PRESENT WATER QUALITY OF KASTELA BAY (ADRIATIC SEA) AND SOME PROPOSALS FOR ITS PROTECTION AND IMPROVEMENT

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ABSTRACT

The research of the physical-chemical properties of the Kastela Bay waters carried up to now (1952-2000) showed it to be a highly eutrophic area and one among the most polluted along the eastern Adriatic coast. For the past few years the waters of the Bay have shifted into the highest category of productivity (500 mg C m^2 y^{-1}) of the sea water.
Kastela Bay, and particularly its eastern part – Vranjic basin – is the recipient of ever growing quantities of organic matter and nutrients, causing phytoplankton blooms every summer. Frequent anoxia in the bottom layer along with microbiological pollution often cause mass mortality of marine organisms in that part of the Bay. What makes things even worse is the fact that waste waters reach the Bay completely untreated in spite of the legislation in force. The quantities of waste waters this basin receives amount to 474 x 10^6 m^3 y^{-1}. Unfortunately, we have not yet been able to control neither the quantities nor the quality of waste waters. Building of the system of collection of almost all urban effluents, their at last, mechanical purification and their disposal in the Brac Channel, has been an enormous step forward in the protection and preservation of the sea in the vicinity of the town of Split. Completing of this system by building the sewage system for effluents purification in Stobrec is an aim and wish of all of us for our benefit and for benefit of our descendents.

Key words: Kastela Bay, nutrients, eutrophication, pollution, remedial measures.

1. INTRODUCTION

The number of urban inhabitans in cities is rapidly growing, producing further increase of amount of waste: bacterial/viral pollutants acting as potential disease pointer, and nutrient generating severe eutrophication of coastal waters. The eutrophication has become an acute environmental problem especially in semi-enclosed areas and gulfs with small exchanges of water with surrounded areas, like the Kaštela Bay (Split area, Fig.1).
The enrichment of water by nutrients, (especially compound of nitrogen and phosphorous) causing accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to balance the organisms present in water concerned. Increases in growth rates of individuals and population are among the first signs of enrichment by nutrients. Often the total biomass increases, such as, for example, the total amount of chlorophyll *a* in the plankton, Nincevic, et *al.* (1998). Growth rate changes lead to changes in species compositions in both planktonic and bentic assemblages.

The extent of nonpoint sources pollution may be greatly influenced by changes in population, land use and land management. Major nonpoints source pollution (Table 2.) of concern in the Kaštela Bay include exess of level of nutrients, bacteria and toxic materials (metals). The excessive level of organic matter and nutrients (P and N-salts) affects water quality by contributing to algal bloom every summer, in eastern part of the Bay- Vranjic basin. (Marasovic and Vukadin, 1982). Frequent anoxia in the bottom layer, along with the microbiological pollution often causes mass mortality of marine organisms in that part of the Bay. Unfortunately, there is no federal agency (in the town or in the country) with overriding responsibility for nonpoint source pollution control.

2. STUDY AREA

The Kaštela Bay is (Figure 1) 14.8 km long, about 6 km wide and, on the average, 23 m deep. The Bay communicates with the adjacent channel through an inlet of 1.8 km width and 40 m depth. The small Jadro River, which discharges into the eastern part of the bay (Vranjic basin) is the most important fresh water source with an annual average inflow of about 10 m^3 s^{-1}. The eastern part of the bay also receives large quantities of untreated municipal and industrial effluents (104 x 10^6 m^3 a^{-1}). The bay has a total area of 61 x 10^6 m^2 with a water volume of 1.4 x 10^9 m^3. Water exchange and changes in the current field are mostly induced by local winds related to the passing of mid-latitude cyclones over the area. The annual average precipitation of 1 m and the total quantity of water over the bay surface exceeds 61 x 10^6 m^3 a^{-1}. The local coastal drainage basin is of area approximately twice size of the bay (i.e. 120 x 10^6 m^3). Precipitation quantities are also doubled there, i.e. 122 x 10^6 m^3 a^{-1}. This amount also includes underground waters sources. The Bay is particularly threatened by the organic matter and nutrients input causing an extreme phytoplankton bloom each summer. Frequent anoxia in the bottom layer appears as the most frequent consequence. Microbial pollution jeopardizes the eastern part of the Bay and northern coast.

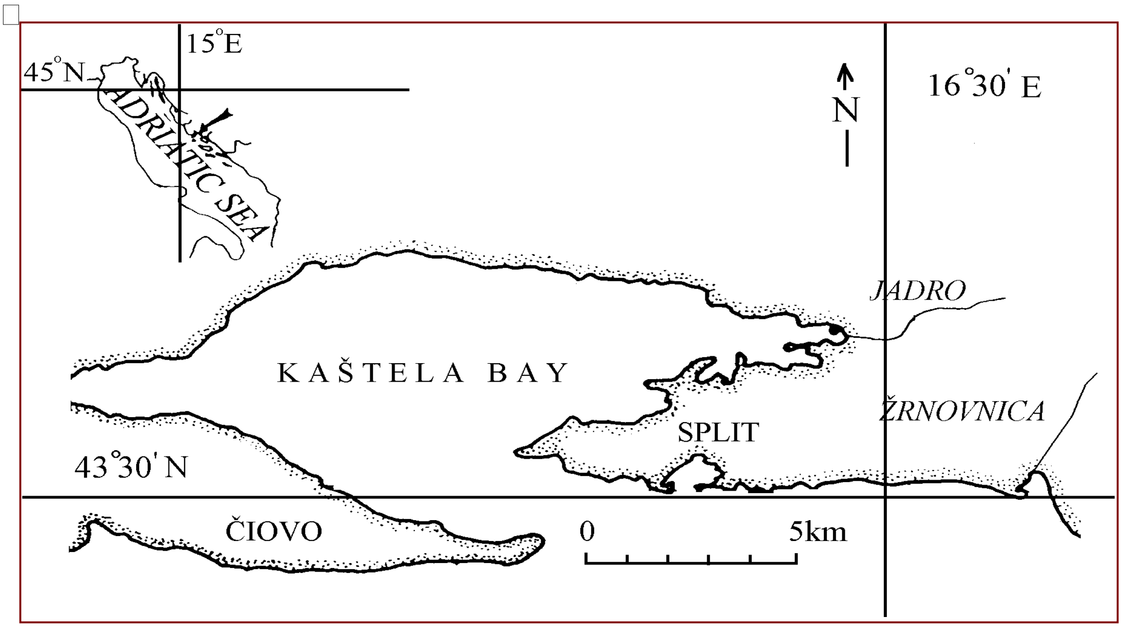

Figure 1. Study area.

3. RESULTS AND DISCUSSION

The long-term studies of chemical and biological parameters in the Kaštela Bay area point to the fact that, during the past decade, an increase in the eutrophication level has persisted in all the areas of the eastern Adriatic coast, (Vukadin, 1998.)

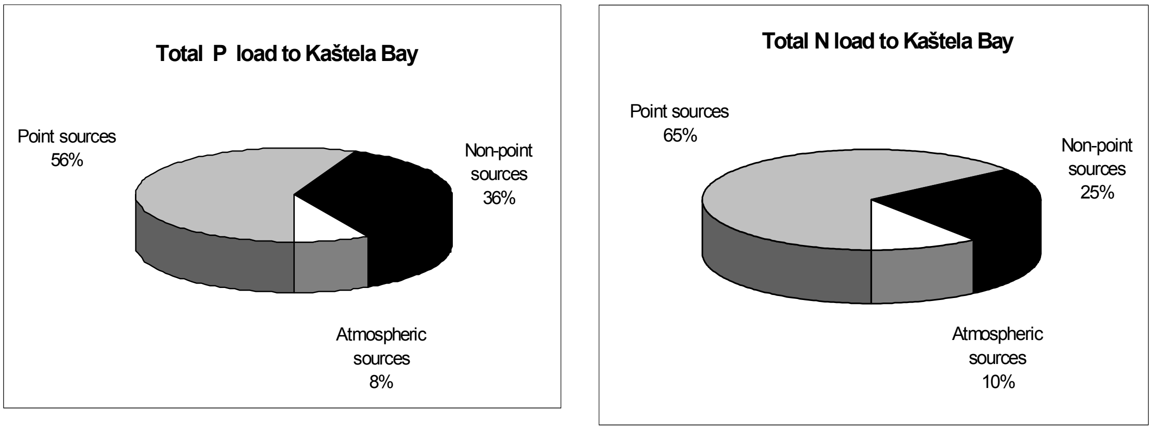

Figure 2. Source of nutrients in the Kaštela Bay

Different types of pollution produce different forms of water degradation. The source of water pollution provides the key to its control. Most people still believe that the industry-big industry-is the problem. Anyhow, most of contaminants do not come out of a pipe (even in the case of urban runoff, where pollutants may come out of a pipe). They come into the Bay ecosystem from diffuse or "non-point" source such as runoff from stormwater and from atmosphere, (see Fig. 2). Stormwater runoff also delivers a certain quantity of nutrients, motor oils, cleaning fluids and assorted contaminants from roadways and parking lots. Nonpoint sources of pollution include all other discharges and involve urban and agricultural runoff, leaches and runoff from individual disposal systems such as septic tanks and marine sanitation device, runoff from construction sites and forest harvest areas, (the Bay sometimes receives herbicides and pesticides). These sources of contaminants are becoming more important all over the Bay, and these sources remain more difficult to quantify as well as to control.

Statistical analyses of 20-50 years trends of selected water quality parameters showed declining water quality conditions in the all areas of the Bay. Nutrients, suspended matter, pesticides, heavy metals and bacteria are the five major causes of severe water quality problems in the Kaštela Bay (Table 1.).(Šolic et *al*. 1994; Vukadin et *al.* 1995).

Source of these water quality impacts are predominantly municipal and industrial discharges, agricultural and urban runoff, waste disposal (failing septic systems – about 5000 fail septic tanks on the coast of the Bay, V. Poljak, personal communication).

Long-term studies of heavy metal concentrations (Zn, Cu, Cd and Hg) in seawater, sediments and some marine organisms in coastal area of the middle Adriatic have shown that the Kaštela Bay is one of the most threatened areas along the eastern coast, as shown in Table 1. (Vukadin, 1994; Vukadin. *et al*. 1995, Zvonarić and Odžak, 1998).

Nowadays we know a fear amount about inputs of toxic metals into the Bay, we are still just learning how to measure the effect of those contaminants on the Bay organisms, and on the Bay ecosystem itself. Exposure to trace metals and other contaminants can effect on phytoplankton population, for example, causing shifts in species composition, and these changes could have significant impact throughout the ecosystem. (Greer, 1996, Nincevic and Marasovic,1998).

Because of the evidence of biological impact - even at relatively low level of contaminants - it is imperative that we further investigate the effect of contaminants at environmentally realistic levels, having as the key aspect the Bay's food web.

Table 1. Mean values of heavy metals in water (**ng dm^{-3}**) sediments (**mg kg^{-1} DW**) and marine organisms (*M. galloprovincialis,* (**mg kg^{-1}** FW) in the open sea stations (***a***) and in the Kaštela Bay (***b***); **Fs** is the sedimentation flux of heavy metals (**µg Me m^{-2} d^{-1}**)

	Seawater		**Sediments**		***Mytilus galloprovincialis***		**Sedimentation**
Metal	**(a)**	**(b)**	**(a)**	**(b)**	**(b)**	**(b*)**	**Flux (Fs)**
Zn	**234**	**2170**	**29**	**342**	**16.5**	**29.4**	**26.4 x 10^3**
Cu	**112**	**196**	**8.6**	**27.6**	**0.66**	**1.65**	**40.6 x10^3**
Cd	**21**	**48**	**0.1**	**0.37**	**0.08**	**0.15**	**19.2**
Hg	**10**	**52**	**0.02**	**1.86**	**0.3**	**3.32**	**35.0**

b∗ Station just near CAP (chlor-alkali plant)

4. CONCLUSION

The following points are among the significant conclusions resulting from this paper in order to minimizing pollutant fluxes from land-based sources:

- Many existing industries represent pollution hot spots in coast of the Bay. Old and abandoned industrial plant have had in the past contamined land and water of the Bay. New companies nowdays need to pay their attentation to need of environmental protection as a "strategic opportunity", facilities for environmental protection should be obliged, as well as, clean proces technology, waste minimization and control of emissions from waste.
- To reduce the flux of water-polluting elements and compounds from point and non-points sources, as well as from agricultural sources and deposits of urban sludges.
- Reducing the emission from trafic sources, (especially in summer period), mining activities and cement industry.
- The planing of waste water treatment plants needs to include many low-cost plant serving large population, to reduce their discharges of toxic materials to a minimum level.
- "Environmental education " program for yang people and adults. These program can prepare better tomorrow's generation as informed stewards for our threatened coastal seas and their irreplaceable living resources.
- Monitoring program. These programs include monitor level of conventional pollutants and some toxic elements and compounds in water, sediments and marine organisms as well. These programs has helped characterize water quality conditions in the Bay, helped determined early trends, provide baseline information for (mathematical) model which helps to identify water quality changes. Monitoring program also include the bacterial quality of waters phitoplankton communities, as well as, monitoring of benthic macroinvertebrate and fisheries assessments.

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Table 2. Examples of nonpoint source pollution impact in the Kaštela Bay area

I M P A C T*

POLLUTION SOURCE	SEDIMENT	NUTRIENTS	PESTICIDES	METALS	PH	T ^{O}C	HYDRO-CARBONS	BACTERIA
AGRICULTURE					√	√		√
SIVILCULTURE					√	√	√	
URBAN DEVELOPMENT	√			√	√		√	
WASTE DISPOSAL	√	√	√	√	√	√	√	√
MINING AND CEMENT INDUSTRY	√			√	√			
STORAGE TANKS							√	
SEPTIC TANKS	√	√	√					√

**Actual impact may vary considerably or overlap at specific sites*