Water quality evaluation of the Akumal aquatic ecosystem (SE Mexico)

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Abstract

The results of an initial research carried out in Akumal coastal aquifers are exposed. The studied area is situated in the southern part of Quintana Roo, Mexico. The study of the water quality of Yal Kú and Lagartos lagoon shows that the fecal coliform densities are conditioned by human activities (waste water discharge), and by natural processes. Variations in water quality will increase the stress on available water resources and valuable ecosystems, especially the adjacent coral reef.

Keywords: *water quality, estuary, coastal lagoon, aquifer*

Introduction

Pollution of water resources by untreated or poorly treated domestic wastewater is an increasing concern for human health and for the negative effect on the worldwide environment. The dramatic population growth is affecting the natural ecosystems, and coral reefs are declining on a global scale and sewage pollution is a main factor (Elmir *et al*. 2007; Sanchez-Gil *et al*. 2004; McKenna *et al*. 2001; Paul *et al*. 1997).

The geology of Yucatan Peninsula is characterized by karst aquifers with fractures and groundwater streams, therefore contaminants can be transported long distances with little dilution. As a consequence, water quality can deteriorate severely, which can result in very high economic and social costs in order to clean the polluted sites and restore the ecosystem (Parise and Pascali 2003; Nicod 1991). According to Doerfliger *et al*., (1999), karst environments are highly vulnerable to a variety of degradation and pollution problems.

Likewise, karst aquifer systems of Akumal have extensive connectivity to the coastal marine environment and thus directly influence marine water quality impacting the coral reef. The coral reef in Akumal, part of the Mesoamerican Barrier Reef system (the second largest after the Great Barrier Reef in Australia), makes this region very attractive for the tourism industry. Tourism activities have immediate and vast consequences for ecological systems, which are particularly vulnerable in this region.

This study forecasts the water quality condition of the aquatic ecosystems of Akumal Quintana Roo, Mexico (20°23’46’’N/ 87°18’50’’W) (Fig. 1).

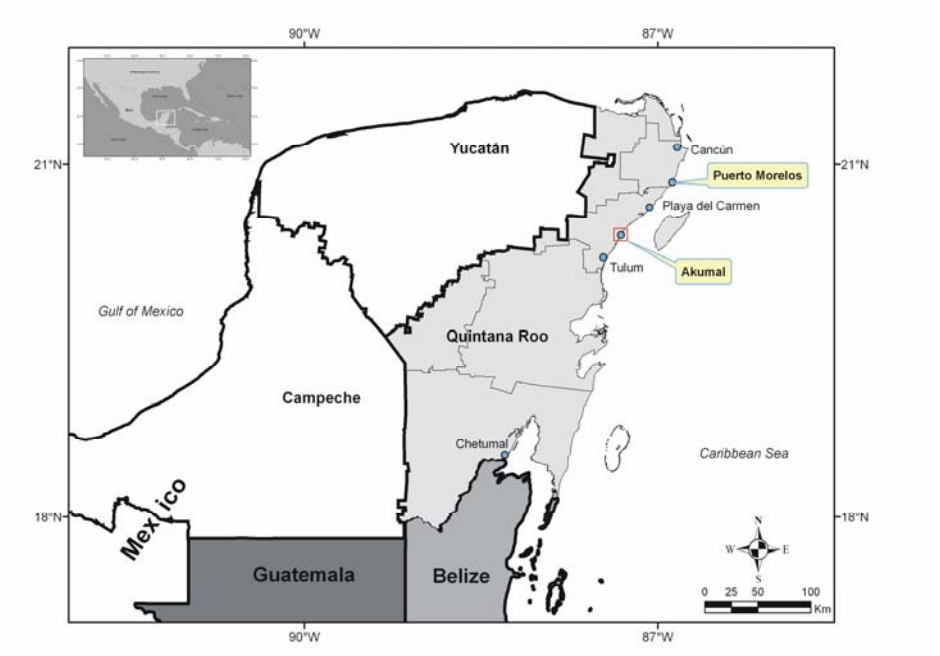


Figure 1. Location of study site

Methods

Waters entering the Yal Kú estuary and Lagartos coastal lagoon were sampled and analyzed for physicochemical and bacteriological parameters. Water samples were collected at seven locations in Yal Kú and four locations in Lagartos lagoon during 2007 campaigns. The physicochemical measurements (pH, temperature, salinity), were performed by a data sonde, (Hydrolab®). Samples for bacteriological analysis (E. coli) were taken in sterilized bottles. The *Escherichia coli* densities were determined in laboratory with Colilert method (IDEXX®).

The bacteriological analyses of all samples were conducted the same day, no longer than 6h after collection. The chromogenic substrate methods, such as those manufactured by IDEXX Laboratories, Inc., have recently been gaining popularity. The U.S. Environmental Protection Agency has approved Colilert for use in drinking water monitoring (Federal Register 1989 and 1992), and analyses of *E. coli* in fresh (Eckner 1998) and marine (Emir *et al*. 2007; Shibata *et al*., 2004) natural waters have been published.

Results

Three fresh groundwater sources entering Yal Kú (YK2A, YK5 and YK7) were identified (Fig. 2). These fresh water sources are due to local karst hydrogeology formed by caverns and fractures. The groundwater discharge from the Yucatán Peninsula has been detected in many places along the coast (Back *et al*., 1979). Most of fresh water discharge points are small, and no published maps currently exist, due in part to the seasonal nature of some springs. Sea water enters Yal Kú from the east, salinity of samples ranging from 15 to 35 ppt (Fig. 3a). Temperature values were found to be 25-30 °C. Concerning pH, the levels are between 7 and 8.

The results in some points of Yal Kú show coliform densities (E. coli) higher than recommended Mexican guidelines for recreational waters (<200 MPN/100 ml). Relatively high concentrations of *Escherichia coli* bacteria densities were measured in august, just one week after hurricane "Dean" impact in the area, with a significant decrease in subsequent months (Fig. 4a). Yal Kú estuary has exceptionally high levels of tourism and local residents throughout the year. Likewise, studies conducted by Fujioka *et al*. (1999, 1997), and Toranzos and Marcos (2000), have shown that in the absence of any known sources of human/animal waste, enterococci and E. coli are consistently present and recovered in high concentrations in the subtropical environment.

With this scenario, Yal Kú will face constant pollution and additional pressure will be added to the ecosystem vulnerability. If regulation measures are not taken in order to develop sustainable tourism programs, and urban development plan is not respected, the Akumal ecosystems quality will be seriously endangered.

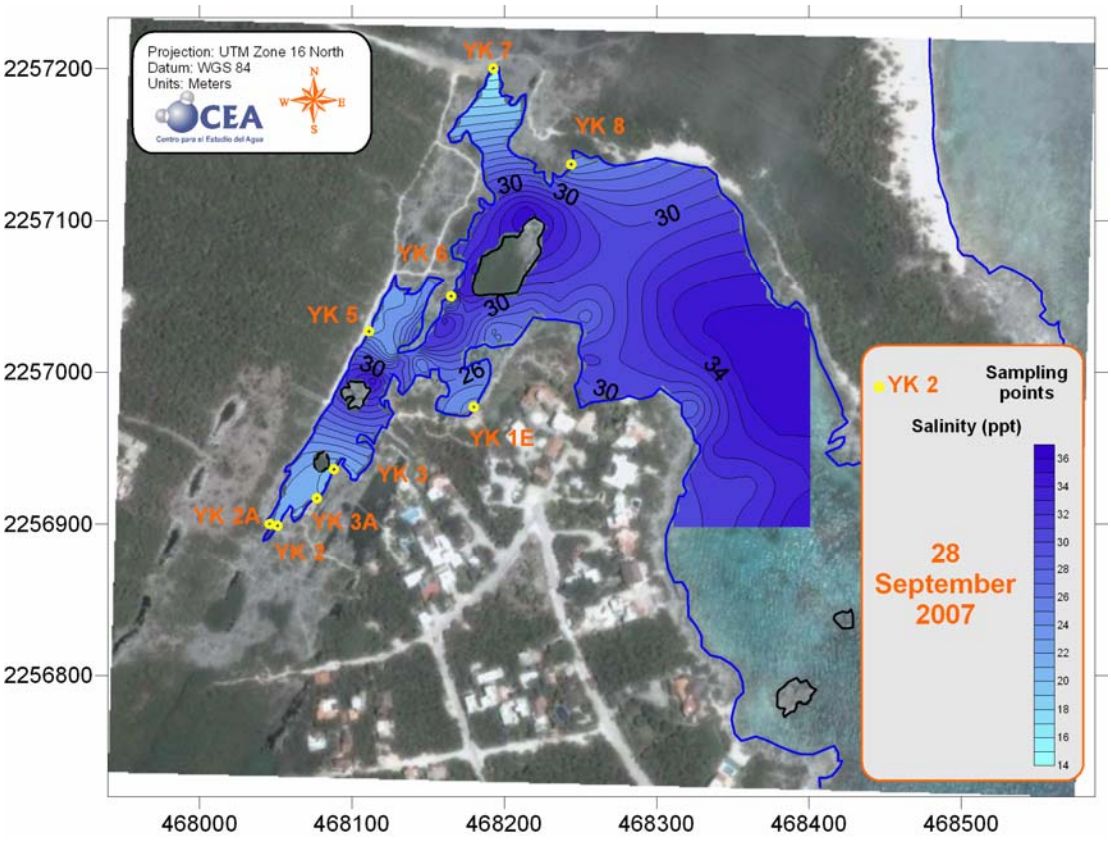
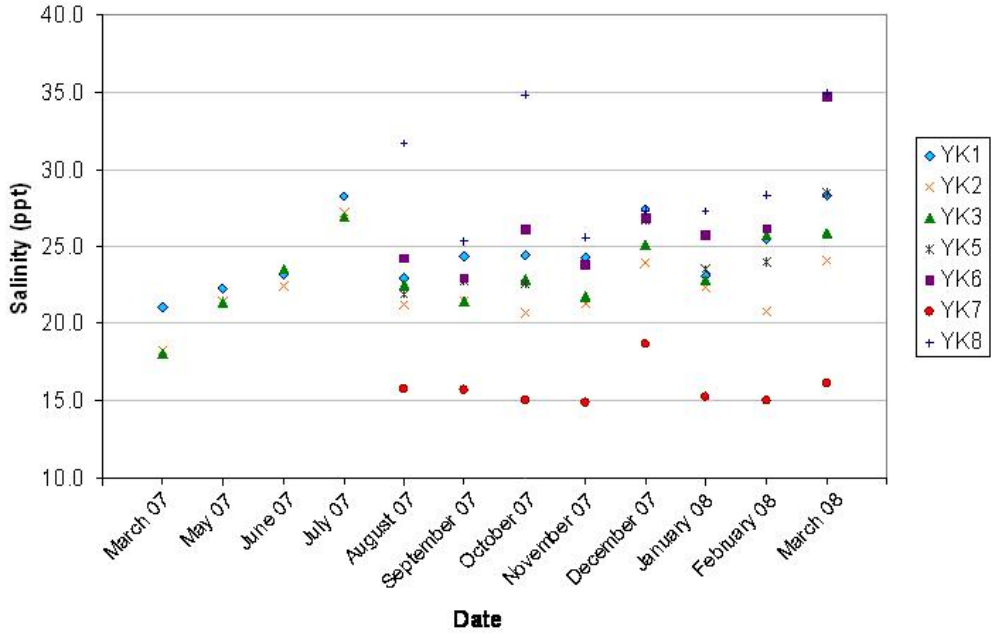
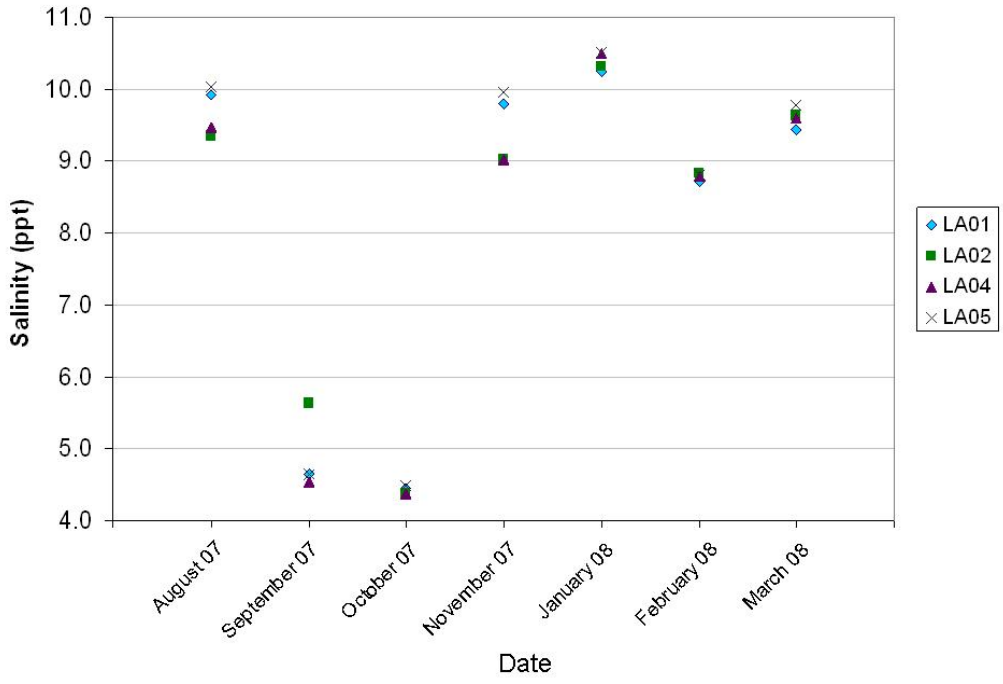


Figure 2. Salinity distribution map of Yal Ku in September 2007



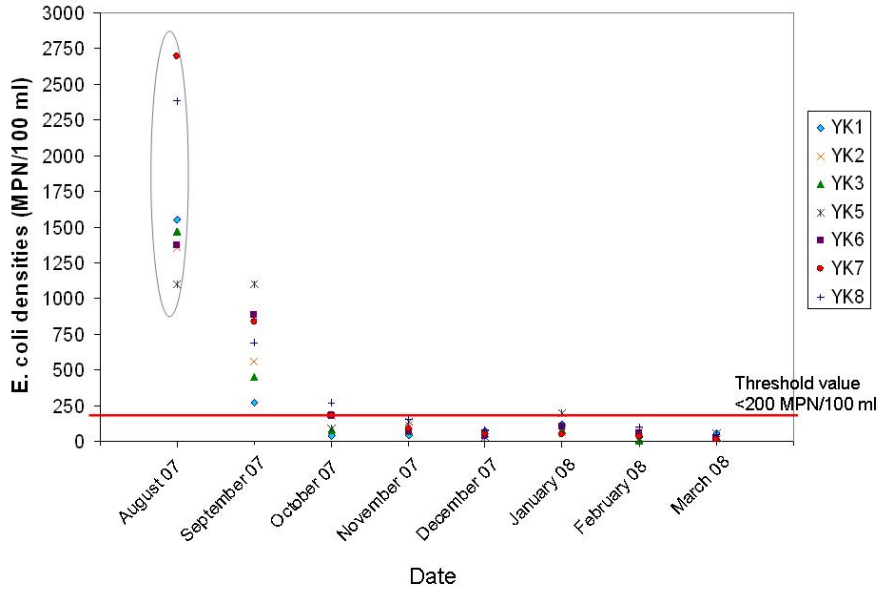
(a)



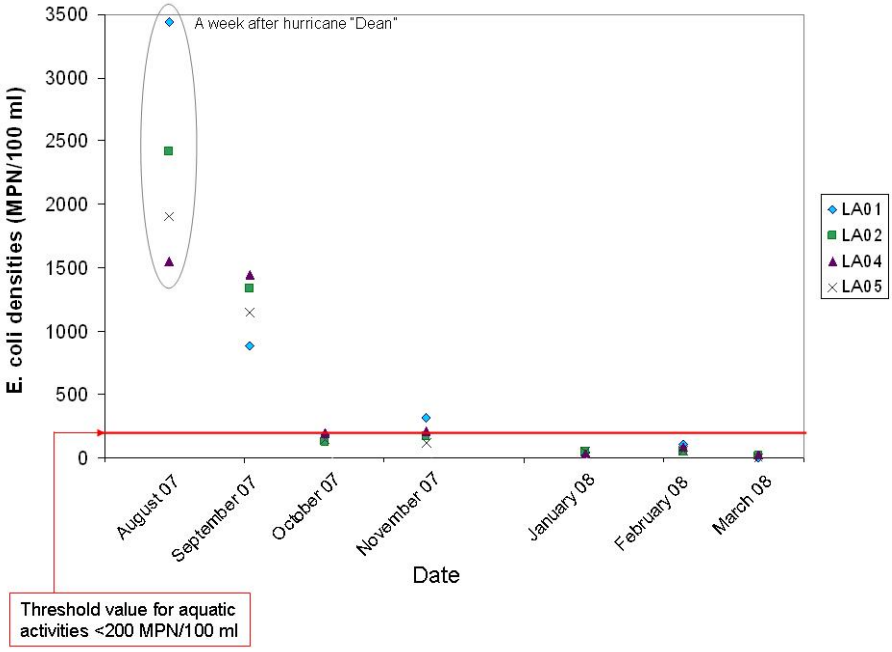
(b)

Figure 3. Seasonal distribution of salinity in Yal Ku estuary (a) and Lagartos lagoon (b)

Concerning Lagartos lagoon, temperatures of the samples were fairly regular, from 26 to 29 °C. The pH values are similar a those founded in Yal Kú between 7 and 8. Salinity of the lagoon varies between 4 and 11 ppt; the highest values were measured in January 2008 and the lowest in October 2007 (Fig. 3b). The distribution of chlorides in Lagartos lagoon shows a general increase of the concentration down gradient, to the north towards the coastal line. Regarding *Escherichia coli* densities in august present the highest values, as a result of hurricane "Dean" impact. The E. coli densities decrease in October 2007 (Fig 4b).



(a)



(b)

Figure 4. Densities of Escherichia coli in Yal Kú waters (a) and Lagartos lagoon (b). Encircled values correspond to august monitoring, a week after hurricane "Dean"

Conclusions

Different types of pollution characterize the different waters in Akumal. The impacts of toxic pollution on ecosystem health and hence on human health were tracked. The relationship between Escherichia coli and other parameters like rain or tourist number is not very clear. Nevertheless, contamination by fecal coliforms has been established. Variations in water quality will increase the stress on available water resources and valuable ecosystems, especially the adjacent coral reef.

The results of this monitoring will provide baseline data to propose and/or improve protection, conservation measures as well as suggest further research on human health in the area. Seasonal monitoring let us track the impact of events like hurricanes, wastewater discharges, etc., on the aquifer, as well as in the reef lagoon.

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