CROATICA CHEMICA ACTA
CCACAA, ISSN 0011-1643, e-ISSN 1334-417X
Croat. Chem. Acta **83** (3) (2010) 333–339.
CCA-3424

Original Scientific Article

Impact of Tourism on Trace Metal Concentrations (Pb, Cr, Ni, Cu and Zn) in Sediments of Telašćica Bay (East Adriatic – Croatia)

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RECEIVED NOVEMBER 27, 2009; REVISED MARCH 24, 2010; ACCEPTED APRIL 21, 2010

Abstract. Trace metal concentrations (Pb, Cr, Ni, Cu and Zn), the distribution of natural and artificial ^{137}Cs radionuclide and sedimetological characteristics (grain-size analyses) in recent sediments at selected stations of Telašćica Bay (Nature Park at Dugi Otok, East Adriatic, Croatia), were evaluated. It was established that trace metal concentrations were within the range of unpolluted Adriatic sediments. The highest Cu, Zn and Pb concentrations were found along navigational routes and areas used for anchoring boats. Gamma-spectrometric measurements of naturally occurring radionuclides spatial activity showed that terrigenous material input is highest in the NW part of the Bay and lowest in its central part. Grain-size analysis classifies the Telašćica Bay sediment mostly as poorly sorted sandy silt. Since trace metal concentrations in the sediments of Telašćica Bay were not measured previously, results will contribute to the sustainable development of the Nature Park (calculation of the boat environmental capacity, construction of new objects, berths and other interventions in the bay ecosystem).

Keywords: trace metals, anthropogenic influence, radionuclides, sediments, Telašćica Nature Park, Adriatic

INTRODUCTION

Telašćica Bay is situated at Dugi Otok Island (middle Adriatic) and due to its specific geomoprhological, biological and archeological characteristics, is proclaimed Nature Park in 1998. The Bay is 16 km long and maximal 1.6 km wide with 25 smaller bays and 5 islets. It is semi-closed bay so precipitated material and pollutants accumulate in sediments as "ultimate sink".

Sediments in Telašćica Bay were not investigated so far. Therefore, geochemical study, especially on the trace metals (Pb, Cr, Ni, Cu and Zn) concentrations, of natural (^{40}K, ^{232}Th, ^{226}Ra and ^{238}U) and artificial radionuclides (^{137}Cs) activities distributions would give necessary data for the Nature Park management plan. It is important to evaluate the sediment origin by investigation of natural radionuclide spatial activity distributions.

Ecotoxic trace metals input, quantitative analysis and distributions in sediments are crucial topic for protected areas evaluation.

In the marine ecosystems trace metals (Pb, Ni, Zn, Cr and Cu) in sediments are introduced by atmospheric input (rain and particles), rocks leaching, soil weathering, river inflow and anthropogenic input. Sediments pollution history can be estimated by measuring trace metals and radionuclides concentrations/activities in their columns.[1,2] Ecotoxic trace metals input in the sea ecosystems is important due to its impact to the marine biota, especially of Cd, Pb and Hg, as well as essential metals Cu, Mn, Cr, Ni and Zn.[3,4] When interpreting the source of the elevated concentrations of trace metals in sediments, enrichment can be caused by anthropogenic input, but also by natural processes.[5]

Natural radionuclides exist in precipitates, surface and groundwaters, fresh and saline. Uranium radioactive decay series ^{238}U ($t_{½}$ = 4.5×10^9 y) yields ^{230}Th ($t_{½}$ = 8×10^4 y.) and ^{226}Ra ($t_{½}$ = 1600 y.) radionuclides. The portion of radioactive isotope ^{40}K ($t_{½}$ = 1.28×10^9 y, 1 % concentration of stable potassium) in the sediments is proportional to the share of mineral clays and present in lower concentrations in the sediments rich with organic matter. The activity of is. Dissolved uranium in sea water is predominant form,[6–8] while Th is much less soluble.[9]

Introduction of artificial radionuclides into the environment was detected in the mid 1940's with the use of nuclear weapons. Artificial radionuclides peak inputs to the environment were between 1954–1958 and

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1961–1964.[10] The latest major accident was in May 1986 from the nuclear reactor in Chernobyl (Ukraine).[11] Artificial radionuclide ^{137}Cs is soluble in water; its mobility in the aquatic environment is small due to its strong adsorption on clays in suspended material and sediments.[13–15] The aim of this manuscript is to give an overview of the "groundback" situation in the Nature Park Telašćica Bay considering trace metals and radionuclides appearance in the marine sediments. Unequivocally, it is important contribution to the estimation of the present state of the bay sediments exposed to various pollutants, as it is burden by nautical tourism, in the first place.

Sampling Site Characteristics

Telaščica Nature Park is located in the central part of the Adriatic Sea (E 15°10'37.85" and N 43°53'35.80") and occupies the south-east extension of the Dugi Otok Island (Long Island) (Figure 1). The total surface is 70.5 km^2 of which 56 % is marine. The marine area consists of: Telaščica Bay which is about 8 km long, a 1.6 km wide, with 25 smaller bays; 69 km of coastline and 5 islets; Lake Mir 900 m long and 300 m wide with the maximum depth of 6 m; and a marine area in the SE part of the island.

EXPERIMENTAL

Sampling

Sediment sampling was performed in January, 2006 (samples **1**, **2** and **3**) and September, 2007 (samples **A**, **A1**, **B**, **C**, **D** and **E**) by autonomous diving with hand drive plexiglas corers and in February, 2008 (samples **I** and **II**) gravitational corer. Sample (**1**) was taken in the Mir cove from depth of 30 meters, sample (**2**) in the vicinity of the cove Dragnjevica from depth of 14 meters and sample (**3**) in the vicinity of the cove Čušćevica from depth of 26 meters. Samples **A** and **A1** were gathered in the vicinity of the Grozdenjak rock from depth of 27 meters, sample **B** northwest of the cape Raknić from depth of 27.5 meters, sample **C** in the Krušćevica cove from depth of 17.2 meters, sample **D** in the Farfarikulac cove from depth of 16.2 meters and sample **E** southeast from the islet of Donji from depth of 12.5 meters. Samples **I** and **II** were taken in the widest part of Telašćica Bay, southeast of the islet of Korotan, from depths of 62 and 64 meters (Figure 1). Samples were stored into the portable fridge immediately after collection and transported to Martinska marine station, where were frozen at the temperature of –10 °C. Frozen samples were transported to the Ruđer Bošković Institute in Zagreb on the following day, defrosted, and prepared for analysis.

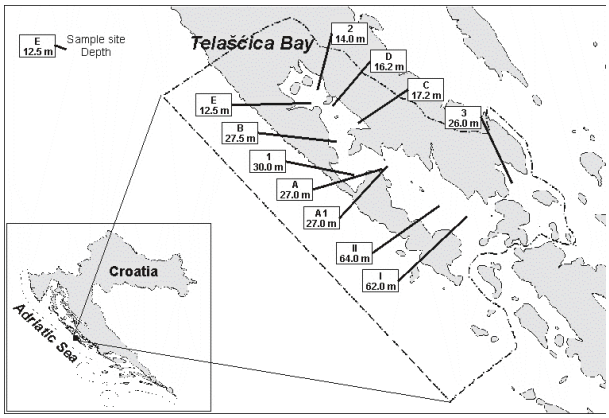

Figure 1. Telašćica Bay location map and sampling sites.

Sample Preparation and Analyses

Geochemical analyses of microelements (Pb, Cr, Ni, Cu and Zn).was performed by X-ray fluorescence method (energy dispersive X-ray fluorescence, EDXRF). Gamma-spectrometric analyses of natural radionuclides ^{40}K, ^{232}Th, ^{226}Ra and ^{238}U activity as well as artificial radionuclide ^{137}Cs, were also performed. Sedimentological (grain-size) analyses at positions A, B, C, D and E were performed by combined method – wet sample sifting through a set of ASTM sieves intended for fractions over 32 μm in size, and analysis of the remaining fractions with the particle counter (Coulter Counter TA II).

Trace metal concentration analyses

Samples were dried in the laboratory to constant weight at 105 °C, ground to dust in mortar and prepared for analysis as fat targets. Total concentrations of elements of Pb, Cr, Ni, Cu and Zn were measured.

Fat targets prepared were analyzed by X-ray fluorescence method (energy dispersive X-ray fluorescence, EDXRF) by the MiniPal 4 spectrometer (PANalytical, Almelo, Nederland). Samples were subjected to X-rays with an Rh anode (maximum power: 9 W; window Be (75μm); maximum voltage: 30 kV, maximum current: 300 μA; air cooling). In order to reduce the noise, appropriate filters were used between samples and source. Optimum measurement parameters for each group of elements were depicted in the Table 1. Three sequences were defined for the measurement of previously mentioned elements. Time of measurement for each sequence was 200 s and measurements were performed on air. The detection of characteristic X-rays from the

Table 1. Optimum measurement parameters for each group of elements

Sequence	U/kV	I/μA	Filter	d_{filter}/mm	Elements
<Cr-Co>	20	200	Al	200	Cr
<Ni-Ag>	30	300	Ag	100	Ni, Cu, Zn, Pb

Table 2. Middle values ($\bar{X}$) and standard deviations (SD) of elements calculated from 10 successively measures of the standard referent materijals "NIST-2702" ("inorganics in marine sediments"), and certificated values of the same elements (μg g^{-1}, dry weight)

Element	$\bar{X}_{measured} \pm$ SD	$\bar{X}_{certificated} \pm$ SD
Cr	329.6 ± 10.4	352 ± 22
Cu	103.7 ± 3.3	117.7± 5.6
Ni	72.7 ± 2.1	75.4 ± 1.5
Pb	130.8 ± 1.6	132.8 ± 4.2
Zn	437.3 ± 3.1	485.3 ± 4.2

sample was made by Si drift detector (surface: 5 mm^2, FWHM at 5.9 keV ^{55}Fe: 145 eV; window: 13 μm Be; cooling: thermoelectric (peltier). Entry and exit ray angles were 45°. Spectra obtained were analyzed by MiniPal/MiniMate program version 3.0-63 (2.64) (PANalytical, Almelo, Nederland). The so called spinner system, which allows constant rotation of samples during measurement, was used to reduce errors caused by inhomogeniety of samples.

Calibration model for qualitative and quantitative analysis was developed by measurements of following standard reference materials of the: IAEA-SL1, IAEA-Soil 7, IAEA 405 and IAEA SL3. The first measurement quality control was performed by measuring the same standard reference materials in unknown samples, followed by the measurement of standard reference material "NIST-2702" in sediment not included in the calibration. Measurement results relative to certified values are depicted in Table 2.

Radionuclide activity analysis

Samples were stored into standard measuring vessel (125 cm^3), weighted and hermetically sealed. Hermetically sealed measuring vessels were left undisturbed for a minimum of 4 weeks prior to measurement to set radiochemical equilibrium between ^{222}Ra (half-life of 3.8 days) and its long-life predecessor ^{226}Ra in the sample. After 4 weeks, samples were counted by multichannel HPGe gamma-spectrometer.

Samples were measured (counted) for 80,000 seconds. Activities of ^{226}Ra were established by the means of its descendant ^{214}Bi, determined from the photo-peak at 609.4 keV. In almost all natural samples activities of ^{232}Th correspond to the activities of ^{228}Ra, evaluated from the photo-peak of its descendant ^{228}Ac progeny at 911.1 keV. Activities of ^{40}K were determined from the photo-peak at 1460.7 keV, activities of ^{238}U through activities of ^{235}U, by applying the activity ratios of ^{235}U/^{238}U of 0.04603. Activities of ^{235}U were determined from the photo-peak at 186 keV, after detracting the overlapping part of the photo-peak of ^{226}Ra from the photo-peak surface. The value of the summary error consisting of the error in the speed of counting, unreliability of establishment of the photo-peak surface and unreliability of establishment of the share of background during counting, has been taken as an error.

Samples were counted on HPG detector Canberra, model GC 2519-7935-7, with resolution (FWHM) of 1.76 keV at 1.33 MeV (^{60}Co), relative efficiency of 25.4 % at 1.33 MeV and photo-peak ratio according to Compton of 52.3:1 at 1.33 MeV. This detection system was placed in low-noise iron protective casing and connected to the computer monitoring of the spectrum collection and GENIE 2K spectrum processing program. The efficiency of measurement geometry and system reliability was regularly inspected by standards counting (IAEA-306, IAEA-313, IAEA-314).

Grain-size Analyses

Grain-size analysis was done in five sediment samples. Since the sediment samples were dry, each sample was mixed with water and treated for 5 minutes in the ultrasonic tube prior to analysis. The analysis was performed by combined method – wet sample sifting through a set of ASTM sieves intended for fractions over 32 μm in size, and analysis of the remaining fractions with the particle counter (Coulter Counter TA II).

RESULTS AND DISCUSSION

Trace metal concentrations

The results of Pb, Cr, Ni, Cu and Zn concentrations analyses in sediments are presented in Table 3. In samples **1** and **3** were found to be lower or within the range measured in unpolluted Adriatic sediments.

The results of analysis from stations A, A1, B, C and D show increased Cr and, especially, Ni concentra-

Table 2. Trace metal concentrations (μg g^{-1}, dry weight) in Telašćica Bay sediment

Element	Site 1	Site 2	Site 3	Site A	Site A1	Site B	Site C	Site D	Site E	Site I	Site II
Pb	8 ± 0.1	10.7 ± 0.1	13 ± 0.2	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	5.3 ± 0.1	7.1 ± 0.1
Cr	60 ± 1.9	90 ± 2.8	70 ± 2.2	101.5 ± 3.2	100.1 ± 3.2	116.6 ± 3.7	136.1 ± 4.3	108.7 ± 3.4	149.9 ± 4.7	72 ± 2.3	81 ± 2.6
Ni	14.5 ± 0.4	21 ± 0.6	19 ± 0.5	53.7 ± 1.6	63.5 ± 1.6	41.6 ± 1.2	87.2 ± 2.5	52.2 ± 1.5	77.9 ± 2.2	25 ± 0.7	21 ± 0.6
Cu	15 ± 0.5	16 ± 0.5	21 ± 0.6	8.1 ± 0.3	8.4 ± 0.3	8.7 ± 0.3	9.2 ± 0.3	6.6 ± 0.2	14.3 ± 0.5	19 ± 0.6	22 ± 0.6
Zn	20 ± 0.1	39 ± 0.3	34 ± 0.2	57.8 ± 0.4	57.3 ± 0.4	60.6 ± 0.4	54.1 ± 0.4	55.9 ± 0.4	83.7 ± 0.5	32 ± 0.2	28 ± 0.2

Table 4. Trace metal concentrations (μg g^{-1}, dry weight) in the relatively unpolluted different Adriatic sediments. (m.v. – middle values)

Source	Element				
	Cr	Cu	Ni	Pb	Zn
Paul and Meischner, 1976, North Adriatic	18–78	20–25	–	–	–
Frignani *et al.*, 1978, Delta Po-Pesaro	24–66	15–35	–	–	–
Costa et al., 1978	–	5–44	–	–	–
Prohić and Juračić, 1989, Krka River	37–200	2–65	42–100	18–70	20–50
Martinčić *et al.*, 1990, Krka River (m.v.)	–	9.6	–	28.8	40.7
Martinčić *et al.*, 1990, Kornati Islands	–	13.7	–	12.4	23–30.5
Valković and Moschini., 1990, Puntarska cove	25–93	25–93	–	16.4–129	31–163
UNEP,1994, North Adriatic	–	20–22	–	25–50	105–130
Mihelčić *et al.*, 1996, Rogoznica Lake (m.v.)	–	14.2	–	23.3	32.5
Dolenec *et al.*, 1998, North Adriatic	40–129	4.1–33.4	19–86	7–51	29–167
Oreščanin, 2001, Plomin Bay	25.1–61.7	20.1–43.6	19.6–40.3	7.1–26.7	69.1–102.9
Mihelčić *et al.*, 2006, Morinje Bay (m.v.)	96.9	27.2	51.9	16	55.8
Mihelčić *et al.*, 2008, Telašćica Bay (this work)	60–208	6.6–21	14.5–87.2	< 0.6–13	20–83.7

tions in comparison to unpolluted Adriatic carbonate sediments, while Pb concentrations were extremely low (below instrument detection limit). Measured concentrations of Cu and Zn are also lower or within the range of reference values listed in Table 4.

The results of trace metals concentrations in sediment samples from the deep profile at the station E are presented in the Table 5. Concentration variations detected were not significant in comparison to concentrations at other stations and there was no trend of change in concentrations with sediment depth. That data suggest the mixing of sediments and lack of substantial anthropogenic contribution. The values of trace metals concentrations were typical for unpolluted Adriatic sediments.

Pb, Cr, Ni, Cu and Zn concentrations measured at stations I and II showed that there are no significant deviations from the station 3. Since these stations were far from the coast and the sea was deepest, the possibility of the released trace metals re-suspension was great, rendering interpretation more difficult. However, obtained values of trace metals concentrations suggest a carbonate sediment with poor anthropogenic burden, and low terrigenous contribution.

Table 5. Trace metal concentrations (μg g^{-1}, dry weight) in the relatively unpolluted different Adriatic sediments (m.v. – middle values)

Element	0–3 cm	3–6 cm	6–9 cm	9–12 cm
Pb	< 0.6	< 0.6	< 0.6	< 0.6
Cr	201.3 ± 6.6	180.6 ± 5.7	187.3 ± 5.9	208 ± 6.6
Ni	52.5 ± 1.5	56.8 ± 1.6	53.3 ± 1.5	59.1 ± 1.7
Cu	11.7 ± 0.4	12.7 ± 0.4	10.6 ± 0.3	14.1 ± 0.4
Zn	80.5 ± 0.5	81.8 ± 0.5	81.8 ± 0.5	80.4 ± 0.5

Table 4 shows that trace metals concentrations measured in the sediments from selected locations in Telašćica Bay were relatively low, being in the range of the unpolluted reference sea ecosystems.

Although concentrations of trace metals measured in the sediments from most areas in Telašćica Bay were within the range of the eastern Adiratic coast unpolluted sediments or lower, the analyses did show anthropogenic impact in the sediments taken from the navigation routes and anchorages.

The effect was the result of release from copper-based antifouling paints. Furthermore, increased zinc concentrations, being also a result of the some antifouling paints (Hempel's Antifouling Olympic 86950 have chemical composition – $C_4H_6N_2S_4Zn$), and also result of the waste water release. Slightly increased chromium concentrations at anchorage points can be attributed to the boat and yacht chromed parts in the Telašćica aquatorium. Increased lead concentrations at the same anchorage points may be explained by gas release.

Radionuclide activities

The measured ratio of ^{238}U and ^{226}Ra activities was the result of ^{238}U geochemical behavior in the sea environment. Due to stressed solubility of uranium, its activities in oxic sediments were relatively low, opposite to those in the reductive environment in which geochemical balance was established due to limited diffusion.[7] The ^{226}Ra activities, as well as those of other descendants of uranium decay sequence in sea water were lower than

Table 6. Radionuclide spatial distributions (Bq kg^{-1}, dry weight) in Telašćica Bay sediments (sampling sites: 1, 2, 3, A, B, C, D, E and A1)

Site	^{40}K	^{232}Th	^{137}Cs	^{226}Ra	^{238}U
1	69.3 ± 4.7	16.3 ± 1.1	0.4 ± 0.1	15.4 ± 0.7	21.5 ± 2.9
2	289.8 ± 7.8	26.6 ± 1.3	1.3 ± 0.2	26.0 ± 0.9	26.4 ± 3.0
3	171.7 ± 6.8	11.4 ± 1.0	3.4 ± 0.3	14.3 ± 0.7	27.6 ± 3.2
A (0–3 cm)	55.7 ± 4.4	7.1 ± 0.8	0.8 ± 0.2	9.0 ± 0.6	12.5 ± 2.4
B	231.0 ± 7.9	26.7 ± 1.4	0.8 ± 0.2	26.6 ± 1.0	21.6 ± 3.2
C	70.1 ± 4.9	10.8 ± 0.9	0.3 ± 0.1	11.8 ± 0.7	12.5 ± 2.5
D	79.2 ± 5.2	12.1 ± 1.1	0.8 ± 0.2	13.3 ± 0.8	14.0 ± 2.7
E	317.2 ± 9.4	31.6 ± 1.6	1.9 ± 0.2	30.3 ± 1.1	27.2 ± 3.6
A1	66.4 ± 5.0	7.7 ± 0.9	0.5 ± 0.2	12.6 ± 0.7	9.8 ± 2.5

Table 7. Radionuclide spatial distributions (Bq kg^{-1}, dry weight) in Telašćica Bay sediments (depth profile in the sampling site E)

Depth (cm)	^{40}K	^{232}Th	^{137}Cs	^{226}Ra	^{238}U
0–3	272.6 ± 8.5	24.2 ± 1.4	1.2 ± 0.2	25.2 ± 1.0	28.8 ± 3.5
3–6	305.3 ± 9.3	27.2 ± 1.5	1.8 ± 0.2	29.6 ± 1.1	30.8 ± 3.8
6–9	287.8 ± 8.8	28.4 ± 1.5	1.8 ± 0.2	28.6 ± 1.0	30.2 ± 3.5
9–12	266.4 ± 8.6	27.2 ± 1.5	1.7 ± 0.2	26.2 ± 1.0	25.9 ± 3.3

^{238}U activities, due to its low solubility and therefore the affinity to migrate.[9] Permanently oxic sedimentation conditions probably prevailed, since the ^{238}U activities were approximately the same as ^{226}Ra activities, *i.e.* they were in the natural misbalance, due to their geochemical characteristics. The greatest activities of radionuclide ^{40}K were measured at stations 2, B and E, rather lower at station 3 and relatively low at other stations, indicating a relatively high share of mineral clays and a relatively low share of organic matter in the sediment, with the share of mineral clays (Table 6). Since these presumptions were based on the geochemical characteristics of isotope ^{40}K, they cannot be taken as fully reliable; consequently mineralogical sediment analysis and laboratory measurement of content of organic matter in the sediments will be performed in the further investigations of the area. The results of the activity measurement in the sediment vertical profile taken at station E are presented in the Table 7. Apart from natural radionuclides, the sediment also contains negligible (< 2 Bq kg^{-1}) quantities of artificial radionuclide ^{137}Cs. Almost uniform activities of ^{137}Cs across the measured profile point to the well pronounced sediment re-suspension processes (possibly caused by bioturbation, sea currents and/or waves). The content of natural radionuclides (the sediment contains approximately 0.9 % potassium, 2.5 μg g^{-1} uranium and 6–7 μg g^{-1} of thorium) the significant portion of the terrigenous input at location E can be presumed.

The ^{137}Cs activities in the surface sediments and deep profile at sampling site E were lower than in the surface sediments of similar coves as Morinje Bay (1.65 g cm^{-2} per year (dry weight)), and Rogoznica Lake (0.093 g cm^{-2} per year (dry weight)).[17,18] That leads to the conclusion that sediment mixing occurred at all locations in Telašćica Bay (bioturbation, re-suspension and other processes). Further geochemical and physical-chemical parameters (pH, Eh, organic matter content, activities of ^{137}Cs, etc.) need to be measured to gain a better insight into the actual conditions in the water column and sediments from Telašćica Bay. Among others, this would give insight of the sedimentation rate

Table 8. Grain-size distribution in Telašćica Bay sediment (sampling sites A, B, C, D and E)

Site	φ / %				Sediment type
	Gravel (> 2mm)	Sand (0.063–2 mm)	Silt(0.002–0.063 mm)	Clay (< 0.002 mm)	
A	16.00	69.20	13.80	1.00	Gravel-coarse silty sand
B	0.00	28.00	69.10	2.90	Coarse silt
C	0.00	27.60	69.80	2.60	Coarse silt
D	6.90	75.10	17.60	0.40	Sand
E	0.00	33.40	62.60	4.00	Coarse silt

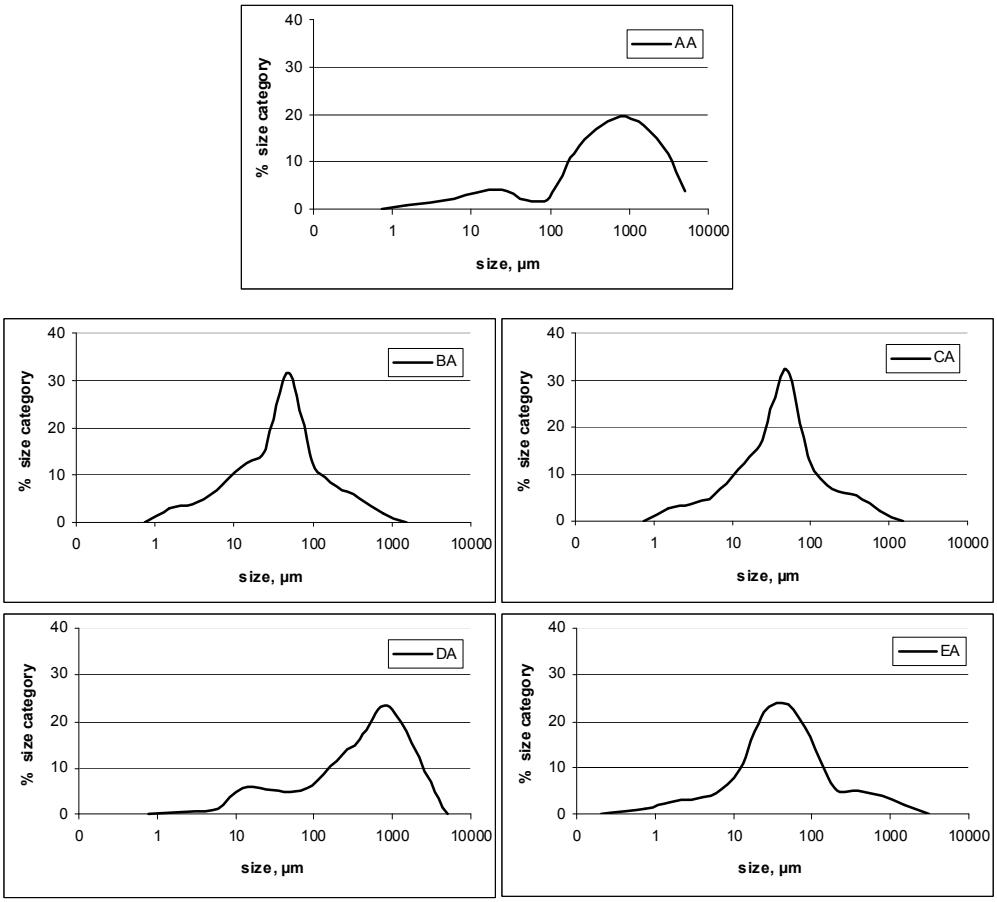

Figure 2. Grain-size distribution curves in Telašćica Bay sediment (sampling sites A, B, C, D and E)

and trace metals distributions. These parameters would also allow the interpretation of the history of anthropogenic influence in the last 60 years.

Grain-size Distribution

Grain-size analyses were performed in samples at stations A, B, C, D and E. Results are presented in Tables 8 and 9, and Figure 2.

Results of analyses showed that sample **A** contained particles over 100 µm in size – mostly sand with substantial portion of gravel and a smaller portion of silt. Samples **B** and **C** were almost identical and contain 70 % of silt particles, with the remainder of fine sand; sample **D** was mostly sand (75 %); portion of the silt was approximately 18 %, with the remainder containing a substantial portion of the fine sand.

Due to the significant portion of the gravel size particles (> 2 mm), granulometric parameters for samples **A** and **D**, were very high (Table 9). The average grain size (Mz) was 476.30, *i.e.* 307.80 µm. Due to demonstration of all size fractions, sorting (So) was mostly very poor. Samples **B**, **C** and **E** were slightly better sorted, but also have a significantly smaller average grain size (33.5, 35.2 and 39.8 µm).

Table 9. Granulometric parameters in Telašćica Bay sediments (Mz = mean size, So = sorting)

Site	Mz (µm)	So
A	476.30	2.46, very poorly sorted
B	33.50	1.99, poorly sorted
C	35.20	1.89, poorly sorted
D	307.80	3.37, very poorly sorted
E	39.80	2.05, very poorly sorted

Acknowledgements. This work was supported by the Ministry of Science, Education and Sports of the Republic of Croatia, within the project 0098132 "Geochemistry of recent and ancient sedimentary systems of the Adriatic carbonate platform", and the Natural Park Telašćica. The authors are grateful to Nikolina Baković, for useful information about Telašćica Bay. Thanks also due to Dr. Marina Mlakar for useful comments and for correcting the English.

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SAŽETAK

Utjecaj turizma na koncentracije metala u tragovima (Pb, Cr, Ni, Cu i Zn) u sedimentima uvale Telašćica (istočni Jadran – Hrvatska)

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U ovom radu prikazani su rezultati istraživanja koncentracija metala u tragovima (Pb, Cr, Ni, Cu i Zn), te raspodjela prirodnih i umjetnog ^{137}Cs radionuklida u površinskim sedimentima uvale Telašćica na odabranim lokacijama. Također su analizirane i prikazane sedimentološke značajke (granulometrijske analize). Rezultati pokazuju da su koncentracije istraživanih metala u tragovima relativno niske i u okvirima izmjerenih u nezagađenim jadranskim sedimentima. Nešto povišene koncentracije Cu, Zn i Pb izmjerene su u područjima plovnog puta brodica i jahti, te na mjestima njihovog sidrenja. Iz rezultata aktivnosti prirodnih radionuklida može se zaključiti da je najveći terigeni donos akumuliranog materijala u sjeverozapadnom dijelu zaljeva, dok je najmanji u centralnom dijelu. Granulometrijske analize karakteriziraju sediment kao loše sortirani pjeskoviti silt. Budući da se, do sada u području parka prirode Telašćica nisu mjerile koncentracije metala u tragovima, rezultati prikazani u ovom radu će bitno doprinijeti optimalnom upravljanju ovog zaštićenog područja (izračun prihvatnog kapaciteta brodica i jahti, utjecaj planiranih objekata na ekosustav Telašćice, te druge intervencije unutar parka prirode).