

On the radioecological issues of natural radionuclides in water and sediment of a highly contaminated lagoon from Mexico

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INTRODUCTION

Some aquatic ecosystems from Mexico, such as rivers and lagoons, are affected by wastes enriched with potentially toxic elements generated by precious metal mining activities [Iskander, 1994]. Contamination of water, sediment and affected biota has produced several environmental issues, including biological effects in some species of flora [Huerta-García, 2016]. On the other hand, mineral processing activities may also generate effluents containing high activity concentration levels of natural radionuclides and, in this case, the wastes may be considered as technologically enhanced naturally occurring radioactive materials (TENORM). The release of TENORM in the aquatic environment may represent a radiological and ecological contamination issue [USEPA, 1999]. Therefore, the need for monitoring and assessing the radioecological impact of mining activities has been increased. In this study, measurements of the activity concentration levels of natural radionuclides in water and sediment from a continental lagoon in Central Mexico are performed.

Analysis of sediment by gamma-ray spectrometry

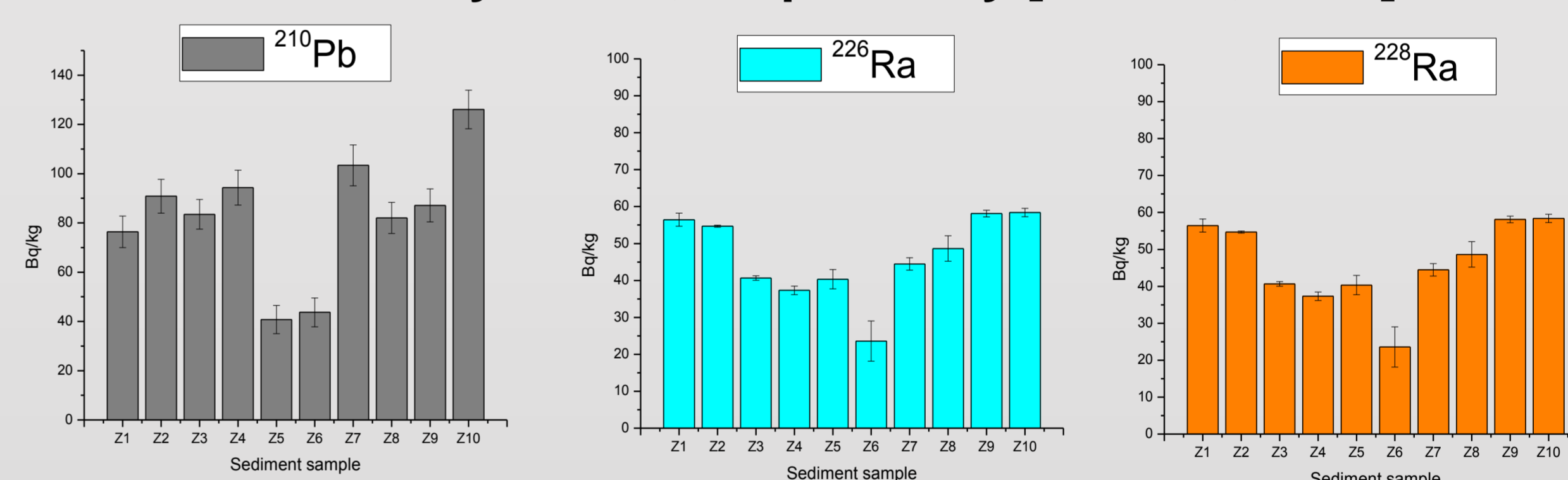


Gamma-ray spectrometry system used in this study: HPGe detector and lead shielding.

High resolution gamma-ray spectrometry was used to perform the radiometric characterization of the sediment samples in a Canberra HPGe (Hyperpure Germanium) detector type XtRa (extended range), with a relative efficiency of 40% and resolution of 1.77 keV for the 1.33 MeV photopeak of ⁶⁰Co. Efficiency calibration was performed using IAEA reference materials (RGU1, RGTh1). Self-absorption corrections were done for ²¹⁰Pb calculations.

RESULTS AND DISCUSSION

Activity concentration of ²¹⁰Pb, ²²⁶Ra and ²²⁸Ra in the sediment samples of the studied lagoon presented an average value of 83±26, 46±11 and 62±12 Bq/kg, respectively. This values are very similar, but also higher than levels in soil from the cities of Zacatecas and Guadalupe, which present ranges of 11-38 and 8-38 Bq/kg for radionuclides from the ²³⁸U and ²³²Th natural decay series, respectively [Mireles, 2003].



Activity concentration of natural radionuclides in sediment of the studied lagoon

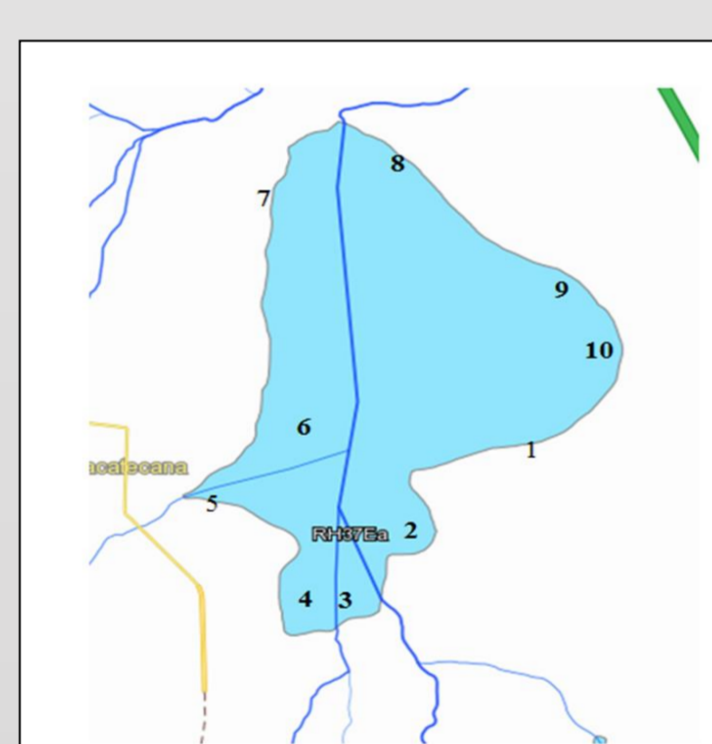
METODOLOGY

Study Area



Map of Zacatecas city

Sampling



El Pederalillo lagoon is located in Central México, within the mining district of Zacatecas. 10 samples of water and 10 samples of sediment were collected from the shore.

Sediment preparation



Sediment was dried, grinded and sieved. A representative aliquote of sediment was packed in cylindrical geometry

Analysis of water by alpha spectrometry

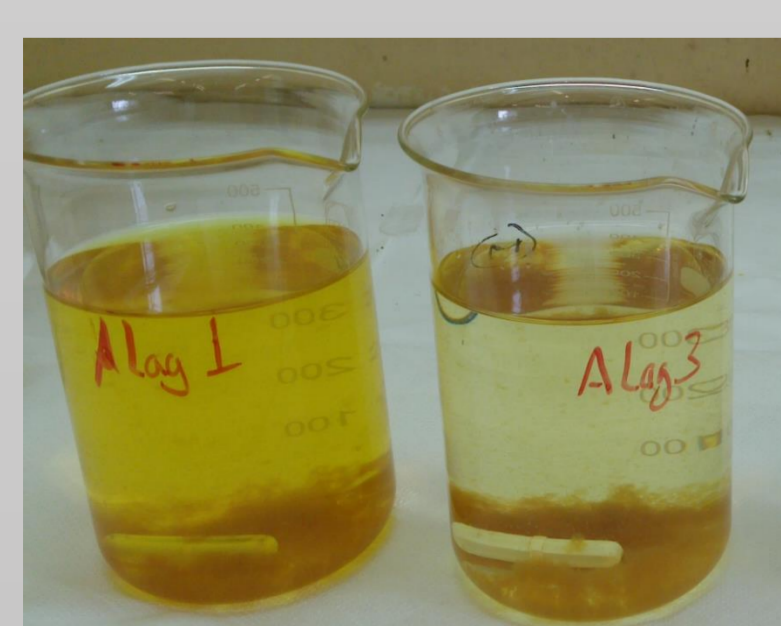


Radiochemical processing of water samples

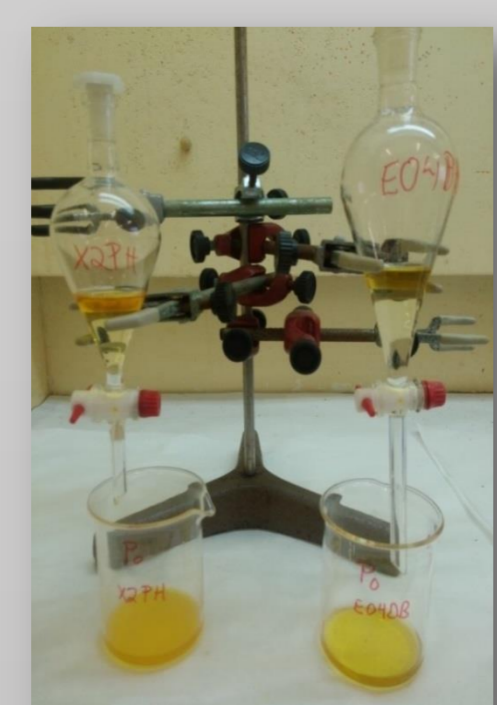
Preconcentration

U-Po Separation

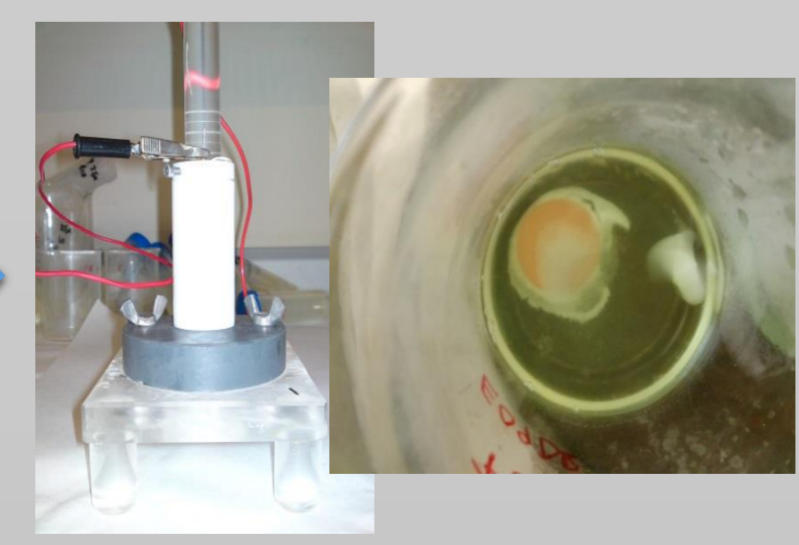
Source preparation



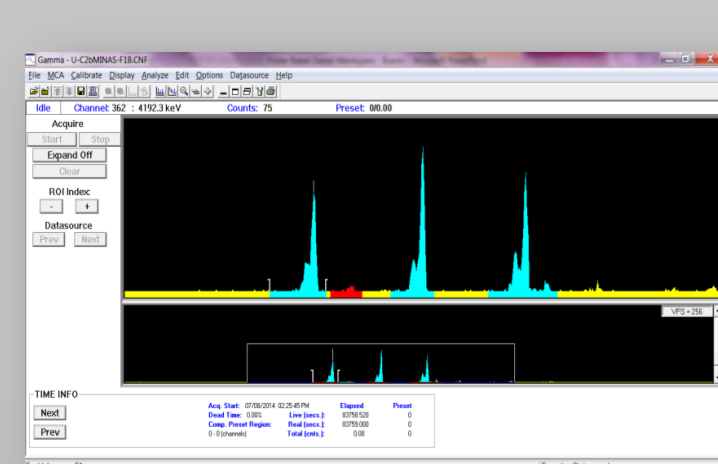
Actinides coprecipitation with iron hydroxide



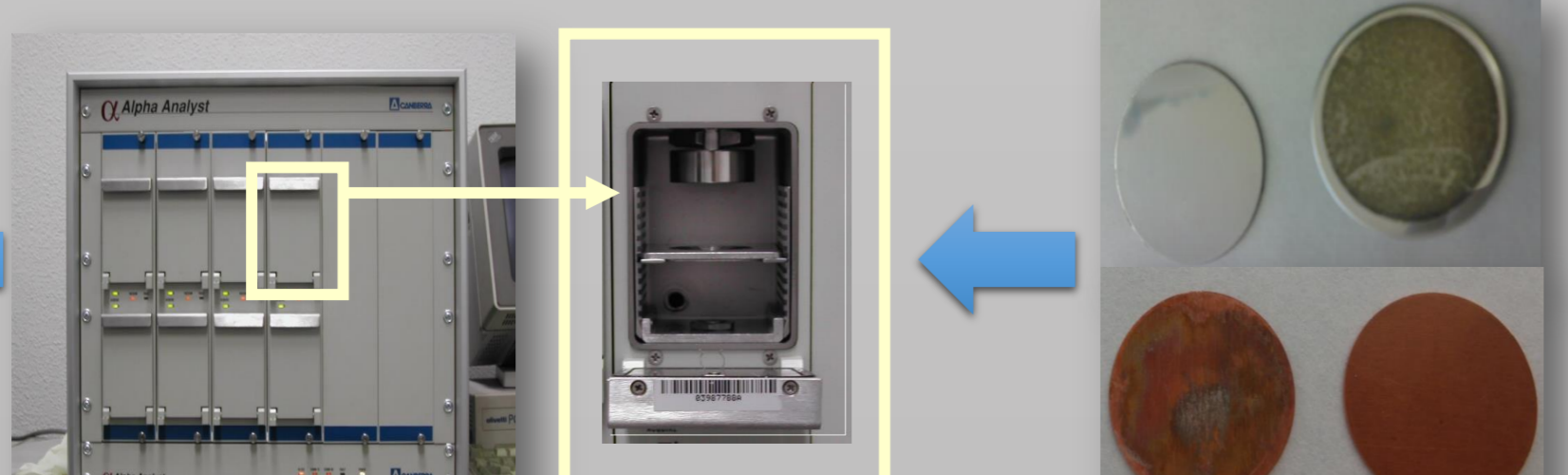
Liquid-liquid solvent extraction (TBP)



Electrodeposition (U) or self-deposition (Po) in metallic plates



Spectrum Analysis with Genie 2000



Measurement with PIPS detectors in a Canberra Alpha Analyst System

Regarding alpha-particle spectrometry measurements in water, uranium isotopes presented activity concentration average values of 155±104, 380±252 and 7.0±4.2 mBq/L for ²³⁸U, ²³⁴U and ²³⁵U, respectively. Average concentration of ²¹⁰Po in water was 25±19 mBq/L. Uranium levels in the studied lagoon are lower than U levels in surface water from the Arizona copper belt (2960–3100 mBq/L) [USEPA, 1999], but higher than U levels in water from and estuary influenced by acid mine drainage in the Iberian Pyrite Belt (1.8–131 mBq/L)[Villa, 2011].



CONCLUSION

Activity concentrations of natural radionuclides in water and sediment from the lagoon El Pederalillo have been determined. Levels of radium isotopes and ²¹⁰Pb in sediments are within reference levels of the studied region. On the other hand, uranium concentration levels in water are high, specially ²³⁴U exceed the USEPA guidelines levels for total uranium in natural waters (185 mBq/L). Because water from the suited lagoon is used for irrigation of nearby crops and animal consumption, radioecological implications may emerge from uranium bioaccumulation in the food chain. It is necessary to extend this study to the radioanalysis of biota and continue monitoring the levels of U in the Zacatecas environment.

REFERENCES

- [Huerta-García, 2016] Huerta García, et al... Evaluación de Mercurio y otros metales pesados en sedimentos de la presa la Zacatecana y su efecto fitotoxicológico en maíz (Zea mays) y frijol (Phaseolus vulgaris L) cultivados en áreas aldeanas. Informe de proyecto de investigación UAZ-2015-36928 (2016).
- [Iskander, 1994] Iskander F.Y., Vega-Carrillo H.R., Manzanares E. Determination of mercury and other elements in La Zacatecana Dam sediment in Mexico. The Science of the Total Environment 148: 45-48 (1994).
- [Mireles, 2003] Mireles F., Dávila J.L., Quirino L.L., Lugo J.F., Pinedo J.L. and Rios C. Natural soil gamma Radioactivity levels and resultant population dose in the cities of Zacatecas and Guadalupe, Zacatecas, Mexico. Health Phys. 84 (3): 328-372 (2003).
- [USEPA, 1999] United States Environmental Protection Agency. Technologically Enhanced Naturally Occurring Radioactive Materials in the Southwestern Copper Belt of Arizona.
- [Villa, 2011] Villa M., Manjón G., Hurtado S., and García-Tenorio R. Uranium pollution in an estuary affected by pyrite acid mine drainage and releases of naturally occurring radioactive materials. Marine Pollution Bulletin 62 (2011) 1521–1529