ABSTRACT

Diverse and complex natural processes continually change coasts physically, chemically and biologically, at scales that range from microscopic (grains of sand) to global (changes in sea level). Kalpakkam (12° 33’ N and 80° 11’ E), situated in southeast coast of India hosts Madras Atomic Power Station (MAPS), India’s first fully indigenously constructed nuclear power station. The power station has two units of 225 MWe power generating capacity. A 500MWe capacity Prototype Fast Breeder Reactor Project (PFBR) at about 680m south of MAPS is proposed to be established. Thermal discharge from both PFBR and MAPS will pass through an engineering canal of ~ 1.66km length with a fixed opening, through which at present warm water from MAPS is flowing. Shore protection work (seawall) i.e., a rubble mound bund approximately at 50 m distance landward of the outfall channel has been constructed to protect PFBR and MAPS premises from the possible future attack of tsunami. Mahabalipuram, a world heritage site, also famous as the sixth center of Pallava art and architecture of south India is situated 4 km north of the power plant. Owing to its historical significance, the shore temple at Mahabalipuram is protected by a seawall over a length of ~ 0.5km which protrudes slightly into the sea.

The present study focuses on understanding the sediment dynamics of Kalpakkam in terms of the nearshore coastal processes and the impacts of
construction of seawall and engineering canal. The study was carried out for a period of two years i.e. 2010 and 2011 wherein surface sediment samples were collected every month from 12 stations in transect pattern at beach and at distances 200 m, 500 m and 1 km into the sea. With the given complexity of the problem, the issue was addressed using a combination of field measurements, satellite data analysis and numerical simulations using MIKE 21.

Textural assessments reveal that majority of the beach samples are coarse, the nature of seabed sediments are altered to medium and fine sand. At the mouth of the engineering canal (S7), sediment deposition of varying thickness is observed along the inner side of the boulders positioned on the south and on the top of the stones kept on the north. Sediments could not be retrieved from several stations during the period of study indicating active bed load movement. In S11 and S12 especially during monsoon, the non availability of sediments can be attributed to the submerged structures/pagodas. The sediments of Kalpakkam reflect formation by a combination of beach and fluvio-marine environment.

CIA and CIW values reflect low weathering except for the station in front of seawall (CIA = 82.21 and CIW = 89.01) which shows advanced weathering due to the wave action on these boulders. Beach and seabed sediments of Kalpakkam suggest the presence of ferromagnesian minerals (likely to be pyroxene). The provenance studies for Kalpakkam reveal derivation from granitic to gneissic or from a sedimentary source area, mobilisation of alkalies, beach sediment deposition in passive margin setting
and seabed sediments in active continental margin in humid (seabed) to semi-
humid (beach) climatic conditions.

X-ray diffraction carried out to understand the mineral composition
reveal that minerals found in Kalpakkam are monazite, magnetite, ilmenite,
garnet, zircon, etc., along with quartz, feldspar, olivine and sphene.
Radioactive minerals are Uranmicrolite, Dessauite, Dumontite and Sedovite.
Concentration of heavy minerals are the highest near S9 i.e. Kokillamedu
(99%) and its gets diluted progressively offshore. The sediments of
Kalpakkam-Mahabalipuram sector are characterized by abundant angular
grains with conchoidal features, ‘V’ marks, chatter marks, chemical etching,
precipitation etc revealing marine origin.

The long term shoreline changes reveal that the highest rates of
change are observed in the northern sector (Mahabalipuram) with the lowest
in the southern region (Sadras). Severe erosion noticed at south of
Mahabalipuram is owing to obstruction of littoral drift by the seawall around
the historic shore temple. The shore protection structures do not alter the
shoreline morphology which is evident from the shoreline analysis of 2006
and 2009. The field measurements and satellite data analysis indicate that S2
(200m north of Sadras) and S11 (200m south of Mahabalipuram) undergoes
erosion whereas S3 (Meyyurkuppam village), S6 (front of seawall) and S8
(Edaiyur) are accreting.

The coastal hydrodynamics of Kalpakkam reveal that the northerly
currents in pre monsoon and post monsoon with current speed ranging from
0.05 to 0.45 m/s whereas during monsoons the current is southerly with current speed of up to 0.65 m/s in the Mahabalipuram region. The alongshore sediment transport trend suggests a dominant northward movement whereas onshore transport is higher when compared to offshore transport.

Band 2 (520 – 590 nm) centered at 555nm of LISS data was used for the estimation of SSC. A linear equation was found to fit best with $r^2 = 0.85$. Band 5 (centered at 555 nm) / band 3 (centered at 490 nm) used for OCM analysis yield a linear correlation of $r^2 = 0.85$. Southerly movement during monsoons and northerly movement during rest of the periods are discernable from satellite data analysis.

From the study, it can be inferred that beaches of Kalpakkam are characterized by coarse sand, limited shoreline mobility, greater profile mobility, high bedload transport, microtidal in nature. The shelf sediment dynamics are not altered drastically due to the recent activities of Indira Gandhi Centre for Atomic Research (IGCAR). Sediment deposition at the mouth of the engineering canal follows a cyclic pattern indicating a possibility for closure of the mouth which requires continuous monitoring. Though a high wave energy environment is prevailing in the study area, dominant northward sediment transport along the Kalpakkam-Mahabalipuram coast is not altered due to human interventions. Accretionary nature of the shoreline and beach building activity in front of the seawall ensures the safety of IGCAR from wave actions without causing any significant changes to the coastal environment.