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Foraminifera as an Indicator of Marine Pollution

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Sediment samples from five stations at the Shihwa Lake sewage outfall, west coast of Korea, were collected to evaluate the effect of the outfall on benthic foraminifera. Heavy metal (Cu and Zn) polluted eastern part of the Shihwa Lake, adjacent to the Shihwa-Banwol Industrial Complexes, shows barren or nearly barren of benthic foraminifera, and the lowest number of species both at the core top and downcore. Excepting for the barren zone, pyritized benthic foraminifera abundantly occur both at the surface and downcore sediments in the western part of the Shihwa Lake, suggesting that foraminiferal disease by anoxic bacteria.

Recent intrusion of pollutants from the Shihwa-Banwol Industrial Complexes and adjacent six major streams severely polluted the Shihwa Lake as shown by the low abundance (number/10 g) of benthic foraminifera, low number of *A. beccarii*, low species diversity, and absence of both *Elphidium* spp. and ostracodes at the surface sediments compared to the downcore. Except the barren zone, both pyritized and non-pyritized *Ammonia beccarii* occur dominantly in the surface sediments and downcore. *Elphidium* spp. (either pyritized or non-pyritized) do not occur in the surface sediments of whole stations. However, they occur from the entire downcore sediments except in the eastern part of Shihwa Lake.

Arenaceous foraminifera do not inhabit in the heavily polluted areas as evidenced by the occurrence of relatively deep core depth (11-50 cm). Ostracodes occur at the downcore sediments, but they do not occur at the surface sediments. Ostracodes also do not occur at the heavily polluted areas in the eastern part of the Shihwa Lake both at the surface and downcore sediments, indicating that the abundance of ostracodes also can be used for a pollution indicator.

1. Introduction

Foraminifera, which has a sand-sized test, are consist of calcium carbonate. There are two types of foraminifera based on their life mode. Planktonic foraminifera live in the surface water column (surface to down approximately 1000 m water column). Benthic foraminifera live in the bottom of the ocean. Foraminifera inhabit from the tropical to Antarctic (also Arctic) surface and bottom water. Foraminifera also tolerate wide ranges of salinity conditions. They live 0.1 to 70 ‰ of salinity values. But foraminifera most commonly occur at normal marine salinity value (35 ‰).

Foraminfera are widely used as pollution indicator in different environmental settings (Collins *et al*., 1995; Culver and Buzas, 1995; Scott *et al*., 1995; Samir, 2000). To date, systematic studies of the influence of pollution upon foraminiferal populations have addressed: (1) industrial wastes, (2) agricultural and domestic waste, (3) paper processing, (4) effects of oil-gas seepages from sediments, and (5) effects of trace metal contaminated sediments (Yanko *et al.*, 1994). The aim of this study is to document the effect of pollution on the benthic foraminifera in the Shihwa Lake.

2. Materials and Methods

Sediment, approximately 10 cm sampling intervals, from five short piston cores are used for the benthic foraminiferal studies. Approximately 2-4 g of dried sediments were used for the study of benthic foraminifera. The coarse fraction content (>63 μm) in the sediment, abundance (number/10 g), species composition, and species number of benthic foraminifera, number of pyrite-filled foraminifera, and number of ostracodes are counted and identified. Benthic foraminifera are picked from greater than 63 μm size fraction. Number of ostracodes greater than 63 μm size fraction is also counted.

3. Results and Discussion

3.1 Benthic foraminifera at the surface and downcore sediments

The eastern part of the Sihwa Lake, which is located adjacent to the Shihwa-Banwol Industrial Complexes, contains barren or nearly barren of benthic foraminifera at the surface sediment samples compared to those of the western part. The eastern part contains 0 to 7 and the western part contains 0 to 60 specimens of benthic foraminifera in 10 g of dried sediments.

The low number of foraminifera in the eastern part of Shihwa Lake is due to the heavily polluted nature. Particularly, stations located adjacent to the Sihhwa-Banwol Industrial Complexes, lots of sewage and industrial pollutants are dumped through six major streams. Heavy metal (Cu and Zn) contents in the surface sediment are very high compared to those of the other stations. These heavy metals prevent the foraminifera from surviving in the eastern part of Shihwa Lake. Increased heavy metal pollution causes not only impoverishment of foraminiferal fauna (Alve, 1991, 1995), but also local extinctions (Culver and Buzas, 1995). Seiglie (1973) also showed that the poor in number of living foraminifera on or in the sediment of polluted areas. Therefore, absence of foraminifera at stations is due to the proximity to the pollution source areas.

The eastern part of the Shihwa Lake, the downcore abundance of benthic foraminifera shows almost barren compared to the western part. This strongly suggests that the various pollutants severely affected to the bottom sediment in the eastern part of Shihwa Lake compared to the western part.

3.2 Benthic foraminifera assemblages in the surface and core sediments

Ammomia beccarii is the most abundant species in the surface and downcore of the Shihwa Lake. Alve (1995) reported that *A. beccarii* is abundant species in the most polluted areas. Significantly low number of this species at the surface sediment, compared to that of the downcore, at the western part of Shihwa Lake suggests that the relatively recent intrusion of pollutants modified the ecology of Shihwa Lake. Significant accumulation of pollutants into the lake is probably after the completion of the Shihwa Seawall construction in January of 1994.

It is very interesting to note that *Elphidium* spp. (*E. advena*, *E. excavatum*, and *E. subincertum*) do not occur in the surface sediment of the study area. However, both non-pyritized and pyritized *Elphidium* spp. commonly occur at the downcore. *Elphidium advena* and *E. excavatum* are commonly occur in continental shelf areas, which have a normal salinity (Oki and Yamamoto, 1992). The absence of *Elphidium* spp. in the surface sediment might be partly due to the fresh-waterized nature of the Shihwa Lake after the completion of Seawall.

3.3 Species diversity

The polluted Shihwa Lake contains very low number of species(1-5 species) in the surface sediments. The lowest number of species also reported at various sewage outfall areas (Bates and Spencer, 1979; Alve, 1995). Bates and Spencer (1979) reported that the number of living benthic species and total benthic (living+dead) species are the lowest at the Chesapeake-Elizabeth sewage outfall, Virginia in USA. The lowest number of species is also observed near the Hadera power station in Israel, where a coal was the major source of pollution into the surface sediment (Yanko *et al.*, 1994). In the study area, the number of species in the surface sediments is very low (or almost absent) compared to those of the downcore. It is believed that this low value of species diversity at the surface sediment is affected by the recent input of pollutants.

4. Summary

(1) The heavy metal (Cu and Zn) polluted eastern part of the Shihwa Lake shows barren or nearly barren of benthic foraminifera both at the surface and downcore sediments.

(2) Recent intrusion of pollutants after the construction of the Seawall in 1994 severely modified the Shihwa Lake environment as evidenced by the low number of benthic foraminifera, low number of *A. beccarii,* low species diversity, and absence of *Elphidium* spp., and ostracodes in the surface sediment compared to those of the downcore sediments.

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