensional in a batch is two-dimensional;d) The size of the openings or mineralization of fractures, determines the extent of the storage area;e) The opening of a fracture or its variation will determine the changes between the turbulent or laminar flow;f) The relationship between the flow and the gradient is very complex, it is not possible to establish a simple relationship, or a general law that can easily express this relationship for not having found no linear correlation between the effective aperture and the flow velocity ;g) There is observed a significant linear relationship between the turbulent flow and the hydraulic gradient;h) The effective aperture has a much more pronounced effect on the traffic conditions on smooth surface fractures in the rough;i) The changes in hydraulic conductivity increase with the increase of pressure;j) The flow is not the Darcy type, is not held in porous media;l) The anisotropy determines variations in the flow of wells along a fracture same and does not allow reliable results observatories wells (piezometers) in the flow tests; m) The reduction in specific capacity is directly proportional to the load loss;m) The transmissivity does not maintain proportionality with relegation, due to pressure loss.

The above conditions set by Haussmann (1984) influence markedly in the behavior of the fractured medium. Complications of this type of flow should have more influential elements, which have not yet been defined and may be responsible for the indeterminacy of reliable hydraulic characteristics in fractured aquifers of Conceição do Coité municipality.

III. RESERVATIONS OF CALCULATION

According Feitosa *et al* (1997), permanent reserves (Rp) of groundwater for an unconfined aquifer (and fissural medium can be considered so) correspond to groundwater located in the saturated zone below the minimum position of the oscillation level seasonal piezometric surface does not vary depending on the annual rainfall and allow a greater exploitation, regularized in various periods of years.

One can calculate the permanent reserve by the following expression

R p → = (A.b.ηe), where: A = area of occurrence (km^2),b = Average thickness (m),ηe = average effective porosity. (%)

In the municipality studied is estimated a saturated average thickness (b) of 56,95m (by subtracting the average depth of the static level of the average depth of the wells). Admitting that about 5m, value used in PERH (BAHIA, 2003) is the seasonal variation of surface piezometric due to fluctuation of rainfall (between dry and wet periods) and the aquifer discharges can work with a saturated average thickness of 52m, which is close to the value of 50 m used in the State Water Resources Plan (BAHIA, 2003) by SRH for the state of Bahia.

In the municipality of Conceição do Coité, then: Rp = (A.b.ηe). Rf = → (832,000,000m^2 x1.0 m x 52%) = 432 640 000 Rf = 4.33 m^3 or m^3 x 10^8

According Feitosa *et al* (1997), the method of regulating reserves (Rr) or transient may be performed in various ways. One of the methods used is given by the natural flow of the aquifer flow (VEN), which can in natural equilibrium conditions be seen as an effective infiltration volume, or in other words, the aquifer recharge.

It can be given by: → VEN = A.Δh. ηe.

A = the aquifer occurrence area, DH = water level variation, ηe = Effective Porosity.The calculation of regulatory reserves is done by the expression:Rf = Δh.A.S Where: A=the aquifer occurrence area,DH=water level variation, Storage Coefficient =S

As for free aquifers S = ηe, then you can use the following formula to calculate by:rr:Rf = Δh.A. ηe.

The calculation of Rr to the municipality of Conceição do Coité considering an area of 832km^2, an effective porosity (ηe) 1% to a saturated average thickness (DH) of 5 m is:→ Rr = (832 million m^2 x0.01x 5m) = 4,160,000m^3 =4,16x106m^3

The calculation of the aquifer potential (Po) is equivalent to 15% plus Rr. Logo: Po = Rr x% → 115 Po=4.16x106m^3x1.15 = 4,784,000=4.784x106m^3.

The actual availability is the total volume that can be used aquifer, not way, using only reserves or regulatory depletiva using permanent reservations.

The exploitable reserves correspond to the quantities of water that could be exploited annually without provoke regional downgrades in water levels, with a view to secure annual renewal of these values. They correspond to a fraction of 50% of renewable regulatory reserves (REBOUÇAS, 1976)

To the municipality of Conceição do Coité these numbers are 4.16 million m^3 x 0.5 = 2,080,000 = 2.08 x 106 m^3/year.

IV. AVAILABILITY

Installed Availability: is the maximum volume that can be obtained from existing well construction, operating at its maximum permissible operating, provided that will not undermine the permanent reserves. Usual Availability: is represented by the volume that is being exploited in funding projects already installed, with flow rates below its exploitable limit system less than 24/24 hours (FEITOSA *et al* 1997).

Considering the 51 wells drilled and inventoried in the municipality that have an average flow of 3,323 m^3/h and assuming that each work about 8 hours a day (24/24 h below the limit) it has been a flow of daily exploitation of 26.584 m^3/day/ well, which will result in an annual harvest of 4,949 x 105 m^3/year (8 H x 26.584x360daysx51wells). These values are very small in relation to permanent reserve (RP) calculated 4.33 x 108m^3, affecting only 0.11% of the total storage volume and 10.34% of regulating reserves, there is still a certain exploitable availability, which is the exploitable resources, corresponding to the maximum volume that can be withdrawn from the aquifer without commitment, not only of groundwater, but also the surface water system.

Water Resources And Demand Estimates.

The municipality of Conceição do Coité presents a rainfall marked by extreme irregularity of rainfall in time and space. For the calculation of water balance were used information collected between 1961-1990 in Serrinha station of the National Institute of Meteorology (INMET), available in the Brazilian Agricultural Research website (EMBRAPA, 2007).

The water balance shows the evolutionary curve of precipitation values, potential and actual evapotranspiration. It appears that there is a deficit both in the normal monthly water balance, except in the months of May to July. On an annual basis observes a water stress for the aqueous system in the region.

To estimate the water demand was considered that daily consumption "per capita" of the urban population (in the conventional system - with domestic connection) is estimated at 150 liters per day, which corresponds to 54.75 m^3/year/inhabitant and the rural population (in simplified supply system - no household connection, only with fountains) at 50 liters per day, which is equivalent to 18.25 m^3/year/inhabitant (BAHIA,

2003). Using census data presented by IBGE in 2000, the demands of water for the urban population, rural and overall county can be estimated by the following:

• Urban population - 28 026inhabitants x 54.75m^3 / year = 1,534,423.5 m^3/year.
• Rural population - 28,291inhabitants x 18.25m^3 /year = 516,310.75 m^3/year.
• Total consumption = 2,050,734.25 m^3/year.

If the municipal supply was made whole through groundwater, consumption would compromise only 0.47% of the permanent reserves of the municipality, calculated on 432,640,000 m^3.

V. CONCLUSIONS

From what has been exposed and discussed the following conclusions were reached: i) The municipality of Conceição do Coité has a drainage network with a dendritic pattern that consists mainly of rivers and intermittent streams, where the attitudes of fractures and the directions of the valleys are quite similar, indicating that there is a correlation between surface structures and the directions of the valleys, serving this statement as indicators of well construction for the exploitation of underground water. ii)• In terms of exploitable water resources, can be considered an average flow of 3,323 m^3/h to have 51 wells drilled and inventoried in the municipality and assuming that each work about 8 hours a day, you have one daily exploitation flow of 26.584 m^3/day/well, resulting in an annual extraction 4,949x105m^3/year.iii)• These values are very small in relation to permanent reserve (R p) calculated at 4,326 x 108 m^3, affecting only 0.11% of the total storage volume and 10.34% of regulating reserves (Rr) estimated at 4,874 x 106 m^3.iv)• The demands of water for the local population estimated at 68,146 inhabitants are 2,050x106 m^3/year. This corresponds to 0.47% of the permanent reserves and 42.06% of regulatory reserves the municipality.

The data presented in this article show the urgent need of government agencies in planning the future development of this region of the state of Bahia, Brazil .

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