Groundwater as a socio-economic constraint: the Yucatan Peninsula, Mexico example

Luis E. Marín[1], Julia Pacheco[2] & Oscar Escolero[3]

[1]Instituto de Geofísica, Universidad Nacional Autónoma de México, Cd. Universitaria, México City, México CP 04510; email: lmarin@tonatiuh.igeofcu.unam.mx
[2]Facultad de Ingeniería, Universidad Autónoma de Yucatán, Mérida, Yucatán, México; email: pavila@tunku.uady.mx
[31]Instituto de Geofísica, Universidad Nacional Autónoma de México, Cd. Universitaria, México City, México CP 04510; email: oescolero@yahoo.com

Abstract: Underneath the Peninsula of Yucatán lies a thin, fresh water lens that is the only source of water for the entire region. The thickness of the lens underneath Merida, the largest city in the region (population > 600,000 inhabitants) is only 60 meters thick. The upper 20 meters of the freshwater lens are currently considered unfit for human consumption. Additional anthropogenic activities such as agriculture, injection of raw sewage below the interface and poor solid waste management are also reducing the available ground water.

Key words: Karst, Yucatan, saltwater, intrusion

Introduction

The hydrogeology of the Yucatan Peninsula (Fig. 1) consists of a thin, fresh water lens that is underlain by saltwater. This thin, fresh water lens is the sole-source aquifer that supplies the needs of the Peninsula for water. There are no surface water bodies in the Yucatan.

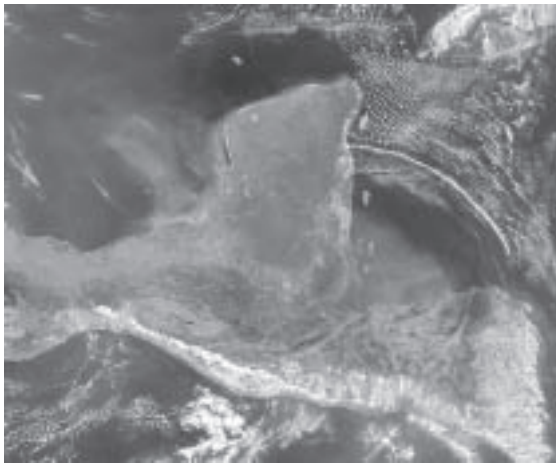

Figure 1. The Peninsula of Yucatan

The upper hundreds of meters of rocks consist of practically pure carbonate and evaporite rocks, and as a result, in the northern coastal plain, there is a thin to non-existent soil cover. As a result, a mature karstic system has developed. This aquifer is particularly vulnerable to contamination (MARÍN, 1990; MARÍN AND PERRY, 1994). STEINICH AND MARÍN (1996) have mapped saltwater more than 110 kilometers from the coast using electrical resistivity methods.
Since the limestone is exposed at the surface, no wastewater collection system exists for the city of Merida (population > 600,000). Common practice in the larger cities in Yucatan call for septic tanks that are holes finished three to five meters below the land surface. The unsaturated zone underneath Merida varies from 8-12 meters. Thus, the septic tanks are finished three to seven meters below the water table. MARÍN ET AL., (2001) report that there are more than 83,000 septic tanks in the greater Mérida aerea. All wastes including raw, untreated waters, municipal and industrial effluents are discharged directly into the aquifer. As a result of this practice, the Regional Office of the National Water Commission of Mexico has determined that the first 20 meters of the fresh water lens underneath Merida are unfit for human consumption. MARÍN ET AL., (2000) report that the National Water Commission is considering three alternative management options: a) collecting and injecting the raw, untreated sewage several hundred meters below the fresh/salt water interface; b) piping and discharging the untreated sewage to the ocean (33 km from Mérida), and c) using the untreated sewage to irrigate agricultural fields around Mérida. The three possibilities are less than ideal. Injecting untreated effluents at 200 meters below land surface may backfire, since warm, fresh water would be injected below the salt water. This water may rise in the future, causing the water quality to degrade in the lower portion of the aquifer due to induced mixing with contaminated saline water. Pumping raw effluents over a distance of more than 30 km and discharging them out at sea is not economical due to the large volume involved. Ocean dumping is also questionable from an ecological point of view. Finally, using the effluents for irrigation, while feasible, may pollute the aquifer rapidly.

RESULTS AND DISCUSSION

In addition to the problems found in Merida, other practices contribute to the contamination potential of the aquifer including: 1) a growing citrus industry that is freely using pesticides, and fertilizers; 2) pervasive presence of porcine and chicken farms; 3) poorly regulated solid disposal practices, and 4) (particularly along the Caribbean Coast), but also present in Northwestern Yucatan, there has been an explosive growth of tourist resorts.
In the southern part of the state of Yucatan, PACHECO ET AL., (2001) have reported that nitrate concentration in the groundwater during the dry season (September-May) is higher than 200 mg/L. During the rainy season, a dilution effect is noted, and concentrations drop to approximately 60 mg/L (still in excess of the drinking water norm, which calls for 45 mg/L maximum). Porcine and chicken farms can now be found throughout Yucatan. The larger farms have wastewater treatment plants. The smaller farms should also have some system to collect and treat their wastes, but more often than not, they do not have any such system.

Thus, all of the organic waste from the smaller farms reaches the aquifer in a very short period of time. Tourist resorts are growing at an incredibly fast pace along the entire Yucatan coastline. Although the hotels along the coastlines are required to have wastewater collection and treatment systems, the support towns that grow around these resorts have few urban services such as piped drinking water or wastewater collection and treatment systems.

Conclusions

Already one third of the potentially available water supply for Merida is considered as unfit for human consumption. What is desperately needed for the whole of the Yucatan Peninsula is a comprehensive water management plan including an estimate of the available groundwater, residence time, and a plan to manage municipal (primarily waste waters) and industrial wastes, as well as legislation that would restrict some of the pesticides being currently used. Unless such an action is taken, the sustainability of the Yucatecan Aquifer will be at risk.

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