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Ground Water Quality Research on Cozumel Island, State of Quintana Roo, Mexico

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INTRODUCTION

An interdisciplinary research on the ground water system has been carried out to analyze the options to improve the quantity and quality of the drinking water on Cozumel island. The predicted growth of the population within the next 10 years is expected to double the actual number of 70,000 inhabitants which would cause a considerable increase in the use of drinking water (Fig. 1). Actually sea water intrusion causes problems in the exploitation of ground water and limits its increase.

DISCRIBTION OF THE STUDY AREA AND ITS CLIMATE

The surface of the island Cozumel is 453 Km² with an average height of 5m above sea level (10m at the highest point above sea level). The island has a subtropical climate with the maximum precipitation in summer.

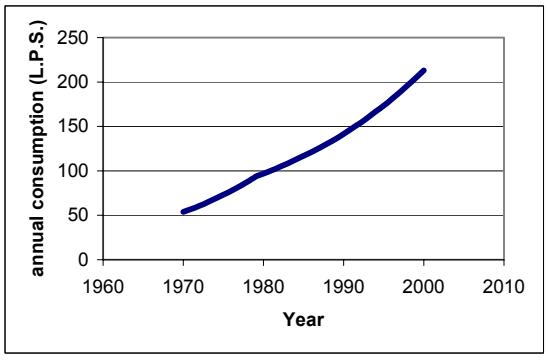


Figure 1: Annual consumption of water on Cozumel island [CAPA, 1999].

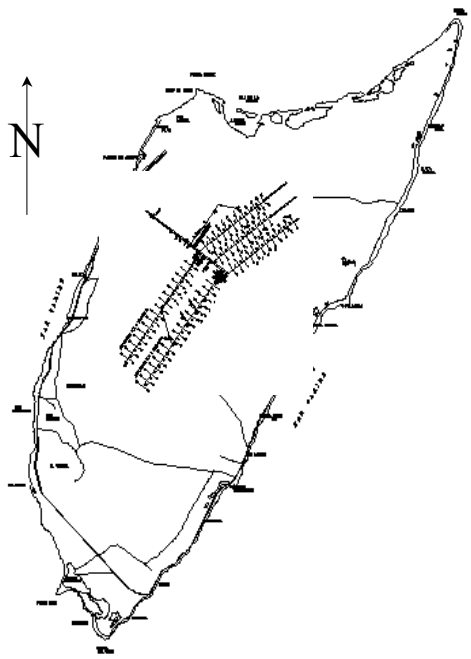


Figure 2: Map of Cozumel and the position of 226 production wells in the centre [CAPA, 1999].

Perforations indicate that the island was formed by reef sediments with a depth of 100m and more, which date from the Oligocene and the Quaternary ages. A karstic aquifer has been developed in these limestones.

HYDROLOGICAL BALANCE

The hydrological balance indicates that 75% of the yearly precipitation of 1,500 mm is lost as a consequence of the evapotranspiration and only 6% is recuperated in the natural recharge (CAPA, 1999). The total amount of water produced from the wells, run by the "Comisión de Agua Potable y Alcantarillado" (CAPA), is 4.1 million m^3 in a year (about 10% of the total annual recharge).

GROUND WATER MONITORING

From the 226 existing production wells in the centre of the island (Fig. 2) 58 are not in use or have been closed because of sea water intrusion. The CAPA is monitoring the ground water quality by taking water samples every month. The parameters analyzed in 168 wells in August 2000 by CAPA are: Electric conductivity, pH, Chloride and Hardness (Calcium). In August 2000 more than 400 mg/l of chlorides were found in 12 wells. Based on these analyses we took another 17 samples of different types of water (including precipitation, ocean water and 11 ground water samples). Finally we used the PHREEQC computer program (Parkhurst and Appelo, 1999) to perform aqueous geochemical calculations in respect to the dissolution of calcite.

RESULTS

The water, supplied by the CAPA, contains an average of 270 mg/l of chlorides which exceeds the maximum level permitted by Mexican regulation (250 mg/l). On the island, two types of water are predominant and the ground water forms a mixture between them: precipitation, which is in permanent contact with lime stones of the aquifer, and ocean water (Fig. 3).

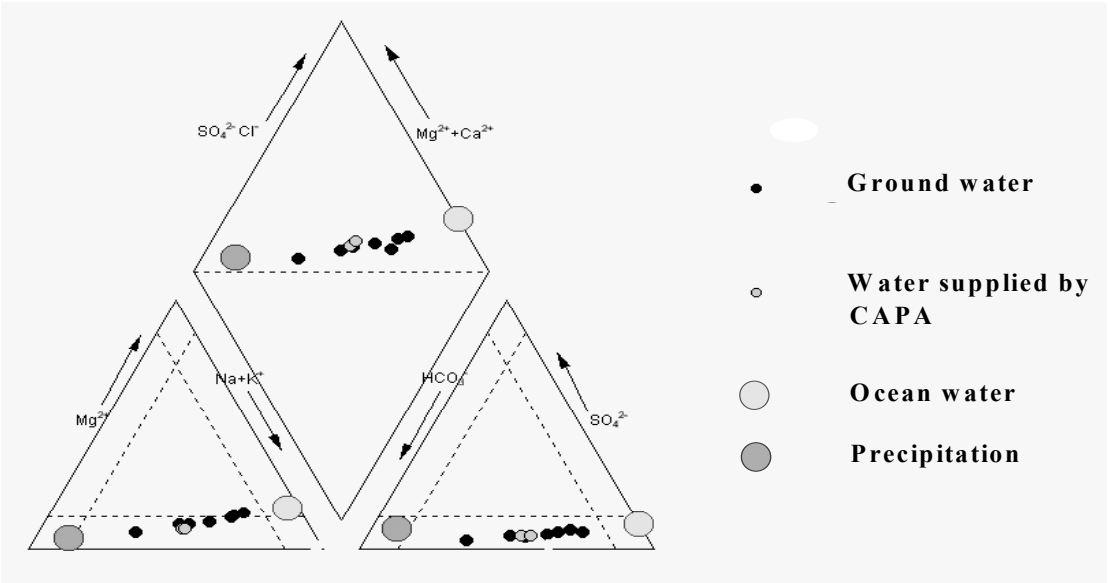
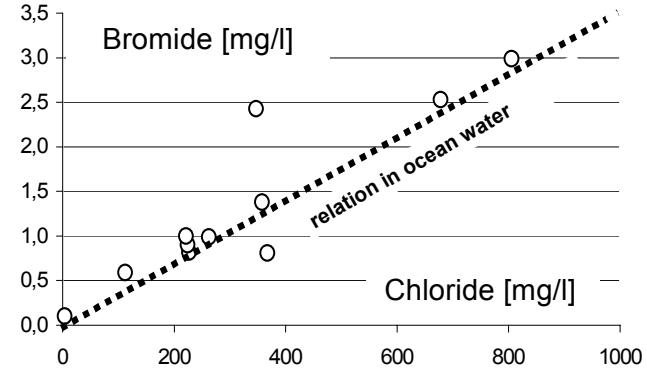


Figure 3: Diagram (after Piper, 1944) of 11 ground water samples from Cozumel island.

The relation between chloride and bromide, found in most of the samples (Fig. 4) is equal to the relation, found in the ocean water, therefore the higher mineralisation in the wells has the ocean water as source. The relation between chloride and sulfate points to a light outweighing of chloride in comparison to the relation in sea water, affected by sulfate reduction in the aquifer.



igure 4: Concentration of chloride and bromide in 11 ground water samples compared to the relation, found in ocean water.

Aqueous geochemistry calculations using PHREEQC (Parkhurst and Appelo 1999) show that the mixing process between the two predominant types of ground water (intrusion of ocean water and ground water from precipitation) causes a negative saturation index for Calcite in the ground waters. A saturation index of less than –0,1 results if the content of ocean water is between 5 and 10 percent (Fig. 5).

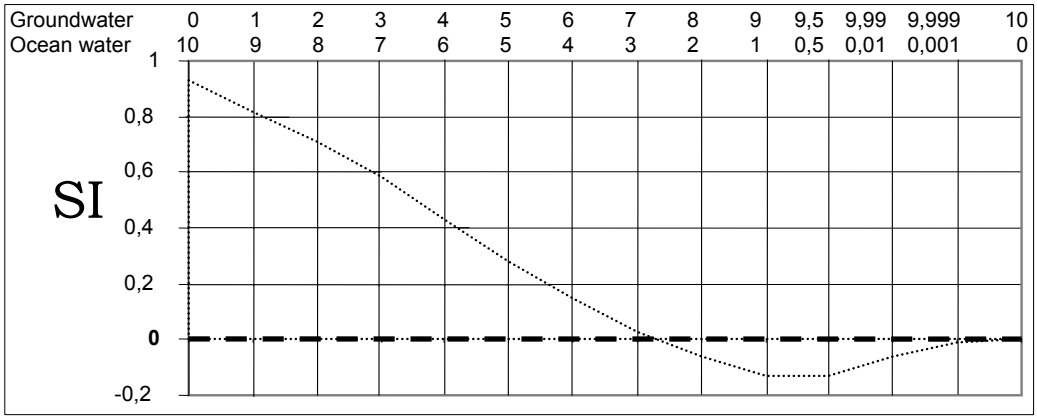


Figure 5: Change of the saturation index for Calcite in mixed waters with a different relation between ocean water and ground water using PHREEQC (Parkhurst and Appelo, 1999).

CONCLUSIONS

The electric conductivity can be used as main parameter to monitor the intrusion of ocean water in the wells. The intrusion of ocean water in the wells is a reversible process. A fast reduction in the electrical conductivity has been observed in some of the contaminated wells with only 800 μS per centimeter after one month. The salinity in the wells is affected by its hydraulic regime and from this point of view, the closing of wells with a higher mineralisation is not an appropriate method to solve the problem. The suggestion is to measure the electrical conductivity of in the production wells continuously and reduce the pumping rate in case of higher mineralisation. In the mixing zone between the ground water and the ocean water, a dissolution of Calcite may occur, which could cause a slightly higher permeability of the aquifer.

References

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Keywords: Hydrochemistry, Cozumel, aqueous geochemical calculations, intrusion of ocean water.

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