Review Article

Review of sediment budgeting in the Indian scenario

Madan Kumar[1] Dr. Pradeep Kumar[2]

[1]Research Scholar, Singhania University, Rajasthan, India

[2]Associate Professor HBIT Kanpur

---♦-------------------------------------

OVERVIEW

According to CEM (2002), coastal zone is "the transition zone where the land meets water, the region that is directly influenced by marine and lacustrine hydro dynamic processes. It extends offshore to the continental shelf break and onshore to the first major change in topography above the reach of major storm waves. On barrier coasts, it includes the bays and lagoons between the barrier and the mainland" . The definition of a few of the zones in the coastal zone are (US Army, 1984 and 2002):Coastal zones, encompassing the coastal planes and continental shelves, are regions that exhibit close interaction between the hydrosphere, lithosphere and atmosphere.

These are highly dynamic and diverse ecosystems that are characterized by strong environmental and geological gradients. It consists of near shore zone, gulfs, bays, inlets, creeks, tidal deltas, lagoons, coastal lakes, estuaries, coral reefs, shoals, tidal flats, mudflats, beaches, sand ridges, coastal dunes, mangroves, marshes, strand features, salt-affected land, rocks, cliffs, reclaimed land, deltaic plains and similar features. The developments attained through over exploitation of the resource of the coastal zone at the cost of the environmental quality would inadvertently destabilize the delicate balance between the biological, geological and meteorological component of the system. These resources have been plundered at an alarming rate contributing to the loss of functional integrity and reducing the capacity to retain material such as water, sediments and organic matter. While industrial developments, climatic modifications, sea level changes and changes in land use pattern affect the coastal zone globally, the direct use of coastal resources has local or regional impact.

The coastal region has been the centre of anthropogenic activity right from the prehistoric periods. The river valley civilisations of Egypt, Persia, India and China originated in the coast where the great rivers, the Nile, the Euphrates, the Tigris, the Indus and the Huango Ho met the oceans and flourished along the banks of these rivers. Human activity in the coastal region (e.g., agricultural production including fisheries, commercial activities including construction of buildings, ports and hotels, industrial activities including chemical processing industries, mineral exploitation and cultural activities) intervenes the natural processes active in this coastal system (an all inclusive term covering the region, the coastal processes and the human activities).

The buffering capacity of the system absorbs the impact of human activity and maintains the system in a state of dynamic equilibrium. However, intense human activity may bring about appreciable imbalances in the system resulting in loss of this equilibrium. Many a times, these changes bring about catastrophic effects on the current users of the system.

SEDIMENT BUDGET

Sediment budgeting is the study process to understand the sediment sources, sinks, transport pathways and magnitudes for a selected region and within a defined period of time. For coastal regions, the sediment budget is a balance of volumes (or volume rate of change) for sediments entering (source) and leaving (sink) a selected region of the coast, and the resulting erosion or accretion in the coastal area under consideration (Rosati, 2005). The sediment budget may be constructed to represent short-term conditions such as for a particular season of the year, to longer time periods representing a particular historical time period or existing conditions at the site. Sediment budgeting is an important tool to unravel the complex processes that take place in the coastal zone. Sediment budgeting involves making assessment of the sedimentary contributions (credits) and losses (debits), and equating these to the net gain or loss (sediment balance) in a given beach compartment or littoral cell. It is very difficult to quantify these sources and sinks. So any beach sediment budgeting studies include detailed collection of hydro dynamical and sediment logical data and also model studies to assess different sources and sinks. Model results are compared with historical conditions and used to predict the evolution of beach. Thus sediment budget can be used for two purposes; first to analyze the present situation, and second, using the present conditions, to predict the coastal changes either due to any constructions or due to natural conditions.

BACKGROUND OF STUDY

The Chavera coast of Kottayam district, Kerala is world famous for its rich placer deposits. The heavy mineral content in the beach sand goes up to as high as 950/0. Sand extraction by Indian Rare Earths Ltd (IREL) and its predecessor companies has been going on at various sites along the Chavera coast (Fig. 1.7) since 1930. Two sources contribute to the heavy mineral sand in-take by IREL at .present: (i) the beach washing from the Vellanathuruthu and Kovilthottam mining sites of IREL and the collection by the local populace, mainly from the Kayamkulam inlet area and (ii) the dredging from the hinterland sites of IREL. The intake from the beach constituted a major share of the sand extraction by IREL . The Chavera coast is also known for the occurrence of erosion. What is the role of mining on erosion along this coast? This has been a long pending question which was not answered due to lack of studies on beach-nearshore sedimentary dynamics of this coast. In fact many dwellers of this coast believe that erosion along this coast is caused due to mining and there have been occasional attempts to block the mining.

LITERATURE REVIEW

As already mentioned sediment budgeting studies are lacking in the Indian scenario. But such studies are available for some coastal locations of the world. Depending on the objective of the study, sediment budgets are constructed with different time frames. Sediment budget on geological time scales has been attempted (Belknap and Kraff, 1985; Oxford et al., 1996; Riggs et al., 1998; Schwab et al., 2000) to bring out the influence of natural forces on the geomorphology of the beach systems. Studies on a historical time frame (several hundred years) are undertaken to unravel the influence of large-scale human activities like dam, jetty and seawall construction on changes in beach systems (Hess and Harris, 1987; Fitz Gerald et al., 1989; List et al., 1991; Pilkey and Dixen, 1996; Cooper and Nevas, 2004). Contemporary (annualdecadal) time scale studies based on sediment budget are planned to bring out the influence of human activities such as dredging, dredge spoil disposal, beach replenishment, sand mining etc. (Pilky et al., 1989; Fenster and Dolan, 1994; Hill et al., 2004).

Bowen and Inman (1966) introduced the general sediment budget concept, based upon coastal geology and longshore sediment transport. The authors estimated longshore sediment transport rates from calculation of the longshore components of wave power and for specified sources (river influx, sea cliff erosion) and sinks (submarine canyons, dune building processes) for the sediment calculation cells (littoral cells).

Carter (1986) constructed a sediment budget for the South Otago continental shelf andcoast between Nugget Point and Otago Peninsula. The study revealed that modem (post 6500 y) sediment input was dominated by the Clutha River. Contributions from other sources (Taceri River, adjacent southland shelf and biogenic production of calcareous shell debris) accounted for only 28% of the input. About half of the bed load (sand and gravel) reaching the Otago shelf is stored within a large nearshore sand wedge in the protected waters of Molyneux bay, off the Clutha River. Suspended load (mud) accounts for over half of the sediment input and is nearly all transported from the study area to accumulate in northeasterly shelf and slope. Hess and Harris (1987a&b) compared a series of historical maps and bathymetric charts of coastal areas to evaluate changes in sand volume and to infer directions of sand movement over the past century at Rockaway barrier beach New York. Fitzgerald et al. (1989) also employed similar methodology for evaluating the morphodynamics of the tidal inlet systems in Maine. While evaluating the large-scale coastal evaluation of Louisiana's barrier islands, List et al. (1991) also adopted a similar methodology.

Jimenez et al. (1991) constructed the first sediment budget for the Ebro Delta and explained the effects of changing sediment supply on the coastal system and the large scale morphological responses of the coastal system. Sediment budget study conducted by Best and Griggs (1991) for the Santa Cruz littoral cell, California evaluated only the rate of sand movement over limited time periods by directly quantifying sand fluxes in and out of the system.

Gulfenbaum et al. (1999) constructed a regional sediment budget for the Columbia river littoral cell, to gain a better understanding of the Columbia river dispersal system. To help separate natural from human induced changes in the littoral cell sediment budgets were constructed separately for prehistoric, historic and contemporary periods. Estimation of the discharge of the Columbia river was a critical component of the sediment budget calculations and it was found that average discharges per annum varied from 20 million rrr' during prehistoric period, through 8.7 million m3 during early historic periods to 4.3 million rrr' since 1950s. The study also reveals that the early historic shoreline accretion rates are much greater than prehistoric rates; and in general, greater than recent accretion rates. The timing of the rapid accretion in the early part of the century and the long shore variation in the accretion indicated changes in the ebb-tidal deltas after jetty construction as the primary cause.

A sediment budget approach was used to study the erosion problems being experienced on the popular tourist beach in S1. Queen's Bay, Jercy Channel Islands by Cooper and Pethick (2005). It has been found that the beach lowering and sediment losses being experienced are primarily related to the cessation of sediment input from the finite offshore sources, the construction of a seawall which has exacerbated the erosion and the mining of beach sand. The study provided a fundamental baseline upon which coastal management options could be proposed which offer sustainable solution to the problems being experienced. Park and Wells (2005) studied the littoral processes under a wide range of wave conditions that impact the complicated coastal geometry at the Cape Lookout cuspate forelands, North Carolina, and constructed a regional sediment budget for the region using a numerical wave refraction/diffraction model and through use of aerial photographs and nautical charts.

REFERENCES

- Aagaard, T. and Greenwood, B., 1994. Suspended sediment transport and the role of infragravity waves in barred surfzone. Marine Geology, 118, 23-48.
- Antony, M.K., 1990. Northward undercurrent along west coasts of India during upwelling- some inferences. Indian Journal ofMarine Sciences, 19,95-101.
- Baba, M. and Joseph, P.S., 1988. Deepwater wave climate off Cochin and Trivandrum. In: Ocean waves and beach processes of south west coast of India and their prediction (Eds: Baba, M. and Kurian, N.P.), CESS, Trivandrum, 129-139.
- Belknap, D.F., Kraft, J.C., 1985. Influence of antecedent geology on evolution of barrier systems. In: Special Issue: Marine Geology (Eds: Oertel, G. and Leatherman, S.P.), 63, 235-262.
- Black, K.P. and Healy, T.R., 1983. Side-scan Sonar Survey, Northland Forestry Port Investigation, Northland Harbour Board. Project Report, ASR, 88p.
- Chandramohan, P., Nayak, B.D., Sanil Kumar, V. and Pathak, K.C., 1994a. Beach process between Mulgund and Shiroda, West coast of India. Indian Journal of Marine Sciences, 23,102-104
- Christiansen, C., Aagaard, T., Bartholdy, J., Christiansen, M., Nielsen, J., Nielsen, N., Pedersen, J.B.T and Vinther, N., 2004. Total sediment budget of a transgressive barrier-spit, Skallingen, SW Denmark: A review. Danish Journal ofGeography, 104,107-126
- Fenster, M. and Dolan, R., 1994. Large-scale reversals in shoreline trends along the U.S. mid-Atlantic coast. Geology, 22,543- 546

- Fredsoe, J. and Deigaard, R., 1992. Mechanics of Coastal Sediment Transport. World Scientific, Singapore, 369p.
- Green, M.O. and Vincent, C.E. 1990. Wave entrainment of sand from a rippled bed. Proc. International Conference in Coastal Engineering, ASCE, 1990, 22002212.
- Hameed, T.S.S., 1988. Wave climatology and littoral processes at Alleppey. In: Ocean waves and beach processes of south west coast of India and their prediction, (Eds: Baba, M. and Kurian, N.P.), CESS, Trivandrum, December 1988, 67-90
- Hanson, H., and Kraus, N.C. 1989. "GENESIS: Generalized Model for Simulating Shoreline Change. Technical Report CERC-89-19, V.S. Army Engineer
- Waterways Experiment Station, Vicksburg, MS Varma, P.U. and Varadachari, V.V.R. 1977. Stability of the coastline from Manakodam to Thottappalli along the Kerala coast. Proc. Indian Academy of Science, 85p.