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## Baseline

## Heavy metal pollution monitoring with foraminifera in the estuaries of Nellore coast, East coast of India

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## ABSTRACT

A total of 112 bottom water and sediment samples collected at fixed stations in pre-monsoon and post-monsoon from four estuaries (Pennar, Uppateru, Swarnamukhi, and Kalangi) showed foraminiferal test abnormalities in heavy metal concentrations (Co, Cr, Cu, Fe, Mn, Ni, and Pb). Low diversity of fauna was due to the predominance of a limited number of opportunistic species capable of achieving high densities in adverse environmental conditions and the reduction in the number of species intolerant of such conditions. In this study, classification of 54 common species according to their distribution is presented. Approximately 15 species showed quite low diversities at stations 23–27 and 44–51. Because of the effect of heavy metal pollution in these estuaries, drastic changes in the number of species and diversity of foraminifera were observed. These changes in foraminiferal species and the increase in test abnormalities are proxies of environmental stress on the estuarine ecosystem.

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As the coastal environments worldwide are of paramount importance for cultural development and diversity, a high degree of pollution is expected in these regions. Rivers, which debouch into the Bay of Bengal after flowing long distance along the course, collect huge outputs of various domestic, industrial, agricultural, and aquacultural contaminants from the estuaries at the bay. Contaminants derived from river runoff have been shown to accumulate in estuarine sediments, reaching concentrations potentially capable of causing biological effects (Alve, 2003; Elizabeth, 2005; Jayaraju et al., 2008, 2011a; Sundara Raja Reddy et al., 2009; Gothankar et al., 2014). Demonstration of effects, however, is difficult due to strong natural environmental gradients and the effects of the past and present point source of contamination. The increased use of pesticides and fertilizers in both agriculture and aquaculture sectors along the coastal tract of Nellore district of Andhra Pradesh, India, further increases the effluence of pollution into coastal water bodies. As a result, Pennar (P), Uppateru (U), Swarnamukhi (S), and Kalangi (K) rivers suffer immense stress in their ecosystems (Jayaraju et al., 2008). Therefore, estuaries of these rivers were chosen as the respective river systems in this study. The abundance, diversity, temporal and spatial distribution, and test morphology of foraminifera in these estuaries can reveal the associated degree of pollution, when related to the concentrations of heavy metals (Fe, Mn, Pb, Ni, Co, Cu). Recently, benthic foraminiferal assemblages have been used as proxies

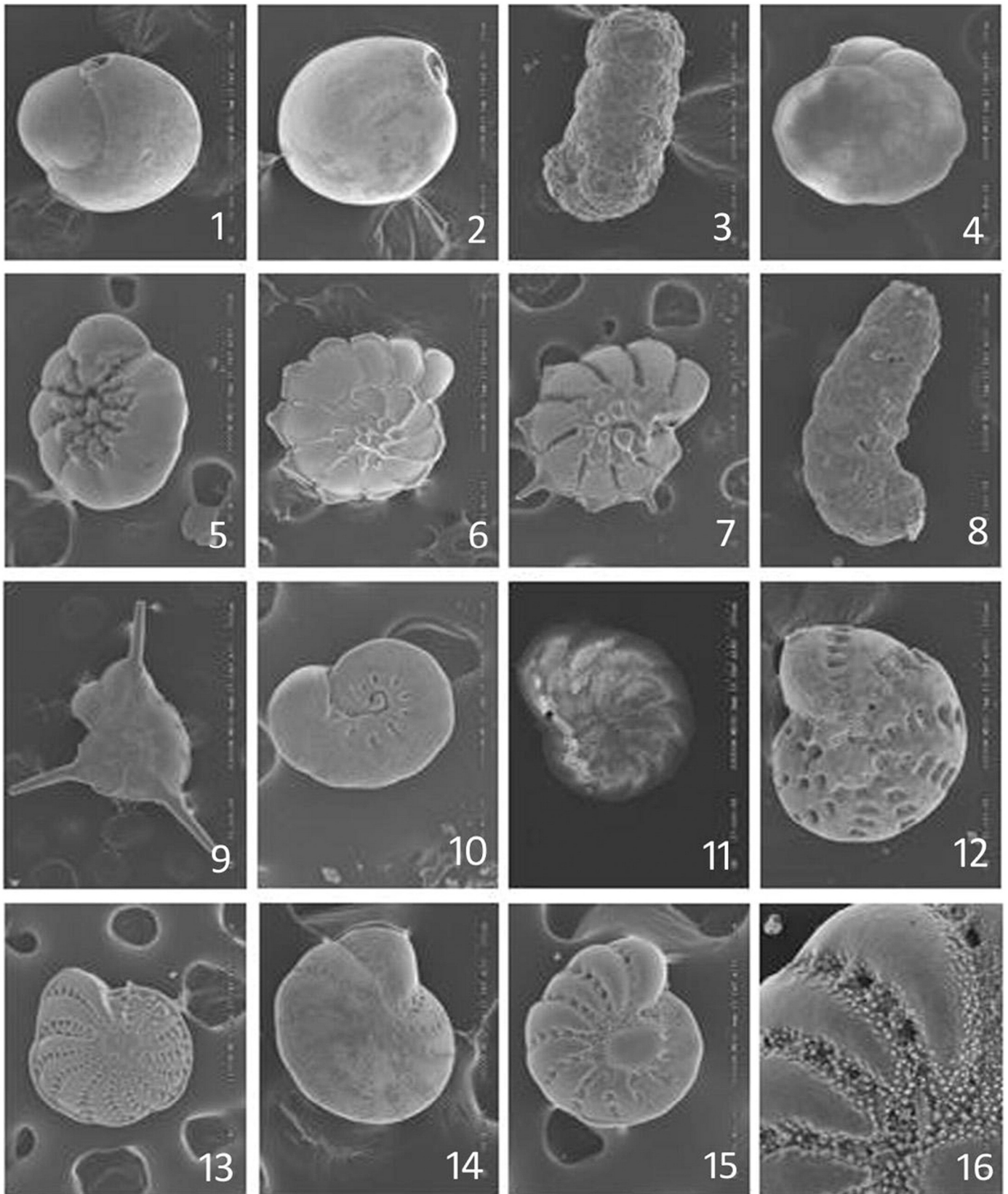
to monitor the effects of pollution on the marine marginal waters (Debenay et al., 2001; Scott et al., 2005; Roshni Narayan and Pandolfi, 2010; Angelidis et al., 2011; Capotondi et al., 2015). Benthic foraminifer community structures provide information on ecological conditions, especially in the highly changing parallel environments (Hayward and Hollis, 1994; Olff et al., 2009), while some species are sensitive to environmental parameters (Debenay et al., 2001; Martins et al., 2015). Distributions of benthic foraminifera were significantly related to those of environmental variables and were ordinated along the axes that correlated both natural environmental variables and pollutants. Test morphology may also be related to environmental characteristics and is sometimes used as a bioindicator. Recently, changes in the test morphologies have been taken as proxies (Yanko et al., 1998; Geslin, 1999; Elizabeth, 2005; Nigam et al., 2005; Jayaraju et al., 2008, 2011a, 2011b; Angelidis et al., 2011; Jayaraju et al., 2011a, 2011b; Youssef, 2015). To date, there has been no study on the benthic foraminiferal testimony of marine pollution of these areas. The present study is the first of its kind to monitor the effects of pollution on bioindicators of the four estuarine environments of Nellore coast, East coast of India.

A total of 112 bottom water and sediment samples were collected at fixed sampling stations (Table 1) in two seasons, October–December 2009 (pre-monsoon) and April–June 2009 (post-monsoon), from four estuarine environments along Nellore coast.

The study area covering Pennar (P), Uppateru (U), Swarnamukhi (S), and Kalangi (K) estuaries is located in the Survey of India toposheet numbers 66 B/2, 66 B/3, and 66 C/2, at the scale of 1:50,000. The study

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**Plate 1.** (Scale = 100  $\mu$ m).

area lies between longitudes  $80^{\circ} 08' - 80^{\circ} 11' 54''$  E and latitudes  $13^{\circ} 35' - 14^{\circ} 36' 13''$  N (Fig. 1 and Table 1).

All the samples were collected using local mechanized boat at fixed stations in the two seasons. Bottom waters were collected using a

shallow water sampler, and the samples were acidified with nitric acid. The samples were then filtered using a Whatman filter paper to remove particulates and collides, stored in polyethylene bottles fitted with tight stoppers and screw caps, and indexed accordingly. The

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