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CANYON ESTUARIES OF THE DALMATIAN KARST RIVERS - 2. ANTHROPOGENIC DIFFERENCES IN THE ESTUARINE VEGETATION OF KRKA AND ZRMANJA

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Résumé: Par ses caractéristiques naturelles, les estuaries de Krka et Zrmanja en Dalmatie septentrionale sont semblables mais ils sont diversifiés par les influences anthropogenes. Dans l'estuaire degradé et pollué de Krka une végétation rudérale est prédominante tandis que dans celui de Zrmanja sont dominantes les phytocénoses naturelles originales avec nombreux endémiques.

The effluent area of the Krka river estuary covers cca 2088 km^2, with an annual quantity of average precipitations of 1500 mm. The river length of Krka is 72.5 km, and a domicile population of 53000 inhabitants is directed to this estuary. The largest part of this estuary is inside the Sibenik commune.

Sibenik town is a reputed historical settlement and one of the most important cultural and economical centers in Dalmatia, lying in the lower part of the Krka river estuary. With its 38000 inhabitants, Sibenik became a considerable immigration center from the Dalmatian inlands (Zagreb county) especially because from 1960ies there is developed a number of industrial and service activities. Together with an uncovenable treatment of the related waste waters, this resulted by a considerable deterioration in the natural ecosystems of lower estuarine areas, but also in the upper river course of Krka where occur also some settlements with ca 15000 inhabitants.

The most important anthropogenic effluents directed to the Krka estuary are the next ones. The Šibenik town besides its domicile inhabitants includes also ca 630000 touristic sleepings, then a marine in the port Skradin (upper estuary) including ca 200 yachts, then two considerable factors in E coast of estuary, a farm with ca 30000 higs lying directly in a confluent of Krka, then Drnis town whose waste waters are also distributed in the Čikola rivulet (a left effluent of Krka), and Knin town with its day output to 4000 m^3 of waste waters ejected in the upper Krka course. Including also 400000 tourists that during a year visit the Krka waterfalls, and also a considerable frequence of ca 250 motorised boats sailing per a day across this estuary up to its cascades during the summer, the total anthropogenic impact on the Krka estuary may be considerable.

Thus one may include in this charge all communal and industrial waste waters from the narrower area of Šibenik town and from its surroundings, and also the outflows from other adjacent urbane and rural settlements directed to the lower river course and to its estuary. Among the natural sources one included here all precipitation waters from the effluent area of Krka river, but with a special reference on these precipitation waters that pass across the Sibenik city area, cf. Table 1. From this table one may note that in the total amount of waters reaching this estuary, the precipitation waters include 98%, but the rest of 2% are the waste waters of anthropogenic origin that bring with them 84% of all presented nutrients, and even a major percentage of other toxic matters (hydrocarbons, heavy metals, etc.). Although the upper effluent area of Krka includes rather pure waters, by the anthropogenic charge they are transformed downwards into the oligo-beta-mesosaprobic waters, up to the beta-mesosaprobic ones.

The effluent area of Zrmanja estuary is ca 910 km^2, and Zrmanja river by its length of 69 km almost belongs to the Obrovac commune. This commune of 12500 inhabitants (with its main settlements Obrovac only 1457 inhabitants), belongs among the scarcely inhabited and undeveloped areas of Dalmatia. The main economical characteristics of this country are a primitive agriculture, an almost neglectable industry, the agricultural and forest surfaces are scarce with a very degraded woody vegetation, and the unique considerable activity there is the cattle breeding. Although the Zrmanja estuary is very prominent by its natural attractivity, the development of tourism in this area has been neglectable. The total number of the domicile inhabitants directed to its estuarine shores is ca 8800 only, so as one may predict that the anthorpogenic impact by the pollution in this river is almost neglectable (cf. Table). From the table, one may note that there the natural inflow is uncomparably major that the anthropogenic one, especially concerning the nutrients, and this estuarine ecosystem is naturally stabilised at the lower nutrient levels. Thus these estuarine waters belong to the oligosaprobe ones, that is also confirmed by the originality and extraordinary diversity of the biocenoses in Zrmanja estuary. Thus also this estuary may be used as a referent undisturbed station for the comparative studies of other Adriatic and Mediterranean estuaries of the similar karstic type.

Among all Yugoslav estuaries, the flora of Zrmanja canyon is the most diversified and the richest one in the endemic halophytes as are Artemisia biasolettiana Vis., Asperula rigens M.G., Astragalus dalmaticus (Vis.) Bunge, Centaurea aliena Wagn., Goniolimon dalmaticum (Presl.) Rchb., Limnonium anfractum Salm., Microrrhinum aschersonii (Simk.) Sp., Peucedanum crassifolium Hal., Plantago wulfenii Rchb., Silene microloba Kotschy, Vincetoxicum croaticum Jord., & Four. The very degraded estuarine flora of Krka is poor, including 2 times less of algal species and even 3 times minor number of coastal halophytic taxa, and the endemic plants there are almost absent.

In the Zrmanja canyon occur also a number of distinctive phytocenoses, absent in Krka and other degraded estuaries, that indicate the original natural structure of this estuarine ecosystem: Corylo ponticae--Carpinetum caucasicae (humide rockwoods in coastal ravines), Tamarici-Salicetum amplexicaulis (frutescent ecotone at beaches), Aurinio-Astragaletum dalmatici (estuarine cliffs), Microrrhino-Artemisietum maritimae (flat rockfields in karst shore), Limonio-Goniolimonetum dalmatici (beach psammophytes), Batrachio-Potamogetum siculi (interior estuarine benthos) and Lamprothamnio-Coleogetum zosteracei (calcareous tuff barriers). Krka estuary includes the next widespread ruderal communities of degraded and polluted seashores, being absent in Zrmanja: Rubo-Viticetum (degraded ectone), Salsolo-Xanthietum (polluted beaches), Junco-Scorzoneretum candollei (degraded coastal grasslands), Cheirantho-Parietarietum (polluted cliffs), Cynodonti-Plantaginetum coronopi (trampled stony coast), Coleogeto-Zannichellietum (degraded shingle bottom), Enteromorphion intestinalis (polluted rocky bottom), and Chaetomorpho-Valonietum (bottoms covered by rubbish and wastes). In Krka estuary occur only the subfossile tuff barriers without specific vegetation.

Although the biologically poorer estuary of Krka is included in the related National Park (1985), the very richest Zrmanja estuary is not conserved, and this indicate the uncovenable conservation criteria, with a neglecting of the natural biocenological peculiarities and endemism in the recent conservation program concerning E Adriatic estuaries.

Table. ESTIMATION OF THE LOADING OF THE KRKA AND ZRMANJA ESTUARIES FROM THE ANTHROPOGENIC AND NATURAL SOURCES (int/year)

SOURCES	WATER QUALITY	BOD	COD	SM	TN	TP	Deterg.
City area	4.7	883	1400	926	230	127	26
Surrounding area	4.2	2153	3373	1385	277	58	21
Adjacent settlements	2.8	582	907	493	148	27	15
Precipitations (affluent area)	1253	1378	2631	6265	150	50	-
Precipitations (city area)	6.6	396	924	792	79	46	0.3
All sources of Krka	127.3	5392	9235	9861	884	308	62.3
Anthropogenic	0.2	33	68	39	4	1.4	0.7
Precipitations (affluent area)	680	796	1632	4080	50	16	-
All sources of Zrmanja	680	829	1700	4119	54	17	0.7

BOD - biological oxigen demand; COD - chemical oxigen demand; SM - suspended mater; TN - total nitrogen; TP - total phosphour; Deterg. - detergents

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SEDIMENT CHARACTERIZATION IN THE NILE DELTA COASTAL LAGOONS

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One of the Nile Delta coastal lagoons (lake Brullus) was selected for the study of seasonal variations in grain size, carbonate, and organic matter contents of sediments.

This lake (Fig.1) may serve as a model for understanding the sediment characteristics and sedimentary processes in such depositional environments and applying the general principles to similar Nile Delta lagoons.

Lake Brullus receives a permanent inflow of drainage water (20 - 145 m^3/sec) resulting in a high rate of precipitation over evaporation and formation of a barrier for the invasion of sea water.

The lake deposits are formed on the account of two main sources: allochthonous and autochthonous, both contribute by 90 % of the total sediments. The other 10 % come from aeolian transport and shore erosion.

The results of analyses (Table. 1) indicate that the bottom is covered by calcareous sand-silt-clays, being more or less homogeneously distributed. Shells and shell fragments constitute significant portion of the sand fractions. Thus, their response to bottom agitation in comparison to silt and clay causes some variations in the distribution of mean grain size and the related textural parameters.

The disintegration of these calcareous shells produces materials of different sizes, shapes, and densities resulting in the poor sorting of sediments especially in the absence of effective hydrodynamic energy. The silts are the more poorly sorted than sands and clays, hence, their increasing amounts result in platykurtic size frequency curves. On the other hand, due to almost equal share of sand, silt and clay, the skewness tend to be near-symetrical.

Seasonal variations in sediment parameters are noticed only in winter, being represented by a decrease in sand content accompanied by a prominent increase in silt content and subsequent changes in textural parameters. These variations are caused by the breakdown of shells into silt size ranges by the winter vigorous water energy. The carbonate content does also show some increase in winter due to sweeping off the piled shells away from the shores of islets which are very frequent in the lake proper.

Average seasonal values of sediment textural parameters, carbonates, and organic matter

Season	n	mean	sorting	kurtosis	skewness	sand	silt	clay	carbonate	org. m.
		phi				%				
Winter	22	6.9 ± 1.0	2.5 ± 0.6	0.7 ± 0.2	0.17 ±0.3	18 ± 18	44 ± 12	38 ± 9	44 ± 24	1.6 ± 0.9
Spring	18	6.1 ± 1.5	3.0 ± 0.6	0.9 ± 0.2	-0.03±0.3	28 ± 19	35 ± 10	36 ± 16	29 ± 20	2.0 ± 1.1
Summer	23	5.6 ± 2.1	3.1 ± 0.7	0.9 ± 0.4	-0.07±0.4	35 ± 25	31 ± 12	34 ± 16	28 ± 22	1.6 ± 0.6
Autumn	24	5.9 ± 1.5	3.0 ± 0.5	0.9 ± 0.2	0.03 ±0.2	34 ± 21	36 ± 10	32 ± 14	28 ± 20	2.5 ± 1.2
Total	87	6.2 ± 1.6	2.9 ± 0.6	0.9 ± 0.3	0.05 ±0.3	29 ± 22	42 ± 53	35 ± 23	32 ± 23	2.0 ± 1.2

n = number of samples

org. m. = organic matter

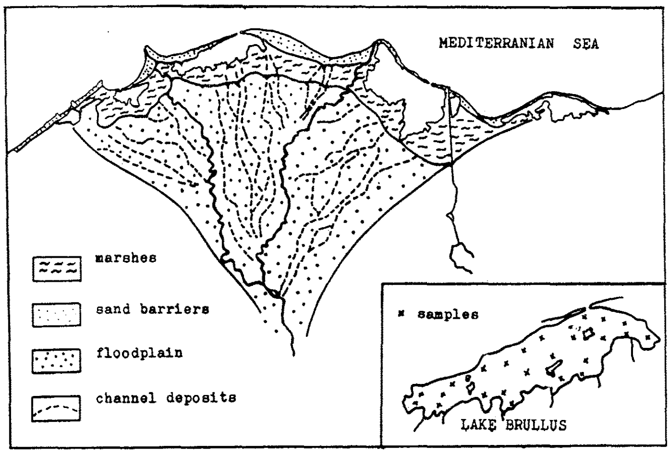

Fig. 1. Nile Delta physiographic units (ASRT Tec. Rep)