



## Baseline

# Heavy metal concentration in mangrove surface sediments from the north-west coast of South America



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## ABSTRACT

Mangrove ecosystems are coastal estuarine systems confined to the tropical and subtropical regions. The Estero Salado mangrove located in Guayaquil, Ecuador, has suffered constant disturbances during the past 20 years, due to industrial wastewater release. However, there are no published data for heavy metals present in its sediments and the relationship with anthropogenic disturbance. In the present study, metal concentrations were evaluated in surface sediment samples of the mangrove, showing that B, Cd, Cu, Pb, Se, V, and Zn levels exceeded those declared in international environmental quality standards. Moreover, several metals (Pb, Sn, Cd, Ag, Mo, Zn and Ni) could be linked to the industrial wastewater present in the studied area. In addition, heavy metal levels detected in this mangrove are higher than previous reports on mangrove sediments worldwide, indicating that this mangrove ecosystem is one of the most disrupted on earth.

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Mangrove ecosystems are unique coastal estuarine systems confined to the tropical and subtropical regions (Bayen, 2012). These zones are dominated by mangrove plants, which are highly productive and play a vital role, both as the major primary producers in estuarine ecosystems (Bayen, 2012; Wang et al., 2013), and by providing great ecological services (Lewis et al., 2011). Among the services provided are: protection from tidal events and erosion, as well as hosting approximately 4100 species of flora and fauna, presenting an overall economic value around 181 billion dollars (Alongi, 2002; Du Laing et al., 2009; Lewis et al., 2011). Also, mangroves generate economic benefits to adjacent human populations, mainly due to tourism and fishing (Bayen, 2012; Franco-Dias et al., 2012).

In spite of their great ecological relevance, mangrove forests are rapidly disappearing, with up to 50% being lost over the past 50 years due to direct anthropogenic interference (Bouillon, 2011). Today, less than 10% of the mangroves around the world are considered protected areas (Lewis et al., 2011). Due to their high ecological relevance, many cities have settled in nearby mangroves, which are, therefore, constantly exposed to severe disturbances (Valiela et al., 2001). These disturbances are caused by exposure to a variety of chemicals, including heavy metals,

which are considered to be among the most potentially serious anthropogenic pollutants in mangrove ecosystems (Wang et al., 2013). In addition, heavy metals are particularly relevant because of their ability to accumulate in surface sediments, leading to a gradual increase in their concentration in this area (Bayen, 2012).

The content of heavy metals in sediments of various mangrove systems worldwide has been determined; for example, As, Cd, Co, Cr and Ni in Malaysia (Sany et al., 2013); Cu in the Gulf of California (Soto-Jiménez and Páez-Osuna, 2001); Pb in Portugal (Caeiro et al., 2005) and Zn in Puerto Rico (Mejias et al., 2013) among others. These studies make it clear that the long-term pollution processes observed in many mangroves are caused by human activities (Bayen, 2012; Tam and Wong, 2000), with a direct effect on the ecological conditions of the sediments (Essien et al., 2009), biogeochemical cycles (Lenoble et al., 2013) and primary production of the ecosystem (Bai et al., 2011; Bayen, 2012; El-Said and Youssef, 2013). In contrast, there are some mangrove systems with undetermined levels of heavy metals, such as the present in the northwest coast of South America.

The Gulf of Guayaquil is one of the most productive areas on the northwest coast of South America. This area contains 81% of the Ecuadorian mangrove system (Monserrate et al., 2011), covering 615 km of coastline. One of the principal parts of the mangrove, the Estero Salado, has been surrounded by Ecuador's most populous city, Guayaquil (2°11'44"S, 79°53'18"W). In this sense, the Estero Salado has suffered constant disturbances during the

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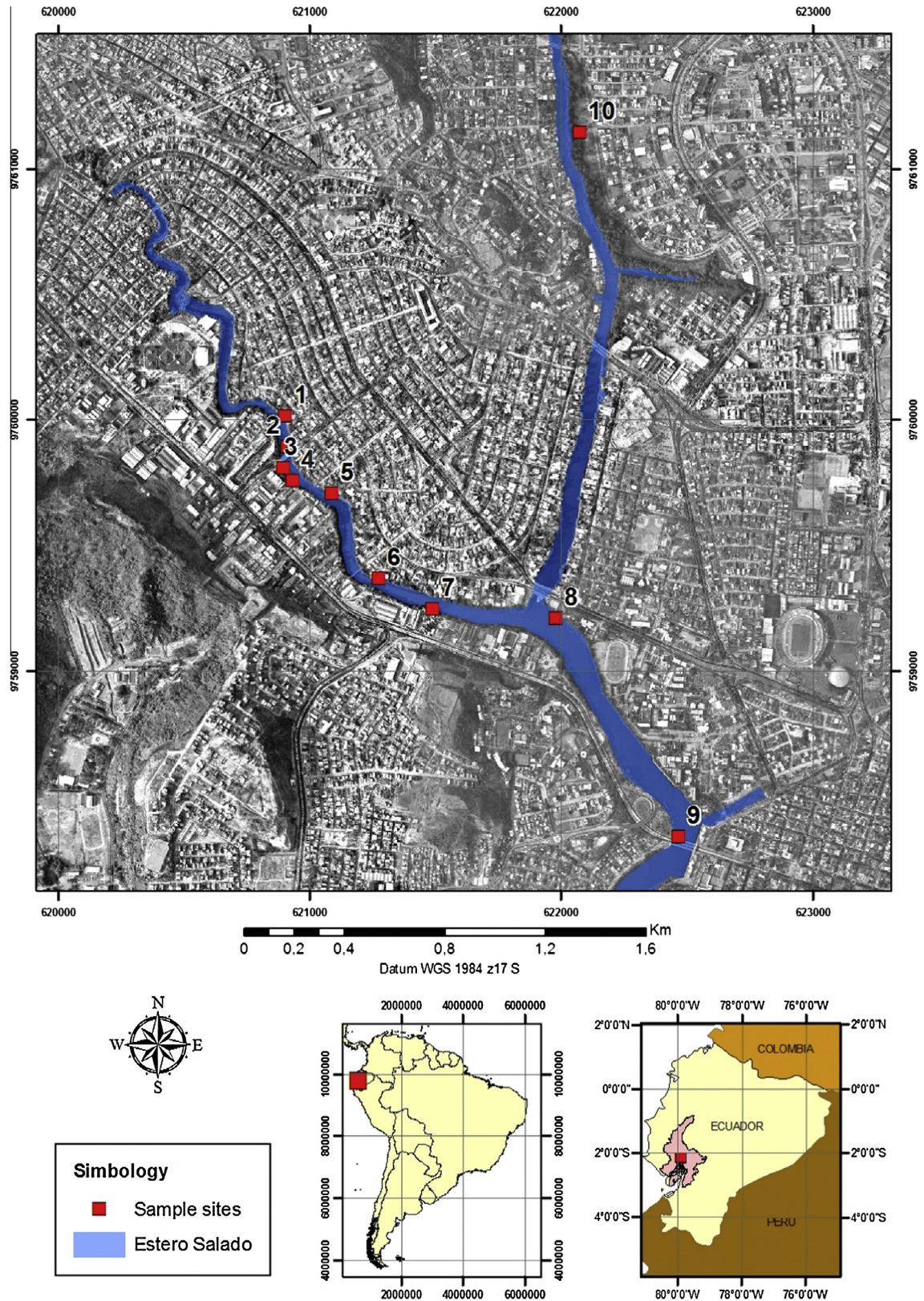


Fig. 1. Aerial photography showing the geographic localization of the 10 sampling sites analyzed in this study.

past 20 years, mainly due to industrial wastewater release (Monserrate et al., 2011).

The aim of this study was to determine the concentration and distribution of heavy metals in mangrove surface sediments from

the Estero Salado and to contrast them with the presence of heavy metals reported for other mangroves worldwide. To evaluate associations between metals and to infer similar biogeochemical origins, a Pearson correlation matrix was performed. Furthermore,

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