Marine Pollution Bulletin xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Baseline

Freshwater lenses as ecological and population sustenance, case study in the coastal wetland of Samborombón Bay (Argentina)

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ARTICLE INFO

Keywords:
Hydrogeomorphological units
Hydrogeochemistry
Water resources
Ecosystemic services
RAMSAR site

ABSTRACT

Freshwater lenses associated to shell ridges and sand sheets exist on the coastal wetland of Samborombón Bay. As they constitute one of the most vulnerable aquifer systems, it is the aim of this study to determine the hydrogeochemical processes that condition the chemical quality of its groundwater and to assess their present and future capability as sustenance of native woods and local villagers. To achieve this, hydrogeomorphological field surveys were made and groundwater samples were taken. Results show that lenses have a mean thickness of 12 m and its chemical quality depends on the dissolution of $CO_{2(g)}$ and carbonates, weathering of silicates and ion exchange. Lenses can be affected by long-term climatic variability and mining. The study of morphology and geochemistry of the freshwater lenses bring lights into important information about the management of water resources and conservation of the environment.

Coastal wetlands are located in a critical interface between land and sea environments where they constitute one of the most productive and valuable regions of the world providing many ecosystem goods and services (Odum and Harvey, 1988). The rational management of these areas is a particular challenge as they are sensitive environments for which any change in the quantity, quality and water flow, has the potential to fundamentally affect the integrity of the ecosystem (Fletcher et al., 2011). Most of these wetlands are developed in coastal plain areas of clayey silt sediments formed during sea level oscillations in the Quaternary where shallow groundwater tends to be saline (Carol et al., 2009). Shell ridges are geoforms genetically associated to coastal plains where the positive morphology and higher permeability of its sandy sediments favors rainwater infiltration and freshwater lenses formation (Maas, 2007; De Louw et al., 2011). The presence of freshwater lenses in coastal wetlands dominated by saline groundwater enables the existence of particular ecosystems and, on the other hand, secures the water supply for the local villagers. Their limited extension and topography determines that they are one of the most vulnerable aquifer systems in the world (Morgan and Werner, 2014) due to easily salinized by natural (sea level arise) or anthropic processes (intensive exploitation).

The Ajó coastal plain (Fig. 1) on the Samborombón Bay coastland (Argentina) comprises an extensive wetland designated as a RAMSAR site in 1997. The groundwater within the coastal plain and associated marsh is saline with values that reach 30.29 mg/L (Carol et al., 2009; Carol et al., 2016). Within the plain, shell ridges are developed in the northern and central sector of the wetland where the freshwater lenses are harbored (Carol et al., 2010). These lenses form a particular environment within the wetland that not only is the sustenance to protected native species like the *Celtis tala* forest, also constitute the only source of potable water for the local people. The objectives of this paper are to determine the geochemical and hydrological processes that condition the chemical quality of groundwater in the freshwater lenses and to assess the present and future capability of the lenses as sustenance of native woods and local villagers.

In order to characterize the fresh water lenses, a water balance for the period 2015–2016 was carried out by means of monthly temperature and rainfall data (Thornthwaite and Mather, 1957). At the same time, we made a water balance for a more extended period (1960–2016) to determine excess and deficit water periods for the study area. A hydrological and geomorphological characterization of the units that harbor the freshwater lenses within the coastal plain was achieved on the basis of background data, the analysis of satellite images and topographic maps and field surveys.

A regional monitoring network was created with 29 sampling points, among mills and household wells (ca. 12 m depth), shallow exploration wells (4 m depth) and abandoned quarries where the water table arises (Fig. 1). The data analyzed correspond to the sampling collected in September 2016. At the central sector of the bay, a monitoring network at a local level was carried out in order to define

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http://dx.doi.org/10.1016/j.marpolbul.2017.05.050
Received 10 February 2017; Received in revised form 17 May 2017; Accepted 19 May 2017

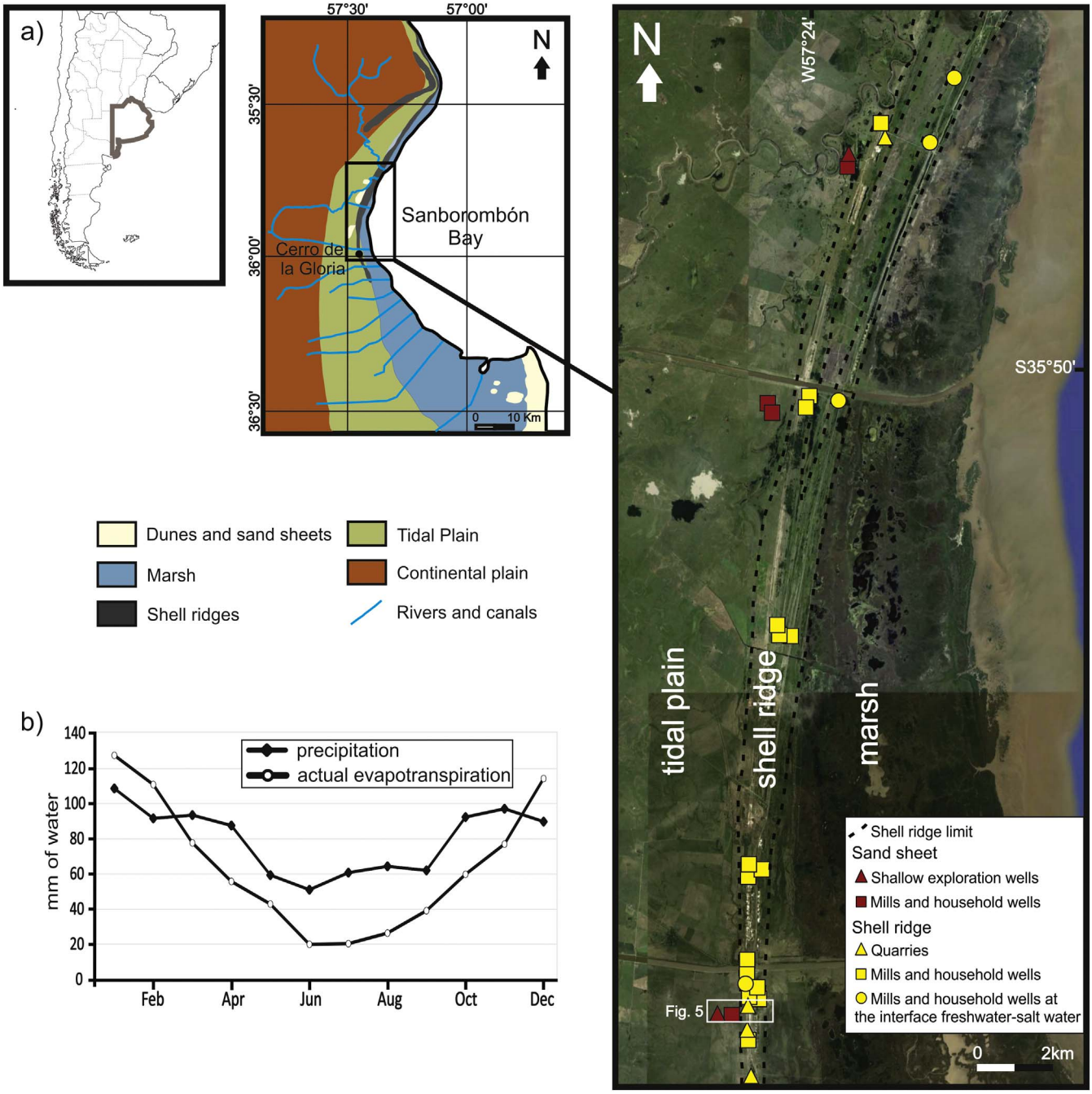

Fig. 1. Location of the study area: a) geomorphological map and sampling points; b) water balance for the 1960–2016 period. The white box shows Fig. 5 detailed profile in the study area.

a detailed morphology of the water lenses and see the seasonal variations regarding salinity. It comprises 7 wells located in a perpendicular transect to the shell ridge and 7 wells in a parallel transect. This network has been monitored since 2014 with sampling during water deficit periods as well as excess periods. In this way, sample collection, preservation and chemical analysis were carried out according with the standard methods proposed by the American Public Health Association (APHA), 1998. Electrical conductivity and pH were determined in the field immediately after sampling by means of portable equipment. Chemical analysis of the major elements was conducted at the Centro de Investigaciones Geológicas (CIG). Carbonate (CO_3^{2-}), bicarbonate (HCO_3^-), calcium (Ca^{2+}), magnesium (Mg^{2+}) and chloride (Cl^-) were determined by volumetric methods. Sodium (Na^+) and potassium (K^+) were determined by flame photometry. Sulphates (SO_4^{2-}) were measured by turbidimetry and nitrates (NO_3^-) by UV-spectrophotometry. The analytical error in 90% of the samples was below 10%.

Compositional analyses of the sand-fraction were carried out using a polarization microscope Nikon Eclipse E-200 and X-ray diffraction studies were run on an X PANanlytical model X'Pert PRO diffractometer of the CIG, using Cu/Ni radiation and generation settings of 40 kV and 40 mA. Routine air-dried mounts were run between 2 and 32° 2θ at scan speed of 2° 2θ/min. Ethylene glycol-solvated and heated samples were run from 2 to 27° 2θ and 3 to 15° 2θ, respectively, at a scan speed of 2° 2θ/min.

The results demonstrate that the water balance for the 1960–2016 period shows a mean annual precipitation of 954 mm and an annual actual evapotranspiration of 767.5 mm (Fig. 1b). It can be seen that from March to November the precipitation is higher than the actual