

# Heavy metal(loid)s contamination in water and sediments in a mining area in Ecuador: a comprehensive assessment for Drinking Water Quality and Human Health Risk

## PROBLEM

The Santa Rosa River is the primary source of water catchment for the treatment plant Los Jardines, which supplies drinking water to more than 85% of the inhabitants of Santa Rosa. However, the water quality of the Santa Rosa River has been a concern because of the history of mining pollution in the upper part of the river (Fig. 1).

## OBJECTIVE

This study aims to assess the human health risk caused by heavy metal(loid)s in tap water in Santa Rosa city, and the ecological risk of stream water and sediments in the Santa Rosa River.

## MATERIALS AND METHODS

Concentrations of As, Cd, Cr, Cu, Ni, Pb, and Zn were evaluated in tap waters (n=85), stream waters (n=48), and sediment samples (n=20) in the rainy and dry seasons in 2021. The Metal Index (MI), Geo-accumulation Index (Igeo), Potential ecological risk (PERI), and the levels of carcinogenic (CR) and non-carcinogenic risk (HQ) for residents were determined. The spatial distribution of the heavy metal(loid)s in waters and river sediments was mapped using the Geographic Information System software ArcMap 10.8.2.

## RESULTS

The results revealed severe pollution levels, mainly in the dry season, in *Los Gringos* and *El Panteón* streams, both tributaries of the Santa Rosa River, which is the primary water source for Santa Rosa inhabitants. More than 20 % of the surface water samples showed severe contamination (MI > 6), and 90% of the tap water samples showed slight to moderate pollution. Drinking water presented high levels of As, with 83% of the houses in the dry season above the recommended concentration set by the WHO and Ecuadorian legislation (Fig. 2). The Igeo-Cd in the sediment samples was significantly high (Igeo > 3), and the PERI showed very high ecological risk (RI > 600), with Cd as the main pollutant (Fig. 3). HQ and CR were above the safe exposure threshold (Fig. 4), suggesting that residents are at risk from tap water consumption.

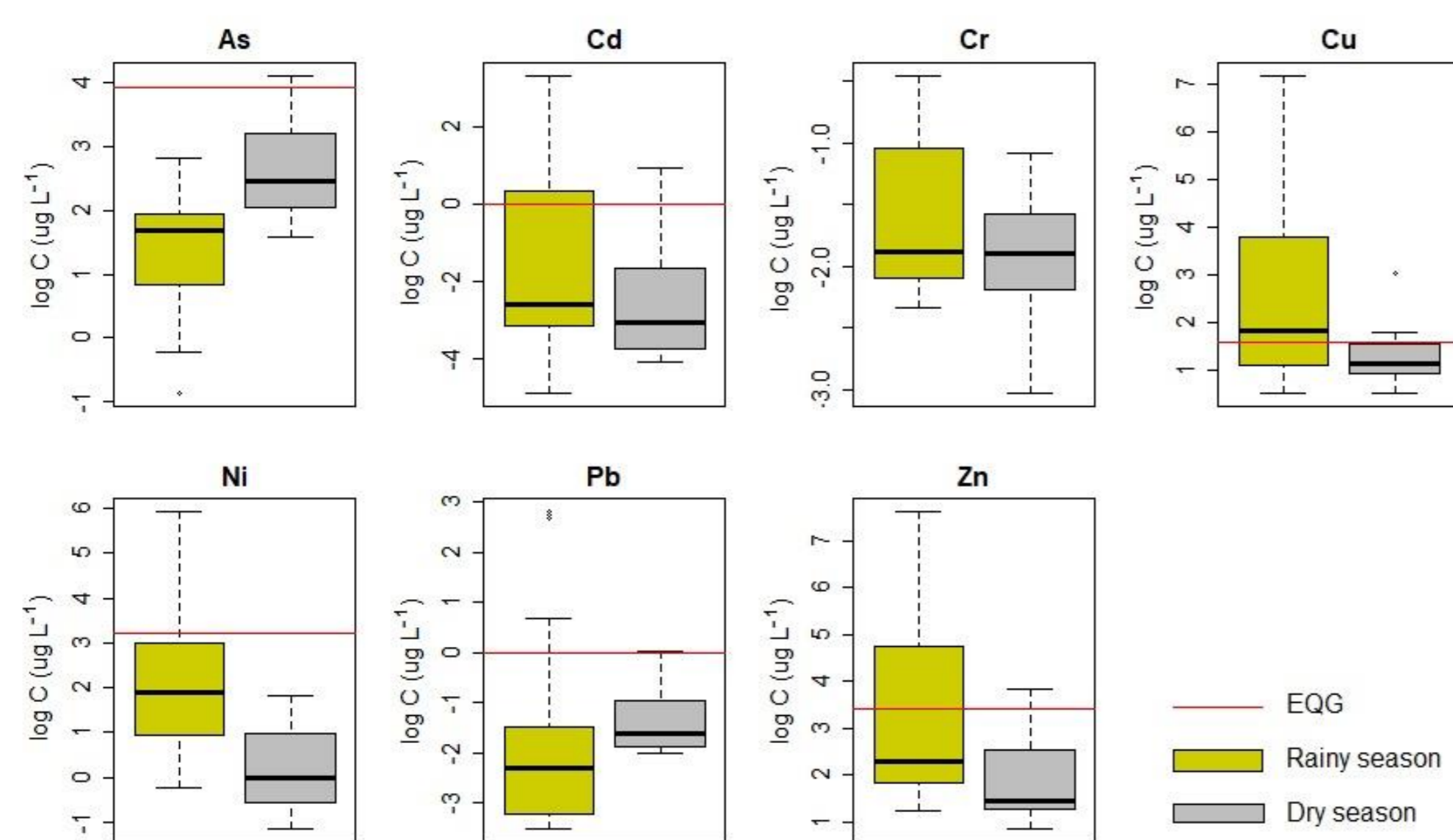


Fig. 2 Boxplots for the heavy metal(loid)s concentration detected in tap water. The red line represents the maximum allowable concentration according to Ecuadorian water quality guidelines (EQG)

## CONCLUSIONS

- This study provides valuable knowledge about the human health risk to which the inhabitants of Santa Rosa City are exposed. The non-carcinogenic and carcinogenic risks were above the safe exposure threshold, mainly through tap water ingestion. Drinking water showed high levels of As, with 83% of the houses in the dry season above the recommended concentration set by the WHO (10 ug L<sup>-1</sup>) and Ecuadorian legislation. This result indicates that direct tap water consumption should be avoided since there is a high probability of adverse health effects caused by As exposure via tap water ingestion. This is worrisome, particularly for children, who are the most vulnerable among the population.

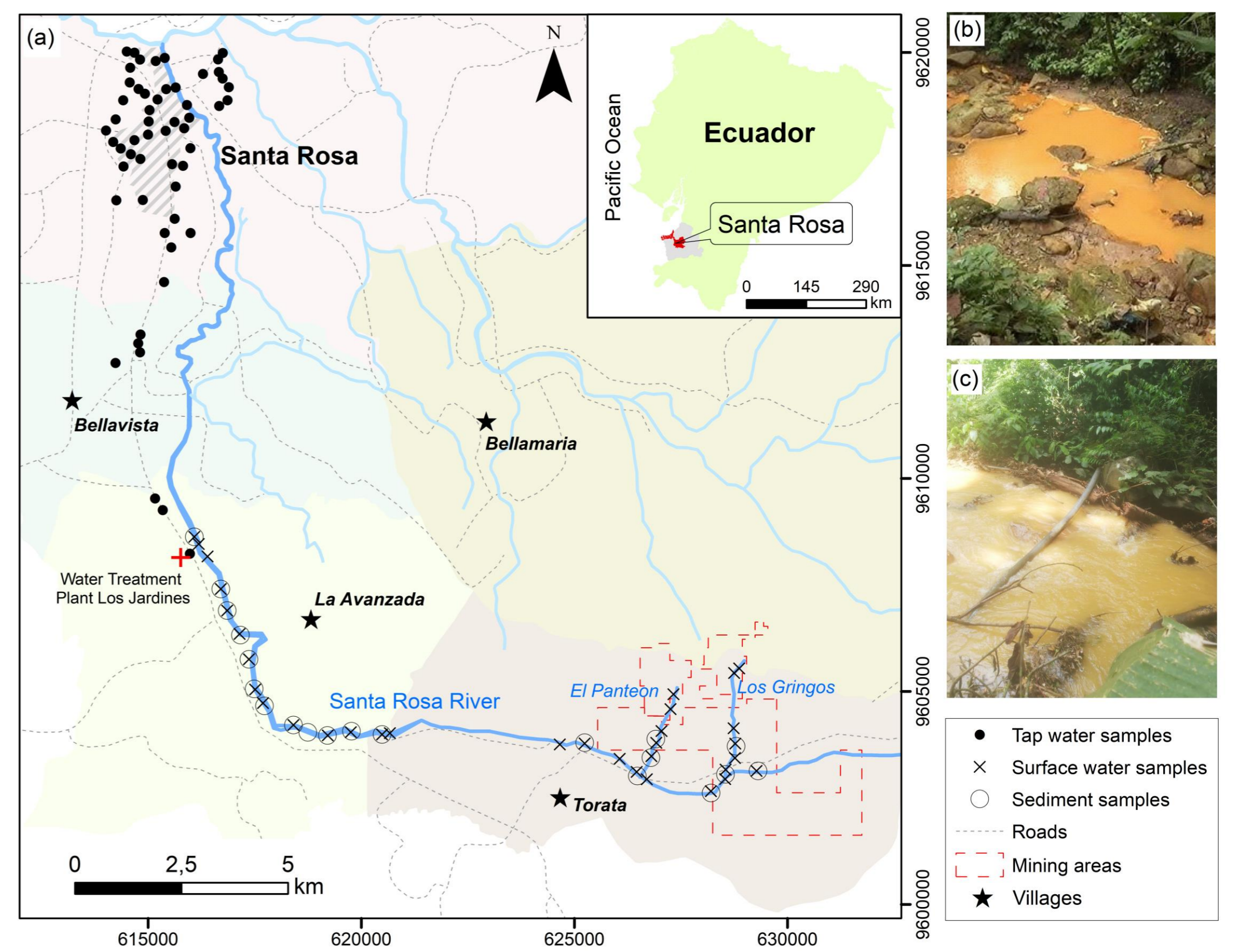


Fig. 1 (a) Location of the study area, and (b) *El Panteón* and (c) *Los Gringos* streams potentially polluted.

$$MI = \sum_{i=1}^N \frac{C_i}{(MAC)_i}$$

$$I_{geo} = \log_2 \left[ \frac{C_i}{1.5 \times B_i} \right]; PERI = \sum_{i=1}^n E_r^i$$

$$HQ = \frac{ADD_i}{RfD_i}; CR = ADD_i \times SF_i$$

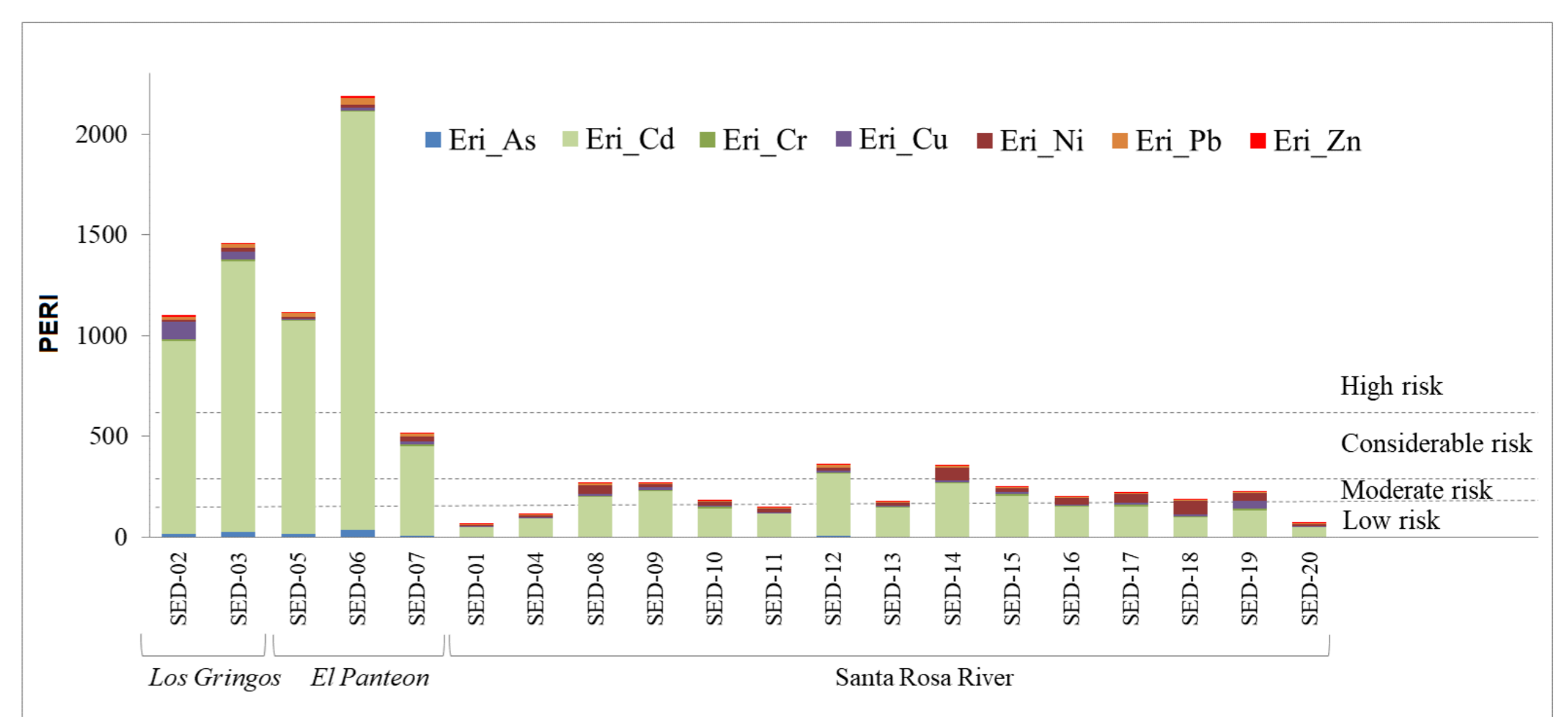


Fig. 3 Potential ecological risk (RI) and Ecological Risk Index (Eri) in the sediments from the Santa Rosa River, Los Gringos, and El Panteón tributaries.

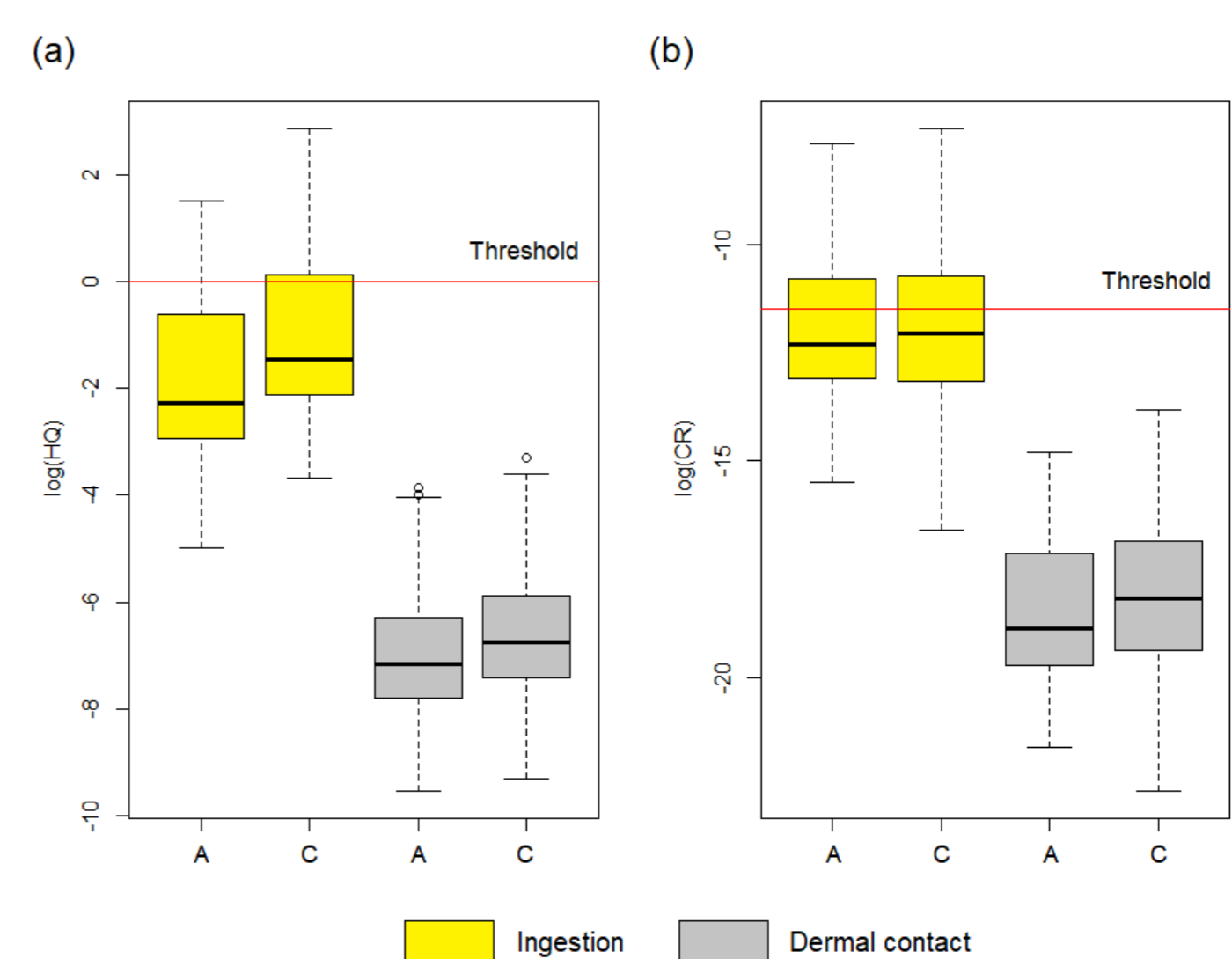


Fig. 4 (a) non-carcinogenic risk and (b) carcinogenic risk by exposure route and receptor (A: adult and C: children).

As-ingestion through drinking water in Santa Rosa is a health hazard. In contrast, the risk related to Cd, Cr, Cu, Ni, Pb, and Zn exposure for both receptors were very low; thus, these metals are negligible contributors to the human health risk.

## RECOMMENDATIONS

- Epidemiological studies are strongly advised to detect the signs of As poisoning in all the population. In addition, public policies are needed to guarantee the quality of drinking water supplies. Finally, it is recommended to implement treatment systems to remove As from drinking water or consider alternative water supply sources for Santa Rosa City. The high contents of heavy metal(loid)s detected in the upper part of the Santa Rosa River, may have of geogenic origin due to the well-known geological and mineralogical characteristics of the area. Therefore, it is crucial to carry out a deeper investigation to identify the local background values and be able to differentiate between geogenic and anthropogenic contamination.