

Evaluation of elemental composition of sediments from the Adriatic Sea: Underground military harbors

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Introduction: Military underground harbors are used to secure military ships and their crews from the bad weather, to provide logistic support to ships and their crews, and to enable ship maintenance and crew training in order to sustain the level of military readiness against the potential threats. In addition to berths, most of underground harbors also provide storage facilities and atomic shelters.

These harbors were used intensively by the former Yugoslavian army from 1960s to late 1980s. In June 19, 2004, the harbors of special purposes – military harbors of importance for Republic of Croatia, were established by the Decree of the Croatian government. Among other military harbors, all of the 12 underground military harbors located along the Croatian sea territory were listed:

1. Zgarcina – Island of Dugi otok
2. Papratna - Island of Dugi otok
3. Bokasin - Island of Dugi otok
4. Parja - Island of Vis
5. Maslinova – Island of Brač
6. Smrka – Island of Brač
7. Kruscica – Island of Brač
8. Sito – Island of Lastovo
9. Kremena - Island of Lastovo
10. Duba – city of Ploče
11. Brijesta – city of Ploče
12. Soline – city of Ploče

Although abandoned for more than 30 years, these harbors are still in good condition and some of them are used by fishermen or by fish and shellfish farmers. The purpose of the study was the assessment of the marine environment in underground harbors by determination of the sea floor species and by analysis of elemental composition of collected sediments.

Methods: In each of 12 military underground harbors 4 samples of sediment (3 within the harbor and 1 outside the harbor), 1 sediment core sample and 2 samples of biota collected by divers were analyzed. In addition, physical-chemical properties of sea water column have been measured *in-situ*. Sediments were analyzed by the Energy Dispersive X-ray Fluorescence (EDXRF). A location and photo of entrance of military harbor “Papratna” is presented in Figure 1.



Figure 1: Location of underground military harbor “Papratna”, Island of Dugi otok. and photo of harbor entrance.

Results and Discussion: The Table 1 present results for Ni, Cu, Zn, As and Pb for the surface sediments (S1- sediment taken at the end of the tunnel, S2 – from the middle, S3 at the entrance, and S4 out of the tunnel) and for sediment core taken at the middle of the tunnel (S5). The increase of concentrations can be noticed for samples taken towards the end of the tunnel and also for the depth 3-6 cm representing period from 1950s to 1980s (precipitation rate 0.8 mm/year).

Table 1. Concentrations of elements measured in sediments of underground harbor “Papratna”.

Sample ID	Ni ppm	Cu ppm	Zn ppm	As ppm	Pb ppm
S1	36	23	78	14	17
S2	51	26	69	11	15
S3	15	13	36	3	4
S4	12	13	31	3	4
S5 (0-3 cm)	50	22	88	16	15
S5 (3-6 cm)	55	24	89	13	17
S5 (9-10 cm)	44	19	54	8	8