IAEA BRIEF 2019/1

Industry

Radiotracers and Sealed Sources Applications Help to Monitor Sediment Movement

SUMMARY

1. Globally more than half the world's population lives on maritime shores, estuaries and river banks where sediment transport challenges exist as a direct consequence of accelerated littoral erosion.
2. Studies on sediment transport in rivers and coasts are critical to build and maintain key infrastructure, such as ports, docks, coastal reclamation, dredging and irrigation projects.
3. Radiotracers and sealed sources applications are largely employed to monitor sediment movements in rivers and seas to provide vital details necessary to build and maintain river and maritime works, such as dams and harbours.

INTRODUCTION

Coastlines and sea beds are dynamic regions, with sediments undergoing stages of erosion, transport, sedimentation and consolidation. The main causes of these changes include rising sea levels, waves and tsunamis caused by earthquakes, mudslides, intense rainfalls, and storms. Human activities, such as the construction of sea-walls and jetties, and the dredging of stream mouths, could also disrupt the natural flow of sand.

The related socio-economic consequences of sediment change are global challenges of concern. However, there are viable options available to provide relevant information for tracking and assessing sediment transportation, one of which is using radiotracers and sealed source applications.

Gamma scattering and transmission gauges such as the JJD3 turbidity gauge, are used for field measurement of high concentration of sediments deposited in harbours, navigation channels, dam reservoirs and rivers.

(Photo: P. Brisset/IAEA)

The IAEA supports countries in monitoring sediment movement using radiotracers. These radioactive methods can help in investigating sediment dynamics, providing important parameters for better design,

maintenance and optimization of civil engineering structures. Since the 1960s, radioisotopes as tracers and sealed sources have been useful and often irreplaceable tools for sediment transport studies.

WHY IS IT IMPORTANT TO STUDY SEDIMENT TRANSPORTATION?

Sediment management is a key consideration for all countries when it comes to protecting coastlines and their population from sediment movement, which can result in widespread flooding, landslides or loss of floodplains and agricultural land.

Understanding the behaviour and impact of sediment movement is important for port and harbour development, dredging, engineering projects, pollution transport, flood and coastal protection, population protection, water quality, tourism, coastal zone management and environmental habitat protection.

Having accurate and conclusive field datasets detailing sediment movement and the conditions leading to erosion and transport allows countries to develop effective management strategies to prevent environmental damage, as well as cost effective measures to protect and prevent sediment depletion.

A typical problem facing sediment movement is managing water depth in ports and harbours, ensuring it is sufficiently deep to handle ships' movements. To that end, dredging operations are conducted. Selecting an appropriate dumping site for dredged material is very important to minimize the flow of sediments back into the navigation channel.

WHAT ARE RADIOTRACERS?

Tracers are substances with atomic, nuclear, physical, chemical or biological properties that can help identify, observe or follow the behaviour of various physical, chemical or biological processes. Radioactive tracers are widely used to measure the flow rate of liquids, gases and solids.

RADIOISOTOPE TECHNIQUES HELP TO TRACK SEDIMENT MOVEMENT

Scientists have been using nuclear techniques to study sediment build-up and transport across major ports and harbours, providing vital support is to many civil engineering projects. Radioisotope techniques are largely employed to monitor sediment (gravels, sands and silts) displacements in rivers and seas. This information is necessary to build and maintain river and maritime works, such as dams, navigation channels, harbour basins, as well as to design and maintain barriers for beaches and littoral protection from erosion.

There are two kinds of radioisotope techniques used for sediment transport studies:

1. Radiotracers that trace and track the movement of solid particles under the action of water currents and waves; and
2. Radioisotope sealed sources (nucleonic gauges or nuclear instruments) to measure the sediment concentration or the density of sediment and water mixtures in rivers, estuaries, dams and navigation channels.

These techniques help to obtain quantitative information, such as the direction, velocity and thickness of sediment movement. Tracers help to determine sediment transport by assimilating tidal currents and wave dynamics and the sediment transport processes of erosion, transport, settling and deposition. While, gamma scattering and transmission gauges are used for sediment monitoring, radiotracers are used for either static or dynamic measurement of concentration of deposited sediments.

Radiotracer techniques are an effective method of investigating sediment dynamics, as they can provide a real time, accurate assessment of where and how 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 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, which help to measure the depth of water, or mathematical and physical models that are tailored for such examinations. 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.

SEDIMENT CHARACTERISTICS

Sediment transport is mainly influenced by wind, wave and climate conditions. To understand sediment behaviour in different environments, it is useful to know some of the definitions and properties of sediments.

The density of most sediments is about 2.65 g/cm^3, although their dimensions and forms are varied. Sediments can be classified by their grain size, from clay to gravel. Wentworth's classification (1922)[1] is one of the most widely used in the field of sedimentology. It comprises four main classes of particles:

1. Gravel: particles greater than 2 millimetre (mm) in diameter;
2. Sand: particles between 63 micrometre (µm) and 2 mm in diameter;
3. Silt: particles between 2 µm and 63 µm in diameter; and
4. Clay: particles less than 2 µm in diameter.

Sediment transport studies in seas, rivers and dams commonly deal with sand and silt. There are different sub-classifications of sands according to their sizes.

[1]Wentworth, C. K., 1922, *A Scale of Grade and Class Terms for Clastic Sediments*, in The Journal of Geology, Vol. 30, No. 5, pp. 377-392. Available at: www.jstor.org/stable/30063207

Portable gamma spectrometric detection system GISPI (Gamma in Situ Portable Device) mounted in front of a vehicle such as cars that are used to map the natural radioactivity of sediments in coastal areas. (Photo: J. Bezuidenhout/School for Science and Technology, Stellenbosch University, South Africa)

IAEA SUPPORT

The IAEA supports its Member States in the promotion and application of the radioisotope technologies to protect coastline and coastal engineering structures and to better serve the environmental sector. This helps to:

- Promote and provide the services of radiotracers and sealed sources for coastal engineering, river management and dam maintenance;
- Promote graduate students of environmental and civil engineering faculties to expand their knowledge and to make use of radiotracer and sealed source techniques in research and development; and
- Increase awareness among engineers and managers in the environmental and coastal engineering sectors of the potential of radiotracer techniques for investigating complex littoral sites and structures.

Through the IAEA's technical cooperation programme, training has been provided at the IAEA laboratories

Training provided by IAEA experts on the use of a nucleonic gauge for the monitoring of sediment concentration along the access channel in Larache harbour, Morocco. (Photo: P. Brisset/IAEA)

in Seibersdorf, Austria, and trainees have also been sponsored at designated Member States laboratories involving radiotracer applications for sediment studies. The IAEA plays a major role in facilitating the transfer of radiotracer technology. It assists countries with the development of their human resources, supports the education of young specialists and helps maintain good practices that are needed to ensure the sustainability of technologies and knowledge transfer. Developing training materials for radiotracer specialists and radiotracer practitioners is among the key goals of this important assistance to enhance coastal and rivers protection.

AREAS WHERE MEMBER STATES MAY BENEFIT FROM IAEA SUPPORT

- Building capacity in the area of using radiotracers for coastal protection.
- Widening awareness of how these techniques can support improved sediment management programmes.
- Establishing regional linkages to identify challenging areas of sediment transportation and to assess how radiotracers can support the improvement of effective actions to prevent and control sediment depletion.

IAEA Briefs are produced by the Office of Public Information and Communication
Editor: Aabha Dixit • Design and Layout: Ritu Kenn

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