ENVIRONMENTAL IMPACTS OF THE PORT OF KOPER

VPLIVI LUKE KOPER NA OKOLJE

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Keywords: port, environmental impacts, total particulate matter deposition, PM10, waste water, sea water protection, quality of sediments, noise level, dust emission concentration, VOC emission concentrations, wastes, flora, fauna
Ključne besede: luka, okoljski vplivi, celotna količina odloženih suspendiranih delcev, PM10, odpadne vode, zaščita morske vode, kakovost usedlin, raven hrupa, emisijska koncentracija prahu, emisijska koncentracija VOC, odpadki, flora, favna

ABSTRACT

This paper provides an insight into the extent and degree of the environmental impacts of the Port of Koper. For this purpose, the following indicators were selected: maritime throughput, imission concentration of PM10, total particulate matter deposition, emission concentrations of dust and emission concentration of volatile organic compounds (i.e. gasoline, jet fuel and o-xylene), noise levels, shares of waste collected separately, environmental load unit for waste water, quality of sediments. The selected environmental indicators are presented over a period of time and compared to some normative references. The first stage of the marine flora and fauna research in the Port's basins is presented.

IZVLEČEK

Pričujoči članek poskuša osvetliti obseg in stopnjo vplivov delovanja Luke Koper na okolje. V ta namen so bili uporabljeni naslednji kazalniki: tovorni promet, imisijske koncentracije suspendiranih delcev PM10, celotna količina odloženih suspendiranih delcev, imisijske koncentracije prahu in hlapljivih organskih zmesi (npr. bencin, gorivo za reaktivne motorje, o-ksilen), raven hrupa, deleži ločeno zbranih odpadkov, enota obremenitve okolja za odpadne vode, kakovost usedlin. Izbrani okoljski kazalniki, ki zajemajo daljše časovno obdobje, so primerjani z nekaterimi normativnimi referencami. Predstavljena je prva faza raziskav o morski flori in favni v luških bazenih.

1. INTRODUCTION

The Obalno-Kraška (Coastal-Karst) region is one of the smallest regions in Slovenia in terms of its size and among the most developed in terms of its economic conditions. The Port of Koper is a public limited company, whose activity leaves an impact on the development of the Obalno-Kraška region, giving it a positive and dynamic economic pulse. The expansion of the port, in economic and physical terms, nowadays has to take into account its impacts on the nearby urban contexts. These impacts affect the environment and the local community. The challenge is now to balance the economic, environmental and social issues. The concept of sustainable development has become one of the basic challenges in the field of maritime transport, including port activities. The Port of Koper strives to achieve and demonstrate a

proper attitude towards the environment. Preservation of the environment and a system for dealing with the environment in the narrower and broader area influenced by the Port of Koper are becoming increasingly important components of the comprehensive quality system. Thus, monitoring and controlling environmental impacts is turning into one of the company's regular activities.

Many human activities are aggravating the environment, and port activities with its daily operations are no exception in this respect. Waterborne commerce is increasing rapidly and presenting ports with challenges that could not have even been imagined two decades ago. At the same time, lifestyle changes have made the cruise industry the fastest growing segment of the travel industry. To accommodate increases in trade volume, increases in the size of cargo and cruise ships, new security requirements in ports are investing in infrastructure improvements.

1.1 BAY OF KOPER

The Bay of Koper has been considered a sensitive area, since it is endangered by industrial and domestic land based activities and pollution sources along the coast and its watershed as well as by polluted waters of the Gulf of Trieste. A wide variety of economic activities are running in and along the Bay of Koper. Most of its coastline is built-up and urbanized. The central port of Slovenia, the Port of Koper, is located in the Bay. Activities in the port are increasing every year, and currently around 15 million tons of cargo are handled per year. The area is also industrially developed. Metal manufacturing, production of chemicals and food industry are the main branches of industry situated in this area. Tourism and recreation also exerts certain pressure on the environment and is particularly extensive in summer months. Municipal wastewaters are an important source of pollution in the Bay. They are primary treated and discharged in the estuary of the Rižana river, i.e. in Basin II of the Port of Koper. Around 122 tons of TN and 17 tons of TP are annually discharged into to the sea from the Koper wastewater treatment plant (Gosar et Muri 2005). River effluents are additional significant source of pollution. The Rižana and Badaševica rivers supply the sea with nutrients and other harmful pollutants from the coastal area and the watershed. Nevertheless, the Bay of Koper can be also endangered by polluted waters, entering the Bay from other parts of the Gulf of Trieste. Some areas on the Italian coast are highly industrialized and urbanized and, consequently, polluted. In addition, effluents of the Soča river are discharged into the Gulf and their impact can also be seen in the Slovenian part of the Gulf. All these factors can thus enhance the deterioration of the waters and the coastline of the Bay of Koper.

1.2 THE PORT OF KOPER PROFILE

The Port of Koper is a public limited company, situated in the Bay of Koper with a surface area of around 17 km^2. It provides port and logistics services and is a quickly developing port and logistics group, one of the most important in the Northern Adriatic region. It represents a stronger link in the logistics chain connecting Central and Eastern Europe as well as the

Far East. In 2007, the development impetus was enhanced by exceptional growth in container and general cargo throughput, by providing one of the largest distribution centres for vehicles, by setting up inland terminals, by expanding the range of additional services, by efficient technological processes, by new modern equipment and information solutions, and by a socially accountable approach (Figure 1).

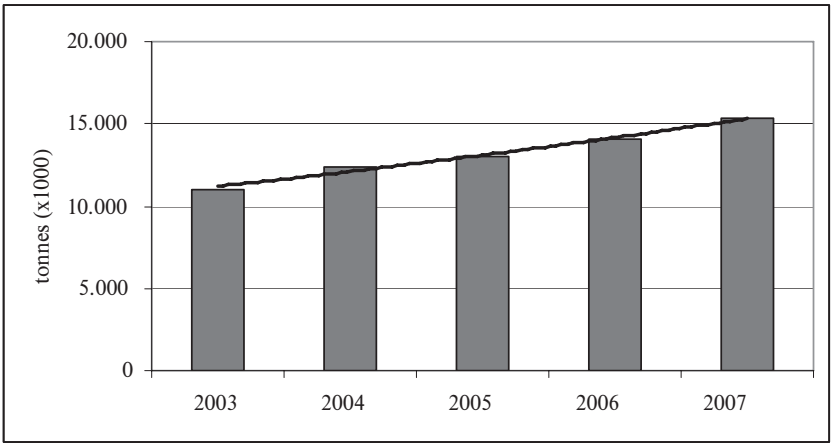

Figure 1: Increasing maritime throughput in Port of Koper
Slika 1: Rastoči tovorni promet v Luki Koper

The port lies on 255 hectares of land area where:

- 30 hectares are destined for indoor warehouses,
- 95 hectares for outdoor warehouses, and
- 26 ship moorings on 3.134 metres of shore alongside 173 hectares of sea area.

The Port of Koper manages 12 specialised terminals with modern equipment for various types of cargo (Table 1).

Table 1: List of The Port's specialised terminals and their potential effect on the environment
Tabela 1: Seznam terminalov Luke Koper in njihov potencialni vpliv na okolje

Terminals	**Potential effect on environment**
Container and Ro-Ro	Noise
Car Terminal	Noise
General Cargo Terminal	Noise
Fruit Terminal	Air
Timber Terminal	Noise
Terminal for Minerals	Air
Terminal for Cereals and Fodder	Air
Alumina Terminal	Air
European Energy Terminal	Air
Liquid Cargoes Terminal	Water, Air
Livestock Terminal	Water
Passenger terminal	Noise

The port procedures and operation are focused on the prevention of conditions that could endanger the environment or the people's health and safety. The Port of Koper is the only port in the Northern Adriatic to operate according to ISO 9001 standards - Quality management system, ISO 14001 - Environmental management system and OHSAS 18001 - Occupational health and safety management system. The established environment management system is systematic and well-planned, integrated into the business system of the port, and is supported and carried out by all employees. The next step is to implement an Eco-Environmental Management and Audit Scheme - EMAS (Regulation (EC) No. 761/2001..., OJ EC L 114(44) 2001).

The organisation strives to achieve and demonstrate a suitable attitude towards the environment. This means continuously controlling the impacts of the Port's activities, products and services on the environment. Preservation of the environment and a system for dealing with the environment in the narrower and broader area influenced by the Port of Koper are becoming increasingly important components of the comprehensive quality system.

The port is developing new methods and models for efficient environmental protection and management. Some of the environmental considerations that the port involves are: management of estuaries, all forms of pollution at ports, managing ecology and habitat, management of chemicals in or near water environments, oil discharge prevention and response, dredging and sediment removal including its disposal, management of the port, management of waste from vessels, loading and unloading of ships, management of ballast water, safety of ships and the people living around harbours, security of goods.

The responsible attitude towards natural and living environment is reflected in consistent implementation of the environmental policy, raising the awareness of the employees as regards preventive actions and rational use of energy sources and investments in environmental programmes.

2. ENVIRONMENTAL IMPACT OF THE PORT OF KOPER

2.1 AIR QUALITY

2.1.1 Particulate matter (PM10) imission levels

In 1987, EPA replaced the earlier total suspended particulate (TSP) air quality standard with a PM10 standard (BS EN 12341). The new standard focuses on smaller particles that are likely responsible for adverse health effects due to their ability to reach the lower regions of the respiratory tract. EPA's health-based national air quality standard for PM10 is 40 $\mu g/m^3$ (measured as an annual mean) and 150 $\mu g/m^3$ (measured as a daily concentration) (Council Directive 1999/30/EC..., OJ EC L 163(41) 1999). The main sources of primary PM10 are road transport, stationary coal combustion and industrial processes, including bulk handling, construction, etc. (Agencija RS za okolje / The Environment Agency 2007).

Major concerns for human health from exposure to PM10 include: effects on breathing and respiratory systems, allergic reactions, damage to lung tissue, cancer (Eržen et al. 2003).

Since 2003, the Primorska Institute of Natural Sciences and Technology has been conducting continuous measurements of PM10 in the immediate area of the source of imission - the bulk cargo disposal site in the port (Figure 2). The average measured PM10 concentrations are shown in Table 2. The legally prescribed limit (40 μg/m^3) has never been exceeded. The Port of Koper has set itself the task to halve this value by 2010, as required by the European and Slovenian legislation. This goal will be achieved by preventive measures and activities aimed at reducing dust particles in the atmosphere. The port has already implemented techniques such as the use of equipment that minimises the height of drop and speed of descent and free fall height, e.g. using height adjustable cascade tubes, the use of water sprays for moistening the heap surface (coal yard) by a sprinkler system, the use of enclosed conveyors with well designed, robust extraction and filtration equipment, the use of large volume silos, regularly cleaning of roads, the use of 11 m high windshield round the coal yard. Future approaches and techniques regarding the further reduction of dust emissions are the complete covering of the coal open storage, the development of a diffusion model of dust emission from the port, the use of alternative power systems (e.g. shore side power supply for ships, hybrid technology, biodiesel) and to further optimize the bulk cargo handling systems.

Two more sampling stations will monitor the concentration of PM10 at port border sites in 2009.

Figure 2: The continuous PM10 particulate monitoring station (TEOM 1400A) in the Port of Koper
Slika 2: Stalna postaja za spremljanje suspendiranih delcev (TEOM 1400A) v Luki Koper

Table 2: Average annual concentration of PM10
Tabela 2: Povprečna letna koncentracija PM10

Measuring period	Concentration (μg/m^3)
April 2003 – April 2004	32.0
April 2004 – April 2005	33.0
April 2005 – April 2006	25.1
April 2006 – April 2007	35.0
April 2007– April 2008	32.5
Permitted annual average concentration	40.0
Target annual average concentration in 2010	20.0

2.1.2 Total particulate matter deposition

Dust is generally understood to be an aerosol of solid particles, mechanically produced, with individual particle diameters of 0.1 μm upwards and can be a problem in almost any industry, from bakeries to building sites. The term dust particulate matter refers to particulate matter, which has fallen out of suspension within the atmosphere. It is no longer legally prescribed that such dust imissions have to be measured, but the maximum annual recommended imission level of particles of 200 mg.m^{-2}.day^{-1} is considered (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit 2002). The sampling is performed over a thirty day period of time using a Bergerhoff deposit dust gauge sampler (VDI 2119-2).

The sampling design for this study was not statistically based; rather, sites were chosen to provide data on dust flux at studied sites and to answer specific questions about the relations of port activities to the total dust deposition-imission regarding to the distance from source, climate influence, wind direction, etc.

A total number of 20 sampling points were selected (Figure 3). These 20 monitoring sites were distributed as follows:

- Points 11, 12, 13 for studying particulate matter flux,
- Points 14, 15 were chosen where complaints about dust deposition were often expressed,
- Point 16 as urban background,
- Points 17, 19, 20 as urban site,
- Point 18 as rural background,
- Points 1a,1b,1c-8 inside the port area.

In the studied period, the limit (200 mg.m^{-2}.day^{-1}) was not exceeded, except at the measuring site in the approximate vicinity of the pier extension (Points 4 and 6) or owing to other intensive building activities (Point 5, Figure 4). At sampling point 18 (rural background), an average concentration of 71 mg.m^{-2}.day^{-1} was calculated. The concentrations of total particulate matter deposition in the surrounding area (also rural background) and at other port sampling locations range from 57 mg.m^{-2}.day^{-1} to 120 mg.m^{-2}.day^{-1} (except for points 4, 5 and 6) and thus do not exceeded the recommended level of 200 mg.m^{-2}.day^{-1}. The results showed that the total particulate matter concentration is influenced by local emissions, the areas affected by natural dust re-suspension, desert dust transport, low rainfall rates favouring dust accumulation, long-range transport of pollutants, by sea-spray at coast sites, contribution from the local traffic, the urban background contribution and that from the port activities (Poljšak et al. 2007, Jereb et al. 2008).

Further study is being conducted to quantify the real influence of port activities regarding the total particulate matter deposition in the surrounding urban area.

Figure 3: Geographical location of the measurement of particulate matter deposition (source: http://maps.google.com/; sampling points were added)

Slika 3: Lokacije meritev suspendiranih delcev (vir: http://maps.google.com/; z dodanimi vzorčišči)

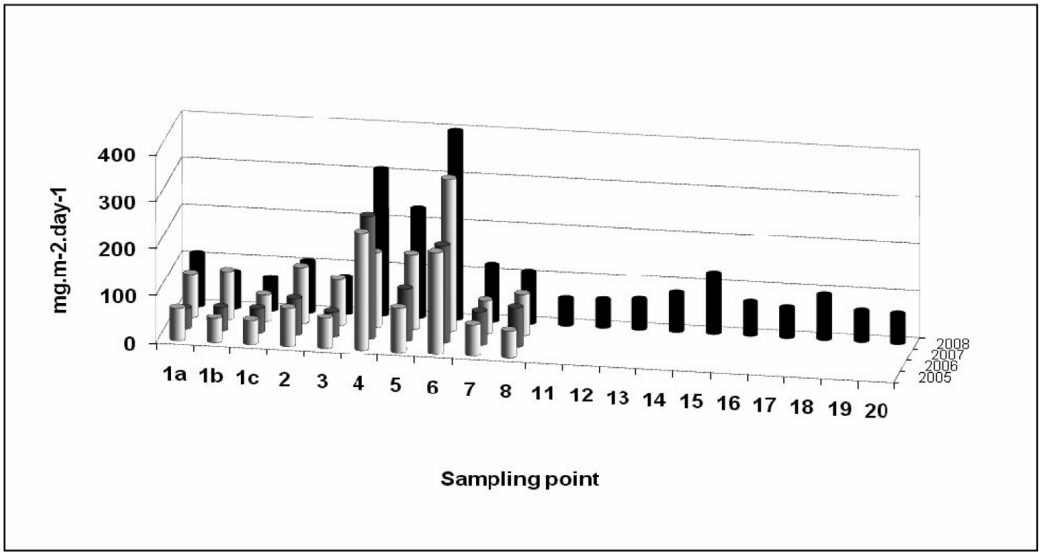

Figure 4: Annual particulate matter deposition at different sites

Slika 4: Letna količina odloženih suspendiranih snovi na posameznih vzorčiščih

2.1.3 Volatile organics and dust emissions levels

Because of the activities at the Port´s Liquid Cargo Terminal, European Energy Terminal, Alumina Terminal and Dry Bulk Cargoes Terminal, volatile organic compounds (gasoline, jet fuel, o-xylene) and dust are emitted. A regular monitoring network, measuring emissions of various pollutants from relevant sources, was set up and is regulated by the Environment Agency of the Republic of Slovenia (Council Directive 96/61/EC..., OJ EC L 257 1996).

In the Port of Koper, emissions levels of selected pollutants are measured every year by the competent authority since 2003. At each terminal, up to 10 sampling points were selected with regard to the possibility of emissions from cargo handling and storage.

The legally prescribed values for dust emission are defined in view of the total dust mass flow, i.e. 50 mg/m^3 or 150 mg/m^3 (Uredba o emisiji snovi v zrak, Ur.l. RS 31/07, 10/08). The results of measurements are summarised in Figure 5. The concentration of dust was too high only in 2004 at a single measuring point.

The total amount of emitted volatile organic compounds is presented in Figure 7. The total emitted amount of VOC is calculated from the measured mass flow at the specific source multiplied by the annual number of the operating hours. Maximum allowed losses are limited to 0.01% or 0.005% in view of the national legislation for fuel storage and handling (Uredba o emisiji hlapnih organskih spojin v zrak, Ur.l. RS 11/99). These values, however, were never exceeded (Figure 8).

Nevertheless, the Port employs several activities and preventive measures to reduce total air pollution. At Liquid Cargo Terminal, best available techniques for the storage of liquids and liquefied gases are practiced (European Commission 2006). The built tanks are equipped with floating, flexible or fixed covers, vapour recuperation systems are implemented, proper tank colours are used reducing unnecessary solar heating, regular inspections and maintenance are performed, instrumentation and automation systems to detect leakage are used, etc.

Although the total cargo load is increasing, the total measured emissions into air are decreasing (Figures 6, 8).

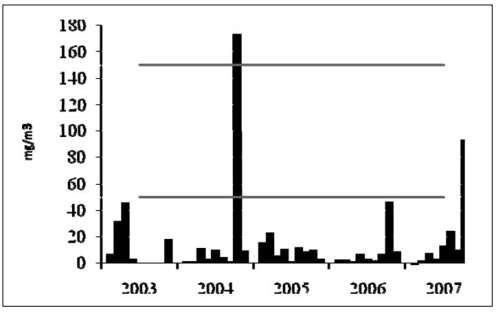

Figure 5: Emission concentrations of dust from different sampling points at European Energy Terminal, Alumina Terminal and Dry Bulk Cargoes Terminal
Slika 5: Emisijske koncentracije prahu na vzorčiščih različnih terminalov

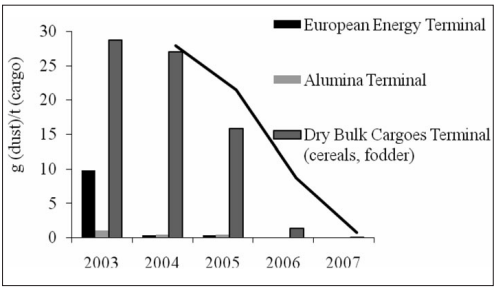

Figure 6: Annual emission levels of dust calculated in view of the total loaded cargo at different terminals
Slika 6: Letne emisijske ravni prahu glede na skupni tovor na različnih terminalih

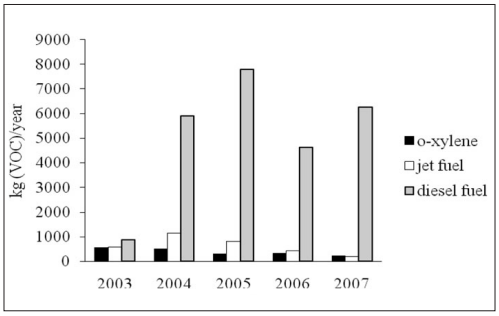

Figure 7: Emission concentrations of volatile organic compounds (VOC) at Liquid Cargo Terminal
Slika 7: Emisijske koncentracije hlapljivih organskih zmesi (VOC) na terminalu za tekoče tovore

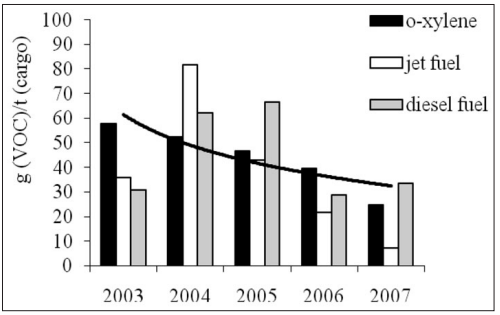

Figure 8: Emission levels of volatile organic compounds (VOC) calculated in view of the total loaded cargo at Liquid Cargo Terminal
Slika 8: Emisijske ravni hlapljivih organskih snovi (VOC), izračunane glede na skupni tovor na terminalu za tekoče tovore

2.2 NOISE LEVELS

The principal noise sources are ships, straddle carriers, cranes, forklifts, refrigerated containers, trucks and trains, and log handling equipment such as log grabbers, etc. The measurements of noise levels in the natural and living environment have been carried out since 1998 at three port border sites: near the town centre of Koper and at border points towards Ankaran and Bertoki (Directive 2002/49/EC..., OJ EU L 189(12) 2002). In 2007, three measuring devices were installed for continuous noise measurements (Figure 9). The measurements are performed by the competent institute. The average annual values do not exceed legally prescribed limits calculated regarding the distance of the measuring device to the nearest residential houses (Uredba o mejnih vrednostih..., Ur.l. RS 105/05). The results of average annual measurements are summarized in Table 4. Nevertheless, the Port has already taken certain measures to reduce noise, e.g. some noisy operations have been moved away from residential boundary, operational procedures were optimised to minimise the noise from loading, night operation hours have been limited, traffic speed in the Port has been limited, etc. The Port is also developing strategic noise mapping that will be used as a source of information and as base for action plans for further reduction of noise levels, identification of problems and situations that need to be improved, reduction of sound transmission, a tool for noise prediction, etc.

The Port usually has no direct influence on sound sources, such as ships at berth (engine noise), but is working on the possibility of installing the shore-side electrical power supply for ships, as already implemented for tugboat. In order to further reduce noise as well as gas emissions from trucks, the port entrance gate has been moved away from the residential area.

Table 4: Comparison of average noise levels in different port location areas
Tabela 4: Primerjava povprečnih ravni hrupa na različnih luških lokacijah

Measuring point	**Toward the town centre of Koper**		**Toward the settlement of Bertoki**		**Toward the settlement of Ankaran**	
	Daily noise level (L_d)	***Night noise level (L_n)***	***Daily noise level (L_d)***	***Night noise level (L_n)***	***Daily noise level (L_d)***	***Night noise level (L_n)***
2000	62	54	56	49	55	49
2001	63	55	60	54	60	57
2002	62	56	56	46	56	49
2003	61	57	51	46	57	46
2004	64	60	60	53	58	54
2005	62	50	59	55	57	52
2006	62	53	58	52	53	47
2007	62	58	60	56	55	51
Calculated legally prescribed limit	62	58	71	61	65	55

Figure 9: Equipment for continuous measurement of noise in the Port of Koper
Slika 9: Naprave za stalno merjenje hrupa v Luki Koper

2.3. WASTE MANAGEMENT SYSTEM

In order to avoid and minimize the potential effects of generated wastes, the Port of Koper has developed and implemented port waste management plans according to the national regulations (Uredba o obremenjevanju tal..., Ur.l. RS 34/08, Pravilnik o prevzemu ladijskih odpadkov, Ur.l. RS 66/05) and provided adequate reception facilities for oil, chemical and garbage wastes, and to remove, as far as practicable, any disincentives to landing waste in the port. As part of this process, the Port encouraged the responsible management of waste, including minimization and recycling, at the point of generation on ships, reception in ports,

transportation and disposal, and ensured that the Port employees and users dispose of garbage and other wastes responsibly in facilities provided and report on any spills or large pieces of floating garbage to the Port authority.

The Port of Koper performs the mandatory public utility service of collecting solid and liquid waste from vessels in the Port area. The environmental awareness of the employees is also reflected in the separate collection and recycling of waste. At the Port, up to 70% of all waste is collected separately and then handed over for recycling. Figure 10 represents the Port's average shares of waste collected separately.

The Port of Koper has its own plant for managing wastes. In the Port area, a composting system consisting of an aerobic decomposition of biodegradable organic matter (food, mostly vegetables or manure) is also operating. The decomposition is performed primarily by facultative and obligate aerobic bacteria, yeasts and fungi, helped in the cooler initial and ending phases by a number of larger organisms. The produced compost is used as a fertilizer.

The Port has an ambitious idea to become an energetic self sufficient port. This can be achieved by the re-use of its internal resources, namely port generated wastes and municipal solid wastes from the nearby local communities.

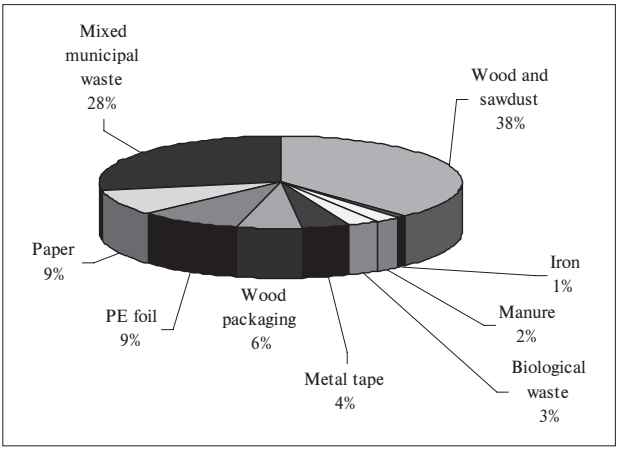

Figure 10: The average shares of waste collected separately in the Port
Slika 10: Povprečni deleži odpadkov, ločeno zbranih v Luki

2.4 WASTE WATER QUALITY

Slovenia has many sources of pollution at the coast and its watershed. Liquid pollutants as well as air pollutants are emitted from these sources. A regular monitoring network, measuring emissions of various pollutants (as directed by the law) from these of these sources was set up and is regulated by the Environment Agency of the Republic of Slovenia (Uredba o emisiji snovi in toplote..., Ur.l. RS 47/05, 45/07, Pravilnik o prvih meritvah..., Ur.l. RS 74/07).

The Port of Koper has some outflows of industrial waste waters and they are monitored by the competent authority. At the Liquid Cargo Terminal, a modern biological and chemical

treatment system is operating. A total number of 32 separator systems are also used. They treat oil-contaminated rainwater (run-off) from impervious areas, e.g. car parks, roads and hall yard areas, covering 28 hectares of the Port area.

The majority of waste water produced in the Port is municipal waste water (Figure 11). A part of the municipal waste water is treated in small port wastewater treatment systems with up to 50 population equivalent. The total number of such treatment systems reaches the number of 40. The main part of the Port's originating municipal waste water is treated in the Koper central municipal waste water purification system. Figure 11 shows the environmental load unit (LU) that is calculated from the average measured chemical oxygen demand regarding the total amount of waste water (Uredba o okoljski dajatvi..., Ur.l. RS 123/04, 142/04, 68/05, 77/06, 71/07, 85/08).

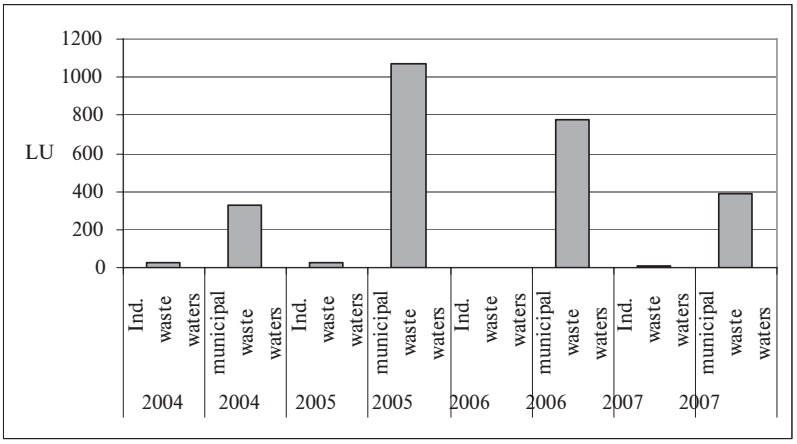

Figure 11: In the Port of Koper, the municipal waste water represents the main source of waste water
Slika 11: V Luki Koper so občinske odpadne vode glavni vir odpadnih voda

2.5 SEA WATER QUALITY

2.5.1 Sea water protection

Services related to the prevention and elimination of the consequences of sea pollution are carried out on the basis of the contract concluded between the Republic of Slovenia and the Port of Koper (Uredba o upravljanju koprskega tovornega pristanišča..., Ur.l. RS 71/08). The Port of Koper has opened its Sea Protection Department and formulated the plan known as Action and informing plan in the event of hazardous substance spills at sea. The Sea Protection Department has acquired two ecological intervention vessels to be used in the event of sea pollution, fitted with all the equipment necessary for remediation of small-scale pollution designed for patrolling and quick interventions in extraordinary events at sea (Figure 12). The Port has established, prepared, implemented and practiced oil spill contingency plans in order to provide guidance and direction to those responding to oil or chemical spills and to set in motion all the necessary actions to stop or minimize the pollution and to reduce its effects on the environment.

In 2007, the Sea Protection Department systematically began to register the number of interventions and to analyse the causes (Table 5).

Table 5: The statistical data of the Sea Protection Department - Port of Koper
Tabela 5: Statistični podatki o delovanju luškega Oddelka za varovanje morja

Year	Total number of registered events at sea	Number of required interventions at sea	Number of non-required interventions at sea
2007	51	39	12
2008	53	43	10

Interventions by the Sea Protection Department is required when material (branches) is brought down the Rižana or Badaševica rivers, when illegal oil spills from ships are observed, when bulk cargo is accidentally released into the sea, etc. The efficiency of the intervention is measured either visually (e.g. removing floating material) or quantitatively (chemical analyses, e.g. oil spill). The main factor influencing the efficiency of the intervention at sea is the response time. All the interventions in the years 2007 and 2008 were effectively performed, and all of them were carried out in port basins. A study of seawater current pattern in port basins is being conducted for a better prediction of spill movements.

Figure 12: One of the Port's ecological boats
Slika 12: Eden izmed luških ekoloških čolnov

2.5.2 Flora in fauna in selected parts in the Port's basins

Degradation of marine waters has been observed in the inner parts of Koper and Piran Bays. Inputs of organic matter and nutrients from insufficiently treated municipal and industrial wastewaters, as well as effluents of the Rižana, Badaševica, Dragonja and Drnica rivers are issues of the highest concern and have locally deteriorated marine waters along the Slovenian coast (Gosar et Muri 2005).

Several underwater investigations of flora and fauna have taken place within port basins in recent years (Štirn et Richter 2007, 2008). The collection of data has been carried out primarily by SCUBA diving, on linear transects inside the Port's water belt. The field work has been recorded with a photo-camera. The study has not included the assessment of fish diversity.

In the tidal zone or deeper, the following organisms have been found: *Fucus virsoides, Ulva rigida, Crassostrea gigas, Mytilus galloprovincialis, Balanus and Chthamalus species, Actinia equine, Anemonia sulcata, Eriphia spiniforms.* The concrete port underwater columns constitute a habitat suitable for many species such as: *Pleraphysilla spinifera, Dysidea fragilis, Eudendrium cf. rameum, Sabella spallanzani, Schizobrachiella sanguine, Phallusia fumigate, Polycarpa pomaria, Maia squinando.* At the bottom, Cymodocea nodosa, Pinna nobilis and Ubogebia species have also been found. The above organisms also inhabit the shallow Slovenian Sea (Lipej et al. 2000), but further study will have to be performed for a complete inventory of the flora and fauna in the Port's basins.

2.6 CHEMICAL DATA AND QUALITY CLASSIFICATION OF SEDIMENT SAMPLES

In 1998 and 1999, some sediment samples were taken and analysed from the Port's basins No. II and III. The concentration ranges of microelements from different sampling points in the Northern Adriatic region are summarised in Table 6. Microelements values are comparable to those from the inner part of Koper Bay, thus suggesting that the quality of sediments in port basins has not been altered by the Port's activities though the years.

Some organisations have set numerical guidelines involving processing of any information relating to a particular contaminant into two separate datasets, those that produce biological effects and those that do not (Table 7). The comparison of the results with some references regarding the quality of marine sediments has indicated that the quality of port sediments is not problematic regarding those values (Sediment quality guidelines http://www.mincos.gov.au...).

At the national level, the quality of sediments is evaluated in view of the legislation for depositing dredged material on shore since they are taken on land for alternative use, such as land reclamation, restoring mudflats or construction purposes. In this case, sediments are being regarded as waste material (Uredba o ravnanju z odpadki, Ur.l. RS 34/08).

Table 6: Comparison of concentration ranges of microelements from different sediment samples
Tabela 6: Primerjava koncentracij mikroelementov v različnih območjih na podlagi vzorcev usedlin

	Pb *(mgkg^{-1})*	**Cr** *(mgkg^{-1})*	**Hg** *(mgkg^{-1})*	**Ni** *(mgkg^{-1})*	**Zn** *(mgkg^{-1})*	**Cu** *(mgkg^{-1})*
Bay of Koper (Ogorelec et al., 1987)	32-77	64-209	0.06-0.28	60-145	12-95	25-42
Gulf of Trieste (Faganeli et al., 1991, Donazzolo et al., 1981)	10-65	15-183	0.1-3.0	12-230	20-410	25-45
Basins in Port of Koper (Ožbolt et al. 1998, Šömen-Joksič et al., 1999)	10-19	23-52	0.06-0.3	60-91	22-103	15-33

Table 7: The comparison of the quality of sediments (microelements) from the Port of Koper with some quality guidelines

Tabela 7: Primerjava kakovosti usedlin (mikroelementov) v Luki Koper z nekaterimi smernicami o njihovi kakovosti

Micro-element	***Unit***	**AZNECC**		**USEPA/ NOAA**		**CCME**		**SLO**	**Concentration range of microelements- different sediment samples from Port of Koper**
		ISOQ-L	ISOQ-H	ERL	ERM	ISOQ	PEL		
As	*mgkg^{-1}*	20	70	8.2	70	7.24	41.6	30	1-2
Cu	*mgkg^{-1}*	65	270	34	270	18.7	108	60	15-33
Zn	*mgkg^{-1}*	200	410	150	410	124	271	300	22-103
Cd	*mgkg^{-1}*	1.5	10	1.2	9.6	0.7	4.2	1,1	0.1-0.3
Cr	*mgkg^{-1}*	80	370	81	370	52.3	160	90	23-52
Pb	*mgkg^{-1}*	50	220	46.7	218	30.2	112	100	10-19
Hg	*mgkg^{-1}*	0.15	1	0.15	0.71	0.13	0.7	0,7	0.06-0.3

AZNECC: Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian and New Zealand Environment and Conservation Council
USEPA: US Environmental Protection Agency; National Sediment Inventory, Appendix D- Screening Values for Chemicals Evaluated
NOAA: National Oceanic and Atmospheric Administration, Sediment Quality Guidelines Developed for the National Status and Trends Program
CCME: Canadian Council of Ministers of the Environment, Summary of Existing Canadian Environmental Quality Guidelines, ISQG- Interim Sediment Quality Guideline and PEL- Probable Effect Level
SLO: Uredba o obremenjevanju tal z vnašanjem odpadkov. Ur.l. RS 34/08.

3. CONCLUSIONS

In the present article, an overview of the environmental influence of the Port of Koper is presented, based on data collected over the last few years and on comparison to some normative references. As indicated in the article, the potential Port's effects embrace a wide range of environmental issues that has to be taken into account, such as water pollution, emissions

of dust and volatile organic compounds, noise, contamination of bottom sediment, marine ecology, waste discharges, oil leakage and spillage, and so forth. The Port has introduced an extensive monitoring program to constantly monitor its influence and its effectiveness in performing preventive actions towards reducing its impacts.

The indicators referring to the air quality (PM10, particulate matter deposition, volatile organic compounds) show accordance with the legislation normative reference values. The average PM10 concentration has been gradually reduced (about 7%) in the last two years, thus indicating that the overall preventive measures and activities performed by the Port are effective.

In the study of the total dust particulate matter deposition, higher concentrations of total dust have been observed only at sampling points near the approximate vicinity of the pier extension owing to the intensive building activities. The concentrations of total particulate matter deposition in the surrounding area and in other port areas range from 57 to 120 $mg.m^{-2}.day^{-1}$ and thus do not exceed the recommended level of 200 $mg.m^{-2}.day^{-1}$. At the sampling point classified as rural background, an average annual concentration of 71 $mg.m^{-2}.day^{-1}$ was measured. The losses of volatile organic compounds, due to handling and storage, have never exceeded the limit of 0.01% or 0.005%.

The Port continues to monitor noise levels at three permanent listening stations. Through its noise management system it attempts to be in compliance with the legislation and to further reduce the annoying degree of unwanted sound, e.g. some noisy operations have been moved away from residential boundary, operational procedures were optimised, night operation hours have been limited, traffic speed in the port has been limited, port entrance gate has been moved away from the residential area.

The result of the ports effective waste management system is the high share (70%) of separately collected waste. Furthermore, the Port is going to re-use its internal resources (wastes) for the purpose of producing green energy.

The municipal waste water represents the main source of waste water in the Port. Many purification systems are used to treat port waste waters. The Port has managed to halve the environmental load unit in the last three years.

The quality of port sediments is comparable to those from other parts in Koper Bay. Because of its quality, the dredged sediments can be re-used for land reclamation, restoring mudflats or construction purposes.

The results of environmental indicators and their trends indicate a positive approach towards reducing port environmental influence and will be further used as a diagnostic tool.

4. SUMMARY

Environmental indicators are powerful tools that serve many purposes, useful as tools for performance evaluation, public information, estimation of the environmental influence, reporting on progress towards sustainable development.

The article presents a dynamic set of environmental indicators on priority issues for which the Port of Koper maintains monitoring programs. The main goal of this article was

to provide an insight into the extent and degree of the environmental impacts of the Port of Koper. For this purpose, the following indicators were selected: maritime throughput, imission concentration of PM10, total particulate matter deposition, emission concentrations of dust, and emission concentration of volatile organic compounds (i.e. gasoline, jet fuel and o-xylene), noise levels, shares of waste collected separately, environmental load unit for waste water, quality of sediments. The selected environmental indicators were presented over a period of time and compared to some normative references. All the environmental measurements were performed by competent authorities using standardized methods and equipment.

The indicators referring to the air quality (PM10, particulate matter deposition, volatile organic compounds) show accordance with the legislation normative reference values. The average PM10 concentration has been gradually reduced (about 7%) in the last two years, thus indicating that the overall preventive measures and activities performed by the Port are effective. The concentrations of total particulate matter deposition in the surrounding area and in other port areas range from 57 mg.m-2.day-1 to 120 mg.m-2.day-1 and thus do not exceed the target level of 200 mg.m-2.day-1. The losses of volatile organic compounds, due to handling and storage, have never exceeded the limit of 0.01% or 0.005%.

Through the noise management system, the port attempt to be in compliance with the legislation and to further reduce annoying degree of unwanted sound. The port average daily noise levels range from 55 dB to 62 dB, while the average night noise levels range from 51 dB to 58 dB.

The result of the Port's effective waste management system is the high share (70%) of separately collected waste. Furthermore, the Port is going to re-use its internal resources (wastes) with the intention to produce green energy.

The municipal waste water constitutes the main source of waste water in the Port. Many purification systems are used to treat port waste waters. The Port has managed to halve the environmental load unit in the last three years.

The quality of port sediments is comparable to those from other parts in Koper Bay. Because of its quality, the dredged sediments can be re-used for land reclamation, restoring mudflats or construction purposes.

The results of environmental indicators and their trends indicate a positive approach towards reducing port environmental influence and will be further used as a diagnostic tool.

POVZETEK

Okoljski kazalniki so učinkovito in priročno orodje za ugotavljanje stanja na marsikaterem področju, na primer za ocenjevanje funkcionalnosti, pri javnem obveščanju, za ocenjevanje okoljskih vplivov, pri poročanju o napredku trajnostnega razvoja, etc.

V pričujočem članku je predstavljena dinamična skupina okoljskih kazalnikov glede prednostnih nalog, za katere v Luki Koper opravljajo programe monitoringa.

Glavni namen članka je osvetliti obseg in stopnjo vplivov delovanja Luke Koper na okolje. V ta namen so bili uporabljeni naslednji kazalniki: tovorni promet, imisijske koncentracije

suspendiranih delcev PM10, celotna količina odloženih suspendiranih delcev, imisijske koncentracije prahu in hlapljivih organskih zmesi (npr. bencin, gorivo za reaktivne motorje, o-ksilen), raven hrupa, deleži ločeno zbranih odpadkov, enota obremenitve okolja za odpadne vode, kakovost usedlin. Izbrani okoljski kazalniki, ki zajemajo daljše časovno obdobje, so primerjani z nekaterimi normativnimi referencami. Vse okoljske meritve so opravile pristojne službe z uporabo standardnih metod in opreme.

Kazalniki kakovosti zraka (PM10, odloženi suspendirani delci, hlapljive organske zmesi) kažejo na skladnost z normativnimi referenčnimi vrednostmi zakonodaje. Povprečna koncentracija PM10 se je postopoma zmanjšala v zadnjih dveh letih (za približno 7 %), kar govori v prid dejstvu, da so skupni preventivni ukrepi in dejavnosti, ki jih opravljajo v Luki Koper, učinkoviti. Koncentracije vseh suspendiranih delcev, odloženih v obdajajoče okolje in v druga luška območja, se gibljejo med 57 mg.m-2.dan-1 in 120 mg.m-2.dan-1 in zatorej ne presegajo ciljne ravni 200 mg.m-2.dan-1. Izgube hlapljivih organskih zmesi, kot posledica pretovarjanja in skladiščenja, niso nikoli presegle meje 0,01 % ali 0,005 %.

Luka Koper si s svojim sistemom za nadzor hrupa prizadeva ravnati v skladu z zakonodajo in hkrati skuša še nadalje zmanjšati raven motečega in neželenega hrupa. Povprečne dnevne ravni hrupa Luke Koper se gibljejo med 55 dB in 62 dB, povprečne nočne ravni pa med 51 dB in 58 dB.

Posledica luškega učinkovitega upravljanja z odpadki je visoki delež (70 %) ločeno zbranih odpadkov. Poleg tega v Luki načrtujejo reciklažo svojih notranjih virov (odpadkov) z namenom, da se vpelje proizvodnja zelene energije.

Občinske odpadne vode so glavni vir odpadnih voda v Luki. V rabi so mnogi sistemi za čiščenje luških odpadnih voda, in tudi to je razlog, da je v zadnjih treh letih Luki uspelo zmanjšati enoto okoljskega obremenjevanja kar za polovico.

Stanje usedlin v luki je primerljivo s tistim v drugih delih Koprskega zaliva. In prav zaradi njihove kakovosti se lahko te usedline uporabijo za osuševanje zemljišč, obnavljanje polojev ali pa v gradbene namene.

Rezultati okoljskih kazalnikov in njihovi trendi kažejo na pozitiven pristop k zmanjševanju vplivov Luke Koper na okolje in bodo še naprej uporabljani kot primerno diagnostično orodje.

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