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Spatial and temporal distribution of cyanobacteria in Batticaloa Lagoon

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ABSTRACT

The necessity to understand the relationship between cyanobacterial species abundance and water quality variations in coastal lagoons is crucial to develop strategies to prevent further cyanobacterial proliferation. This paper evaluates the relationship between water quality variations on the distribution of cyanobacteria during a 12-month period in Batticaloa Lagoon (Sri Lanka) using Redundancy analysis and Pearson correlations. Drastic variations in pH, temperature, salinity, dissolved oxygen (DO) and total phosphorus (TP) levels were reported, but not turbidity and NO_3^-. This brackish waterbody is hypereutrophic (TP levels > 0.1 mg/L). The cyanobacterial community contained 13 genera and 22 species. NO_3^-, TP and turbidity levels positively influenced cyanobacterial abundance during all seasons indicating that nutrient (largely phosphorus) and sediment entry control is highly crucial along with periodic monitoring of cyanobacterial growth.

Introduction

Batticaloa Lagoon (located between 7°58′N and 81°29′E to 7°20′N and 81°52′E) is the third largest brackish water body in Sri Lanka with more than 90% of the area located in the Batticaloa District in the Eastern Province. The lagoon supports diverse ecosystems including marine habitats such as mangroves. However, due to poorly planned infrastructure development, aquaculture ponds and government security clearances the original mangrove cover of 1490 ha has been reduced to 321 ha at present during a 20 year period (IUCN Sri Lanka and the Central Environmental Authority, 2006; NECCDEP, 2010; Kularatne, 2014). Moreover, indiscriminate dumping of Municipal Solid Waste (MSW) by the local community and some local government authorities (*e.g.*, Kattankudy Urban Council), disposal of untreated sewage, rice mill effluents, shrimp farm effluents and slaughterhouse effluents (*e.g.*, in Urani area) tends to pollute the lagoon (Kularatne, 2014). Significant Pb contamination has been already reported by Kularatne (2014). Also occurrence of cyanobacteria (blue-green algae) (*e.g.*, *Microcystis aeruginosa*, *Oscillatoria* sp., *Lyngbya* sp., *Cylindrospermopsis* sp., *Nostoc* sp. and *Anabaena* sp., *etc.*) has been reported by Harris and Vinobaba (2012a) indicating that there is some nutrient enrichment and further lagoon pollution is expected due to considerable anticipated unplanned developments in the

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Batticaloa area since the cessation of the ethnic conflict in May, 2009 (Kularatne, 2014).

Cyanobacteria secrete various cyanotoxins that are harmful to the biota. For example, *M. aeruginosa*, *Oscillatoria* sp., *Nostoc* sp. and *Anabaena* sp. secrete microcystins (which are cyclic peptide hepatotoxins) that could cause death in mammals in acute doses by hypovolaemic shock (Codd et al., 1999; Falconer, 1999; Sathishkumar et al., 2010; Metcalf and Codd, 2012). *Anabaena* sp. as well as *Lyngbya* sp. and *Cylindrospermopsis* sp. secretes saxitoxins which are a group of about 30 neurotoxic carbamate alkaloids (Falconer, 1999; Metcalf and Codd, 2012). Moreover, odor attributed to the secretion of metabolites (example, 2-methyl isoborneol and geosmin/trans-1,10-dimethyl-trans-9 decalol) is aesthetically unpleasing since tourism is an important commercial activity in the Batticaloa Lagoon. Also some species secrete skin irritants such as the phenolic bislactones aplysiatoxins (*e.g.*, *Oscillatoria* sp. and *Lyngbya* sp.) and indole alkaloid lyngbyatoxins-A, -B and -C (*e.g.*, *Lyngbya* sp.) (Falconer, 1999; Metcalf and Codd, 2012) which could be a concern to bathers in the lagoon.

There is a need to analyze cyanobacterial species and abundance variability in relation to water quality variations so that this information can be used to develop strategies to prevent further cyanobacterial growth. Redundancy analysis (RDA), a constrained linear ordination method has been used to evaluate the effects of environmental variables on freshwater cyanobacterial communities (Tian et al., 2012; Lu et al., 2013). In this study, we use RDA to evaluate the impact of seasonal variations of selected water quality parameters on the distribution of cyanobacteria in Batticaloa Lagoon.

1. Materials and methods

1.1. Study area

The 16 sampling points were previously defined based on the different biotypes in the lagoon (Fig. 1) and characteristics such as bottom substrate, surface, topography, depth, salinity and human impact level. The precise location of each station was determined using a portable GPS meter (Garmin, USA) (Table 1).

1.2. Sampling and water quality analysis

Water sampling was carried out during the period of March 2012 to February 2013 (*i.e.*, twice a month) between 9 am and 11 am covering the different seasons. Period of November–February is the heaviest north-east monsoonal rainy period with intermittent or few showers occurring in the first inter-monsoonal period (March–April) and second inter-monsoonal period (September–October). South-west monsoonal period (May–August) is the driest period in Batticaloa.

Samples were collected in triplicate by dipping well labeled sterilized plastic containers of 1000 mL to about 50 cm below the surface film. pH, surface temperature, salinity and turbidity were analyzed *in-situ* using calibrated instruments (Hanna, Romania portable HI 98128 water proof pH meter for pH and temperature, Portable ATAGO, Japan, S/MillE Hand Refractometer for salinity and Hanna, Romania portable HI

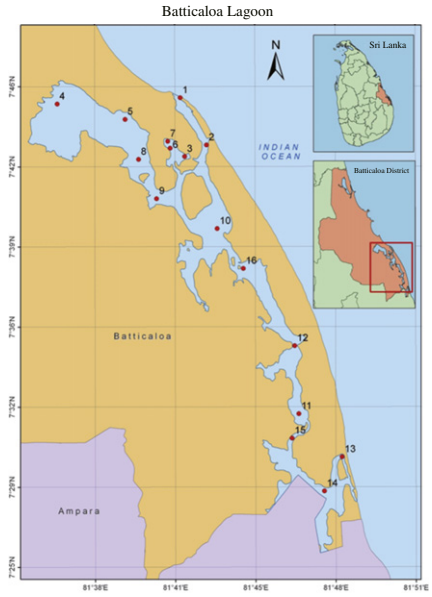

Fig. 1 – Map of the study area showing the sampling locations. Locations 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 and 16 denotes Palameenmadu, Kallady, Kottamunai, Eravur, Sathurukkondan, Thiruperumthurai, Urani, Valayaravu, Vavunativu, Kattankudy, Kaluthawalai, Chettipalayam, Kallaru, Kallaru stream, Pattiruppu and Kokkaticholai, respectively.

93703 C turbidity meter for turbidity) as per standard methods (APHA, AWWA and WEF, 2005).

Water samples were kept in a cool, dark environment and carried to the laboratory for analysis of nutrients. Prior to nutrient analysis, water samples were filtered through GF/C filter papers to remove any green color interference of algae. Nitrates (NO_3^-) and phosphates as total phosphorous (TP) were measured within 48 hr using the UV screening method and Molybdate Blue method, respectively (APHA, AWWA and WEF, 2005). Separate water samples were collected for dissolved oxygen (DO) analysis within 48 hr using modified Winkler's Method (APHA, AWWA and WEF, 2005).

1.3. Collection of cyanobacterial samples, identification and enumeration

Cyanobacterial samples were also taken at each sampling point (5 samples per location) using a plankton net (Hydro-bios, Germany) with the end of the net having a collecting bottle with a capacity of 250 mL. Cyanobacterial samples were collected slowly by horizontal hauling without causing disturbances to the cyanobacteria (at a distance of 10 m from the sampling vessel). The samples were immediately preserved using Lugol's solution (ratio is 1 mL of Lugol's solution to 100 mL of water sample) in order to settle the cyanobacteria and to get a clear view. The samples were then reduced to 10 mL by decanting the supernatant aliquot and centrifuged (Bench model D2230, Brand — Gallenkamp, UK) for 20 min at 4000 r/min. One drop of concentrated sample was investigated under a trinocular bright field research microscope (Labomed LX400, USA). Identification was done