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POLLUTION HOT SPOTS AND SENSITIVE AREAS ALONG THE SLOVENIAN COAST

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ABSTRACT

Pollution hot spots and sensitive areas on the Mediterranean coast of Slovenia were identified according to recent data and UNEP/WHO guidelines. The Bays of Koper and Piran have been considered sensitive areas, since they can be affected by polluted waters of the Gulf of Trieste as well as by land-based sources of pollution along the Slovenian coast. The inner part of the Bay of Koper is receiving effluents from the municipal wastewater treatment plant and individual industries and agglomerations along the Rižana and Badaševica rivers. Domestic and agricultural discharges into the inner part of the Bay of Piran by the Dragonja river, tourism and intensive aquaculture reduce the quality of the water and may cause local changes in the marine ecosystem.

Key words: pollution of coastal waters, wastewater disposal, wastewater treatment, loads, pollution hot spots, sensitive areas, Gulf of Trieste, Adriatic Sea, Mediterranean Sea

AREE CRITICHE E AREE SENSIBILI ALL'INQUINAMENTO NELL'AREA COSTIERA DELLA SLOVENIA

SINTESI

Uno dei maggiori problemi inerenti le acque internazionali comprende il degrado delle risorse acquifere e degli habitat nelle zone marine e costiere, causato da una gestione non appropriata. Nell'articolo vengono presentate le aree critiche e le aree sensibili all'inquinamento situate sulla costa slovena, identificate grazie a dati recenti e alle direttive UNEP/WHO. Gli autori classificano le baie di Capodistria e Pirano come aree sensibili, in quanto possono venir condizionate da acque inquinate provenienti dal Golfo di Trieste come da fonti di inquinamento situate sulla costa slovena. La parte centrale della baia di Capodistria riceve effluenti dall'impianto di depurazione delle acque di scarico municipali eda singole industrie ed agglomerati situati in prossimità dei fiumi Risano e Cornalunga. Tramite il fiume Dragogna, invece, scarichi domestici e agricoli arrivano alla parte centrale della baia di Pirano, dove la qualità dell'acqua viene ridotta pure dalle attività turistiche ed acquacolturali, che sono dunque fonte di disturbo per gli ecosistemi marini.

Parole chiave: inquinamento delle acque costiere, smaltimento delle acque di scarico, trattamento delle acque di scarico, aree critiche, aree sensibili, Golfo di Trieste, mare Adriatico, Mediterraneo

INTRODUCTION

Human activities all around the semi-enclosed Mediterranean Sea produce, in a long term, a strong environmental impact in the form of coastal and marine degradation and a heightened risk of more serious damage. About one third of the Mediterranean population lives within 50 km of coastaline. Urban, industrial developments and agriculture are resulting in mounting pressures on already hard-pressed area.

International efforts to protect the Mediterranean Sea resulted in adoption of the Mediterranean Action Plan (MAP) (1975), Barcelona convention (1976) and related protocols by all Mediterranean countries. Marine pollution control was the initial subject of high priority activities of MAP, requiring a harmonized regional policy and strategy. The Coordinating Unit of MAP in Athens with its six Regional Activity Centers around the Mediterranean has carried out numerous studies in order to assess the environmental problems. The overview of the data and information regarding the state of the Mediterranean Sea is presented in the State of the Marine and Coastal Environment in the Mediterranean Region (UNEP 1989, 1996).

The assessment of main problems and past experience confirmed that sectorial approach to mitigation of coastal pollution has to be replaced by integral coastal zone planning and management. A targeted Strategic Action Program for the Mediterranean Sea (SAP MED) was prepared to address pollution from land-based activities and approved in 1996 (UNEP, 1999). One step of the program was identification and assessment of problems and causes including pollution "hot spots" and "sensitive areas".

By definition, pollution hot spots are point sources on the coast of the Mediterranean Sea which potentially affect human health, ecosystems, biodiversity, sustainability or economy in a significant manner. They are the main points where high levels of pollution loads originating from domestic or industrial sources are being discharged (UNEP/WHO, 1999). Hot spots are also coastal areas where the coastal marine environment is subject to pollution from one or more point or diffuse sources on the coast of the Mediterranean which potentially have significant impact (UNEP/WHO, 1999).

The estuaries and coastal waters of natural or socio-economic value are considered sensitive "if they are at higher risk to suffer negative impacts from human activities". Natural characteristics may determine the vulnerability of a coastal system, human activities determine the level of risk, hence planned development may increase the risk of environment degradation. Both vulnerability and risk contribute to the sensitivity of a particular area or system in the context of this assessment (UNEP/WHO, 1999).

Slovenia has been involved in the Long-term Pollution Monitoring and Research in the Mediterranean Sea (MED POL) since 1976. The overview of activities of Slovenian institutions within the framework of MED POL Phase I and MED POL Phase II and data concerning the state of chemical and sanitary pollution of the marine environment in the southeastern part of the Gulf of Trieste was presented in UNEP (1988) and IAEA/UNEP reports (1993), as well as in yearly reports and numerous other publications. Within monitoring programs, contamination of selected organisms and surface sediments by heavy metals (Kosta *et al.*, 1978; Tušnik & Planinc, 1988; Planinc *et al.*, 1993), organochlorine pesticides (Salihough *et al.*, 1980), anion detergents (Gorenc *et al.*, 1993), contamination by TBT and other compounds used in antifouling paints (Tolosa *et al.*, 1996) were studied in the eastern part of the Gulf of Trieste. More recently the composition, distribution and the sources of polycyclic aromatic hydrocarbons (PAHs) in the water column, sediments and organisms were investigated along the Slovenian coast (Bajt, 2000) and throughout the Gulf of Trieste (Notar *et al.*, 2001). Among heavy metals, mercury distribution and biogeochemistry have been studied as critical contaminant in the Gulf of Trieste in the last few years (Covelli *et al.*, 1999; Horvat *et al.*, 1999; Hines *et al.*, 2000).

Marine eutrophication has been described as one of the major effects of anthropogenic activities and is particularly evident in marine waters with limited water exchange such as the Adriatic Sea. Anthropogenic nutrient contribution to the increasing coastal marine pollution and eutrophication was studied in the Gulf of Trieste already in the early seventies (Štirn, 1971; Štirn *et al.*, 1974). Different concepts and aspects of natural or cultural eutrophication have been published in the last few decades (UNESCO, 1988; Štirn, 1993). However, there is a great diversity of phenomena considered as the symptoms of marine eutrophication, and they are still poorly understood (EEA, 2001). The treatment and disposal of sewage is a problem in populated coastal areas. The main sources of potential pollutants, including those of fresh water inflows and emissions to the whole Gulf of Trieste, were presented by Olivotti *et al.* (1986a, b). Anthropogenic impacts on small stratified estuary was studied in the Rižana estuary (Faganeli *et al.*, 1984, 1988; Faganeli & Turk, 1989; Turk & Faganeli, 1990), as well as the distribution of pollutants and impact of diluted wastewaters discharged into the inner part of the Bay of Koper (Lenarčič, 1980; Turk *et al.*, 1982). Annual inputs of some pollutant fluxes from land-based sources of pollution based on the results of five year monitoring (1983-88) were estimated by Tušnik *et al.* (1989).

In the seventies and eighties, several studies examined the impact of untreated sewage on ecosystems (Malej *et al.*, 1979; Fanuko, 1984; Vukovič, 1994), and the impact of the underwater sewage outfall in the Bay of Piran (Avčin *et al.*, 1979; Malej, 1980; Faganeli,

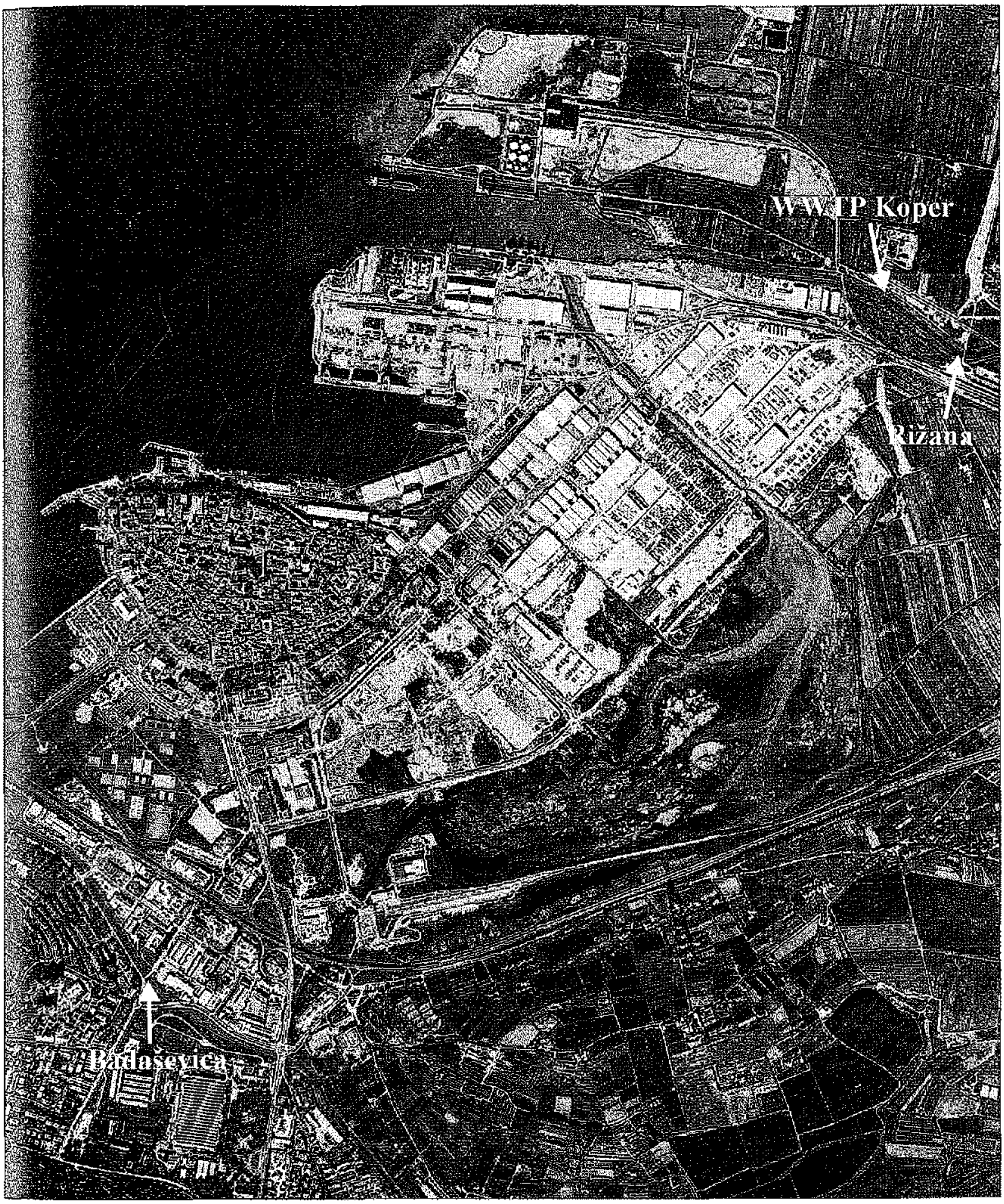

Fig. 1: Sampling locations of the main pollution hot spots in the inner part of the Bay of Koper (WWTP Koper - wastewater treatment plant Koper, the river Rižana and the river Badaševica). (Photo: Ministry of Environment and Spatial Planning, Surveying and Mapping Authority of the Republic of Slovenia)
Sl. 1: Prikaz vzorčevalnih mest žariščnih točk onesnaženja v notranjosti Koprskega zaliva (WWTP Koper - čistilna naprava Koper, reka Rižana in reka Badaševica). (Foto: Ministrstvo za okolje in prostor, Geodetska uprava Republike Slovenije)

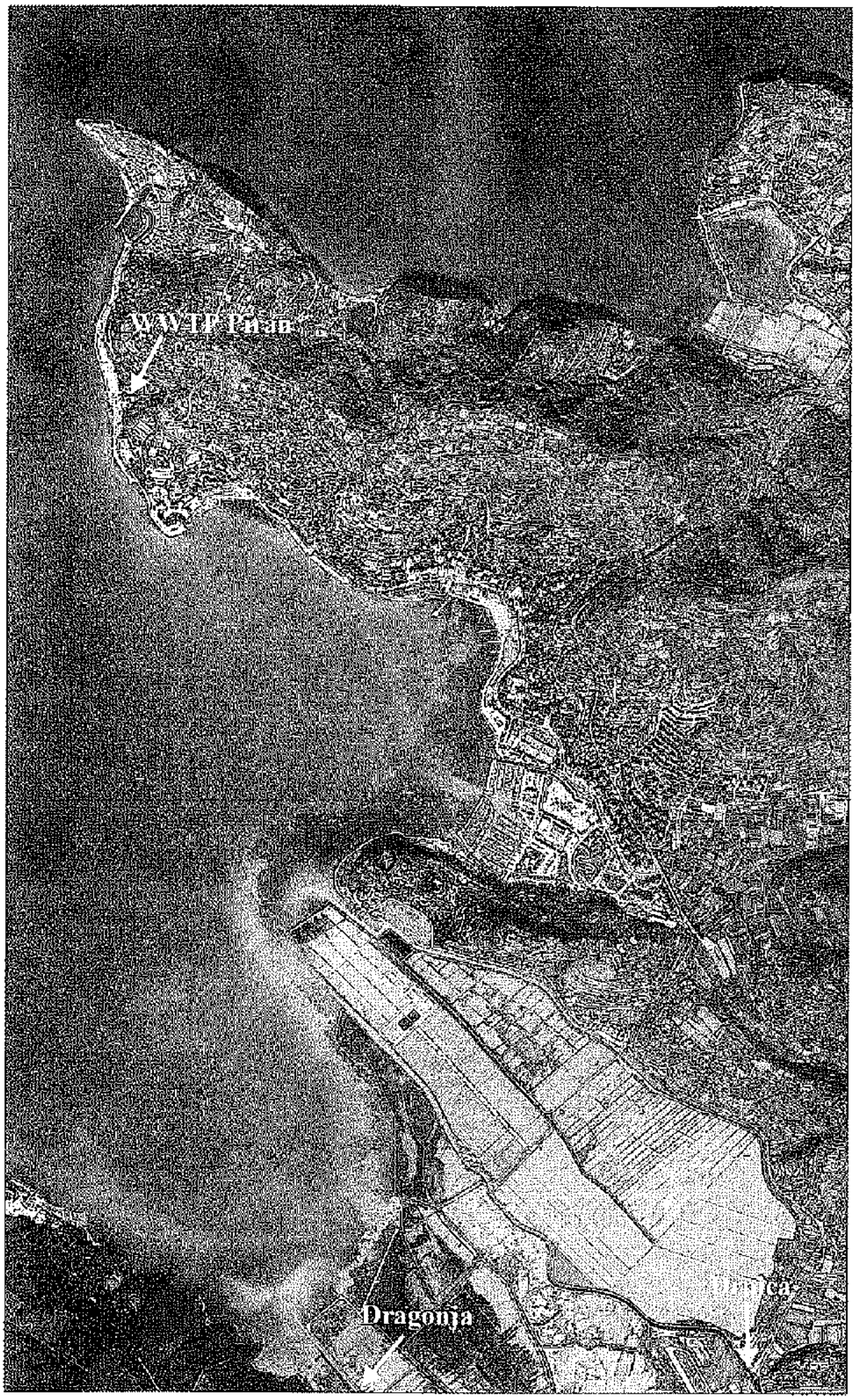

Fig. 2: Sampling locations of the main sources of pollution in the inner part of the Bay of Piran (WWTP Piran - wastewater treatment plant Piran, the river Drnica and the river Dragonja). (Photo: Ministry of Environment and Spatial Planning, Surveying and Mapping Authority of the Republic of Slovenia)

Sl. 2: Prikaz vzorčevalnih mest žariščnih točk onesnaženja v notranjosti Piranskega zaliva (WWTP Piran - čistilna naprava Piran, reka Drnica in reka Dragonja). (Foto: Ministrstvo za okolje in prostor, Geodetska uprava Republike Slovenije)

1982). Recently, more studies examined the distribution of the fluorometric signal in the wastewater near-field around the diffusers of Piran wastewater treatment plant (Malačič & Vuković, 1997) and different nutrients were analysed in relation to microbiological indicators (Mozetič *et al.*, 1999).

In this paper, review of the existing list of hot spots and sensitive areas for Slovenia determined in MAP Technical Reports Series No. 124 (UNEP/WHO, 1999) were presented according to recent data on discharges from coastal cities or urban coastal agglomerates and from main industries discharging directly into the sea. The report summarizes evaluation of the impacts of priority hot spots within criteria on transboudary effects (UNEP, 1997).

CHARACTERISTICS OF SLOVENIAN COASTAL WATERS

Slovenian transitional and coastal waters are considered an ecological unit within the Gulf of Trieste, the northernmost part of the Adriatic Sea with an approx. surface area of 600 km² and volume of about 9.5 km³. The Gulf is a shallow (max depths 20-25 m) marine basin, influenced by freshwater inflow, bottom sediment resuspension and increasing pollution. The Gulf is significantly affected by the general anticlockwise circulation pattern of the Adriatic Sea that brings southern oligotrophic waters. The seasonal variation of water circulation is moreover controlled by fluctuations of the freshwater inflow. Average inflow from the northwestern part is about 120 m³/s with peaks higher than 1000 m³/s (Naudin *et al.*, 1999). The general anticlockwise circulation pattern in the Gulf of Trieste is modulated by local winds, tidal currents, density currents and inertial effects (Stravisi & Cristiani, 1986; Malačič, 1991). Characteristic of the gulf are large temperature (6-26°C) and salinity amplitudes (32-38.5 PSU in the surface layer, 36–39 PSU in the bottom water). The density stratification in the water column starts in spring and intensifies until the late summer, which is often associated with hypoxia/anoxia in bottom waters (Faganeli *et al.*, 1985; Malej & Malačič, 1995). The physical properties of the Gulf of Trieste affect the chemistry and dynamics of the biology of the system (see Malone *et al.* (1999) and Hopkins *et al.* (1999) for review and references).

Slovenia is a country with a total surface area of 20,255 km². Its coastline along the Adriatic Sea is 46.6 km in length. Along most of the length a very narrow belt with flysch cliffs and solitary lime rocks prevail between the flat-bottomed valleys of the Rižana and Dragonja rivers. The coastal area can be subdivided into two parts: the deeper part of the Gulf of Trieste, which is widely open to the rest of the Northern Adriatic, and the second part comprising small shallow bays (the Bay of Koper, the Bay of Strunjan, and the Bay of Piran), which have similar origins but different pollution loading.

MATERIAL AND METHODS

Identification of pollution hot spots

Pollution hot spots were identified on the basis of analyses of available data, adequate questioners and UNEP/WHO guidelines dealing with municipal discharges from coastal cities or urban agglomerates and main industrial sources discharging directly into the sea (UNEP/WHO, 1999):

- *for municipal discharges:* data on permanent population and average seasonal increase, major industries, existence of sewage treatment plan, wastewater flow, type of treatment before discharge, total wastewater discharge, type and location of discharge, pollution loads at the discharge point and quality of the receiving environment;
- *for industrial discharges:* type of industry, data on industrial wastewater treatment (type), way of discharge, wastewater quantity, quality and pollution loads at point of discharge and estimation of pollution loads discharged into receiving waters.

Sampling stations

Monitoring of loads was carried out at the outlet of sewage from urban agglomerations in Izola (Izola outlet - 45°32.33 N, 13°39.75 E), at the outlets of wastewater treatment plant in Piran (WWTP Piran - 45°31.17 N, 13°34.20 E) and Koper (WWTP Koper - 45°33.60 N, 13°45.08 E), and at the outlet of industrial effluents discharged by the fish canning industry "Delamaris" in Izola (DELAMARIS - 45°32.50 N, 13°39.85 E). Monitoring of contaminants in hot spot areas was carried out at the rivers Rižana (45°33.40 N, 13°45.47 E), Badaševica (Semedelski kanal) (45°32.20 N, 13°43.67 E), Drnica (45°28.65 N, 13°37.00 E) and Dragonja (45°27.92 N, 13°36.93 E). Station locations are shown in figures 1 and 2. Sampling of effluents and river waters were carried out seasonally during the year 2000 (Turk *et al.*, 2000).

Evaluation of pollution hot spots

The quality of wastewater and receiving environment were determined according to regular measurement of parameters such as biological and chemical oxygen demand (BOD_5, COD), nutrients (total nitrogen – TotN, total phosphorous – TotP), total suspended material (TSS), detergent (Det), heavy metals (mercury – Hg, cadmium – Cd, lead – Pb, zinc – Zn, copper Cu, nickel – Ni) and microorganisms (faecal coliforms - FC). Data from the monitoring activities for the year 2000 were collected and analyzed (Turk *et al.*, 2000). Pollution loads at the discharge point were calculated according to yearly mean concentration for each parameter and data on the flow capacity of the pumps at the sewage treatment plants for the year 2000 (Turk *et al.*, 2000), or total river flows (HMZ/MOP, 1999, 2000).

To show the severity of each of the effects on the identified hot spots, a ranking system from 1-6 (1-no effect; 6-extreme effects) was prepared using the criteria with effects on public health, drinking water quality, recreation, other beneficial uses (transportation, sport activities, aquaculture), aquatic life (including biodiversity), economical and welfare (including marine resources of economic value) (UNEP/WHO, 1999).

RESULTS

Human pressure and pollution sources

The coastal area has been exposed to strong development pressure shown in the rapid growth of population, town planning and development of business sectors (traffic, trade, tourism, processing activities, agriculture).

The coastal region extends over the territory of three municipalities (Koper, Izola and Piran) with an area of 384 km² (about 1.7% of the total national territory) and with a population of slightly over 80,000 people (about 4% of the total population in Slovenia) (Tab. 1). The population density of the area (232 inhabitants/km²) is more than twice the national average (98 inhabitants/km²). The most of the coastal population (> 80%) lives within the 1.5 km wide strip. The population growth is slightly higher in the coastal region than at the national level, but in the last decade (in the 90's) the population growth stagnated (0.1% increase).

Tab. 1: Population and tourist overnight stays with percentage of average seasonal increase in the coastal region in the year 2000*.
Tab. 1: Število prebivalcev in nočitev turistov z odstotki sezonske rasti v obalni regiji v letu 2000*.

	Area (km²)	Population	Population (%) served by municipal sewer system	Number of total overnight stays	Average seasonal increase (3 months)
Koper	311.2	48,251	57	239,000	5.4%
Izola	28.6	14,590	80	222,818	16.6%
Piran	44.4	17,440	86	1,306,454	81.4%

*Statistical yearbook of the Statistical Office of the R Slovenia (2000)

The principal industries in coastal region include metal manufacturing, production of chemicals and food industry. Economic development caused regression in agriculture activities that now mainly include wine, fruit and olive growing, and vegetable cultivation. Because of good inland transport connections, the Port of Koper has become the most important export-import port in Central Europe and is increasing its activities every year. The Port of Koper handles about 10 million tons of cargo per year (over 1,500,000 tons of oil and oil products and over 100,000 tons of chemicals and inflammable liquids). At the Port of Koper, there is a general cargo terminal (coffee, metal, paper, fruits and vegetables, cotton, textiles), a RO-RO and car terminal, a timber terminal, a terminal for iron and coal, a liquid cargo terminal (chemicals, phosphoric acid, vegetable oil, Latex), a terminal for fertilizers and other bulk cargoes, and a silos for cereals and oilseeds, aluminum). The oil terminal is operated by OMV-ISTRABENZ – Instalacije d.o.o. The main sources of pollution in the port are tank cleaning, inadequate drains, volatile emissions and general spillage during the emptying of hoses. Preliminary estimation of organic loads from industries represents 22,550 PE (population equivalent) (individual loads have been calculated where data were available) (Tab. 2).

Tab. 2: Estimates of pollution load (PE - population equivalent) from industries along the Slovenian coastline.
Tab. 2: Ocena obremenitev slovenske Obale (PE - populacijski ekvivalent) z industrijskimi odplakami.

Contribution from	Load in PE
Delamaris	7,000
Ladjedelnica – shipyard	100
Mehano	200
Argo	100
Droga	1,800
Frigomar	800
Hospital	1300
Cimos – Koper	500
Tomos	800
Intereuropa	250
Kemiplas & Polisinteza	2,500
Luka Koper	2,000
Vina Koper	6,500
Industry total	**22,550**

The sea is also used for bathing and recreation (including sports like sailing, wind surfing, rowing), fishing and mariculture:

- along the Slovenian coastline 29 registered beaches are located;

- fishing (about 2000 tons/y) and mariculture (shellfish: annual production about 50 tons; fish: annual production is about 100 tons (Marčeta, 1997; Statistical yearbook of the Statistical Office of the R Slovenia 2000);
- transportation - in addition to the Port of Koper there are three marinas (in Portorož, Izola and Koper) (Novak *et al.*, 1998). A two-fold increase in moorings and yachting harbors in the last 10 years (from 898 to 1618) indicates the growth of "yachting" tourism (Statistical yearbook of the Statistical Office of the R Slovenia 2000).

Main loads and hot spots

The Rižana river receives mainly untreated urban and industrial wastewater from the town of Koper and inland agglomerations along the river. The combined sewer system (which also collects storm waters) is connected to a mechanical wastewater treatment plant (WWTP), with total yearly effluent about 4.7×10^6 m³/year. About 34% of the wastewater is from industry/enterprises/public sector; 66% is household wastewater. The sewage effluent is discharged into the estuary of the Rižana river. The system also collects effluents from the following industries: VINA KOPER wine production (combined sanitary and technological effluents, pretreatment); CIMOS car industry (combined sanitary and technological effluents, pretreatment); I&I bus service (combined sanitary and technological effluents, pretreatment); INTEREUROPA, AVTOPLUS, CESTNO podjetje, SGP, TOMOS, car washing, lacquering, electroplating (combined sanitary and technological effluents, pretreatment); Port of Koper, washing containers, trucks, cars, store-house (combined sanitary and technological effluents, pretreatment).

There are also some industries with direct discharge into the Rižana river: KEMIPLAS, chemical industry (combined sanitary and technological effluents, pretreatment), INSTALACIJE (combined sanitary and technological effluents, biological treatment), and LAMA - metal manufacturing (combined sanitary and technological effluents, biological treatment). The expected organic load from industries in the Koper Municipality is around 12,550 PE (Tab. 2).

The sewage of the community of Izola is collected in a treatment basin and discharged without treatment into the sea about 300 m from the shore, with a flow rate of about 3.5×10^3 m³/day. In addition, there are several small outlets discharging directly into the sea and discharge from the DELAMARIS fish-cannery pre-treatment plant (discharge rate 82,000 m³/year). The system collects effluents from the following industries:

LADJEDELNICA shipyard, pretreatment, some activities in the dock – wastes directly into the sea; City HOSPITAL, DROGA – food processing, MEHANO – toy factory, other small enterprises. Expected organic load from industries in Izola is app. 10,000 PE (Tab. 2).

The sewage system in the community of Piran has a central sewage treatment plant with a capacity of 30,000 PE and total yearly effluent about 2.7×10^6 m³/year. After mechanical treatment (screening, sand and grease removal, sedimentation), the sewage water is discharged into the sea, through two submarine pipes, 3450 m and 3600 m from the shore, with diffusers at the end. No industry is connected to the wastewater treatment plant.

Tab. 3: Present and future loads (PE) on wastewater treatment plants (WWTP) and the Izola's pumping station*.
Tab. 3: Trenutne in pričakovane obremenitve (PE) čistilnih naprav in črpališča v Izoli*.

	Present winter load	Present summer load	Future winter load	Future summer load	Existing treatment capacity
WWTP Koper	31,569	34,686	52,490	58,605	WWTP for 50,000 PE
WWTP Piran	14,953	27,101	17,780	32,980	WWTP for 30,000 PE
Izola outlet	19,575	23,195	22,330	29,530	none

*Future loads on wastewater treatment plants estimated on the base of demographic industrial and tourism development.
*Pričakovane obremenitve čistilnih naprav ocenjene na osnovi demografskih kazalcev, razvoja industrije in turizma.

Some present and future preliminary individual loads on wastewater treatment plants Koper and Piran as well as on Izola outlet have been calculated separately for summer and winter, since summer loads are higher due to the increase of tourist population (Tab. 3). Future loads on wastewater treatment plants have been estimated by contribution of potential future connections to WWTP-s. These potential factors are population, industrial and tourism development. A net 0.5% population increase per year has been estimated according to the review of Demographic analyses. The contribution to the wastewater treatment plants of pollution originating from the industries is based on figures from the report as performed by IEI Engineering (1999), the pilot testing project in Izola performed by BIO-TEHNA (1991), and the future policies concerning the connection of industrial wastewater to the public wastewater treatment plants.

Assessment of the pollution level

Estimated yearly freshwater input into the Gulf of Trieste from the Slovenian coast is 206x10^6 m^3. The total quantity of urban and industrial wastewaters is 11x10^6 m^3/year, taking account that the existing flow measurements contain rain water as well as intrusion seawater.

The gross fluxes of some pollutants have been estimated for the entire region according to the available data of mean annual concentration and flow rates. The estimated yearly input from the wastewater treatment plants Koper and Piran, and Izola outlets is presented in tables 4a and 4b and for rivers in tables 5a and 5b.

The Rižana and Badaševica rivers are the main pollution hot spots according to data and criteria of severity of effects on public health, drinking water quality, recreation, other beneficial uses (transportation, sport activities, aquaculture), and aquatic life (including biodiversity). For the inner part of the Bay of Koper the pollution loads were estimated from data collected at the sampling stations at both rivers, and at the outlet of primary treated sewage of the WWTP Koper. The estimated gross flux for suspended solids is 1281 t/y, for nitrogen 710 t/y, for phosphorous 23 t/y (Tabs. 4a, 5a), and for heavy metals, such as nickel 2.7 t/y, zinc 2.2 t/y, copper 1.0 t/y and 0.7 t/y for lead (Tabs. 4b, 5b). Both hot spots having mixed sources of pollution account for 56% of total BOD_5 load and 63% for COD. Much lower inputs were estimated for the Bay of Piran for total suspended solids 322 t/y, for total nitrogen 153 t/y, for total phosphorous 9.3 t/y, 0.14 t/y for nickel, 0.6 t/y for zinc, 0.38 t/y for copper and 0.13 t/y for lead (Tabs. 4, 5).

Sites of biological and ecological value

Various economic activities have developed over roughly 80 % of Slovenia's coastline, leaving only about 8 km (20 %) of the coast in its natural state. It is obvious that even on these few kilometers we can not speak of true naturalness since there are numerous indirect and direct impacts from various human activities due to sewage and industrial outlets, traffic and other activities on the urbanized part of the coastal area. Direct impacts on the remaining parts of the natural coastline are derived mainly from tourism (leisure boat traffic, anchoring), fishing and collecting mussels. Salt-pans, flysch cliffs and solitary lime rocks are important littoral ecosystems in terms of biodiversity. The list of landscape parks, nature reserves, and nature monuments of great importance needing protection for their natural assets and biological diversity is presented in table 6 (Turk & Odorico, 1993; Turk & Vukovič, 1994; Turk, 1999).

Tab. 4a: The gross flux of some pollutants estimated on the effluent data for the year 2000.
Tab. 4a: Celoten vnos nekaterih polutantov, ocenjen na osnovi meritev odpadnih voda v letu 2000.

Loads	Flow rate(m^3/y)	Pollutants						
		COD (t/y)	BOD_5 (t/y)	TotN (t/y)	TotP (t/y)	TSS (t/y)	FC* (No./100 ml)	Det (t/y)
WWTP Koper	4.7 x 10^6	2054	583	126	14.6	662	6.3 x 10^5	12.4
WWTP Piran	2.7 x 10^6	594	270	92	8.1	270	1.4 x 10^7	5.4
IZOLA	3.1 x 10^6	1976	641	88	16.2	641	2.4 x 10^7	5.1
DELAMARIS	8.2 x 10^4	399	16	15	2.0	91		0.3
Total	**1.1 x 10^7**	**5023**	**1658**	**321**	**40.9**	**1664**		**23.2**

* mean concentration of seasonal measurements

* srednja koncentracija sezonskih meritev

Tab. 4b: The gross flux of selected heavy metals estimated from seasonal measurements of effluents during the year 2000.
Tab. 4b: Celoten vnos izbranih težkih kovin, ocenjen na osnovi sezonskih meritev odpadnih voda v letu 2000.

Loads	Heavy metals					
	Hg (kg/y)	Cd (kg/y)	Pb (kg/y)	Zn (kg/y)	Cu (kg/y)	Ni (kg/y)
WWTP Koper	0.804	47.3	236.0	520.5	236.0	47.3
WWTP Piran	0.440	13.5	21.6	602.3	280.9	27.0
IZOLA	1.257	46.0	61.3	953.5	371.0	24.5
DELAMARIS	0.021	0.41	0.6	0.018	5.9	1.88
Total	**2.5**	**107**	**319**	**2076**	**888**	**99**

Tab. 5a: The gross flux of some pollutants estimated from the riverine inflow data along the Slovenian coastline for the year 2000.
Tab. 5a: Celoten vnos nekaterih polutantov, ocenjen na osnovi podatkov rečnih vnosov vzdolž obale Republike Slovenije v letu 2000.

Loads	Flow rate (m^3/y)	Pollutants						
		COD (t/y)	BOD_5 (t/y)	TotN (t/y)	TotP (t/y)	TSS (t/y)	Det (t/y)	FC* (No./100 ml)
Rižana	1.5×10^8	2138	688	547	7.4	507	2.3	70,000
Badaševica	1.0×10^7	909	47	38	0.5	112	1.0	33,000
Dragonja	3.0×10^7	85	9	9	0.1	10	0.02	680
Drnica	1.6×10^7	602	28	52	1.1	42	0.3	1860
Total	**1.69×10^8**	**3734**	**772**	**645**	**9.1**	**671**	**3.6**	

* maximum concentration of seasonal measurements
* najvišja koncentracija sezonskih meritev

Tab. 5b: The gross flux of selected heavy metals estimated from the riverine inflow data along the Slovenian coastline during the year 2000.
Tab. 5b: Celoten vnos izbranih težkih kovin, ocenjen na osnovi podatkov rečnih vnosov vzdolž obale Republike Slovenije v letu 2000.

Loads	Heavy metals					
	Hg (kg/y)	Ni (kg/y)	Cr (kg/y)	Cu (kg/y)	Zn (kg/y)	Pb (kg/y)
Rižana	0.42	1308.8	120.0	637.5	945	210.0
Badaševica	0.07	19.8	10.4	24.7	68	10.6
Dragonja	0.002	3.1	1.8	4.9	u.d.l.*	3.5
Drnica	0.01	9.0	7.9	13.7	u.d.l.	6.7
Total	**0.50**	**1341**	**140**	**681**	**1013**	**231**

*u.d.l. Under detection limit
*u.d.l. pod mejo detekcije

Priority hot spots and sensitive areas

Priority hot spots and sensitive areas have been ranked according to the relative importance of their impacts in descending order (Tab. 7). In order to weigh the risk in an equal manner, a multiplier depending on the importance of the effects on the several issues has been applied to the grades: for public health 1.0, for drinking water quality 0.9, for recreation 0.8, for other beneficial uses 0.8, for aquatic life 0.7, for economical and welfare including marine resources of economic value 0.7 (Tab. 7). According to the monitoring data regarding the pressure on and sensitivity of the area, the following pollution hot spots were identified along the Slovenian coast: the Rižana river with Koper wastewater treatment plant, Izola which is without treatment plant, the Badaševica river, the Piran wastewater treatment plant with submarine outfall, and the Dragonja river. The Bay of Koper has been considered a sensitive area, since it can be endangered by polluted water of the Gulf of Trieste as well as by land-based sources of pollution along the Slovenian coast. The inner part of the Bay of Koper is receiving effluents from the municipal wastewater treatment plant and individual industries and agglomerations along the Rižana and Badaševica rivers.

Domestic and agricultural discharges into the inner part of the Bay of Piran by the Dragonja river, tourism and intensive aquaculture reduce the quality of the water and may cause local changes in the marine ecosystem.

Tab. 6: Sites of conservation interest on the Slovenian coast (LP - landscape parks, NR - nature reserves, NM - nature monuments).
Tab. 6: Območja vzdolž obale Republike Slovenije pomembna z vidika varstva narave (LP - krajinski park, NR - naravni rezervat, NM - naravni spomenik).

Protected area	Type	Main characteristics	Area	Protected since
Cape Debeli rtič	NM	geomorphology, great diversity of the underwater life	24.3 ha: sea 21.8 ha, coastal 2.5 ha	1991
Škocjanski zatok	NR	brackish lagoon, important ornithological site	120 ha: lagoon 80 ha, coastal 40 ha	1998
Molet		*Posidonia* meadow	approx. 5 ha	–
Cape Korbat		geology	approx.1 ha	–
Strunjan	NR	unique geomorph. features, submediterranean vegetation, diverse marine plant and animal life	160 ha: coastal 45 ha, sea 115 ha	1990
Strunjan	LP	important natural and cultural heritage	approx. 471.8 ha	1990
Stjuža lagoon	NM	marine lagoon, spawning area	approx.2 ha	1990
Fiesa lakes	NM	freshwater and brackish habitat	2.1 ha	1990
Cape Madona	NM	underwater ridge, diversity of marine life	12.8 ha	1990
Sečovlje saltworks	LP	outstanding natural and cultural assets; more than 200 bird species	864.2 ha	1990, 2001*, Ramsar site since 1993

**Governmental decree replaced previous municipal decree*

DISCUSSION

The degradation of water resources, caused mainly by pollution from land-based activities, and physical habitat degradation of coastal and near shore marine areas and watercourses, as a result of inappropriate management, are major environmental concern relating to waters. Identification of priority pollution hot spots and sensitive areas in the Mediterranean was result of the various activities performed within the framework of the Mediterranean Action Plan: Pollution Monitoring and Research Program, Blue Plan, Priority Actions Program, Specially Protected Areas and Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (UNEP/WHO, 1999). According to results of 20 country reports, 101 priority hot spots have been identified and 51 sensitive areas in the Mediterranean region. To show severity of each of the effects on the identified hot spots in an equal manner, a total weight of the risk was calculated according to the importance of the effect on public health, drinking water quality, recreation, other beneficial uses (transportation, sport activities, aquaculture), aquatic life (including biodiversity), economical and welfare (including marine resources of economic value) (UNEP/WHO, 1999). Only one hot spot (lake Manzala in Egypt) scored a total weight impact greater than 25. Slovenia with 2 main pollution hot spots scored a total weight impact between 15 and 20 (Tab. 7), as one half (45%) of the Mediterranean hot spots determined in MAP Technical Reports Series No. 124 (UNEP/WHO, 1999).

The uneven distribution of human activities and the number of inhabitants along the Slovenian coastal area result in a number of factors that in consequence generate some of the conflicts in the area (growth of the everyday car traffic to the coast and back, designation of large areas for car parking, environmental pollution, increasing pressure on the remaining parts of the natural coastline, *etc.*). Phenomena such as algal blooms and accumulation of gelatinous masses have been frequent over the last decades, reducing tourism and affecting the benthic community. Anoxic events, harmful algal bloom, habitat loss, the exploitation of living resources and translocation of non-indigenous species are obvious examples of alterations caused by the man impact (review and references in Malone *et al.*, 1999 and Hopkins *et al.*, 1999). Within the context of the amended Protocol for the Protection of the Mediterranean Sea against Pollution from Land-based Sources and Activities, regional plans should be elaborated for the elimination of pollution deriving from land-based sources and activities. Internationally, some activities have already been coordinated through MED POL, MAP, CAOS Committee/IOC and trilateral (Slovenian-Croatian-Italian) Commission for the Protection of the Adriatic Sea. An assessment of the vulnerability of the Slovenian coastal belt and its categorization was proposed in view of human pressure, various activities and land – use (Turk,

Tab. 7: Identification of hot spots along Sloevenian coast according to ranking system (1- no effect; 6- extreme effects) and the importance of the effects (depending grade*) on public health, drinking water quality, recreation, other beneficial uses, aquatic life (including biodiversity), economical and welfare (UNEP/WHO, 1999).
Tab. 7: Razvrstitev žarišč onesnaženja vzdolž obale Republike Slovenije glede na stopnjo (1- brez vpliva; 6- najvišja stopnja) in pomen vpliva (*) na zdravje ljudi, na kakovost pitne vode, na kakovost vode za rekreacijo in druge namene, na kvaliteto življenja (vključno z biodiverziteto), na ekonomijo in naravne dobrine (UNEP/WHO, 1999).

Name	Type	Public Health	Drinking Water Quality	Aquatic Life	Recreation	Other Beneficial use	Welfare and economy	Weighted total	Category	Nature of investment
		(1)*	(0.9)*	(0.7)*	(0.8)*	(0.8)*	(0.7)*			
Rižana river	Domestic, Industrial	3	1	3	5	4	5	16.7	C	WWTP extension + sewage system reconstruction
Izola	Domestic, Industrial	3	1	3	5	4	4	16.0	C	WWTP construction + sewage system reconstruction
Badaševica	Domestic, Industrial	3	1	3	4	4	3	14.5	D	See Rižana river and WWTP Koper
Piran	Domestic	3	1	3	4	3	1	12.3	D	WWTP extension + sewage system reconstruction
Dragonja	Domestic, Agricultural	2	1	2	2	2	2	8.9	E	

1999). Being aware of the severe pressure of conflict activities, an integrated coastal management programs (Malačič *et al.*, 1994, 1995; Slovenian coastal zone management - Report 1996) and other activities (Malačič *et al.*, 2000) have been already developed and proposed in the coastal region.

In order to solve the problem of municipal and industrial wastewater, an appropriate management project has to be implemented for a long-term solution of pollution in the region. The future projects should provide a determination of the most cost-effective integrated investment solution for sewage collection and wastewater treatment facilities for the municipalities of Koper, Izola and Piran. The project should cover the preparation of detailed technical specifications for the most cost-effective investment projects and the completion of all the necessary project documentation, such as an identification of the optimal locations for the new wastewater treatment plants, an evaluation of the environmental impacts of the proposed facilities, and the Environmental Impact Assessment.

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ŽARIŠČA ONESNAŽENJA IN OBČUTLJIVA OBMOČJA VZDOLŽ OBALE REPUBLIKE SLOVENIJE

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POVZETEK

Žarišča onesnaženja slovenskega obrežnega pasu in občutljiva območja smo določili na osnovi dolgoletnih podatkov onesnaženja s kopnega in kvalitete obalnega morja po metodologiji in priporočilih Agencije združenih narodov za okolje (UNEP/WHO). Upoštevali smo kriterije naravnih značilnosti morskega okolja Tržaškega zaliva kot ekološke celote severnega Jadrana, vplive številnih dejavnosti in pritiskov s kopnega, ki ogrožajo ekosistem, zdravje ljudi in ekonomski razvoj.

Vnos nekaterih polutantov v obalno morje Republike Slovenije smo ocenili na osnovi razpoložljivih podatkov kvalitete in kvantitete komunalnih in industrijskih odplak, srednjih letnih vrednosti izmerjenih koncentracij izbranih polutantov, pretoka rek in čistilnih naprav ali črpališč za leto 2000. Najbolj obremenjeno je območje notranjega dela Koprskega zaliva, kamor se izlivajo odpadne vode koprske čistilne naprave in reki Rižana in Badaševica. Ocena letnega vnosa za lebdeče delce je 1281 ton, 710 ton za dušik in 23 ton za fosfor, razmeroma visok je tudi vnos nekaterih težkih kovin in mikroorganizmov fekalnega izvora.

Kakovost obalnega morja lahko izboljšamo le z omejevanjem onesnaževanja, ohranjanjem naravnih delov obale, nadzorom nad različnimi dejavnostmi in pravilno zastavljenim razvojem tega prostora. Med prioritete zmanjševanja onesnaževanja sodi vsekakor sanacija komunalnih in industrijskih odplak ter graditev ustreznih čistilnih naprav in izpustov.

Ključne besede: onesnaženje, obalne vode, odpadne vode, čiščenje odpadnih vod, obremenitve, žarišča onesnaženja, občutljiva območja, Tržaški zaliv, Jadransko morje, Sredozemsko morje

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