Radiometric dating of recent sediment cores

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One of the Radioactivity measurements laboratory's major activities is to provide chronologies for sediment cores covering the most recent decades. During this time period, major changes to the environment, often caused by human activities, might have been recorded in the sedimentary record. Up to 100-150 years old sediments can be dated using the natural isotope ^{210}Pb, a member of the ^{238}U decay chain. This isotope has a suitable half-life of 22.3 years and its origin within the sediment is two-fold: Firstly, radioactive decay from its long-lived parent nuclide ^{226}Ra, being a common trace element in mineral grains in the sediment, is responsible for a part of ^{210}Pb, which is called "supported" ^{210}Pb. The second source is the deposition from the atmosphere, whereby ^{210}Pb originates from the gaseous intermediate decay chain member ^{222}Rn, which escapes from the soil. This additional ^{210}Pb contribution is called "excess" ^{210}Pb. With increasing depth (and age) within an undisturbed sediment, the "excess" ^{210}Pb decreases to a known proportion due to radioactive decay. This enables us to date the sediment layers and therefore construct an age model for the sediment core.

Both total and "supported" ^{210}Pb can be measured by a non-destructive technique, gamma-spectrometry. Additional radionuclide tracers detected within the same spectra can be used to verify the accuracy of the ^{210}Pb-based age models: anthropogenic radionuclides that are products of nuclear fission or activation in nuclear reactors or weapons, which can be detected in certain sediment horizons as markers of nuclear fallout periods. Examples of man-made isotopes with suitable half-lives are ^{137}Cs or ^{241}Am. Resulting chronologies provide high temporal resolution and are complementary to the radiocarbon technique, which is not suitable for the last Century, but in turn can date materials of organic origin up to several thousand years old.

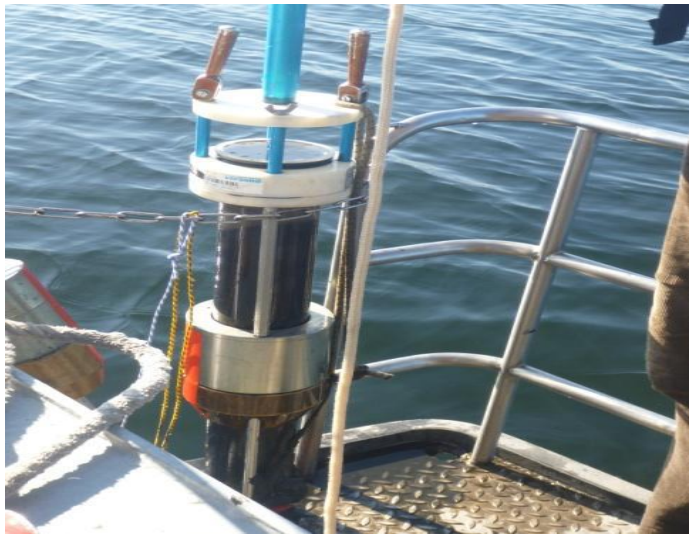

Figure 66: Sampling of a short sediment core at the lake Tegeler See near Berlin.

Lake and marine sediment cores contain information needed to improve our understanding of past environmental changes. Therefore, they serve as valuable archives of climate change, environmental pollution or changes in land use practices. We co-operate with other national or international institutions and provide sediment chronologies within paleoclimate or environmental studies:

- In the terrestrial environment, we have contributed to a study of phosphorous cycling in lake sediments

lead by the Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Berlin (Rothe et al. 2015). This project described retention of phosphorous in the iron phosphate mineral vivianite during early sediment diagenesis in the lake Lower Havel.

- Recent layers from marine sediment cores taken in South Africa at the Namaqualand mudbelt, offshore the Olifants and Orange Rivers, were dated within a study of climate development and related vegetation shifts over the last 2 Millennia. This study (Hahn et al., 2016) of an international team of researchers, led by MARUM – Centre for Marine Environmental Sciences, shows a contrast in timing of wet periods in the catchment areas of both rivers, attributed to the shifts of climate zones, presumably in connection with Antarctic cooling and warming events.
- In another international cooperation led by Uruguay, we have provided a recent chronology for a Río de la Plata Estuary sediment core. This study shows that the studied sediments contain a distinct continental runoff record as a result of short-term climatic variability (Pacific Decadal Oscillation, Atlantic Multidecadal Oscillation and El Niño/La Niña Southern Oscillation) which influences the precipitation patterns over SE South America over the last Century.

In all cases, our contribution consisted in developing age models or calculating sedimentation rates, necessary for a consistent interpretation of other proxy data, and impossible to obtain from the core material without the radiometric methods offered at IUP.

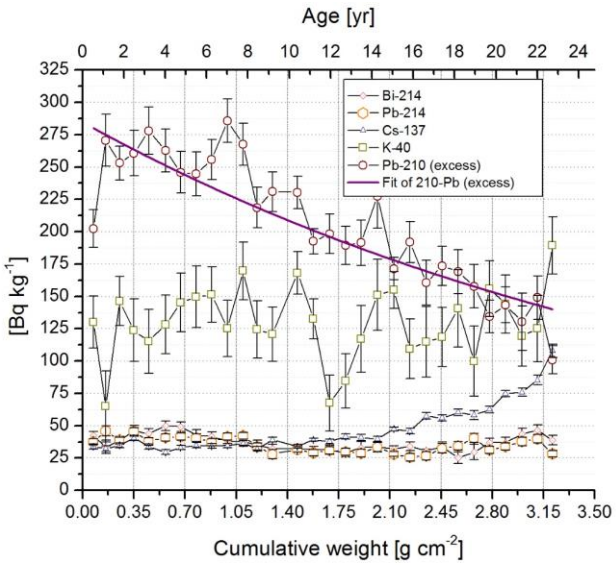

Figure 67: Radionuclide profiles used for interpretation of rates of recent sediment accumulation in Lower Havel Lake, Berlin, used in Rothe et al. (2015). The upper axis shows that, according to the developed age model, the sediment record covers the most recent 23 years. The values of anthropogenic ^{137}Cs are maximum at the depth of the core, and the maximum value related to Chernobyl nuclear reactor accident fallout is expected below the sampled interval. The cumulative weight is a quantity used for compaction corrected depth in sediment.

References

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