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Chemical-physical and ecological characterisation in the environmental project of a polluted coastal area: the Bagnoli case study

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Abstract

The Bagnoli Bay (southern Tyrrhenian Sea, Naples, Italy) has been impacted for about one century by heavy anthropogenic pollution due to an important steel plant. A multidisciplinary environmental research, aimed at the reclamation of the marine contaminated area, was planned in order to evaluate, through quantitative data, the chemical-physical and ecological characteristics of marine sediments; the latter ones are strictly related to the composition and structure of benthic foraminiferal assemblages. A comprehensive statistical approach, considering all data, was attempted in order to single out the influence of pollutants on the single species distribution. The results show strong heavy metal pollution (Fe, Mn, Pb and Zn) in the vicinity of the industrial plant. Many foraminiferal species (Haynesina germanica, Miliolinella subrotunda, Quinqueloculina parvula), have a good tolerance to some trace metals while, Bulimina sublimbata, Elphidium macellum and Miliolinella dilatata show a good tolerance to PAHs pollution.

Keywords: Steel Plant, Foraminifers, Heavy Metals Pollution, Organic Matter, Grain Size, Statistical Analysis.

Introduction

The activity of an important steel plant, which lasted almost one century, had a heavy impact on the Bagnoli coastal marine environment (Gulf of Naples, Italy). Industrial production started in 1905 and ceased in 1990.

Recently, the Ministry of the Environment proposed a law, which provides for the restoration of the coastal marine areas with heavy anthropogenic pollution. To this end, a complete environmental research has to be carried out. Bagnoli was the first site that was studied in the ambit of this law and its characterisation project may be considered as a model for successive studies on other polluted areas. In order to plan the reclamation, an interdisciplinary approach is necessary for evaluating quantitatively the chemical-physical and ecological characteristics of marine sediments. The latter one was determined by the study of benthic foraminiferal assemblages.

In fact, in the last few years, the utility of benthic foraminifers in pollution monitoring has been confirmed by many researches both in natural environments and laboratory cultures (YANKO *et al.*, 1994; YANKO *et al.*, 1998; ALVE & OLSGARD, 1999; STOUFF *et al.*, 1999; COCCIONI, 2000; SAMIR, 2000; DEBENAY *et al.*, 2001; SAMIR & EL-DIN, 2001). They found that heavy chemical pollution determines environmental stress that modifies the composition and structure of benthic assemblages and may be responsible for test abnormalities in some species that may be regarded as bio-markers.

The research on the Bagnoli area was conducted in distinct phases and is still in progress. The first phase concerned a preliminary evaluation of type, degree and extent of pollution, which was achieved by means of physical (grain-size), chemical (heavy metals, PAHs, PCBs, Organic Matter) and ecological (benthic foraminiferal assemblages) analyses (BERGAMIN *et al.*, in press).

Results show strong heavy metal pollution near the steel plant. Chemical pollution has a severe effect on the sea-bottom's ecological health; the increasing heavy metal concentration reduces the benthic productivity, which may result in the total absence of foraminifers. Moreover, a significant percentage of *Miliolinella subrotunda* specimens show an irregular test. The abundance of such specimens seems related to the Cu concentrations (BERGAMIN *et al.*, in press).

The second phase was aimed at checking and developing the results of the first phase. Then, some significant areas identified by preliminary results, were studied in more detail and, as regards foraminifers, new data about bio-indicators were researched. Grain-size, Heavy Metals (As, Cd, Cr, Cu, Hg, Ni, Pb and Zn), Polychlorobiphenyls (PCBs), Polycyclic Aromatic Hydrocarbons (PAHs) and Organic Matter were determined; moreover, the ecological study on benthic foraminiferal assemblages was included in the project.

In this paper, the preliminary results on chemical-physical analyses (grain-size, heavy metals, PAHs, Organic Matter) and the ecological study (benthic foraminifers) are reported. Analytical data have been treated with statistical methods in order to evaluate how the distributional patterns of the single foraminiferal species are influenced by the chemical-physical characteristics of the bottom environment. This approach may be useful to single out those species that may be considered bio-markers as they are particularly tolerant or intolerant of single pollutants.

The study area

The Bagnoli industrial site is located in the eastern area of the Pozzuoli Gulf (Gulf of Naples, Tyrrhenian Sea, Italy), between Nisida Island and Bagnoli town, along the Coroglio-Bagnoli beach (Figs. 1 and 2). The gulf coastline has been strongly modified by construction works. Two long piers were built in 1920 in front of the steel plant in order to permit the access to large tonnage boats to increase industrial productivity. The artificial link between Nisida Island and the mainland was built in 1935, so modifying the local water circulation pattern and sediment distribution. In 1962-1964 part of the sea stretch enclosed between the two piers was filled in, utilising polluted ground taken from the industrial area, in order to permit widening and the development of industrial activity. Consequently, the natural coastline was altered and the new spaces so obtained were utilised for the construction of new industrial buildings and the storage of fossil coal. Finally, some littoral stretches (Coroglio beach and Bagnoli beach) were artificially enlarged with alloctonous sand for touristic purposes.

As regards the geological setting, the Pozzuoli Gulf belongs to the Campi Flegrei volcano-tectonic system. It is an area of recent collapse, which occurred about 12-10 kyr BP; it is characterised by four morpho-structural units: the coastal shelf, a central collapse area, the volcanic banks and the external shelf (DE PIPPO *et al.*, 1984). The presence of many subaerial and submersed hydrothermal sources, linked to volcanic activity, may condition the natural chemistry of coastal marine waters and change the parameters for the evaluation of

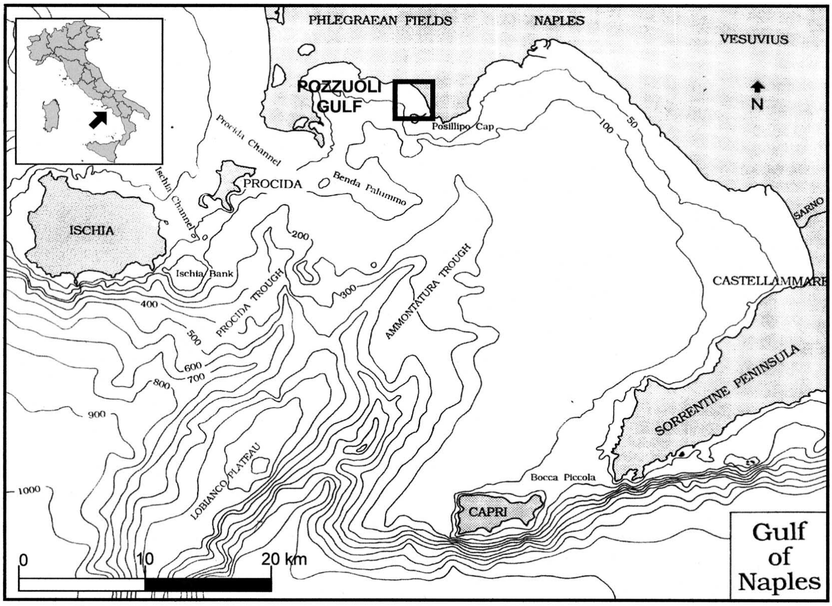

Fig. 1: Location of the Pozzuoli Gulf in the Gulf of Naples. The black square indicates the study area. (after SGARRELLA & MONCHARMONT-ZEI, 1993, modified)

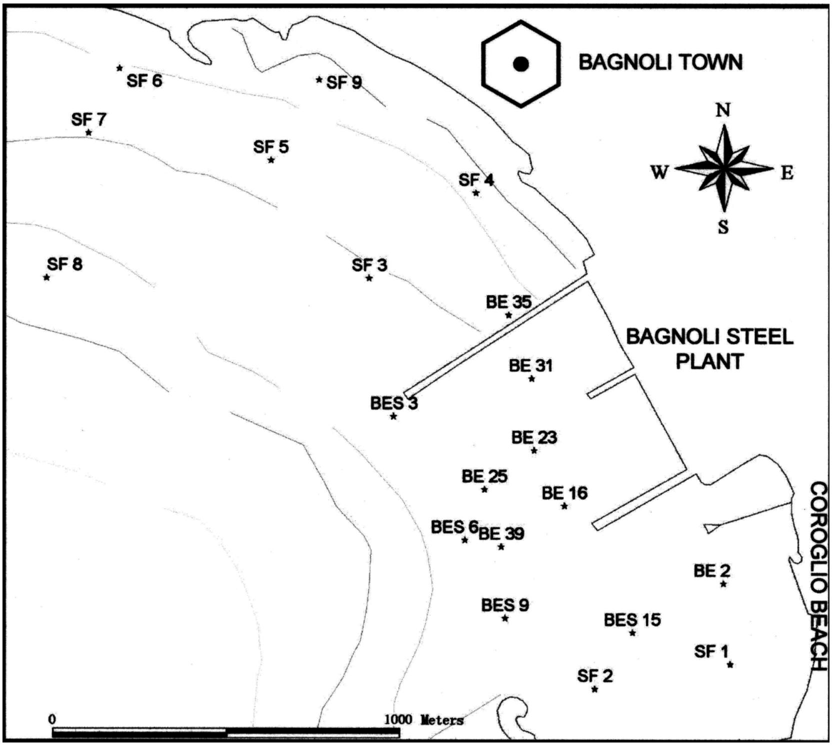

Fig. 2: The Bagnoli marine area. Location map of sampling sites.

change the parameters for the evaluation of anthropogenic pollution.

Sediment distribution in the Pozzuoli Gulf is strictly correlated to climatic and tectonic events. On the littoral shelf, sediments range from coarse sands to sandy-silt. They partly represent relict deposits of ancient beach. The coarse fraction is constituted of bioclastic and pumice-stone elements. In the central basin, sediments consist of silt and silty-clay (DE PIPPO *et al.*, 1988). In the coastal area (0-30 m water depth) of the Pozzuoli Gulf, the sediment samples are normally composed of sand and only in the hydrodinamically-protected areas, like Nisida bay, the pelitic fraction increases (DE PIPPO *et al.*, 1988).

Water circulation in the Gulf of Naples is strictly related to the general circulation in the Tyrrhenian Sea (HAPGOOD, 1960; DÜING, 1965; CARRADA *et al.*, 1980).

PENNETTA *et al.* (1998) recognise, during winter, a clockwise rotating circulation in the inner part of the gulf and a northward current offshore. Conversely, during summer, the inner circulation has an anticlockwise direction and the offshore current is towards the south. The contributions from inland determine a eutrophic coastal subsystem, that is conditioned by human activity. In particular, the Pozzuoli Gulf may be influenced by the contributions from the Volturno River and the Naples harbour.

Material and Methods

Surface sediment was collected by Van Veen grab at 20 stations located in the coastal shelf of the Pozzuoli Gulf, from the shoreline to 20 meters water-depth (Fig. 2). The position of stations was determined by DGPS (Differential Global Positioning System) (Tab.1). The sampling design was planned in order to have a good detail of the area in the vicinity of the industrial plant and to improve the data of the previous sampling phase. Characteristics of sediments such as colour, smell, grain size, presence of shell fragments and of organic debris were described at the time of sampling. Samples for foraminiferal analyses were immediately stained with Rose Bengal for the sorting out of living specimens (WALTON, 1952; MURRAY & BOWSER, 2000). Granulometric parameters, heavy metals (Cr, Cu, Fe, Hg, Mn, Ni, Pb, Zn), Organic Matter and PAHs were determined for all the samples. Moreover, qualitative and quantitative analyses on benthic foraminiferal assemblages were performed. Samples for grain-size analysis were treated with a 30% H_2O_2 solution and separated by wet sieving. The >0.063 mm fraction was dried and fractionated by ASTM series sieves, while lower fraction was analysed by X-ray Sedigraph (ROMANO *et al.*, 1998). Later, they were classified according to Shepard (1954). Heavy metal analyses were performed on aliquot of whole homogenised sample and analysed by AAS (Atomic Absorption Spectrometry)

Table 1
Geographic coordinates and water-depth of sampling sites.

SAMPLE	Water-depth (m)	GEOGRAPHIC COORDINATES WGS 84	
		Latitudine	Longitudine
BE 2	4.6	40°48.19 N	14°10.21 E
BE 16	10.4	40°48.31 N	14°09.88 E
BE 23	9.9	40°48.40 N	14°09.82 E
BE 25	14.1	40°48.34N	14°09.72 E
BE 31	7.6	40°48.51 N	14°09.81 E
BE 35	6.8	40°48.61 N	14°09.76 E
BE 39	14.4	40°48.25 N	14°09.75 E
BES 3	17.0	40°48.45 N	14°09.53 E
BES 6	16.6	40°48.26 N	14°09.68 E
BES 9	15.6	40°48.13 N	14°09.76 E
BES 15	7.5	40°48.11 N	14°10.02 E
SF 1	4.3	40°48.06 N	14°10.22 E
SF 2	10.5	40°48.02 N	14°09.95 E
SF 3	10.5	40°48.66 N	14°09.48 E
SF 4	4.3	40°48.80 N	14°09.69 E
SF 5	7.9	40°48.85 N	14°09.27 E
SF 6	6.5	40°48.99 N	14°08.96 E
SF 7	10.5	40°48.89 N	14°08.90 E
SF 8	25.5	40°48.66 N	14°08.81 E
SF 9	3.9	40°48.98 N	14°09.37 E

according to GIANI *et al.*, (1994). Organic matter was determined on previously dried sediments by loss on ignition at 450° C in a muffle furnace (BYERS *et al.*, 1987).

The 15 Polycyclic Aromatic Hydrocarbons (PAHs) indicated from Environmental Protection Agency (EPA) as important toxicological contaminants were determined: fluorene, acenaphtene, phenanthrene, anthracene, fluoranthene, pyrene, benz(a) anthracene, naphthalene, chrysene, benzo(b) fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, dibenz(ah)anthracene, benzo(ghi)perylene, indeno(1, 2, 3-cd)pyrene. PAHs analyses were performed by a preliminary extraction and a successive purification on silica gel treatment; the determination by HPLC with spectrofluorimetric detector was carried out (AUSILI *et al.*, 1998).

Samples for foraminiferal analyses were washed through a 0,125 mm sieve and finally split into sub samples containing at least 300 specimens. Due to the scarce presence of living specimens, the quantitative analysis was performed only on the total assemblage. The faunal abundance was calculated through the Benthic Number (i.e. the number of tests found in 1 g of dry sediment) and the species diversity was calculated by means of the α-index (FISHER *et al.*, 1943). The LOEBLICH & TAPPAN (1988) classification was used and most of the species were compared with those found by SGARRELLA & MONCHARMONT-ZEI (1993) in their important paper on benthic foraminifers from the Gulf of Naples.

A Principal Component Analysis was performed on the results of chemical physical and foraminiferal analyses to evaluate the comprehensive behaviour of single foraminiferal species and chemical-physical parameters. Moreover, a bivariate analysis was carried out to correlate relative abundance of the single species with any chemical-physical parameter, using the Pearson correlation. The statistical treatment was performed by means of the SPSS statistical software (10.1 version). In order to simplify the matrix, only species more abundant than 4% were considered for the statistical analyses.

Results

Chemical-physical analyses

Following Shepard (1954), all the analysed samples are constituted of sand (Tab. 2). They contain a low pelitic (<0.063 mm) fraction, which is slightly higher in front of the steel plant (up to 21%). In this area, a considerable content in vitreous drosses and iron grains is recovered in the sea-bottom. In the northern sector, coarser sediment with relatively high gravel content is present.

The organic matter in the sediments shows higher percentages in the area located between the two piers (7 - 10%) while, in the other samples, values are lower than 5% (Tab. 3). In the northern area, coarse sediments show the lowest content of organic matter (1-3%).

The highest concentrations of PAHs are recorded mainly in samples located in front of

Table 2
Particle size composition of sediments. According to Shepard (1954). All sediments are sand.

SAMPLE	GRAVEL %	SAND %	SILT %	CLAY %
BE 2	0,1	98,3	1,6	0,0
BE 16	0,0	86,7	11,8	1,5
BE 23	0,0	83,6	15,3	1,1
BE 25	0,0	78,9	19,2	1,9
BE 31	0,0	79,9	16,7	3,4
BE 35	0,0	95,8	4,2	0,0
BE 39	0,6	80,0	17,1	2,3
BES 3	2,0	91,9	6,1	0,0
BES 6	17,8	74,6	7,6	0,0
BES 9	1,3	85,9	11,1	1,7
BES 15	0,2	96,0	3,8	0,0
SF 1	0,8	95,0	4,2	0,0
SF 2	0,8	79,8	16,3	3,1
SF 3	0,8	97,4	1,8	0,0
SF 4	0,0	88,9	9,9	1,2
SF 5	9,2	90,7	0,1	0,0
SF 6	1,0	98,9	0,1	0,0
SF 7	4,3	95,7	0,0	0,0
SF 8	38,0	61,5	0,5	0,0
SF 9	0,1	97,3	2,6	0,0

Table 3
Concentrations of Organic Matter, PAHs and trace metals in the sediment.

SAMPLE	Organic Matter % d.w.	PAHs mg/Kg d.w.	Cr mg/Kg d.w.	Cu mg/Kg d.w.	Fe % d.w.	Hg mg/Kg d.w.	Mn mg/Kg d.w.	Ni mg/Kg d.w.	Pb mg/Kg d.w.	Zn mg/Kg d.w.
BE 2	4,4	0,134	19,7	11,6	3,1	0,09	491	6,39	99	111
BE 16	7,1	1,475	28,5	45,8	7,6	0,41	1670	13,00	254	886
BE 23	9,1	1,279	28,3	34,4	7,5	0,48	1800	12,76	465	1523
BE 25	10,0	4,783	31,6	37,7	6,0	0,53	1914	12,37	387	1346
BE 31	4,2	0,335	38,5	22,6	15,4	0,15	1349	14,20	328	582
BE 35	3,2	0,836	18,9	9,4	3,8	0,08	698	7,70	86	192
BE 39	8,8	2,252	32,6	44,7	6,0	0,75	1808	11,90	326	996
BES 3	8,0	1,589	23,7	11,0	4,3	0,12	1128	8,39	124	275
BES 6	9,2	4,716	39,6	41,5	4,7	0,44	2899	9,69	344	897
BES 9	6,8	1,225	36,5	41,0	5,8	0,39	1882	10,24	255	792
BES 15	5,4	0,283	17,5	27,0	3,7	0,23	847	7,18	171	425
SF 1	5,1	0,161	19,8	36,8	2,9	0,16	522	6,66	92	179
SF 2	5,1	2,019	26,2	48,3	4,2	0,49	950	9,50	245	578
SF 3	2,7	0,281	26,9	8,4	3,5	0,25	813	8,63	58	153
SF 4	5,9	2,651	20,3	11,6	3,3	0,14	1291	7,49	130	280
SF 5	2,6	0,084	18,3	4,1	1,7	0,01	486	7,47	16	52
SF 6	1,0	0,050	25,5	8,9	4,0	0,03	1195	9,21	34	111
SF 7	2,1	0,013	15,2	5,4	1,2	0,15	563	5,86	45	100
SF 8	3,3	0,051	5,3	8,6	2,2	0,05	1570	5,10	128	229
SF 9	9,0	0,361	24,5	8,9	3,5	0,08	1258	7,57	62	188

the industrial plant (1.2 - 4.7 mg/kg d.w.), while in the other areas they generally have low contents. Nevertheless, some samples with high PAHs concentrations (2.02 and 2.65 mg/kg d.w. for SF2 and SF4, respectively), probably due to single accidental episodes, are present at the north and south of the plant (Tab. 3).

Heavy metal analyses show generally low values for Cr, Cu and Ni. High values of Mn may be attributed to the upwelling of hydrothermal waters (CELICO *et al.*, 2001). Very high values for Fe, Pb and Zn content are recorded in front of the industrial plant. In this area, iron reaches values up to 15.4%, while in the northern and southern sector it has low values (1.2 - 4%). Similar distribution is found for Pb and Zn (Tab. 3).

Foraminiferal analyses

Relative abundance of species occurring more than 1% in at least one sample are reported in Appendix 1.

In the northern area, near to Bagnoli town (Fig. 2), all relatively coarse sediments are barren like SF5 and SF7, or have extremely low foraminiferal abundance, like SF6 and SF8. In such samples the most abundant species is *Elphidium crispum*. Many living specimens of *Haynesina germanica, Nonionella atlantica, Quinqueloculina stelligera, Lobatula lobatula, Planorbulina mediterranensis, Rosalina floridana* and *Tretomphalus concinnus* were found. The last four species, which may live attached on vegetated or hard substrates, in these samples, were found living on gravel and coarse sand grains. Two samples (SF4, SF9), collected near the coast at about 4 m water depth, are characterised by relatively fine sediment and show very low foraminiferal abundance. Their assemblage is characterised by *Elphidium advena* and *Quinqueloculina dimidiata*.

Samples collected in the vicinity of the industrial plant (SF3, BE35, BE31) and near the Coroglio beach (BE2, SF1) are barren.

Those taken in the nearby area, starting from 7.5 m water depth, show moderate (BE16, BE23, BE25, BE39, BES3, BSE6, BES9, BES15) or good (SF2) foraminiferal abundance. The most common species found in these samples are *Elphidium advena, Quinqueloculina* spp. (mainly *Q. dimidiata* and *Q. stelligera*), *Triloculina plicata, Buccella granulata* and *Miliolinella subrotunda*. The most common living specimens belong to *Cornuspira involvens, Haynesina germanica, Nonionella atlantica* and *Quinqueloculina laevigata*. Considerable percentages of *E. advena* have slightly irregular tests in samples BE23 and SF2, while many irregular specimens of *M. subrotunda* were found only in samples taken in front of the steel plant (BE9, BE25, BE39 and BES3).

Statistical analyses

The Principal Component Analysis shows that the largest number of variables have positive values for component 1, while they are well distributed both on the positive and the negative side of the component 2 axis (Fig. 4). Variables representing chemical-physical environmental parameters like organic matter, silt+clay and clay show high values for component 1, like many foraminiferal species, which have similar statistical behaviour. This is confirmed by the results of the bivariate analysis (see appendix 2) that show for many species (*Bulimina sublimbata, Elphidium macellum, Haynesina germanica, Miliolinella dilatata, Quinqueloculina parvula and Triloculina plicata*) significant correlation with both organic matter and silt+clay. Even some trace metals (mainly Pb and Zn) show affinity with fine sediments and organic matter, having high values for component 1 in the PCA and a significant Pearson index with such variables in the bivariate analysis. On the contrary, Cu and Fe are completely independent from component 1 and are the sole two trace metals that do not have a significant correlation with fine sediments and/or organic matter in the bivariate analysis. Furthermore, the bivariate analysis indicates that some species have a significant Pearson correlation with some trace metals. In the most of cases they show correlation with two or more pollutants like, Hg, Mn, Pb and Zn. In particular, *Bulimina aculeata* is correlated with Mn, Ni and Zn, *Haynesina germanica, Miliolinella subrotunda*

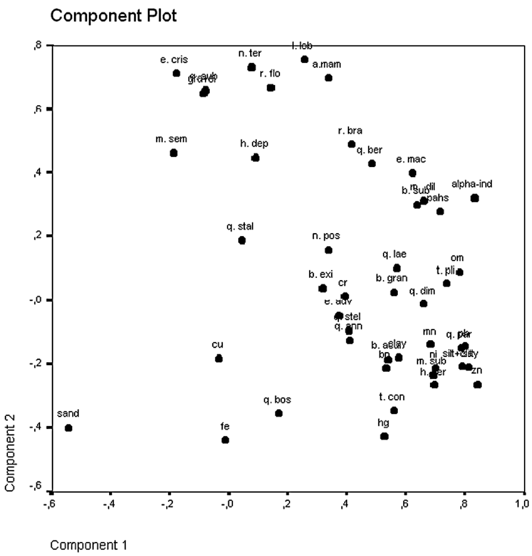

Fig. 3: Plot of the two first components of the Principal Component Analysis.

and *Quinqueloculina parvula* with Hg, Mn, Ni, Pb and Zn. Cu and Fe are the only ones, among the analysed metals, that have no statistically significant correlation with any foraminiferal species.

A group of variables with very low values for component 1, but high values for component 2 comprise gravel and many species that normally are abundant in coarse sediments, many of which may live attached to the grains. The positive significant correlation in the bivariate analysis between gravel and species like *Asterigerinata mamilla, Elphidium crispum* and *Lobatula lobatula* confirms these results. Sand is the sole variable with high negative values both for component 1 and 2. It has also significant negative correlation with some foraminiferal species (*Asterigerinata mamilla, Bulimina sublimbata, Elphidium crispum, E. macellum, Rosalina bradyi*) and with some trace metals (Mn, Ni, Pb and Zn).

Finally, PAHs show in the PCA high values for component 1 and mean values for component 2, like some species like *Bulimina sublimbata, Elphidium macellum, Miliolinella dilatata*. The similar statistical behaviour of such variables is confirmed by the significant positive correlation between these species and PAHs in the bivariate analysis.

Discussion

Benthic foraminifers have been studied with two main aims: the first one was to describe the ecological health of the sea-bottom and the second one was to try to single out bio-indicators of specific pollutants.

As regards the first aspect, foraminiferal abundance may be influenced by several natural and anthropogenic factors and, in the second case, may be indicative of environmental ecological health (ALVE, 1991; SAMIR, 2000). Two barren samples are located in the northern sector of the study area (SF5, SF7); some barren samples are located near the plant (BE31, BE35, SF3); two barren samples are located to the south of the plant, along the Coroglio beach (BE2, SF1).

The statistical analysis (both PCA and bivariate analysis)provides evidence that foraminiferal abundance, represented by the Benthic Number, is positively linked to pelitic fraction (silt+clay). All the barren samples, except BE31, are characterised by low or very low pelitic content (0-4%). On the contrary, BE31 contains an abundant pelitic fraction (20%), but it records a general high trace metals contamination, with the highest Fe concentration (15.4%). Consequently, although in some cases the absence of foraminifers may be at least in part be attributed to natural factors like the type of substrate, metal pollution also seems to contribute to such phenomenon.

As regards the second goal of this research, PCA evidences two groups of species with distinct statistical behaviour (Fig. 4). The largest group (*Quinqueloculina dimidiata, Q. laevigata, Q stelligera, Miliolinella subrotunda, Haynesina germanica, Elphidium advena* among the others) prefers to live in bottoms with relatively high pelitic fraction and organic matter content. Such type of sediment is favourable for the accumulation of some trace metals like Hg, Mn, Ni, Pb and Zn, owing to the absorptive properties of clay minerals. The concurrence of certain species and some metals may be due to their preference for the same type of sediments. Nevertheless, the positive correlation between many species and some trace metals, revealed by the bivariate analysis, let us suppose a certain tolerance of metal pollution. *Haynesina germanica, Miliolinella subrotunda* and *Quinqueloculina parvula* seem the most tolerant species because they are positively correlated with many metals (Hg, Mn, Ni, Pb and Zn). DEBENAY *et al.*, (2001) consider *Haynesina germanica* a tolerant and pioneer species because it was found in the metal polluted sediments of the Port Joinville Harbour and shows a significant positive correlation with Pb in the bivariate analysis. A significant Pearson correlation was also found between *Bulimina sublimbata, Elphidium macellum, Miliolinella dilatata* and PAHs.

The group of species with high component 2 values in the PCA (*Neoconorbina terquemi, Asterigerinata mamilla, Lobatula lobatula, Elphidium crispum*, among others) is not influenced by the organic matter content, while it is strictly linked to coarse sediment. Among these species no one shows a significant correlation with any type of metal pollution.

Conclusions

The strongest heavy metal pollution, mainly due to Fe, Pb and Zn, is recorded in the sediments close to the plant, while it rapidly diminishes with increasing distance from it. Such pollutants seem to have strong environmental impact on the sea-bottom's ecological health because they might be, at least in part, responsible for the complete absence of foraminifers. In a previous study on the Bagnoli site, Bergamin *et al.* (in press) deduced that the absence of foraminifers near the plant, especially between the two piers, could be attributed mainly to iron and copper contamination.

Some trace metals, Hg, Mn, Ni, Pb and Zn, are positively linked to pelite rich sediments, like a large proportion of foraminiferal species. Their concurrence in the same bottom-environment evidences that, at the recorded concentrations, many foraminiferal species have a good tolerance of these metals. *Haynesina germanica, Miliolinella subrotunda* and *Quinqueloculina parvula* are particularly tolerant of a trace metal polluted environment. On the contrary, no foraminiferal species demonstrated to tolerate copper and iron-polluted environment. In addition, a good tolerance of PAHs pollution may be supposed for *Bulimina sublimbata, Elphidium macellum* and *Miliolinella dilatata.*

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Appendix 1

Relative abundance of foraminifers, Alpha-index and Benthic Number. Species occurring more than 1% in at least one sample are reported.

	BE16	BE23	BE25	BE39	BES3	BES6	BES9	BES15	SF2	SF4	SF6	SF8	SF9
Adelosina carinata striata	0.00	0.46	0.00	0.94	0.47	0.00	1.41	0.00	1.64	0.49	0.00	0.00	1.50
Adelosina cliariensis	2.33	2.78	0.99	0.47	1.41	1.39	2.82	2.84	2.46	0.98	1.66	0.45	0.00
Ammonia inflata	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.41	0.00	1.10	2.26	0.00
Ammonia parkinsoniana	0.93	1.39	0.49	1.41	2.36	0.00	0.94	1.42	1.64	2.95	3.31	0.90	2.00
Ammonia tepida	0.93	0.00	1.97	1.41	0.00	0.00	0.47	0.47	2.46	0.00	0.00	0.00	0.00

Appendix 1 (Continued)

	BE16	BE23	BE25	BE39	BES3	BES6	BES9	BES15	SF2	SF4	SF6	SF8	SF9
Asterigerinata mamilla	0.93	0.46	0.49	3.77	2.36	6.97	1.41	0.47	0.00	1.48	0.55	4.98	3.00
Asterigerinata mariae	0.46	0.00	0.00	1.41	0.00	0.46	0.94	0.00	0.00	0.00	0.00	0.00	0.00
Astrononion stelligerum	0.46	0.00	0.00	0.94	0.00	0.93	1.41	0.00	0.00	1.48	0.00	0.90	0.50
Buccella granulata	4.19	7.90	2.47	2.36	6.13	2.33	2.35	4.26	1.64	2.46	1.10	0.00	4.00
Bulimina aculeata	0.46	0.00	0.49	0.00	0.47	2.33	5.16	2.37	1.64	0.00	0.00	0.00	0.00
Bulimina cf. *exilis*	0.00	0.00	0.00	7.54	0.94	0.93	0.00	0.00	0.00	0.98	0.00	0.00	0.00
Bulimina sublimbata	2.33	1.39	6.44	1.41	1.41	5.11	0.94	0.00	1.64	0.00	0.00	0.00	0.00
Cibicides refulgens	1.39	1.39	0.00	0.47	0.47	0.00	1.41	0.95	1.23	1.48	0.00	0.00	2.00
Cornuspira involvens	0.00	0.93	0.99	0.47	0.00	1.39	0.47	1.42	2.05	0.98	0.00	0.00	0.50
Elphidium aculeatum	0.00	0.00	0.49	0.47	0.47	0.00	0.94	0.47	0.00	0.00	0.00	2.72	2.00
Elphidium advena	12.56	8.84	5.45	8.02	12.26	3.25	6.10	13.74	9.84	13.79	1.10	0.00	12.00
Elphidium crispum	0.00	0.00	0.00	0.00	0.00	3.25	0.94	2.84	1.64	0.00	19.88	30.77	0.00
Elphidium granosum	0.00	0.46	1.48	0.94	0.47	0.00	0.47	0.00	2.87	0.00	0.00	0.00	0.00
Elphidium jenseni	0.00	0.00	0.49	0.00	0.47	0.93	0.00	0.47	0.41	1.48	0.55	3.17	3.50
Elphidium macellum	0.93	0.93	1.98	3.77	0.47	5.58	0.00	0.95	4.10	0.00	0.55	0.45	1.00
Elphidium pulvereum	3.71	0.00	0.49	0.94	2.83	0.00	3.28	0.95	2.46	1.97	0.55	0.45	1.50
Elphidium sp.	2.79	1.86	0.98	1.89	2.36	0.46	1.41	1.42	0.82	2.95	0.55	0.00	0.50
Fursenkoina acuta	0.00	0.00	0.49	0.00	1.41	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.50
Gavelinopsis praegeri	0.00	0.00	0.00	1.41	0.00	0.00	0.94	0.00	0.00	2.46	0.00	0.45	0.00
Glabratella erecta	0.00	0.00	1.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hanzawaya boueana	0.00	0.00	0.00	0.00	0.00	0.46	0.47	0.00	0.00	0.98	0.00	1.36	0.50
Haynesina depressula	0.93	1.39	1.97	1.89	0.47	0.00	1.41	0.00	4.10	0.49	9.39	0.00	3.00
Haynesina germanica	0.46	2.79	4.45	0.94	3.30	0.00	1.88	2.36	2.05	0.49	0.00	0.00	1.50
Lenticulina cultrata	1.85	0.46	0.49	0.94	0.47	0.46	1.41	0.00	0.00	0.00	0.00	0.00	0.00
Lobatula lobatula	2.33	0.00	1.48	5.19	4.24	13.01	9.86	4.74	7.38	5.42	3.31	22.17	9.00
Miliolinella semicostata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.73	0.00	3.00

Appendix 1 (Continued)

	BE16	BE23	BE25	BE39	BES3	BES6	BES9	BES15	SF2	SF4	SF6	SF8	SF9
Miliolinella subrotunda	4.17	3.71	5.44	4.72	4.72	5.11	7.05	1.89	3.69	5.90	0.00	1.35	3.50
Neoconorbina posidonicola	1.86	0.00	0.49	1.41	1.41	0.46	5.63	0.00	0.00	1.48	0.00	0.00	1.00
Neoconorbina terquemi	0.46	0.93	2.47	0.00	0.94	2.33	0.47	0.00	1.23	1.48	6.63	2.71	0.00
Nonionella atlantica	3.72	3.25	2.47	1.41	0.47	0.00	0.94	1.42	2.87	0.00	0.55	0.00	0.00
Peneroplis pertusus	0.00	0.00	0.00	0.00	0.00	0.93	0.00	0.00	0.00	0.00	2.76	0.00	2.50
Planorbulina mediterranensis	0.00	0.00	0.99	0.47	0.00	0.93	1.41	0.00	0.82	0.49	0.00	3.17	0.50
Pseudotriloculina subgranulata	0.92	0.46	0.00	0.00	0.00	0.00	0.00	0.47	1.23	0.00	0.00	0.45	0.00
Quinqueloculina annectens	1.39	0.46	0.49	1.89	2.35	0.93	3.75	5.69	0.00	0.00	0.55	0.45	1.00
Quinqueloculina auberiana	0.46	0.00	0.00	0.00	0.47	1.39	4.23	0.00	0.41	0.98	8.28	2.71	0.50
Quinqueloculina berthelotiana	0.00	0.00	2.97	0.94	0.47	6.05	2.82	4.74	5.74	0.00	0.00	0.90	1.00
Quinqueloculina bosciana	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Quinqueloculina dimidiata	15.36	14.88	14.85	6.59	9.90	5.12	6.11	4.73	2.05	23.88	2.75	0.00	12.00
Quinqueloculina laevigata	4.19	6.98	1.98	1.89	7.55	1.85	2.35	3.32	2.46	0.98	0.00	0.45	1.50
Quinqueloculina parvula	2.33	2.79	3.96	2.83	1.41	2.33	0.00	3.32	0.82	0.00	1.10	0.00	1.50
Quinqueloculina seminulum	0.93	3.25	1.98	1.89	1.89	3.25	1.88	1.89	0.82	1.48	2.76	1.35	1.00
Quinqueloculina stalkeri	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.00	0.00	9.36	0.00	0.00	6.00
Quinqueloculina stelligera	10.70	8.37	4.95	2.36	10.38	0.00	0.00	4.26	0.82	1.97	1.10	0.00	5.50
Rosalina bradyi	2.79	1.86	1.98	1.89	2.36	3.25	5.16	5.21	10.25	0.00	0.55	6.79	4.00
Rosalina floridana	0.00	0.00	0.99	0.00	0.47	6.51	0.00	0.00	0.00	5.42	4.41	0.90	2.00
Siphonaperta aspera	0.93	1.39	0.00	0.47	0.47	0.00	0.00	3.79	1.64	0.48	11.04	0.90	0.00
Tretomphalus concinnus	1.39	1.39	0.49	3.30	1.89	0.00	0.47	0.00	0.82	3.44	0.55	0.00	1.00
Triloculina plicata	4.65	13.95	10.39	9.90	3.77	4.19	6.10	12.80	9.43	0.49	0.55	0.90	0.00
Triloculina tricarinata	0.00	0.00	0.00	1.41	0.47	0.00	0.47	0.00	0.00	0.00	0.00	0.00	0.00
Vertebralina striata	0.93	0.46	0.49	1.89	0.94	0.00	0.47	0.95	0.41	1.48	0.00	0.00	0.50
Alpha-index	40.0	26.1	19.2	38.1	38.3	34.4	30.1	22.4	32.4	26.4	18.2	20.3	29.8
Benthic Number	128.6	150.7	188.3	217.4	28.0	257.8	181.6	139.8	2159.5	33.9	1.8	3.8	7.1

Appendix 2

Correlation between relative abundance of selected species of foraminifers (>5% in at least 1 sample) and the chemical-physical parameters of sediments. Only variables with significant Pearson Correlation are reported.

		Cr	Cu	Fe	Hg	Mn	Ni	Pb	Zn	PAHs	OM	gravel	sand	silt	clay	silt+clay
Asterigerinata	Pearson Correlation	0,151	-0,098	-0,242	0	0,244	0,004	0,197	0,077	**0,451**	**0,440**	**0,661**	-0,566	0,006	-0,116	-0,012
mamilla	Sig. (2-tailed)	0,461	0,634	0,234	0,998	0,229	0,984	0,335	0,708	0,021	0,024	0,000	0,003	0,976	0,571	0,955
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Buccella	Pearson Correlation	0,205	-0,123	-0,114	0,242	0,098	0,254	**0,424**	0,298	0,213	**0,518**	-0,196	0,002	0,249	0,006	0,217
granulata	Sig. (2-tailed)	0,314	0,548	0,58	0,233	0,634	0,211	0,031	0,139	0,297	0,007	0,336	0,992	0,221	0,975	0,287
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Bulimina	Pearson Correlation	-0,002	0,047	-0,001	0,38	**0,801**	**0,531**	0,344	**0,674**	0,194	0,218	-0,031	-0,224	0,328	0,258	0,323
aculeata	Sig. (2-tailed)	0,990	0,82	0,997	0,055	0	0,005	0,085	0,000	0,342	0,284	0,881	0,271	0,102	0,202	0,108
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Bulimina	Pearson Correlation	**0,493**	0,021	-0,123	0,251	0,271	0,305	**0,585**	**0,463**	**0,895**	**0,668**	0,108	-0,477	**0,520**	0,279	**0,493**
sublimbata	Sig. (2-tailed)	0,010	0,918	0,551	0,217	0,180	0,13	0,002	0,017	0	0,000	0,598	0,014	0,006	0,168	0,011
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Elphidium	Pearson Correlation	-0,387	-0,118	-0,205	-0,31	0,029	-0,14	-0,196	-0,163	-0,17	-0,308	0,755	-0,431	-0,301	-0,197	-0,290
crispum	Sig. (2-tailed)	0,051	0,564	0,315	0,124	0,138	0,483	0,336	0,425	0,415	0,125	0,000	0,028	0,135	0,335	0,151
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Elphidium	Pearson Correlation	**0,408**	0,018	-0,18	0,332	0,299	0,259	**0,503**	0,371	**0,710**	**0,530**	0,197	-0,504	**0,437**	0,324	**0,427**
macellum	Sig. (2-tailed)	0,039	0,93	0,38	0,097	0,138	0,201	0,009	0,062	0	0,005	0,335	0,009	0,025	0,106	0,030
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Haynesina	Pearson Correlation	-0,024	-0,052	0,008	**0,422**	**0,498**	**0,502**	**0,455**	**0,649**	0,379	**0,502**	-0,234	-0,172	**0,514**	0,238	**0,482**
germanica	Sig. (2-tailed)	0,909	0,801	0,971	0,032	0,010	0,009	0,020	0,000	0,056	0,009	0,250	0,402	0,007	0,241	0,013
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Lobatula	Pearson Correlation	-0,112	-0,122	-0,272	-0,11	0,208	-0,05	0,051	0,014	0,23	0,215	**0,781**	-0,659	-0,026	-0,022	-0,026
lobatula	Sig. (2-tailed)	0,587	0,551	0,18	0,608	0,309	0,808	0,805	0,947	0,259	0,292	0,000	0,000	0,898	0,917	0,900
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Miliolinella	Pearson Correlation	0,371	-0,084	-0,209	0,075	0,193	0,271	**0,456**	0,385	**0,723**	**0,845**	-0,030	-0,347	**0,511**	0,248	**0,480**
dilatata	Sig. (2-tailed)	0,062	0,683	0,305	0,715	0,344	0,18	0,019	0,052	0	0,000	0,883	0,083	0,008	0,222	0,013
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Miliolinella	Pearson Correlation	-0,021	-0,018	0,049	**0,577**	**0,813**	**0,589**	**0,390**	**0,688**	0,297	0,286	-0,057	-0,285	**0,445**	0,298	**0,431**
subrotunda	Sig. (2-tailed)	0,919	0,931	0,811	0,002	0,000	0,002	0,049	0,000	0,141	0,156	0,781	0,158	0,023	0,139	0,028
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26

Quinqueloculina berthelotiana	Pearson Correlation	0,297	0,006	-0,22	0,120	0,136	0,08	0,338	0,202	**0,576**	**0,398**	0,203	-0,398	0,288	0,235	0,285
	Sig. (2-tailed)	0,141	0,975	0,281	0,560	0,506	0,698	0,091	0,323	0,002	0,044	0,320	0,044	0,153	0,248	0,159
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Quinqueloculina dimidiata	Pearson Correlation	0,133	-0,11	-0,087	0,244	0,382	**0,420**	0,380	**0,479**	**0,489**	**0,597**	-0,233	-0,142	**0,473**	0,218	**0,443**
	Sig. (2-tailed)	0,516	0,594	0,674	0,230	0,054	0,033	0,056	0,013	0,11	0,001	0,253	0,488	0,015	0,285	0,023
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Quinqueloculina laevigata	Pearson Correlation	0,210	-0,073	-0,17	0,097	0,056	0,241	**0,437**	0,315	0,313	**0,600**	-0,097	-0,163	0,347	0,124	0,319
	Sig. (2-tailed)	0,302	0,724	0,406	0.637	0,785	0,235	0,026	0,118	0,119	0,001	0,636	0,425	0,083	0,545	0,112
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Quinqueloculina parvula	Pearson Correlation	0,051	-0,006	-0,072	**0,506**	**0,734**	**0,653**	**0,616**	**0,831**	**0,444**	**0,546**	-0,130	-0,250	**0,497**	0,244	**0,467**
	Sig. (2-tailed)	0,805	0,975	0,726	0,008	0,000	0	0,001	0,000	0,023	0,004	0,528	0,217	0,010	0,230	0,016
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Quinqueloculina stelligera	Pearson Correlation	0,135	-0,117	0,038	0,176	0,010	0,216	0,188	0,174	0,113	**0,418**	-0,229	0,054	0,220	-0,033	0,187
	Sig. (2-tailed)	0,512	0,568	0,852	0,391	0,963	0,290	0,357	0,394	0,584	0,033	0,260	0,794	0,281	0,873	0,361
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Rosalina floridana	Pearson Correlation	0,187	-0,104	-0,220	-0,204	0,173	-0,010	-0,018	-0,039	**0,500**	0,179	0,258	-0,168	-0,060	-0,143	-0,073
	Sig. (2-tailed)	0,359	0,613	0,280	0,317	0,399	0,962	0,930	0,849	0,009	0,382	0,203	0,413	0,770	0,485	0,722
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Tretomphalus concinnus	Pearson Correlation	-0,187	-0,003	0,014	**0,459**	**0,812**	**0,612**	0,331	**0,702**	0,165	0,235	-0,168	-0,151	**0,392**	0,284	0,382
	Sig. (2-tailed)	0,361	0,989	0,946	0,018	0,000	0,001	0,098	0,000	0,422	0,248	0,413	0,461	0,048	0,160	0,054
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Triloculina plicata	Pearson Correlation	0,245	0,006	-0,166	0,345	0,234	**0,393**	**0,678**	**0,597**	**0,485**	**0,610**	-0,114	-0,367	**0,618**	**0,425**	**0,599**
	Sig. (2-tailed)	0,227	0,976	0,417	0,084	0,251	0,047	0,000	0,001	0,012	0,001	0,580	0,065	0,001	0,030	0,001
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Benthic Number	Pearson Correlation	-0,105	0,062	-0,004	**0,431**	**0,629**	**0,500**	0,334	**0,601**	0,215	0,125	-0,087	-0,294	**0,466**	**0,483**	**0,475**
	Sig. (2-tailed)	0,609	0,764	0,983	0,028	0,001	0,009	0,096	0,001	0,292	0,544	0,674	0,144	0,016	0,012	0,014
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Alpha-index	Pearson Correlation	0,191	-0,093	-0,230	0,287	**0,534**	**0,492**	**0,453**	**0,553**	**0,528**	**0,663**	0,085	-0,447	**0,498**	0,322	**0,479**
	Sig. (2-tailed)	0,349	0,65	0,259	0,155	0,005	0,011	0,020	0,003	0,006	0,000	0,679	0,022	0,010	0,108	0,013
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Cr	Pearson Correlation	1	-0,046	0,372	0,202	0,085	0,351	**0,494**	0,224	**0,484**	**0,443**	-0,342	-0,124	**0,542**	**0,484**	0,542
	Sig. (2-tailed)		0,823	0,062	0,323	0,680	0,078	0,010	0,270	0,012	0,024	0,087	0,547	0,004	0,012	0,004
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Cu	Pearson Correlation	-0,046	1	0,046	**0,540**	-0,008	-0,309	0,188	0,054	-0,01	-0,038	-0,103	0,121	-0,047	0,005	-0,041
	Sig. (2-tailed)	0,823		0,825	0,004	0,968	0,125	0,358	0,792	0,979	0,853	0,618	0,557	0,818	0,979	0,844
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26

Appendix 2 (Continued)

Hg	Pearson Correlation	0,202	**0,540**	0,258	1	**0,477**	0,194	**0,628**	**0,586**	0,25	0,289	-0,247	-0,092	**0,408**	0,272	**0,394**
	Sig. (2-tailed)	0,323	0,004	0,202		0,014	0,343	0,001	0,002	0,218	0,153	0,223	0,656	0,039	0,179	0,046
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Mn	Pearson Correlation	0,085	-0,008	0,180	**0,477**	1	**0,698**	**0,543**	**0,860**	0,386	**0,392**	0,086	-0,444	**0,493**	0,319	**0,475**
	Sig. (2-tailed)	0,680	0,968	0,378	0,014		0,000	0,004	0,000	0,051	0,047	0,677	0,023	0,011	0,113	0,014
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Ni	Pearson Correlation	0,351	-0,309	0,108	0,194	**0,698**	1	**0,542**	**0,776**	0,371	0,355	-0,186	-0,404	**0,733**	**0,625**	**0,728**
	Sig. (2-tailed)	0,078	0,125	0,600	0,343	0,000		0,004	0,000	0,062	0,075	0,362	0,041	0,000	0,001	0,000
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Pb	Pearson Correlation	**0,494**	0,188	0,186	**0,628**	**0,543**	**0,542**	1	**0,811**	**0,580**	**0,640**	-0,077	-0,536	**0,789**	**0,614**	**0,775**
	Sig. (2-tailed)	0,010	0,358	0,364	0,001	0,004	0,004		0,000	0,002	0,000	0,708	0,005	0,000	0,001	0,000
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Zn	Pearson Correlation	0,224	0,054	0,116	**0,586**	**0,86**	**0,776**	**0,811**	1	**0,505**	**0,583**	-0,108	-0,473	**0,751**	**0,526**	**0,729**
	Sig. (2-tailed)	0,270	0,792	0,572	0,002	0,000	0,000	0,000		0,008	0,002	0,601	0,015	0,000	0,006	0,000
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
PAHs	Pearson Correlation	**0,484**	-0,005	-0,084	0,250	0,386	0,371	**0,580**	**0,505**	1	**0,702**	0,052	-0,513	**0,626**	**0,388**	**0,600**
	Sig. (2-tailed)	0,012	0,979	0,685	0,218	0,051	0,062	0,002	0,008		0,000	0,799	0,007	0,001	0,050	0,001
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
OM	Pearson Correlation	**0,443**	-0,038	-0,038	0,289	**0,392**	0,355	**0,640**	**0,583**	**0,702**	1	-0,094	-0,373	**0,619**	0,317	**0,584**
	Sig. (2-tailed)	0,024	0,854	0,853	0,153	0,047	0,075	0,000	0,002	0,000		0,649	0,061	0,001	0,115	0,002
	N		26		26	26	26	26		26	26	26	26	26	26	26
sand	Pearson Correlation	-0,124	0,121	0,025	-0,092	**-0,444**	**-0,404**	**-0,536**	**-0,473**	**-0,513**	-0,373	**-0,662**	1	**-0,543**	**-0,506**	**-0,545**
	Sig. (2-tailed)	0,547	0,557	0,903	0,656	0,023	0,041	0,005	0,015	0,007	0,061	0,000		0,004	0,008	0,004
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
silt	Pearson Correlation	**0,542**	-0,047	0,237	**0,408**	**0,493**	**0,733**	**0,789**	**0,751**	**0,626**	**0,619**	-0,268	-0,543	1	**0,885**	**0,998**
	Sig. (2-tailed)	0,004	0,818	0,245	0,039	0,011	0,000	0,000	0,000	0,001	0,001	0,186	0,004		0,000	0,000
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
clay	Pearson Correlation	**0,484**	0,005	0,230	0,272	0,319	**0,625**	**0,614**	**0,526**	**0,388**	0,317	-0,236	-0,506	**0,885**	1	**0,914**
	Sig. (2-tailed)	0,012	0,979	0,258	0,179	0,113	0,001	0,001	0,006	0,050	0,115	0,246	0,008	0,000		0,000
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
silt+clay	Pearson Correlation	**0,542**	-0,041	0,240	**0,394**	**0,475**	**0,728**	**0,775**	**0,729**	**0,600**	**0,584**	-0,267	-0,545	**0,998**	**0,914**	1
	Sig. (2-tailed)	0,004	0,844	0,239	0,046	0,014	0,000	0,000	0,000	0,001	0,002	0,187	0,004	0,000	0,000	
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26

LEGEND **Bold** Correlation is significant at the 0,05 level (2-tailed)

Bold Underlined Correlation is significant at the 0,001 level (2-tailed)

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