# ANTHROPOGENIC EUTROPHICATION AFFECTING BENTHIC FORAMINIFERA AND POLYCHAETES OF THE EASTERN MEDITERRANEAN SHALLOW SHELF

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**Abstract**

Seasonal variation in distribution of benthic foraminiferans and polychaetes was studied in the vicinity of a sewage sludge disposal site off the Mediterranean coast of Israel, where a full spectrum of oligotrophic to hyper-eutrophic conditions occurs. The foraminifera *Ammonia tepida* acts as a typical opportunist, reproducing rapidly and colonizing the sea floor anew following each episode of sludge winnowing. Opportunist polychaetes belonging to the Capitellidae respond in extremely high numbers only to the spring event of sludge dispersion.

*Keywords : Eastern Mediterranean, Foraminifera, Polychaeta, Sewage Pollution, Eutrophication.*

The ultra-oligotrophic shallow water environment of the southeastern Mediterranean has been subjected to man-made influences during the last decades. The activated sewage sludge (=biosolids) dumped into the sea off Palmahim exposes marine benthic biota to elevated levels of organic matter and nutrients, and has been monitored for two decades. There is a marked, seasonally dependent, localized impact on the benthic faunas and on sediment quality. Episodes of severe $O_2$ depletion leads to elimination of all benthic groups close to the sewage outfall, but peripheral eutrophication leads to temporary increase in abundance of opportunistic meio- and macrobenthos species (we studied Foraminifera and Polychaeta) [1, 2]. The opportunistic polychaete family Capitellidae becomes very abundant close to the sewage outfall and is an indicator for organic pollution [3]. We here compare the response of benthic foraminifera in this environment with the polychaete response pattern.

Two stations in the vicinity of the sludge outlet off Palmahim, PL3 (200m N of the outlet; hyper-eutrophic) and PL29 (5.5km to the N; oligotrophic) were sampled at 36m water depth bi-monthly between January 2003 and May 2004, for living (stained with Rose-Bengal) benthic foraminifera and sediment properties (the polychaetes were sampled from July 2003 to May 2004). Formalin-preserved and stained macrofauna >500$\mu$m are given as the average of triplicate samples (0.062m$^2$).

Comparison between the meio- and macrobenthos at the two stations focused on seasonal variations in opportunists and presence of rare species. The abundance of polychaetes varied seasonally in both stations, with lowest numbers in late fall/winter, doubling in spring ( 500) at PL29 and much more at PL3 (up to $14*10^3$). The simple diversity is highest at PL29 with 22 polychaete families, and lowest at PL3, with only 5 families. A different seasonality is shown by the foraminifera with the highest total standing stock (TSS) occurring at PL29 during late summer/fall (more than $10*10^4$), and lowest TSS in mid-winter ($8*10^3$). At PL3 TSS is lower, with maximal numbers in January and May (up to $6*10^3$), coinciding with periods of intensive sludge winnowing during storm events (Fig. 1). Species richness at PL29 is significantly higher, with 182 species compared with 75 at PL3.

The benthic foraminiferan *Ammonia tepida* and the capitellid polychaetes are opportunists that thrive in stressed environments. In the Palmahim stations the TSS maximum of *A. tepida* coincides with maximal abundance of the entire foraminiferal assemblage, comprising 70% of the assemblage. Capitellid polychaetes, the dominant polychaete family at Palmahim, comprise 99% of the polychaetes at PL3 and only 40% at PL29, where they are accompanied by paraonids and cirratulids.

The variations in TSS of *A. tepida* at PL3 track the changes in the sludge accumulation, with highest numbers coinciding with periods of total sludge dispersion during winter (01/04) and spring (05/03, 05/04) (Fig. 1). In fall, the hyper-eutrophic PL3 station became azoic due to water column stratification and high organic matter load (9cm in thickness). *A. tepida* behaves as a typical opportunist, inhabiting the newly exposed sea floor each time sludge is dispersed by winnowing. On the other hand, the opportunist capitellid polychaetes only respond to the spring event of sludge dispersal, at which time they occur in extremely high numbers.

Several foraminiferal species living at PL29 are not present at all at PL3. Their absence suggests that they are long-lived or specialized species that cannot survive the periodic ultra-eutrophic conditions in PL3. We conclude that the macro- and meiobenthos used for tracking the eutrophically overwhelmed environment off the Israeli coast have broadly similar seasonal patterns but differ somewhat in the magnitude of their response. The foraminiferan *A. tepida* shows the most typical opportunist response, and is less affected by seasonality. It is a sensitive recorder of recurring sea floor aeration episodes at the most disturbed station, and as such has a potential for monitoring similarly disturbed coastal regions.

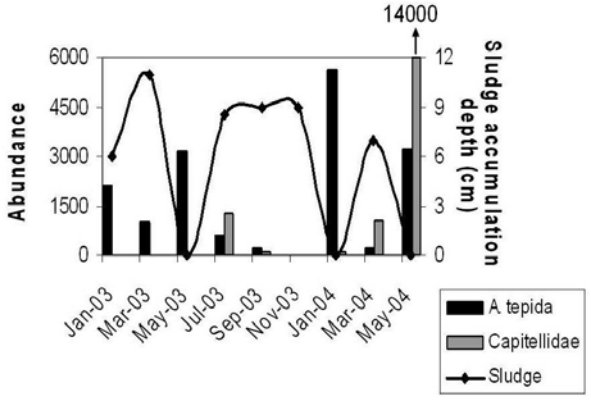


Fig. 1. *Ammonia tepida* and Capitellidae abundance (number of specimens per 0.062m$^2$), taken at station PL3 from 01/03-05/04 (bars) and the depth accumulation of the sludge on the sediment layers (diamonds).

## References

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