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Monitoring and trend mapping of sea surface temperature (SST) from MODIS data: a case study of Mumbai coast

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Abstract Sea surface temperature (SST) is one of the most important parameters in monitoring ecosystem health in the marine and coastal environment. Coastal ecosystem is largely dependent on ambient temperature and temperature fronts for marine/coastal habitat and its sustainability. Hence, thermal pollution is seen as a severe threat for ecological health of coastal waters across the world. Mumbai is one of the largest metropolises of the world and faces severe domestic and industrial effluent disposal problem, of which thermal pollution is a major issue with policy-makers and environmental stakeholders. This study attempts to understand the long-term SST variation in the coastal waters off Mumbai, on the western coast of India, and to identify thermal pollution zones. Analysis of SST trends in the near-coastal waters for the pre- and post-monsoon seasons from the year 2004 to the year 2010 has been carried out using Moderate Resolution Imaging Spectro-radiometer (MODIS) Thermal Infra-red (TIR) bands. SST is calculated with the help of bands 31 and 32 using split window method. Several statistical operations were then applied to find the seasonal averages in SST and the standard deviation of SST in the study area. Maximum variation in SST was found within a perpendicular distance of 5 km from the shoreline during the study period. Also, a warm water mass was found to form consistently off coast during the winter months. Several anthropogenic sources of thermal pollution could be identified which were found to impact various locations along the coast.

Keywords Sea surface temperature · Remote sensing · Spatio-temporal trends · Marine and coastal environment · MODIS

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Introduction

Coastal waters are part of the marine environment as well as the boundary of terrestrial ecosystems. These ecotones are as fragile as they are rich in minerals, crude oil, fish resource, etc. They are also used for disposal of wastes from coastal cities. Thermal pollution of rivers and coastal seas by heated efflux released from industrial sources is a serious environmental problem which causes destruction and imbalance of aquatic life. Many aquatic life-forms are temperature sensitive.

The temperature rise in water body due to thermal effluents can have a cascading effect on the aquatic life. Increased temperatures can directly cause mortalities in the fish species. It may also lead to elimination of certain algal species and introduction of undesirable species. High temperatures can adversely affect the metabolic rates, growth and reproduction. It could also lead to depletion of certain species.

Increase in water temperature also causes reduction of dissolved oxygen content of the water. This rise in temperature also leads to increased metabolic rates for the fish and greater use of oxygen, and increases

photosynthesis, where oxygen is produced (John 1971; Vaquer-Sunyer and Duarte 2011). The balance depends on the supply of nutrient in water. With ample supply of nutrients and increased water temperature, the green and blue-green algae become more active, leading to accelerated eutrophication. (John 1971)

Physicochemical constituents of water body may be disturbed due to thermal discharge which might affect the species composition. Increase in vegetation period and cell size may be observed in phytoplanktons and other marine macrophytes which might result in increased productivity depending on the available nutrient in water. Change in temperature also affects the benthic fauna. (Kulkarni et al. 2011)

The coastal marine environment beside Mumbai, India, constitutes a variety of flora and fauna (Verma et al. 2004) including a rich mangrove growth along Thane, Malad, Manori and Mahul creeks. According to the classification proposed by Central Pollution Control Board (Government of India), the central west coast of India including northern Karnataka, Goa and southern Maharashtra is grouped under the class SW-1, which is supposed to include salt pans, mariculture, contact water sports and ecologically sensitive areas (Varkey 1999). The main sources of pollution of the Mumbai coast are urban sewage, runoff, nutrient pollution and thermal discharges (Gupta et al. 2006).

Availability of satellite data has enabled observation of atmospheric states and processes at various scales varying spatially and/or temporally. Since 1970, remotely sensed imagery has been used to map and monitor coastal areas (Yang et al. 2013). Various aspects such as water quality, coastal dynamics, terrestrial and marine habitats and certain coastal hazards are being monitored using satellite images (McClain 2009). The use of this method has

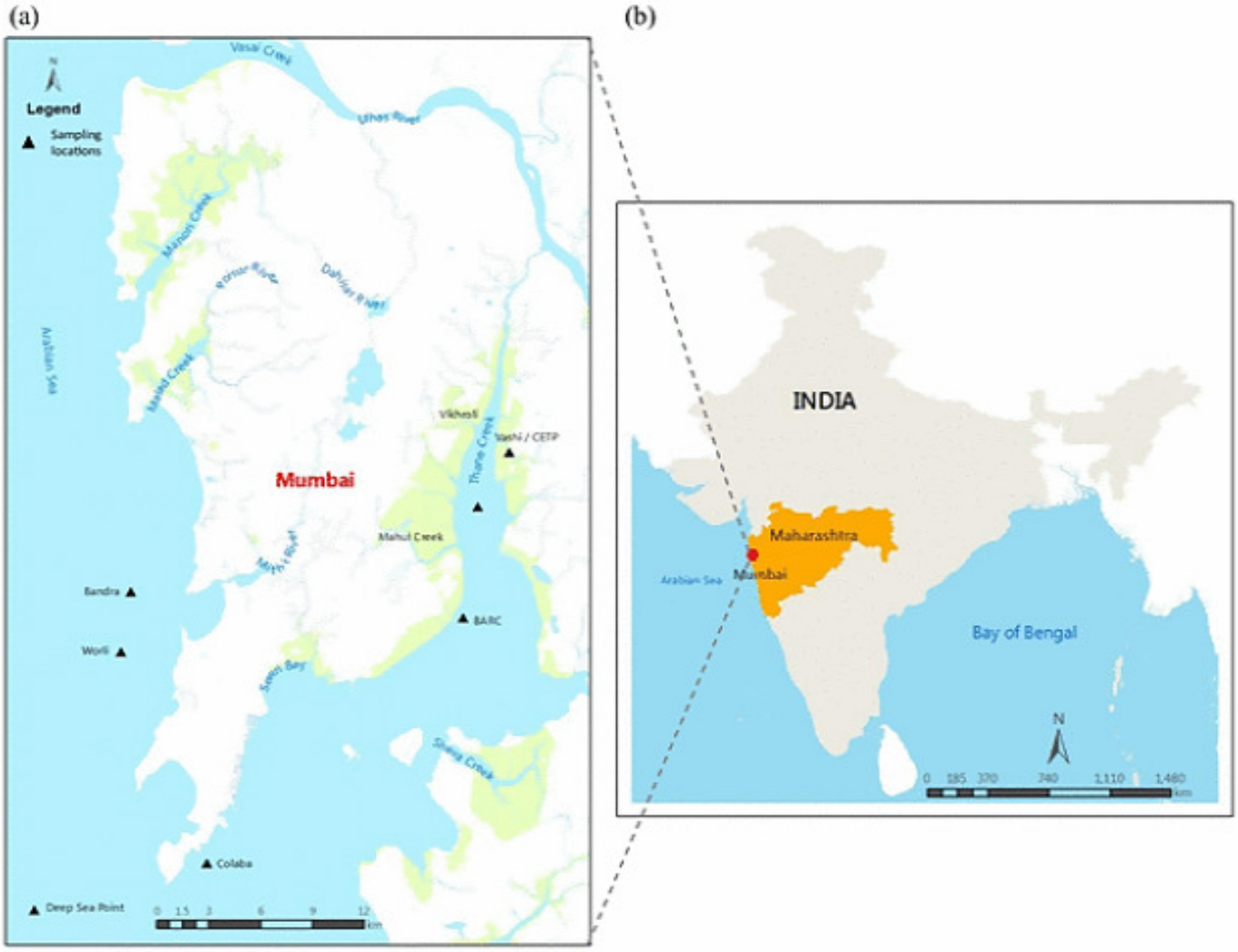

Fig. 1 a Study area map with water sampling locations. b Location map of Maharashtra, India