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CDU 502 O meio ambiente e a sua protecção

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GUARANI AQUIFER IN COkNTEX OF THE GLOBAL CLIMATE CHANGE

Marco Antonio Ferreira Gomes

INTRODUCTION

The environmental alterations mainly according the global climate changes, has great evidence in last years, exemplified by negative effects on life of the all organisms of the world.

According water resources, is visible the climate changes influences, because they affect de hydrologic cycle and, consequently, the rainfall system in several countries.

The cycling of water in its various states solid, liquid, and gaseous is a primary process within the earth's climate system. Information on variability of states and fluxes over time is crucial for the understanding of the sustainability of local, regional, national, and international economies and ecosystems. Therefore, the effect of climate change on stream flow and groundwater recharge varies regionally and between climate scenarios, largely following projected changes in precipitation.

To knowledge the futures possibilities about of the stream flow and groundwater recharge transformation processes through scenarios, contribute in adoption of the prevention actions in adverse environmental conditions or submitted negative impacts, mainly future population in relation to disposability of the drinking water.

In front of this scenario, the Guarani Aquifer, more important and strategic of the South America and one of the largest reservoirs of groundwater in the world, need special attention, mainly in reason your high potential store of the water, capable to supply about 450 million of the people, next 2,5 more the actual Brazilian population, considering rainfall value media 1.500 mm/year and use of the 120 liters/person/day, according Health World Organization. If this rainfall value to modify to more or less or to be unexpected, the capability to supply groundwater will be expressive alterations. This scenario compromises the exploitation of this aquifer, decreasing the disposal of the water to future people of the South America.

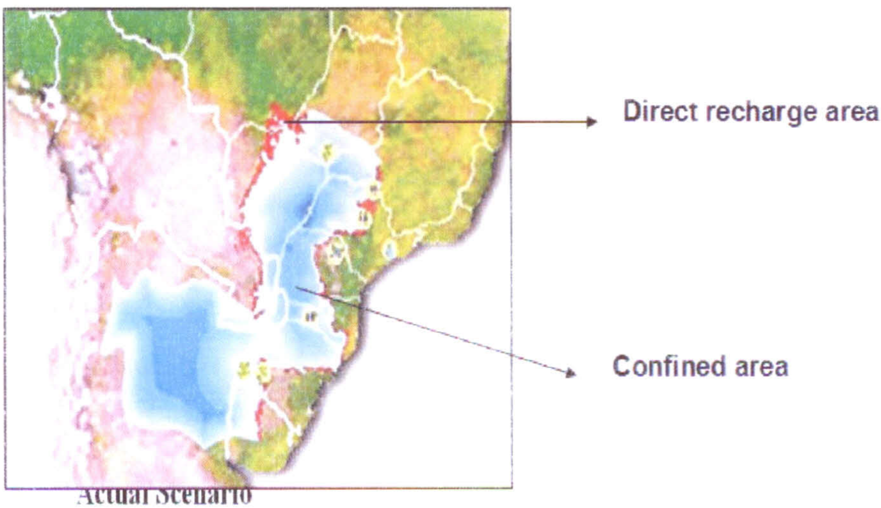
GENERAL CHARACTERISTICS AND IMPORTANCE OF THE GUARANI AQUIFER

The Guarani Aquifer or commonly named Guarani Aquifer System (GAS) is a groundwater reservoir of the South America. The water is found in the pores and fissures of sandstones, formed during the geological times of the Mesozoic (ages between 200 e 130 million years ago), which are typically covered by thick layers of basalts that confined them. The GAS constitutes one of the largest reservoirs of groundwater in the world, with current water storage of approximately 37.000 km and a natural recharge of the 166 km^3/year, considering total area (confined and direct recharge). The water in the sandstones can be found pat depths between 50 m to 1500 m, with temperatures that vary between 33°C and 65°C. This broad thermal range offers possibilities for diverse geothermic applications. The GAS is located in the eastern and mid-southern South America and underlies in some areas of Argentina, Brazil, Paraguay and Uruguay. It is estimated that the total surface of the GAS is 1.195.000 km^2 with 225.000 km^2 in Argentina, 850.000 km^2 in Brazil (São Paulo, Paraná, Santa Catarina, Rio Grande do Sul, Mato Grosso, Mato Grosso do Sul, Goiás and Minas Gerais States), 70.000 km^2 in Paraguay and 45.000 km2 in Uruguay. The whole of these countries composes Plata Hydrographic Basin.

The direct recharge or outcrop areas in Brazil are 104.143 km^2; in Paraguay are 46. 211 Km^2 and Uruguay are 3.197 Km^2. Total value of the direct recharge area =153.551 Km^2. These areas are main portions of the recharge aquifer, reason of need your protection (Borghetti et al, 2004) and showed in figure 1.

Considering the natural recharge of the 166 km^3/ year, the hydrologists to take values equivalent to 25% (next 40 km^3/year) how a security and sustainable exploitation of the aquifer, mainly that sedimentary origin. This percent values to take still average rainfall of the 1.500 mm/year, according Gomes (2008).

Figure1. Location of the Guarani Aquifer, with distribution of areas, both confined and direct recharge.



Source: Revista Superinteressante n. 7 ano 13

ACTUAL SCENARIO

Approximately 24 million people live in the area delimited by the boundaries of the Guarani aquifer and a total of 70 million people live in areas that directly or indirectly influenced it. The main use of the aquifer is for drinking water supply, but there are also industrial, agricultural irrigation and thermal tourism uses (Borghetti et al., 2004).

Actually the agricultural activities expand on direct recharge areas, showing contamination risks of the aquifer. These portions are named *fragile areas* in reason of the high natural vulnerability, exposed by sand soils; these soils contribute to development erosion and lixiviation processes and are classified how Typic Quartzipsamment and Quartzipsammentic Haplorthox (Soil Taxonomy - USA), according Gomes et al (2002).

The scenario showed, more possible climate change, to evidence the possibility of the degradation of the outcrops or direct recharge areas, exposing the aquifer to the contamination risks in medium and long time (Gomes et al., 2002).

TREND OF RAINFALL AND TEMPERATURE DURING THE 21st CENTURY (PLATA HYDROGRAPHIC BASIN)

This work provides a summary of various estimates based on projections of future climate for South America, using the outputs generated for the five models AOGCMs (Atmosphere-Ocean General Circulation Models) of the IPCC-TAR (Third Report of the Intergovernmental Panel Climate Change) and IPCC-AR4 (fourth report) for SRES (Special Report Emission Scenarios) scenarios of high emission of greenhouse gases (scenario A2) or pessimistic, and low emission of greenhouse gases (scenario B2) or optimistic (Marengo, 2006; Marengo, 2008; Nobre et al, 2008).

To estimate the rainfall and temperature in the Plata Hydrographic Basin during the period of 2020, 2050, 2080 and 2100 were then used five types of models described below: 1. Hadley Centre for Climate Prediction and

Research, England (HadCM3); 2. Australia's Commonwealth Scientific and Industrial Research Organization, Australia (CSIRO-Mk2); 3. Canadian Center for Climate Modeling and Analysis, Canada (CCCMA); 4. National Oceanic and Atmospheric Administration NOAA - Geophysical Fluids Dynamic Laboratory, EUA (GFDL-CM2); 5. Center for Climate Studies and Research CCSR/National Institute for Environmental Studies NIES, Japan (CCSR/NIES), according Marengo (2006) and Marengo (2008).

RAINFALL

The HadCM3 (English model) show for B2 scenario (optimist) a tendency positive rainfall, with +0.5mm.day^{-1} in wet and dry seasons; to A2 scenario (pessimist) show negative tendency to rainfall, with -0.5mm day^{-1} ^{1} in wet and dry seasons to period 2020 - 2050, according Marengo (2006). The same model in scenarios A2 and B2 to period 2050 -2100 consider tendency positive rainfall, with + 1mm. day^{-1}in wet season and tendency negative rainfall, with -0,5mm. day^{-1} in dry season.

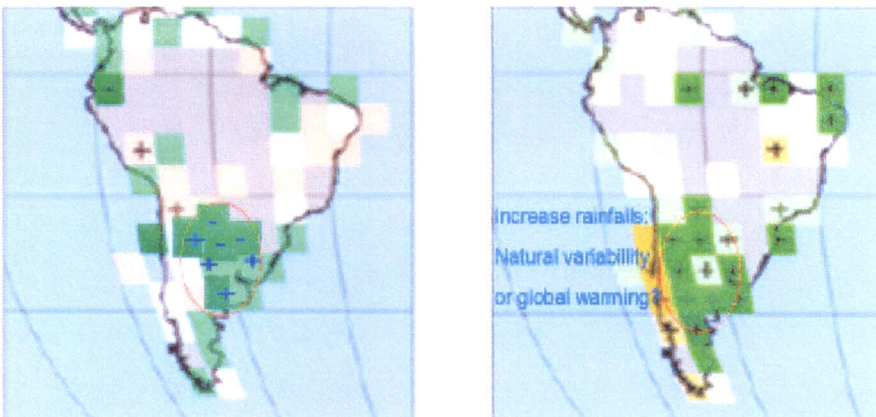
The CCCMA (Canadian model) and GFDL (American model) consider to period 2020 – 2050 – 2100, negative tendency to rainfall, with medium value -1mm.day^{-1} in scenarios A2 and B2 in wet and dry seasons; in portion medium and high of the Plata Basin, the GFDL model consider positive tendency, with values until +1,5mm.day^{-1} to scenarios and B2 in two seasons.

The CSIRO (Australian model) and CCSR/NEIS (Japanese model) consider to period 2020 – 2050, seasons more or less rainy, between +0.5mm.day^{-1} (scenario B2) and -0.5mm day^{-1} (scenario A2). To period 2050 – 2100 present negative tendency to rainfall, with value - 2mm.day^{-1} by year in scenarios B2 and A2. These models also consider a dry season longer, initializing in 2020, with delay rainy season by two months. (Example: rainfalls would start in December and finish in March the following year).

On average, the five rainfalls forecasting models, the scenario A2 (worst or pessimistic) shows increase +0,2 mm.day^{-1} and the scenario B2 (better or optimistic) a increase + 0,3 mm.day^{-1}, according to the propositions of the Intergovernmental Panel Climate Change (IPCC) in Marengo (2006) and showed in figure 2.

Figure 2. Trend of increased rainfall to Plata Hydrographic Basin, according the five IPCC models (periods 2020 - 2050 - 2100). Mean value of +0,2 mm/day in worst scenario (A2) and +0,3 mm.day^{-1} in better scenario (B2).

Scenario A2 Scenario B2

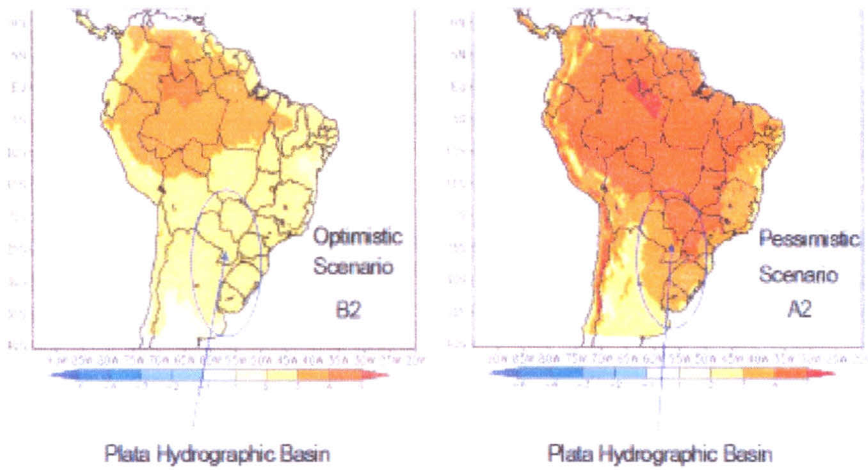


TEMPERATURE

To temperature data, all models showed in the scenario A2 (pessimistic) increase value of until 6ºC and scenario B2 (optimistic) increase value until 3º C.

Particularly, the HadCM3 and CCSR / NIES showed positive anomalies of up to 5º C in 2100, whereas the A2 scenario, the worst case and up to 4° C for the B2 scenario, the most optimistic (Marengo, 2006). Figure 3 below shows the mean temperature for the Plata Hydrographic Basin, considering average values of the five models and the periods of 2020, 2050 and 2100.

Figure 3. Average values of five IPCC models indicate an increase of up to 3° C (optimistic scenario - B2) and up to 6° C (pessimistic scenario - A2) by 2020, 2050 and 2100;



COMPARATIVE ANALYSIS OF ANOMALIES IN TEMPERATURE AND RAINFALL FOR THE PLATA HYDROGRAPHIC BASIN

The Plata Hydrographic Basin is one of the regions of greatest economic importance of South America;

The climate change in this region can seriously affect society, with reduced water availability for human consumption, agriculture and power generation => increase in diseases such as dengue and malaria and other related shortages and compromised water quality;

There is a tendency that the events (rainfall and temperature) fluctuations are concentrated in certain period of years, in favor of natural disasters such as floods;

The pattern of anomalies in rainfall and temperature for the Plata Hydrographic Basin is characterized by an increase in temperature ranging from about (average of five models and scenarios A2 and B2) of 1.2° C in 2020, 2.2° C in 2050 and 3.5° C in 2080;

The temperature values between the most important scenarios A2 and B2 occurs in 2080, where the average of the models for B2 is 2.7° C and A2 is 4° C;

For the anomalies of rain, for both scenarios, all models show variations from 0.2 to 0.3 mm day^{-1} in the years 2020, 2050 and 2080 (Marengo, 2006; Marengo, 2008).

POSSIBLE NEGATIVE IMPACTS CAUSED BY CLIMATE CHANGE IN THE PLATA HYDROGRAPHIC (OCCURRENE GUARANI AQUIFER)

Even with the trend of increasing rainfall in the future, higher temperatures could somehow limit the availability of drinking water, agriculture and power generation due to increased evaporation and evapotranspiration (Marengo, 2006);

The water balance would be affected as well, affecting not only the flow of water courses as well as recharging the aquifer, such as the Guarani Aquifer supply of which is done exclusively by the rain.

Reduction of biodiversity through the extinction of large variety of plant species less tolerant to heat;

Reduction of vegetation cover, with greater exposure of the soil;

Reduction of stability of soil aggregates due to the decline in soil organic matter and other agents of soil aggregation, making their aggregates less stable;

Reduced rates of water infiltration into the soil due to three causes: a) smaller volume of water available, b) increased evaporation and c) reduction of permeability of soil due to greater instability of their aggregates;

Reducing the volume of rivers waters as a natural consequence of the lower volume provided by the rains.

PROPOSALS FOR ACTION TO TOLERATE CLIMATE CHANGE

Preparation of a National Map Integrated Vulnerability to climate change, integrating various sectors: health, agriculture, coastal zone ecosystems and biodiversity, energy, etc., for the identification of populations, areas and regions most at risk in the short, medium and long term ;

Encouragement of scientific research integrated, bringing together the areas of climatology, agriculture, health, economy, demographics, etc. In order to build scenarios Brazilian impacts of climate change for decades to come;

Increasing awareness of the climate change issue with the Brazilian society in general and in particular, in research institutions in the public and federal and state sectors and universities;

Federal and state government actions to discuss global warming and its consequences; need for the creation of the Brazilian Network for Research on Climate Change (Ministry of Science and Technology and Ministry of Environment).

Require the maintenance of the Permanent Preservation Areas (PPA) and expansion of the Environmental Protection Areas (EPA's) what, consequently, contributes to the supply of water from rivers and others water flows (action how sponge effect), especially in drought periods, how results of the presence of the a micro-cooler climes near the headwaters and along all the course until the estuary;

The presence of PPA and EPA's favors several environmental components, such as maintaining biodiversity, and contribute to the protection of slopes, cliffs, edges and margins along the watercourses, avoiding the onset of erosion and consequent negative impacts, especially during periods of concentrated rain, according to the prediction of five models presented in this work;

Crop rotation and integrated systems of agricultural production, while the agricultural suitability of the soil, contribute to the maintenance of its physical, chemical and biological properties, as well as its conservation (erosion control) and water (contribution to infiltration) in the agriculture environment;

Adopting a method of *Agri-environmental Planning* (AP) developed for the outcrops or direct recharge areas of sedimentary aquifers, in order to protect groundwater and, consequently, the sustainability of the Guarani Aquifer System (SAG) as a reference on climate change (Gomes et al, 2008).

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