Identification of Spatial Dispersion Pattern of Dredge Materials in a Coastal River Reach from Radioactive Tracer Experiments and Hydrodynamic Modeling.

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Brief Description of the Project

Maintenance of the navigation channel leading to the dock is a prime concern of any port authority for movement of ships with adequate draft. Generally dredging is done to improve the draft in the shipping channel. For example, in Kolkata Port the navigational channel leading to Haldia from the outer estuary requires maintenance dredging throughout the year. Five to six Trailing Hopper Suction dredgers are deployed to maintain the navigable depth over the shallow critical stretches leading to Haldia Dock Complex. These dredgers use the tidal window to dredge over the critical shallow area, fill up their hoppers and then move to the dumping grounds to dispose of dredged materials in a deeper area (open river disposal). In this process, movement of the dredgers between the dredging site and dumping site takes more time than the actual dredging work. Hence the total cost becomes prohibitive. Dumping into a nearby site may reduce the cost, but there is always a possibility of return of the disposed materials to the dredged site during return of tides. This project aims to identify the movement and dispersion pattern of the dredged materials, using Radiotracer Experiments in the Sea, followed by Hydrodynamic Modeling of the sediment dispersion process.

The present navigational channel in the Hugli estuary near the disposal site is selected as the area under study. Experiences and expertise of the Kolkata Port Trust (CI) regarding the complex nature of the navigational issues and dredging problems helped in obtaining relevant information of flow phenomenon in the said reach. Industrial scale radio-tracer techniques that are practiced and pioneered by IAD, BARC (PC) have been applied to the reach to identify the dynamics of dispersion of the dredged materials. Appropriate hydrodynamic sediment transport model of the said reach of the estuary are being developed by the PI at IIEST, Shibpur. Observations from the radioactive tracer experiments and the results of the hydrodynamic models are being compared for verification and validation. Integration of results of numerical simulation and radiotracer experiments is expected to provide better understanding of sediment dynamics in similar coastal areas.

Keywords: Navigation in Estuaries, Sediment Transport, Radiotracer Experiments, Hydrodynamic Modeling

Methodologies/Approaches Adopted

Sediment dynamics or the dispersion phenomenon of the dredged particles in a costal reach is a very complex process. Apart from the hydraulics of the spatially and temporally varying tidal flow conditions, proper understanding of the hydrology and river sedimentology are essential for identifying and estimating the sediment dynamics in the water course. Usually,an experimental model or a mathematical model is used to identify the dispersion pattern of the dumped dredged materials.

This project uses a combined approach involving a Radiotracer Experiment followed by a Hydrodynamic Model. In the radiotracer experiment. In the radiotracer experiment, suitable radioactive tracers are developed and dumped at the disposal site. These tracers are then tracked over a period of time and their dispersion pattern is identified which resembles the dispersion pattern of the dumped dredged materials. In mathematical modeling, a two-dimensional hydrodynamic and sediment transport model is developed for the estuary containing the navigation channel, the river and its tributaries. Existing bathymetry, water surface elevation, discharge, sediment data and tidal currents are used as input in the model and then the hydrodynamics and transport processes are solved for a long period of time to identify resulting changes in the morphology, depth of flow, velocity pattern and nature of sediment dispersion.

Project Highlights

Sedimentation in navigation channel is a very acute problem, particularly in riverine ports like Haldia and Kolkata, which incurs huge expenses towards dredging. If the sediment dynamics can be determined then appropriate schemes of dredging and dumping of the dredged materials can be developed. With that objective, this project aims to identify the sediment dispersion pattern in Hooghly estuary which is one of the most complex estuaries in the world. This will immensely help the Kolkata Port Authority in maintaining their navigation channels. The models developed can also be used for similar problems in other ports in India and outside.

Figure 1: Location of the Hooghly Estuary

This is a collaborative project between Indian Institute of Engineering Science and Technology, Shibpur (IIEST, Shibpur), Bhabha Atomic Research Centre, Mumbai (BARC, Mumbai) and Kolkata Port Trust (KoPT).

Kolkata Port Trust has been employing extensive maintenance dredging for more than three decades. Apart from providing the logistics supports to conduct the radiotracer experiment in the estuary, researchers at KoPT have shared their experiences and expertise regarding the complex nature of the navigational issues and dredging problems, and provided data necessary to build the mathematical model.

Isotope Applications Division (IAD) of BARC has pioneered the method of radioisotope applications and have applied the technique in the past to study the sediment dynamics of Hooghly estuary. In this project, they have developed the radioisotope, performed the injection and tracking, and analyzed the dispersion pattern from the experimental results.

The Hydrodynamic models are developed and run at IIEST, Shibpur. The Surface Water Modeling System (SMS) software platform is used for this purpose where such problems can be analyzed for a wide range of systems and flow situations.

Project Achievements

In this project, a navigational reach near the Sagar Island in Hooghly Estuary is selected for the experimental study. The radiotracer experiment was conducted in this area on 26th November 2014, followed by subsequent tracking of the tracers during the next five months (December to April). Hydrodynamic models are developed using SMS and a number of simulation runs are performed to identify the sediment dispersion pattern in the study area.

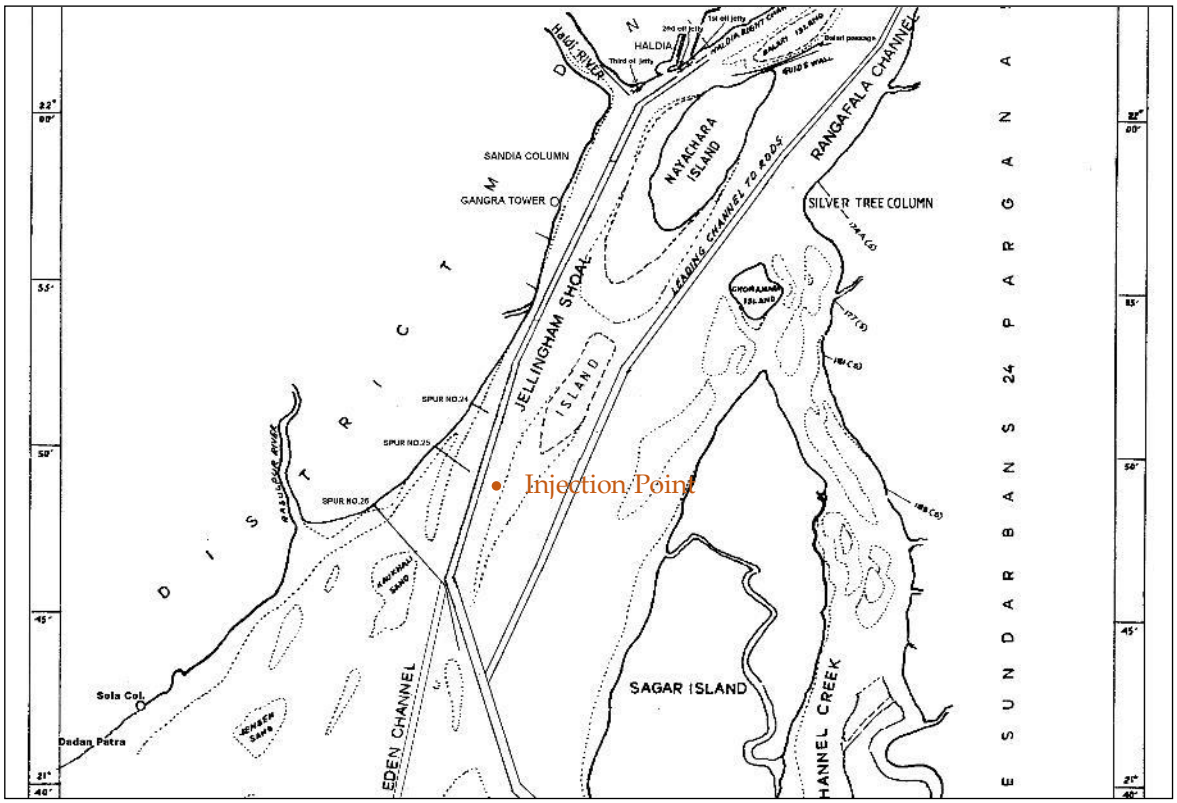


Figure 2: Radiotracer Injection Point

(a) The container and the hoist

(b) The container

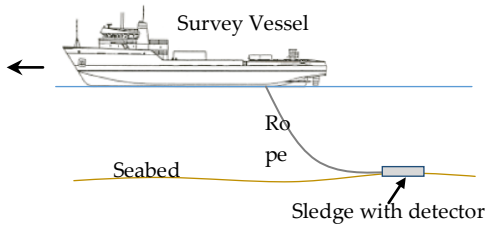
(c) Sediments inside the container

(d) Radiotracer being poured in to the container

(e) Container is being lowered in to the sea

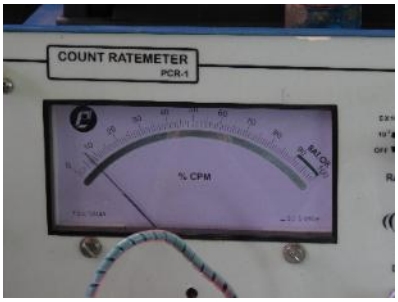
Figure 3: Radiotracer Injection

For tracking the movement of the tracer, the scintillation detector is mounted on a sledge and dragged on the seabed. The concentration at different spatial locations are measured. The track of the survey vessel is fixed using a Differential Global Positioning System (DGPS) available onboard.



(a) Tracking System

(b) Sledge with Detector



(c) Ratemeter connected to the Detector

(d) Track of Survey (DGPS)

(d) Recording Track Data

Figure 4: Tracking Procedure

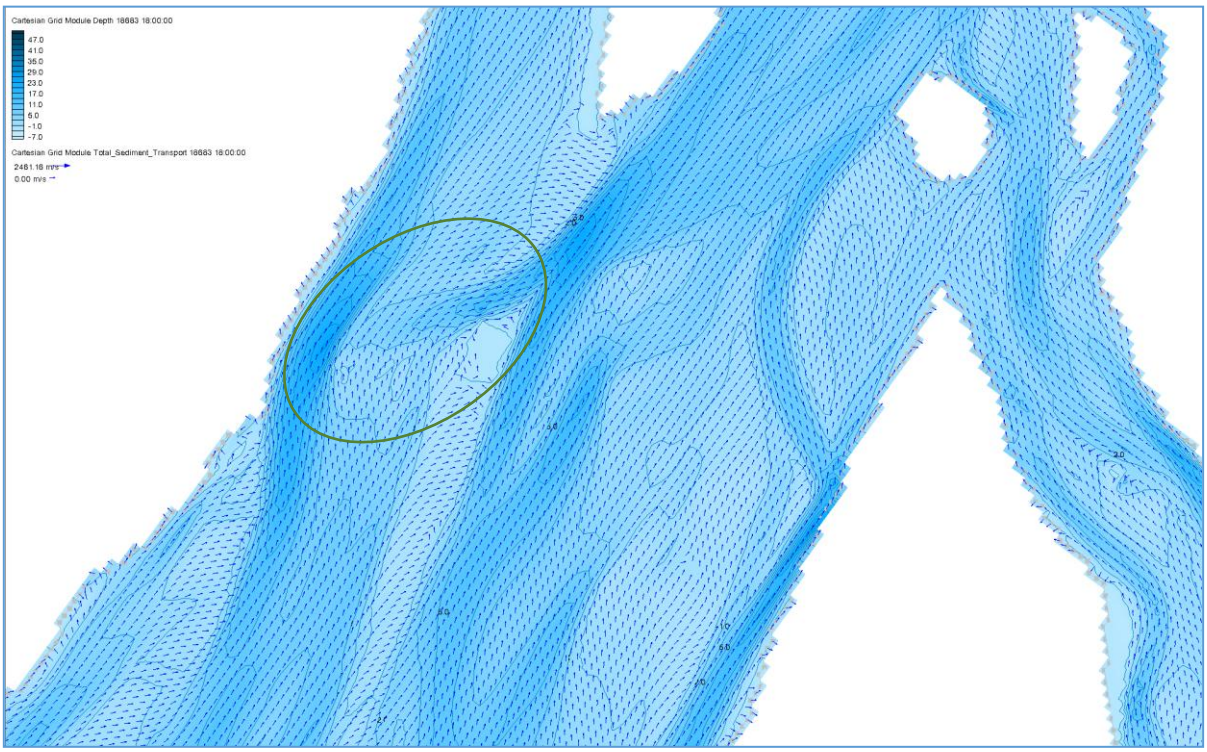


Figure 5: Variation of Depth and Sediment Transport Vector near Injection (Hydrodynamic Model)

Publications

1. Bhar, K. K., Pant, H. J., Sharma, V. K.,Chakraborty, K., Chaudhuri, B., Singh, G., "Studies on sediment dynamics using radiotracer for management of dredging works in Hooghly Estuary, India", 22nd Biennial Conference of the Coastal and Estuarine Research Federation (CERF 2013), 3-7 November 2013, San Diego, USA.

Project Staff (Designation, number, name, qualification, leading to PhD, etc.)

Two Senior Research Fellows, Manoranjan Paul and Subhadeep Kangsabanik are currently working for this project. They have also enrolled for PhD program.

Plan of Future Project Proposal based on the Current Project

Kolkata Port is a nationally important port and has a strategic location that provides sea transport facilities in parts of South-East Asia. To reduce the excessive loads on this port, possibilities of additional port near Sagar Island and alternative navigational roots are under consideration of the authority. It is being planned to extend this project methodology to these new proposed works.