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Baseline

Evaluation of the environmental quality of Parangipettai, Southeast Coast of India, by using multivariate and geospatial tool

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ABSTRACT

The anthropogenic pressure in recent years has driven us to investigate the environmental quality at 22 stations in Parangipettai by collecting seawater samples monthly from 2014 to 2015. The sampling stations were grouped into three different environments, namely, Vellar Estuary (VE), Coleroon Estuary (CE), and Open Sea (OS). Factor analysis showed a total variance of 65.63% and exhibited a strong factor loading for atmospheric temperature (0.914), water temperature (0.917), ammonia (0.767), inorganic phosphate (0.897), total phosphorus (0.783), and phytoplankton (0.829). The index value showed water quality was good in OS (74.18), whereas it was moderate in VE (69.73) and CE (68.47). The visual model developed using Geographical Information System (GIS) displayed a spatial pattern of water temperature and phytoplankton dispersion in a distinct manner. The results obtained through multivariate analysis and GIS-based model are imperative to establish reference for a comparative study with other similar ecosystem for better planning and management of tropical seawaters.

Environmental pollution has obviously occurred in many coastal areas, especially in estuaries and coastal bays with a dense human population in their watersheds (Sahu et al., 2013). Coastal seas and bays are the most valuable and vulnerable habitats (Jickells, 1998). Rapid economic growth and increase in the population have exerted a great impact on coastal environment. The Parangipettai coastal waters, which are enriched with diverse marine flora and fauna, is composed of a dynamic ecosystem of the Vellar–Coleroon estuarine complex; they harbor a good fishing spot, and around 600 boats are being operated for fishing activity, which also exerts pressure on the coastal environment (Sigamani et al., 2015). In the recent years, the human population at Parangipettai increased by 22.22% from 20,901 (in 2001) to 25,541 (in 2011) (Census of India 2011). Additionally, the number of shrimp farms being operated has also increased from 10 (in 2008) to 76 (in 2017) in Parangipettai, of which about 25 farms are located at Pichavaram and Killai, which are close to the mangrove forests (http://caa.gov.in/farms.html); this could also pose a potential threat to the coastal environment.

Anthropogenic activities are evident in and around these estuaries and open sea environment; therefore, it is important to assess the environmental quality on a periodical basis and to provide mitigation measures for coastal pollution. Although few studies have been conducted to assess the health of the Parangipettai coast (Sigamani et al., 2015; Nethaji et al., 2017), this study proposes a multivariate statistical approach and a Geographical Information System (GIS)-based mapping technique to visually delineate the higher and lower concentration zones for understanding the spatiotemporal variations in coastal waters in a simple manner.

Programs on water quality monitoring are vital to collect huge data sets for a better understanding of anthropogenic activities (Jha et al., 2015). However, large data sets are often complex to understand. Thus, an attempt was made to convert the complex data sets into a single indicator of Water Quality Index (WQI). It is a dimensionless number that combines multiple parameters into a single number (on a scale of 0 to 100) (Horton, 1965; Miller et al., 1986). Although several researchers have investigated on the Water Quality Index (WQI) of drinking water (Pesce and Wunderlin, 2000; Liou et al., 2004), there are limited studies on the coastal WQI (Gupta et al., 2003; Kiddon et al., 2003; Jha et al., 2015).

The statistics obtained may be significant to establish mitigation measures to control the pollution level, with an aim to determine the environmental conditions. The present study has the following aims: (1)

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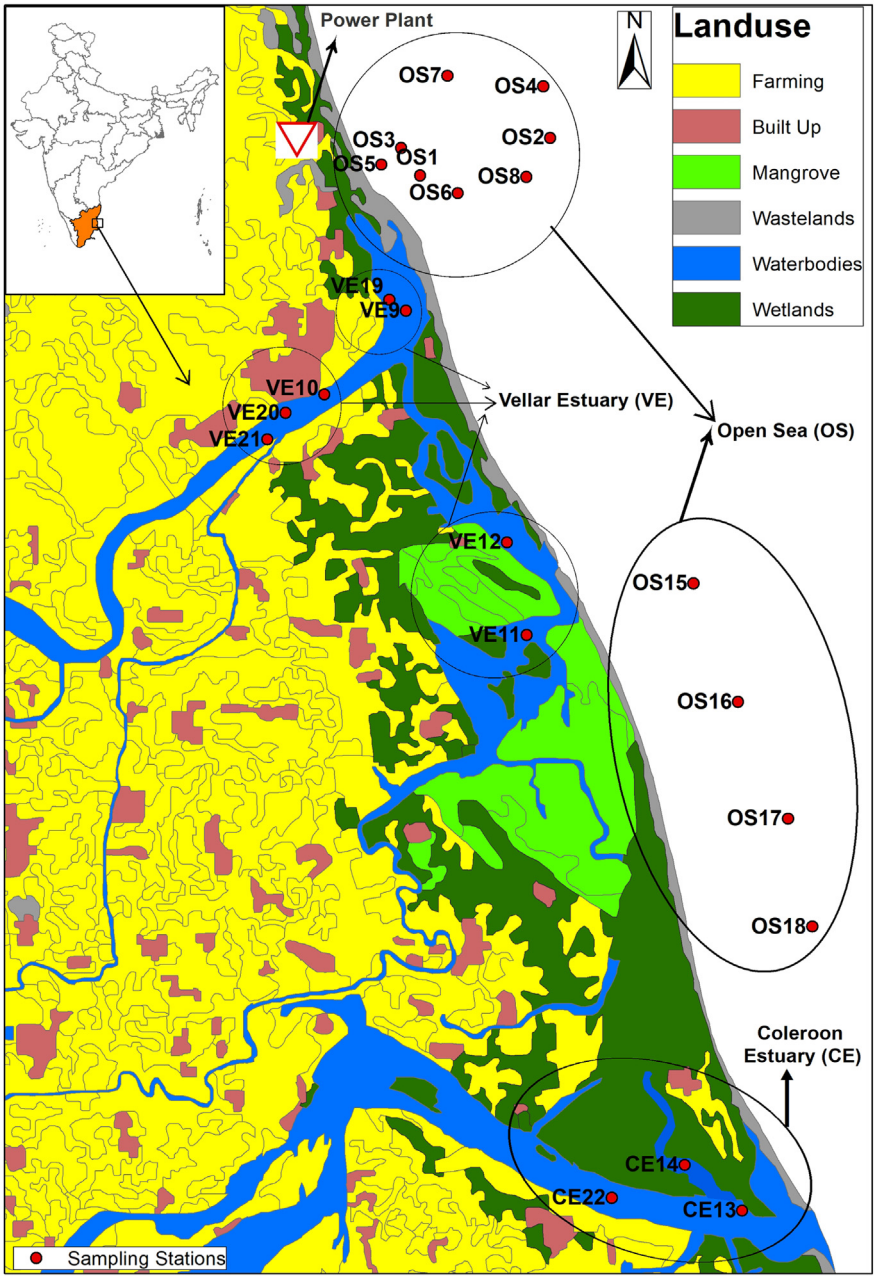

Fig. 1. Sampling locations at Parangipettai.

to assess seawater quality through a multivariate analysis; (2) to derive a WQI using a permissible value; and (3) to propose and develop a visual model using GIS for a better insight into the dispersion pattern in the coastal environment.

Parangipettai is at a distance of approximately 250 km from Chennai city and is located in Cuddalore district on the southeast coast of India. It consists of two estuarine systems, namely, Vellar and Coleroon estuaries, which support one of the largest mangrove ecosystems called Pichavaram. The rainfall in this region occurs from late August (southwest monsoon) to early November (northeast monsoon). The season for present study area has been classified into pre-monsoon (PRM) (March to June), monsoon (MON) (July to October), and post-monsoon (POM) (November to February). Sampling was carried out during low and high tides (22 stations × 2 tides × 24 months = 1056 samples), covering the Open Sea (OS1 to OS8 and OS15 to OS18), Vellar Estuary (VE9 to VE12 and VE19 to VE21), and Coleroon Estuary (CE13, CE14, and CE22) once in a month from January 2014 to December 2015 at Parangipettai (Fig. 1). The stations mentioned above were grouped into three categories, namely, Open Sea (OS), Vellar Estuary (VE), and Coleroon Estuary (CE), respectively, for a better description. A thermal power plant was also located in close vicinity of the study area, and samples were collected from the inlet (OS5) and outlet (OS6) locations of the plant to perceive the spatial pattern.

The surface seawater samples were collected in polypropylene bottles by using a Go-Flo water sampler. Temperature and pH were measured onboard using a calibrated thermometer and a pH meter, respectively. Total suspended solids (TSS) were determined by filtering 1 L of seawater in a predried and preweighed filter paper (0.45 µm Millipore GF/C) and washing with Milli-Q water to remove salt contents (APHA, 1995). The salinity was estimated by the Argentometric titration method. The seawater samples were analyzed for dissolved oxygen (DO) and biochemical oxygen demand (BOD) (APHA, 1995). The seawater samples were also analyzed for nitrite, nitrate, ammonia, total nitrogen (TN), inorganic phosphate (IP), total phosphorus (TP),