Guarani Aquifer System – Groundwater for South America

Edson Wendland, University of São Paulo, Department of Hydraulics and Sanitary Engineering, Brazil

Introduction:
The Guarani Aquifer System (SAG, in Portuguese) is situated in the eastern and south central portion of South America, extending from the Paraná Sedimentary Basin in the East to the Chaco-Paraná Basin in the West (Araujo et al, 1999). This aquifer got attention due to its extension and stored volume of water, being considered one of the biggest transboundary underground water sources in the world. It underlies parts of Argentina (225,500 km^2), Brazil (839,800 km^2), Paraguay (71,700 km^2), and Uruguay (58,500 km^2), covering an area of approximately 1.2 million km^2. The SAG appears to be a sandstone formation, predominantly confined (approx. 90 % of the area) by a huge spill of volcanic rocks. Due to its hydro-geologic characteristics, extension and localization, near to regions of great social-economic importance for the four countries, the aquifer is recognized as a strategic source.

Groundwater recharge in the Guarani Aquifer is supposed to occur based on two main mechanisms:
1. by direct infiltration (Wendland et al. 2007), through the outcrop zones in the Brazilian states (São Paulo, Goiás, Mato Grosso do Sul, Paraná and Santa Catarina), eastern Paraguay and North Uruguay;
2. indirectly, through the overlapping formations that include the fractured basalts of the Serra Geral Formation.

In fact, the water-bearing basalt zones can be seen as a prolongation of the sedimentary overlying sandstones (Bauru Group). According to Rosa Filho et al. (2003) locally, where the basalt thickness become small or the fracture system reach the top of the Guarani Aquifer, infiltration due to leakage may be determining for recharge. Depending on the hydraulic head in the Guarani Aquifer and in the Serra Geral Formation, ascending or descending vertical flow is possible. Viewing the observed potential surface in many places, the basaltic rocks of Serra Geral Formation function sometimes as reservoir and as semi-permeable, beyond its character of hydraulic barrier.

However, understanding the flow behavior in the SAG is still matter of research (GEF, 2003) and no affirmation is definitive. Due to the presence of dikes and sills originated during the volcanic activity, the sandstone formations present many compartments, which are not well understood up to now.

Water availability and demand
Knowledge on water availability is essential for the management of aquifers. The volume of freshwater reserves stored is estimated as around 40.000 km^3 that is equivalent, for example, to the totality of water in the Paraná River with a discharge of about 10.000 m^3/s during 127 years. According to a technical report by the World Bank (GEF, 2002), fifteen million people live in the aquifer´s area of influence. Sustainable exploration is estimated to be able to attend the water demand of a population of 360 million people, considering a per capita use of 300 l/day. Based on spatial, hydro-geologic and hydrologic data, Rocha (1970) found out that such potential would correspond to around 30 times the total water demand of the 15 million inhabitants of the region, in which the water reserves are found.

Despite large surface water reserves, drinking water supply in heavily populated regions is increasingly dependent on groundwater. Thus, future problems may occur, if exploration does

not take place in a sustainable manner, or if waters are polluted. In São Paulo State in Brazil, estimates indicate that 60.5 % of urban centers are served totally or partially by groundwater sources, supplying 5.5 million people. The use of the Guarani Aquifer System's water has increased significantly in the last decades, as consequence of the extreme urbanization pattern of some areas on the one hand and developments in large scale of agriculture schemes on the other. Due to the bad distribution of demand related to high consumption of water resources in regions of population concentration, supply problems can already be observed. Some of the conflicts related to water quantity are already well identified. These include, among others, the reduction of potentiometric and phreatic levels, and the interference between wells experienced in the highly urbanized areas around Ribeirão Preto and Bauru, in São Paulo State (Brazil).

Vulnerability and sustainable development

Research concerning vulnerability and risk mapping of the SAG is being done since the 1970's, in Brazil, by the Department of Waters and Electric Energy of the São Paulo State (DAEE) and Geologic Institute (IG). Currently the concept of aquifer vulnerability includes factors as the degree of protection against contaminants by the overlying layers, groundwater flow conditions, climatic conditions and contamination risks related to soil use and occupation. These factors include the so called anthropogenic and natural or specific vulnerability. Crossing the information contained in the map of natural vulnerability with anthropogenic evolution factors results in a map of aquifer risk or danger. These maps are important instruments for decision making aiming at the protection and sustainable use of water resources.

Projects with participation of official institutions, universities, technical-scientific associations and non-governmental organizations have to be developed. The objective is to share the positive results and to establish a model of management for the SAG, through a program of strategic actions including common scientific, institutional, financial and legal aspects. The main goal is the protection and sustainable use of the Guarani Aquifer System, justifying its condition as strategic source in South America.

References

Araújo LM, França AB, Potter PE (1999): Hydrogeology of the Mercosul aquifer system in the Paraná and Chaco-Paraná Basins, South America, and comparison with the Navajo-Nugget aquifer system, USA. Hydrogeology J. 7(3):313-336.

GEF (2002): Environmental protection and sustainable development of the Guarani aquifer system project. Report 23490, GEF/BIRD.

GEF (2003): Sistema Acuífero Guaraní GEF-BIRD-OEA perfil preliminar del proyecto piloto de gestión y protección en Ribeirão Preto, Brasil. Report Sep 19 2003, GEF/BIRD.

Rocha G (1997): O grande manancial do Cone Sul. Estudos Avançados, São Paulo University, São Paulo, 30:191-213.

Rosa Filho EF, Hindi EC, Giusti DA, Nadal CA, Xavier JM (2001): Distribuição do Geotermalismo na Bacia Sedimentar do Paraná. Revista Latino Americana de Hidrogeologia, Curitiba, 1(1):67-74.

Wendland E, Barreto C, Gomes LH (2007): Water balance in the Guarani Aquifer outcrop zone based on hydrogeologic monitoring. J Hydrol 342:261–269.

Contact:
E. Wendland
e-mail: ew@sc.usp.br
http://www.shs.eesc.usp.br