Keeping ports accessible: Brazil is saving "millions" in dredging costs thanks to nuclear techniques

By Rodolfo Quevenco

"In the same way as a heart surgeon can investigate major blood vessels, or a radiologist can track organic functions of the human metabolism by using medical tracers, radiotracers allow us to assess the hydrodynamic behaviour and main pathways of sediment movement in coastal areas."

— Jefferson Vianna Bandeira, senior researcher, National Nuclear Energy Commission of Brazil

With a coastline of over 8500 kilometres, 90 per cent of Brazil's total exports and imports pass through its ports.

Many of the country's major ports and harbours were built over 100 years ago. Keeping shipping lanes open and enabling these ports to accommodate larger vessels with ever bigger loads requires constant dredging, often at high cost.

Over the years, the use of nuclear techniques to study sediment build-up and transport across major ports and harbours (see box) has saved Brazil millions of dollars in dredging costs, said Jefferson Vianna Bandeira, a senior researcher in the Environment Department of the National Nuclear Energy Commission of Brazil.

With IAEA assistance, Bandeira and a team of scientists have been using radiotracers to map sediment movements that affect Brazil's major ports since the 1960s.

Radiotracer techniques can help economize dredging operations that keep harbours deep enough to accommodate larger ships with bigger loads. (Photo: A. Hardacre/Flickr.com/CC BY 2.0).

Initially, a major focus was to assess the behaviour of sediments dredged from the harbour area of Port Santos after they were dumped. Port Santos, near Sao Paulo, is one of Latin America's largest and busiest ports, currently serving various Brazilian states and handling 28 per cent of the country's foreign trade.

The dumping site has been moved several times in order to minimize the flow of sediments back into the bay system. The use of radiotracers has enabled port engineers to find optimal locations as close to the port as possible.

"In the studies performed in the seventies at Sepetiba Bay, Rio de Janeiro State, for the construction of Ilha da Madeira harbour, we have probably 'economized' over 100 000 kilometres of dredging travel distance," Bandeira said. This has resulted in savings of millions of dollars to Brazilian port authorities, he added.

From port to sea: modelling sediment and water movement using radiotracers

Years of radiotracer investigations at the Port of Santos and other ports in Brazil have also given Bandeira's team extensive knowledge of the dynamics of sediment transport and movement patterns in changing conditions. In the process, they have been able to use mathematical models and accurate data sets of sediment transport and flow patterns that are continually being used in coastal engineering activities.

"We are like surgeons and specialists," said Bandeira, in describing the work he and his colleagues do. "In the same way as a heart surgeon can investigate major blood vessels, or a radiologist can track organic functions of the human metabolism by using medical tracers, radiotracers allow us to assess the hydrodynamic behaviour and main pathways of sediment movement in coastal areas."

This intimate knowledge has been put to good use many times over. For example, in the sediment studies carried out along the coastal shore of what would become known as the Port of Suape, radiotracer labelling

Understanding the dynamics of sediment movement can help identify the best location of dumping sites for dredged sediment, so as to avoid unwanted pollution of nearby beaches. (Photo: R. Quevenco/IAEA)

revealed low bottom sediment transport rates in summer as well as winter. This information was essential in determining the ideal location for the port and indicated that there would be no need for significant maintenance dredging offshore. These studies were performed simultaneously with oceanographic measurements in the nearshore (wave, wind, currents and tide). Suape has since developed into the most important port complex in north-eastern Brazil.

Fighting coastal erosion

Coastlines and seabeds are dynamic regions with sediments undergoing periods of erosion, transport, sedimentation and consolidation. The main causes of erosion of beaches include storms; but human activities, such as dredging of stream mouths, and construction of seawalls and jetties, also disrupt the natural flow of sediment.

"Nuclear techniques are the most useful and efficient methods to assess erosion and movement of silt and sediments in coastal areas," said Patrick Brisset, an industrial technologist at the IAEA. "Such techniques have been and are used in many countries for coastal engineering; many more are just starting to use the technology in support of their development plans."

Through the IAEA's technical cooperation programme, many of Brazil's scientists have received training, Brisset explained. At the same time, many IAEA experts have gone to Brazil to perform sediment transport studies and teach various technicians. Brazilian experts are also now extending help and support to other Member States, including Venezuela, Uruguay and Niger, in projects involving radiotracer applications for sediment studies.

THE SCIENCE

Advantages of using radiotracers to study sediment transport

Most of the world's population lives on coasts or in coastal regions, so understanding the dynamics of sediment transport in these areas is of vital importance to many countries.

Radiotracer techniques are an effective method of investigating sediment dynamics, as they can provide real-time, accurate assessment of where, how and why sediments move. A common procedure involves the introduction of small quantities of a radioisotope (for example, gold-198 or iridium-192) into the sediment samples to be measured, dropping them at key sampling points, and then monitoring their movement using scintillation detectors towed by boats.

Tracer techniques are also often employed to validate the results of other techniques used to assess sediment behaviour, for example bathymetric surveys, or mathematical and physical models. There is also a growing trend towards analysing radiotracer experiments using computational fluid dynamics, a branch of fluid mechanics that uses numerical analysis and algorithms to analyse fluid flows. This is expected to lead to more reliable models and better validation of results.