



REPORT SNO 5061-2005

Rehabilitation of the DTD-Canal in Vrbas

Assessment of the Environmental
Status, Pollution Sources, and
Abatement Measures



Industrial effluents are discharged untreated via I-64 lateral into the DTD-Canal

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Title Rehabilitation of the DTD-Canal in Vrbas. Assessment of environmental status, pollution sources, and abatement measures	Serial No. 5061-2005	Date 2005-09-07
	Report No. Sub-No. O-23046	Pages Price 103
Author(s) Dag Berge and Finn Medbø	Topic group International	Distribution Free
	Geographical area Serbia	Printed NIVA
Client(s) Municipality of Vrbas Ministry of Natural Resources and Environmental Protection (Serbia) Ministry of foreign affairs (Norway)		Client ref.
Abstract During the years 2002-2006 there has been undertaken a Rehabilitation Plan Study of the Grand Canal on the problem stretch from Crvenka to the Triangle downstream Vrbas. The aim of the study has been to assess the environmental status, assess and rank the pollution inputs from the different sources, assess the amount of sediments as well as their content of pollution, and, based on these assessments propose the most relevant mitigation measures to rehabilitate the Grand Canal to an acceptable status to the best of the aquatic environment, the water use interests, and for the people living in the area. The environmental status of the canal is very bad downstream the entrance of the laterals just upstream Vrbas and for the stretch down to the Triangle where dilution water is coming in via the "by-pass" canal (Becej – Bogojevo Canal). Particularly the situation is bad through Vrbas town. Here the canal almost is completely filled in with industrial sludge, there is no oxygen in the water, and there is in fact a great surplus of oxygen demand in the water. The water smells badly of sulphides and there are extremely high concentrations of coliform bacteria (levels of raw sewage). The water causes a health threat for the people living there. The Farmakoop Pig Farm, the two sugar factories Crvenka Sugar and Backa Sugar, and the slaughter house and meat factory Carnex, are the four "hot-spots" which are mainly responsible for the poor environmental situation in the canal. The effluents from these have to be controlled. Otherwise other measures will be of little value. Thereafter, the sewage discharge from the population in the three towns ranks in importance. After the 5-6 main pollution sources are controlled the canal can be dredged for removal of accumulated sediments with long term effects.		
4 keywords, Norwegian 1. Kanalrehabilitering 2. Miljøtilstand 3. Forurensningskilder 4. Tiltaksplan	4 keywords, English 1. Canal rehabilitation 2. Environmental status 3. Pollution sources 4. Abatement measures	



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O - 23046

Rehabilitation of the DTD-Canal in the Vrbas region

Assessment of the Environmental Status, Pollution Sources, and Abatement Measures

Novi Sad 2005-09-07

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Preface

The report contains the following items: Assessment of the environmental status in the canal, in the laterals, in the sediments, assessment of the pollution sources, and analysis and prioritisation of abatement measures. The project is cooperation between the Norwegian Institute for Water Research (Oslo), NECW-Renesansa (Novi Sad), Chem. Inst. Univ. Novi Sad, and Agr. Inst. Univ. Novi Sad, with contribution also from the Czech company Dekonta.

The field work is mainly performed by the local institutions after initial guidance from NIVA. The chemical analysis is performed by Chem. Inst. Univ. Novi Sad with Bozo Dalmacija and Ivana Ivancev Tumbas as responsible persons. The pollution from agriculture is studied by Maja Cuvardic and Vladimir Hadzic at the Agr. Inst. Univ. Novi Sad. The collection of samples, as well as water flow measurements from the industry, is performed by Tanja Bosnjak (NECW Renesansa). The description of the water use is given by Vera Cvejic (NECW Renesansa). The sediment study is performed by Dekonta Inc. from the Czech Republic under the leadership of Ondrej Urban. Snezana Sokolovic has been the interpreter through the whole project period, and through interpreting simultaneously during meetings as well as translating documents and reports, she has facilitated our work considerably.

Finn Medbø (NIVA) has been the project leader throughout the whole project period, and has organised all the work in the project. The treatment of the material and compiling the report is mainly done by Dag Berge, NIVA, with assistance from Vera Cvejic and Tanja Bosnjak NECW-Renesansa.

The clients are the Serbian Ministry of Environment in Beograd, and the Vrbas Municipality lead by the Mayor and his board. The project is financed by the Norwegian Ministry of Foreign Affairs.

I want to thank all the project participants for good co-operation and a positive attitude throughout the project period. I also want to thank the managing and political leadership in Vrbas municipality for giving our work high priority, and the DTD-canal administration for excellent service.

Oslo 2005-09-07

Finn Medboe

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Summary and Conclusions

During the years 2002-2006 there has been undertaken a Rehabilitation Plan Study of the Grand Canal on the problem stretch from Crvenka to the Triangle downstream Vrbas. The aim of the study has been to assess the environmental status, assess and rank the pollution inputs from the different sources, assess the amount and pollution in the sediments, and, based on these assessments propose the most relevant mitigation measures to rehabilitate the Grand Canal to an acceptable status to the best of the aquatic environment, the water use interests, and for the people living in the area.

The monitoring has shown that the environmental status of the canal is very bad downstream the entrance of the laterals just upstream Vrbas and for the stretch down to the Triangle where dilution water is coming in via the “by-pass” canal (Becej – Bogojevo canal). Particularly the situation is bad through Vrbas town. Here the canal is almost completely filled in with industrial sludges, there is no oxygen in the water; there is in fact a great oxygen demand in the water. The water smells badly of sulphides and there are extremely high concentrations of coliform bacteria (levels of raw sewage). The water causes a health threat for the people living there. The concentrations of the plant nutrients phosphorus and nitrogen are extremely high, which cause eutrophication problems both here, and far downstream. The water has periodically high concentration of mineral oil which can both be seen and smelled when passing the Bridge in Vrbas (often smells of diesel). Intermittently, also high values of some heavy metals are found. The sediment that has filled in the canal consists mainly of soil from washing the sugar beets at the two sugar factories, and organic waste from the Farmakoop Pig Farm. However, they are in some places slightly contaminated by heavy metals and PCB. They are regarded as moderately polluted.

The main pollution problems is confined with discharge of oxygen consuming organic material stealing the oxygen out of the canal water, discharge of particulate matter filling in the canal with sediments, nutrients creating nuisance algae and plant growth, as well as contaminating the canal water with tremendous amounts of coliform bacteria. The Farmakoop Pig Farm, the two sugar factories Crvenka Sugar and Backa Sugar, and the slaughter house and meat factory Carnex, are the four “hot-spots” which are mainly responsible for the poor environmental situation in the canal. The effluents from these have to be controlled. Otherwise other measures will be of little value. Thereafter, the sewage discharges from the population in the three towns rank in importance. A new central wastewater treatment plant can, however, also be used to treat some of the industrial effluents in the area, so this measure should be ranked on the same level as the four hot-spots mentioned before. The metal effluents from Istra should be controlled through implementation of measures at the factory.

When the above mentioned 5-6 main pollution sources are controlled the canal can be dredged for removal of accumulated sediments with long term effects. The sediments cannot be disposed as agricultural soils because of contamination, but they can be used for park (recreation) soils, forest soils, etc. They are not so polluted that they will cause any ground water problems.

When the main pollution sources are controlled, after-polish can be done by implementing more diluting flow of water from the Mali Stapar - Vrbas sluice systems. It may be that there also should have been performed some vegetation clearance works along the canal between Crvenka and Vrbas locks, as many years of low flow has created massive reed belts along the canal in many places. This hampers the water flow in the canal.

The diffuse runoff from agricultural fields does not create any significant problems for the canal at this stage. When the “hot spots” measures are successfully carried out the reduction of diffuse area runoff from agriculture can be re-evaluated as an additional measure. The main agricultural pollution

problems are confined with the large scale animal husbandry, and in particular the handling and disposal of manure.

It should be noted that even at the stretches upstream Crvenka, where the canal is regarded as healthy, the canal is highly eutrophic. This is due to discharges from the upstream population and agriculture activities. The same also applies for the stretches downstream of the triangle. When the hot-spots in the Crvenka-Vrbas region are controlled, there should be performed a surveillance of the whole DTD-canal system to check the water quality and identify the most important pollution sources, and to plan an action against these. First then the Grand Canal can serve a healthy aquatic environment and fulfil the quality requirements of the water use interests in the area.

1. Introduction

The Donau-Tisa-Donau Canal, shortly called DTD-canal, or Veliki Kanal (Grand Canal), was built in the 17th century, partly for transport and water supply, but also with the purpose of draining the wet and fertile soils of the Backa district of Vojvodina.

In the 20th century the area between Crvenka and Vrbas was heavily industrialized. This also resulted in increased settlements in the small towns along the canal. The canal became more and more polluted, and in the worst stretch around Vrbas the canal is more or less filled in with industrial sludge. Sugar beet processing factories, pig farms, slaughterhouses, food oil factories, metal processing factories, is the worst polluters in addition to untreated sewage from the towns. In addition to causing local problems, the pollution of the Veliki Kanal is a problem for Tisa River, and constitutes also a significant pollution source for the Danube River.

The aim of the study has been to assess the environmental status, assess and rank the pollution inputs from the different sources according to their importance, assess the amount and pollution in the sediments, and, based on these assessments propose the most relevant mitigation measures to rehabilitate the Grand Canal to an acceptable status to the best of the aquatic environment, the water use interests, and for the people living in the area.

The work comprise study of the pollution status of the canal, the pollution of the laterals, (which are parallel canals leading into the DTD-canal), a study of the discharges from the 10 largest enterprises (concentration x flow), study of the pollution in the sediments, pollution load from agriculture and domestic sewage, abatement measure analysis, preparation of a prioritized action plan including a new central waste water treatment plant. The work is lead by Finn Medboe, NIVA, with assistance from Dag Berge. In Serbia we co-operate with Institute of Chemistry and Institute of Agriculture at the University of Novi Sad, and the consulting firm NECW Renesansa in Novi Sad, where we have the project office. The University of Belgrade are involved in the planning of the new central wastewater treatment plant. The Czech company Dekonta is involved in the sediment study. From Norway the COWI-Interconsult group are also involved.

2. Canal network in Vrbas area

2.1 The DTD-canal system

The DTD canal which joins the Danube and the Tisza from Bezdán to Becej is part of a complex canal system in Backa, and it consists of several canals linked together by locks and gate systems, see **Figure 1** and **Figure 2**. The length of the Grand Canal in the mid Backa is 118 km.

1. The canal "Vrbas-Bezdan", length 80,8 km (starts from triangle in Vrbas and join with Danube near Bezdan lock)
2. The section of canal "Becej-Bogojevo", length about 39 km (from Vrbas triangle to the hydro junction Becej on the confluence with Tisza)

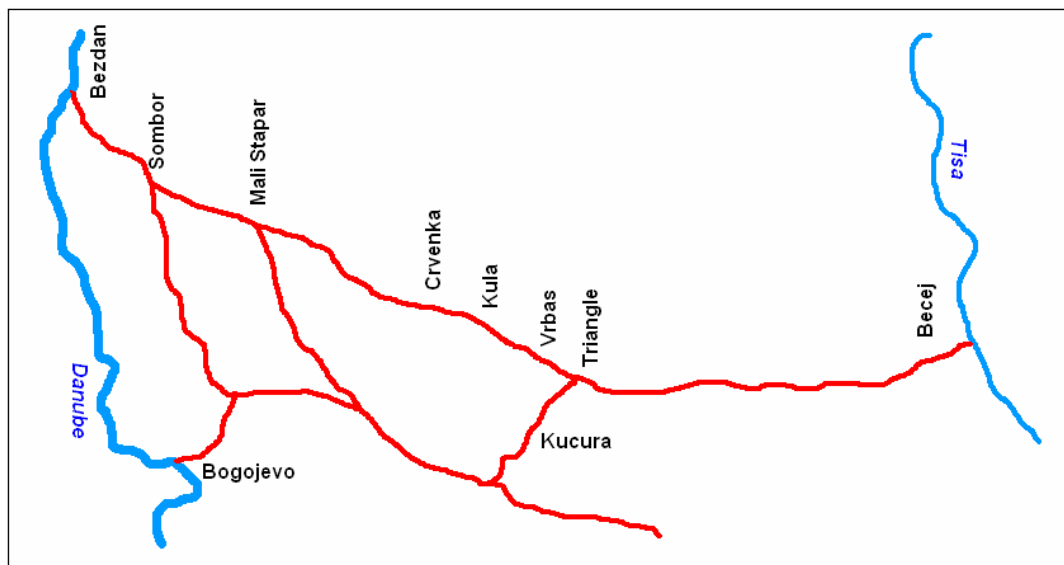


Figure 1. The DTD-canal system connecting Danube and Tisza.

With regard to elevation this part of the canal is split into three steps (basins), see **Figure 2**. These basins are:

1. Basin No.1. (lock Bezdán, pump-station Bezdán II, water gate Sebesfok, lock Sombor, water gate Mali Stapar)
2. Basin No.2 (lock Mali Stapar, lock Vrbas)
3. Basin No.5 (locks Vrbas and Kucura, hydro junction Becej)

All three basins are linked into a unique hydrotechnical entity: basin no. 1 gets water from the Danube, basin 2 gets water from basin 1, and it empties into basin 5.

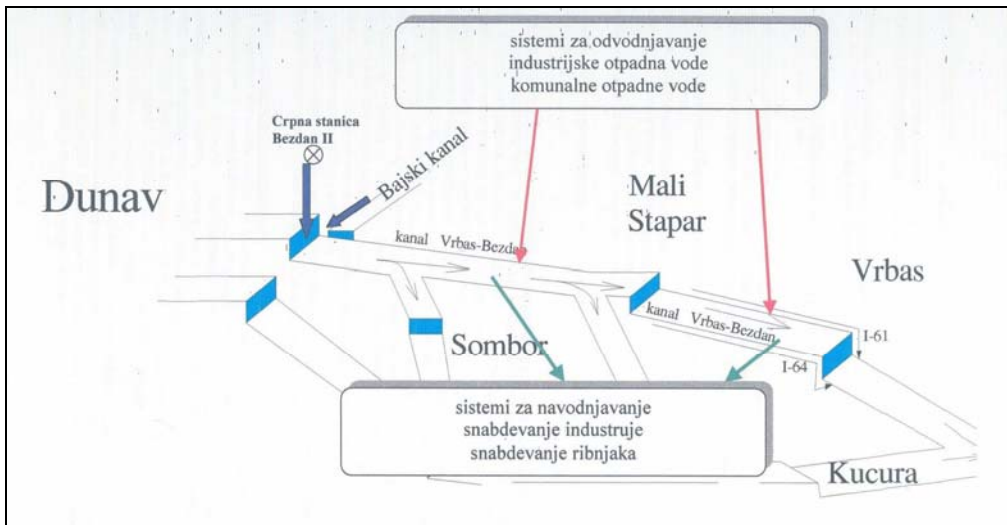


Figure 2. The DTD-canal system with the main locks in the Vrbas region

2.2 Quantity of water taken from the Danube

Annual water volume running through Mali Stapar lock is $51 \times 10^6 \text{ m}^3$ if it is a rainy year (like 2000) and $37 \times 10^6 \text{ m}^3$ if it is a dry year (like 2003), see **Figure 3**.

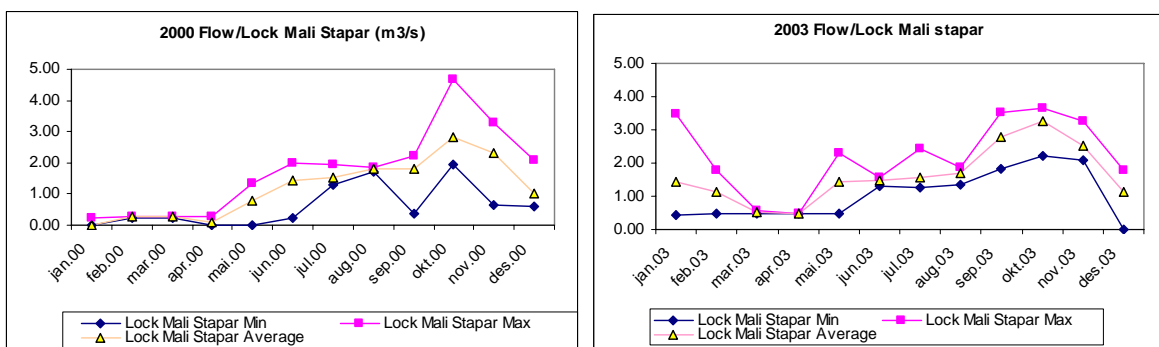


Figure 3. Water flow (m^3/s) through Mali Stapar Lock in a rainy year (left panel) and a dry year (right panel)

Annual water volume running through Kucura lock is $185 \times 10^6 \text{ m}^3$ (rainy year 2000) and $134 \times 10^6 \text{ m}^3$ (dry year 2003), see **Figure 4**.

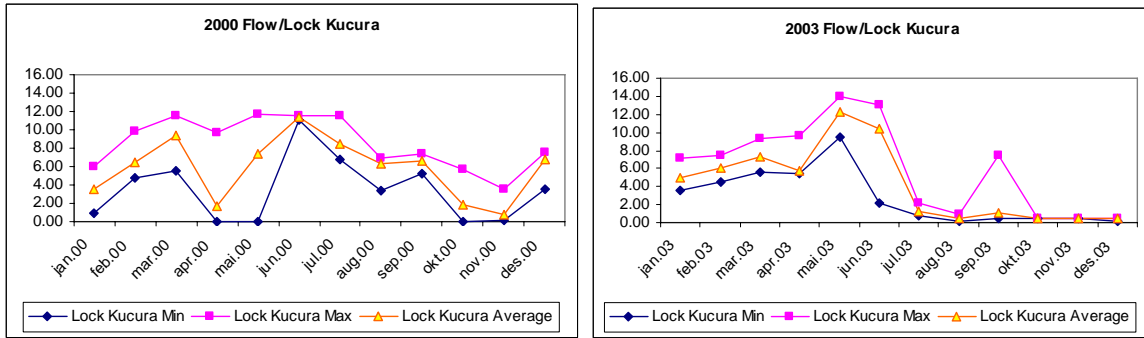


Figure 4. Water flow (m³/s) through Kucura lock in a rainy year (left panel) and a dry year (right panel)

Annual water volume running through Vrbas lock is $19 \times 10^6 \text{ m}^3$ (rainy year 2000) and $10 \times 10^6 \text{ m}^3$ (dry year 2003), **Figure 5**.

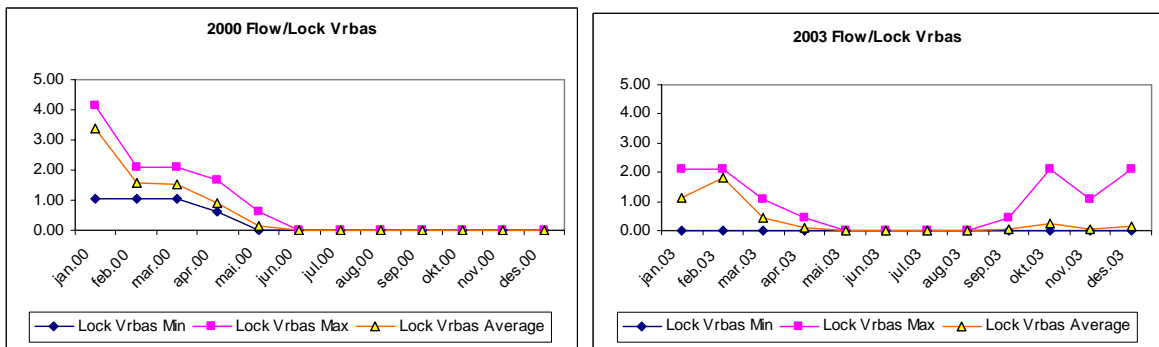


Figure 5. Water flow (m³/s) through Vrbas lock in a wet year (left panel) and a dry year (right panel)

Annual water volume running through Becej lock is $238 \times 10^6 \text{ m}^3$ (rainy year 2000) and $178 \times 10^6 \text{ m}^3$ (dry year 2003), see **Figure 6**.

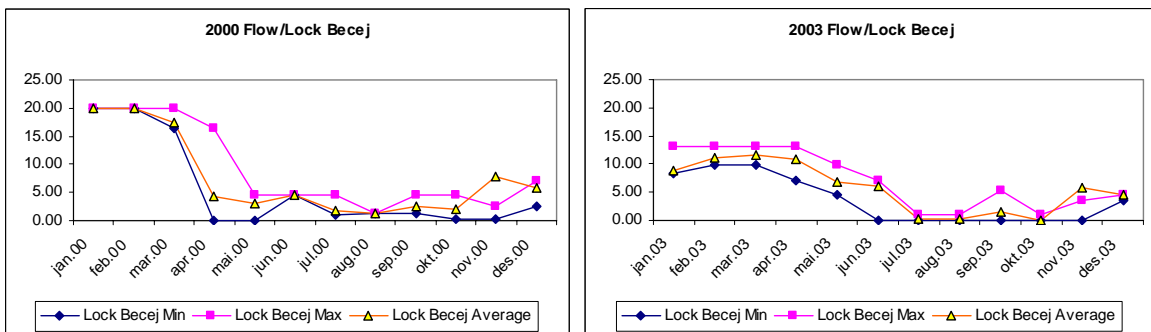


Figure 6. Water flow (m³/s) through Becej Lock in a wet year (left panel) and a dry year (right panel)

2.3 Water regime in Vrbas area

For the water regime in that part of the DTD canal system 3 periods of exploitation are important:

1. Period of high water levels in the Danube near Bezdán- this is a period of flood defence
2. Vegetation period – no-flow period
3. Period of sugar production campaign

Sugar production campaign begins in mid September and lasts until the end of December, depending on the volume of the beet production. Water flow in the Canal is adjusted to the situation of the large waste water quantities generated by sugar beet processing since all waste water reaches the Grand Backa Canal downstream the lock in Vrbas (through the lateral I-64). The polluted water is prevented from entering Tisza by closing the Becej, Kucura and Vrbas locks. The only water that enters the basin 5 in this period is the polluted flow from the laterals I-64, KC-III and I-61.

The flow rate in the canal from Vrbas to Becej slows down during the sugar campaign and the plume of waste water from the sugar production reaches Becej slowly. The fish farm in Becej has enough time to take water from the canal for the winter period and store it in their lakes (large ponds). Under normal flow conditions, the plume would reach Tisza in two or three days, and that part of the canal would become problematic for the fish farming and for all purposes. Use of the canal water in Becej is thus prolonged. The oxygen consuming polluted plume would also have created ecological problems in the River Tisza if it had been allowed to reach Tisza in September, when the water still has high temperatures.

3. User interests

When the Grand Canal was built in the late 17th century, the main purpose was for transport, for drainage of the water soaked soils of this part of Vojvodina, and partly for irrigation water in dry summers. After the canal was built, it was the main water way in the region and settlements increased along the canal, so did establishment of different enterprises. Traditionally the canal has been used/are used for the following purposes:

- Drainage
- Irrigation
- Industrial process water
- Fish farming
- Bathing and swimming
- Fishing
- Tourism
- Recipient for wastewater

3.1 Drainage

One of the main reasons for the Grand Canal construction was to collect and drain water from swampy terrains within the entire area of Kula and Vrbas. Today, the level of underground water is still high in Vrbas, as it is in the whole area, and the Canal has the same important function of drainage. The level of underground water, according to dates VP DTD (2000), is about 1.2-4 m from the soil surface level.

The laterals I-64 and I-61 are originally designed to collect water drained from agricultural areas. Drainage areas in Backa region are 550 000 ha from which the main canal network receives 156 m³/s of water. The Public Water Management Company «Backa» takes care of the Grand Canal user interests.

3.2 Irrigation

Irrigation is very important for Vojvodina's agriculture, but it was neglected during the years of crisis. Analysis shows that all 3.5 million hectares of cultivable areas could be irrigated, but now less than 1 % and not more than 30 thousand hectares of land are irrigated.

PIK BECEJ-POLJOPRIVREDA AD cultivates 14.5 thousand hectares of land, and irrigates 4.5 thousand hectares. Irrigation increases the yield of wheat for about 30 % depending on the meteorological conditions during the year (100 % if it is a dry year).

Dvorski Nandor, B.Sc in Technology, responsible for irrigation in PIK Becej, says that in 2003 they used about 10 million m³ of water for irrigation of 4,000 hectares of land, and in 2004 they used about 1.7 million m³ of water for the same area, which clearly indicates the dependence of irrigation demand on annual rainfall in this region. The water for irrigation has to be of adequate quality, which means it must not contain salt, mainly sodium carbonate (NaCO₃) because soil irrigated with this water might become salty. Salt problem is not directly connected with the DTD canal (there is ca. 300-400 mg of salt in dry residue). The problem is in 26 km of the small canal network controlled by this company; because there the water becomes enriched in salt (salt washes off from agricultural land during hydrological cycles out of irrigation season, about 2000 mg/l of sodium salts). This company has a need for fresh water, so they pump out water from the small canal, and fresh water comes in gravitationally from the Grand Canal. For more than twenty years they have been monitoring the quality of irrigation water on several locations, two times per month during irrigation season and once a month the rest of the year. The season of wheat growth lasts from the beginning of May until the end of August, sometimes in October and November.

The company PIK Becej, with 4,500 ha of irrigated land, represents one sixth of active irrigation systems in Serbia. Director General of this company, Mr. Dragan Sataric, says (to the press) that they will continue to give maximum contribution to irrigation development, which is a very important activity of modern agriculture. For that goal, the company has already prepared development projects; one is to expand the existing system for 900 ha, and new projects for irrigation of 4.5 million ha of land. The aim is to have 10,000 ha out of 14,500 ha of their land irrigated.

PIK Becej also has pig farms with 100,000 pigs. Waste generated on the farm is used as fertilizer, since they collect as much as about 300-500 thousand m³ of manure (the quantity depends on weather conditions). The company saves about 200-300,000 euros/year for fertilizers in that way.

3.3 Water supply

Water supply for people in Vojvodina, like in Vrbas area, mainly comes from underground sources. Some industries take water from the Canal for their processes, like «Panon», «Crvenka Sugar» (Crvenka), «Eterna» (Kula), «Bačka Sugar» and «Vital» (Vrbas).

3.4 Recipient for waste water

The Grand Canal is a recipient of waste waters (industrial and sewage) from Sombor, Odžaci, Kula, Vrbas, Srbobran and Becej. The canals recipient capacity is today clearly exceeded, and the need for effluent treatment is urgent.

3.5 Boat traffic

Boat traffic in the Grand Canal downstream from Sombor to Vrbas is impossible because of the sludge accumulated on the canal bottom downstream of the lateral entrances just upstream Vrbas, approximately 350 000 m³. Annual deposit of sludge is some 20,000 m³ coming mainly from the lateral I-64. The Canal depth on some points does not exceed 30-40 cm and 90% of canal bottom is covered with industrial sludge.

3.6 Fish farming

The rivers Danube, Tisza, Tamis, Begej and others, including the main canal network (DTD-Canal) make this area very rich with water. Total area of fish ponds in Vojvodina is 13,500 hectares. Fish farms breed: Carp, (*Cyprinus carpio*), Pike-perch (*Styzostedion lucioperca*), Catfish (*Ictalurus punctatus*), Pike (*Esox lucius*) and Sturgeons (*Acipenser ruthenus*). Total production of fish in Serbia is about 8 000 – 10 000 tons per year.

RJ "Ribnjak" fishfarm is a part of PIK Bečej-poljoprivreda AD near Becej. This fish farm is located between Becej and Backo Gradiste covering the area of 625 hectares. The basic activities of the fish farm is production of young fish ("stocking fish") and fish for human consumption, mainly for the domestic market, this according to Pavle Duragin, a technician on the fish farm.

The fish farm is connected with the Grand Canal via three water intake pipelines with the capacity of 1.5-2 m³/s. The fish farm consumes 12.5 million m³ of water/year. Water is discharged without any treatment gravitationally into a sleeve of Tisza called the Dead Tisza and from there to the Tisza.

The fish farm produces for its own needs over 200 tons of one-year and two-year old carp fish, also one part of young fish of herbivorous species. Also, they produce perch and catfish, but in small quantities. The problematic species in the fishponds is silver carp, which enters the ponds from the canal, over the water scoop in the spawning period. Annually, fish farm catches and delivers to the market about 450 tons of consumption fish, while another part of the fish production they use for their own retail trade and restaurant. Besides this production, the fish farm also supplies sport fishing and tourism resorts.

Other fish farms in this area are in Ruski Krstur (101 ha), Despotovo (190 ha), Kula (10 ha).

Optimal conditions for fish breeding in the Grand Canal, and in fish ponds are: Temperature of water 0.5-29.6°C, dissolved oxygen more than 5 mg/l, pH value 6.5-8.5 units, BOD₅ less then 8 mgO₂/l, CO₂ less then 10 mg/l. Remaining parameters (ammonium, nitrates, sulphates, chlorides, iron, mercury, etc.) should satisfy the Serbian Water Quality Criteria for class I or II. The ponds take water from the Grand Canal in spring (March-April) when the fish farm starts the annual production cycle with young fish. In the fall (October-November), the fish is taken out and the water discharged. During the winter, the fish farm is empty, but water, in general, is necessary all year round because one part of the ponds contains young fish which spend the winter there, and also fish which has not been sold. It is necessary to renew the water in the breeding season in the fishponds.

The period with highest pollution in the Grand Canal starts with the sugar production campaign in September. By October the pollution reaches the water scoop of the fish farm, and then water in the canal cannot be used in the fish farms. This period last until last January (or more precisely until February), and it is the wave of sugar waste pollution that kills the fish in the canal, and its length is about 3-4 kilometres.



Figure 7. Fish kills happens every year in the canal during the sugar campaign (Photo: Djuragin P.)

3.7 Tourism and recreation

According to the poll conducted by LEAP Vrbas, 83.8 % of the people in this area think that their environment is much endangered, but most of them are concerned about the air quality rather than water quality.

Hunting tourism is well-developed in this region. Domestic and foreign hunters, hunt: pheasants, rabbits, roe deer, and more rarely wild pigs and deer. There is only one hotel in this region, “Fantast” in Becej.

Fishing tourism is not possible in the canal to day due to the pollution problems. Downstream the Vrbas lock, fishing is not an issue, because there is no fish in that stretch of the Canal. The point where fishing might be considered an issue is on the Triangle and further downstream. Upstream the Vrbas lock, people still fish and it is regulated by means of fishing permits, etc. The quality of this fish is a discussable issue. In several countries boat based canal tourism has become popular. This is impossible to develop in the Backa canals with the current bad water quality status.

Bathing has been a forgotten sport in this region for many years. The main reason is the pollution of the canal. The sedimentation has made the canal too shallow and it is dangerous to wade in the soft deep mud. The surface water is dangerous to bath in due to all the different pollutants, particularly the extremely high concentrations of bacteria. Upstream the Vrbas lock bathing is possible, but people now feel safer going to the swimming pools.

4. Environmental and pollution status

4.1 Canal monitoring

As part of the assessment of the environmental status the Grand Canal has been monitored at 5 stations. These are:

Upstream Crvenka	Should give the background status upstream the polluted stretch
Upstream Kula	Should give the impacts from Crvenka area (except for discharges to the laterals)
Downstream Kula	Should give the impacts from Kula area (except for discharges to the laterals)
Bridge in Vrbas	Should give the impacts from discharges via the laterals (I-64, I-61 and KC-III)
Upstream the Triangle	Should include also possible discharges from Vrbas municipality
Downstream the Triangle	Should indicate the improvements due to dilution from the Becej-Bogojevo canal

4.1.1 Biological oxygen demand and oxygen concentration

Figure 8 shows the mean values of the BOD₅ observations at the 6 monitoring stations in the DTD-Canal. Downstream the entrance of the laterals, the canal contains tremendous amounts of BOD, and violates the Serbian water quality criteria for clean water by 40 times. Even the relatively clean looking water at Crvenka has higher BOD than the water quality criteria.

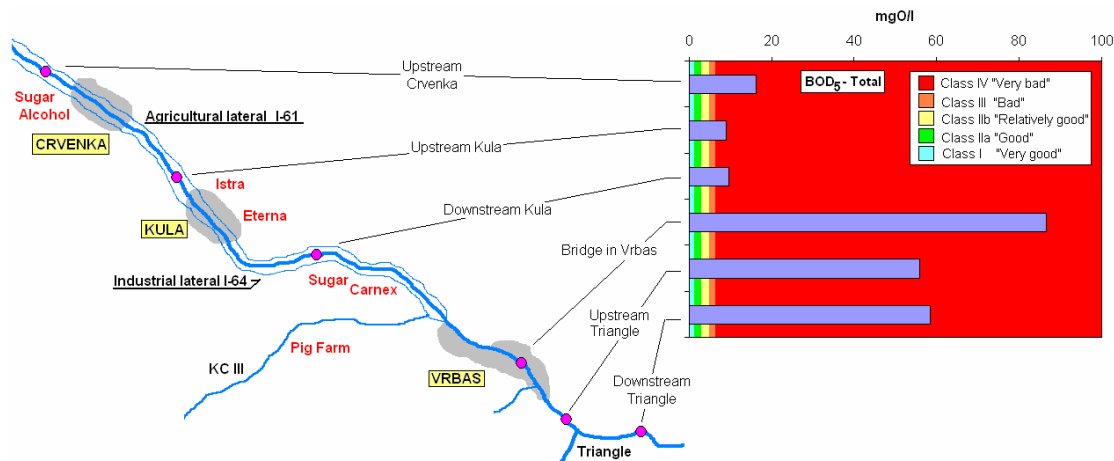


Figure 8. BOD₅-total. Mean values of the 6 observations at the different monitoring stations in the DTD-canal in 2003-2004, as compared with the Serbian water quality criteria.

How this high input of BOD impacts the oxygen concentration in the water is shown in Figure 9.

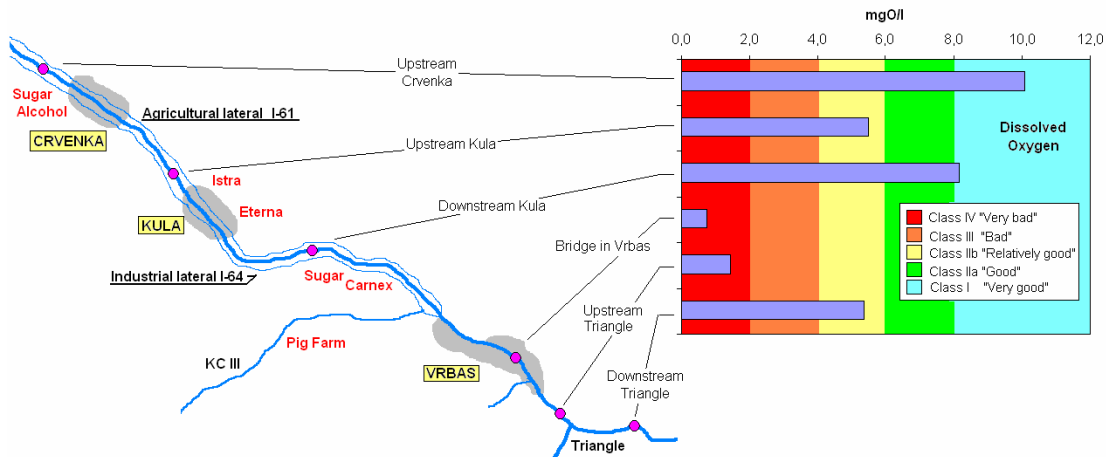


Figure 9. Concentration of dissolved oxygen. Mean values of the 6 observations at the different monitoring stations in the DTD-canal in 2003-2004, as compared with the Serbian water quality criteria.

The oxygen concentration is very bad on the stretch from the entrance of the I-64 lateral and down to the Triangle. Here diluting water is coming in via the Becej - Bogojevo canal. At the bridge of Vrbas several of the observations showed zero oxygen even in the surface.

The reason for the low oxygen is the large discharges of easily decomposable organic matter from the sugar factories, the Carnex, the pig farm, and also a lot of untreated sewage.

More detailed values can be seen in the primary data in the Appendix.

4.1.2 Nutrients - Phosphorus and Nitrogen

Figure 10 and **Figure 11** show the concentrations for total phosphorus (Tot-P) and total nitrogen (Tot-N) respectively. As the Serbian water quality criteria do not contain limits for P and N, we have used the limits recommended by the Danube River Commission (ICPDR) for comparison.

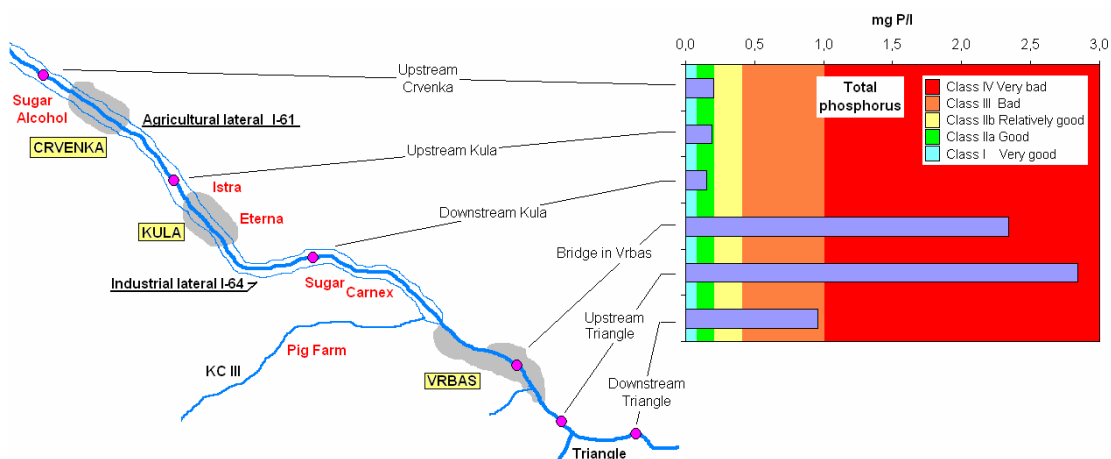


Figure 10. Concentration of Total Phosphorus. Mean values of the 6 observations at the different monitoring stations in the DTD-canal in 2003-2004, as compared with the water quality criteria recommended by the Danube River Commission.

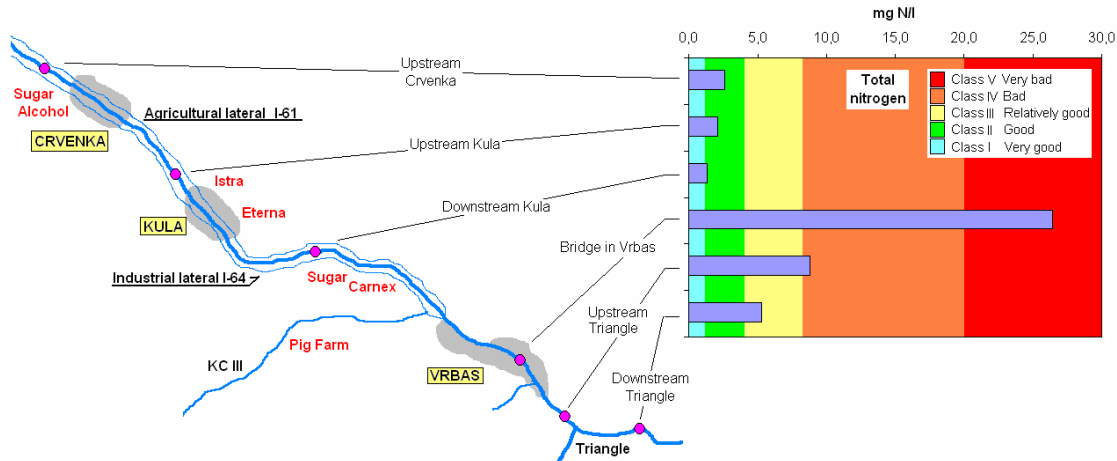


Figure 11. Concentration of Total Nitrogen. Mean values of the 6 observations at the different monitoring stations in the DTD-canal in 2003-2004, as compared with the water quality criteria recommended by the Danube River Commission.

For both P and N the situation is not so bad upstream Vrbas, but downstream the entrance of the laterals, the situation change dramatically and the water belongs to the worst class according to the Water Quality Criteria of the Danube River Commission. Nitrogen is reduced downstream most likely as a result of denitrification in the low oxygen containing water.

The total P is made of both particulate P bound to soil particles from the washing of sugar beet, but also a considerable amount of biological available ortho phosphate is observed from Vrbas and downstream.

The high nitrogen values are for a large part made up of ammonia coming from the industrial and pig-farm discharges via the laterals I-64 and KC III. The ammonia values are in periods above what is toxic to fish. More detailed data over the phosphorus and nitrogen fractions can be seen in the primary data tables in the Appendix.

4.1.3 Suspended sediments

Figure 12 shows mean values of the analysis of suspended solids at the different monitoring stations in the canal. All values are very high and in the worst water quality class of the Serbian water quality criteria. According to the EIFAC (European commission for inland fisheries) it is not possible to have any good fish production in waters above 100 mg/l of suspended sediments. It should be noted that the filter used has a pore size of 10 μm , which means that the clay and the fine silt fraction is not retained on the filter. International standards use filters with a pore size of 1.2 μm for this analysis. Much of the soil particles from I-64 are not retained on the filter. This means that the values from Vrbas should have been much higher. It should also be mentioned that the high values of the stations upstream and downstream Kula is to a large degree determined by one extremely high observation. If this is excluded, these two stations would have much lower values. More detailed information about the particulate content can be found in the primary data in the Appendix.

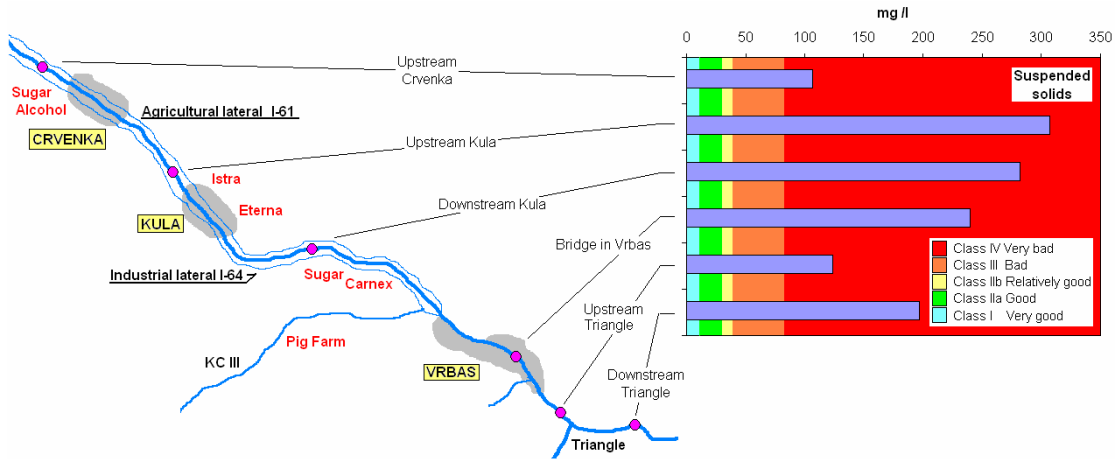


Figure 12. Concentration of suspended solids. Mean values of the 6 observations at the different monitoring stations in the DTD-canal in 2003-2004, as compared with the Serbian water quality criteria.

4.1.4 Total solids

Figure 13 shows the mean concentration of total solids (particulate and dissolved) at the different monitoring stations in the DTD-canal. It can be seen that in Vrbas a large increase in the inorganic part is observed. This is likely due to soil particles from the sugar factory. This analysis is done by evaporation which means that a considerable amount of the material is made up by natural minerals, like Ca, Na, K, Mg, Cl, SO₄, and HCO₃. Therefore, the results can not be related directly to pollution.

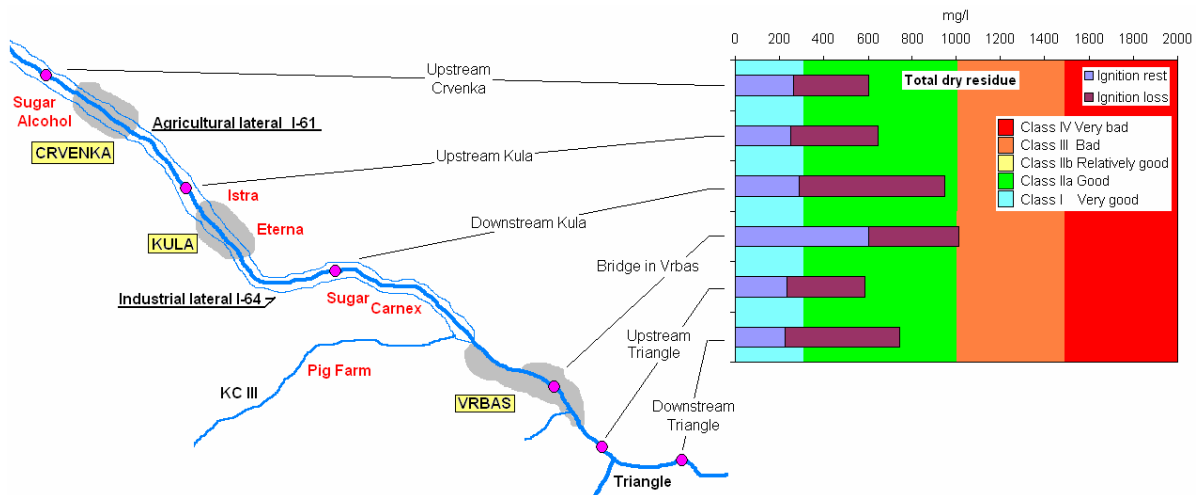


Figure 13. Total particulate matter (dry residue) in the canal at the different monitoring stations. Mean values divided into inorganic and organic fraction.

4.1.5 Heavy metals

In **Figure 14 - Figure 20** there are given values for some heavy metals monitored in the canal. Lead and cadmium exceed the Serbian water quality criteria considerably, while the situation is much better for the other metals.

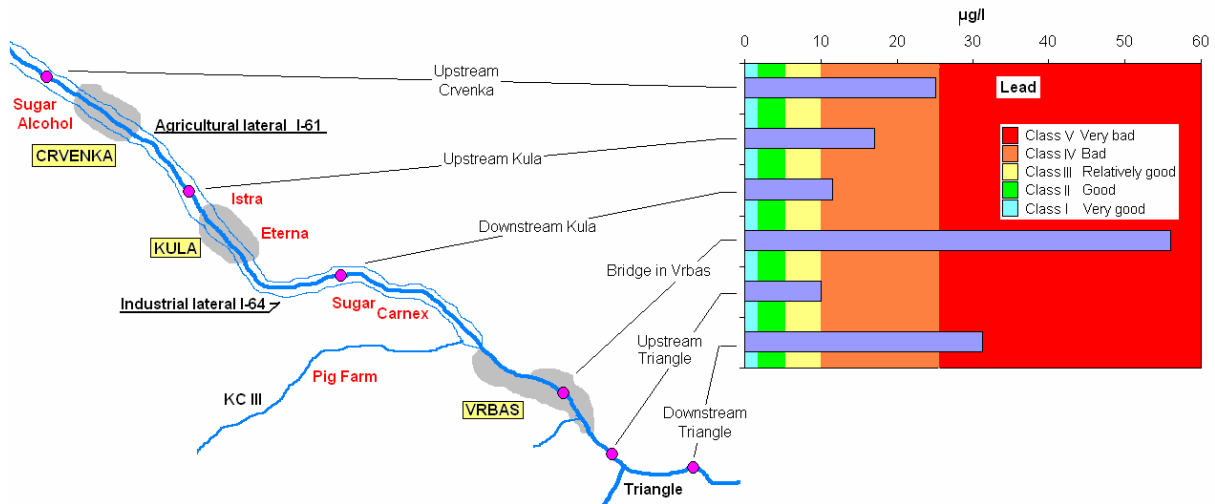


Figure 14. Mean concentrations of lead at the different monitoring stations in the DTD-canal, compared with the water quality criteria recommended by The Danube River Commission.

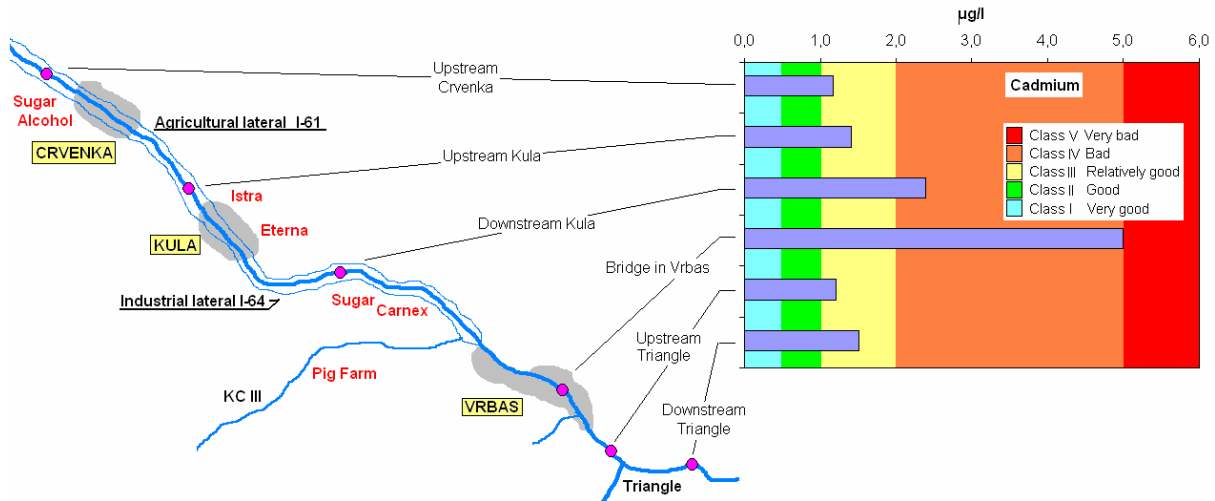


Figure 15. Mean concentrations of cadmium at the different monitoring stations in the DTD-canal, compared with the water quality criteria recommended by The Danube River Commission

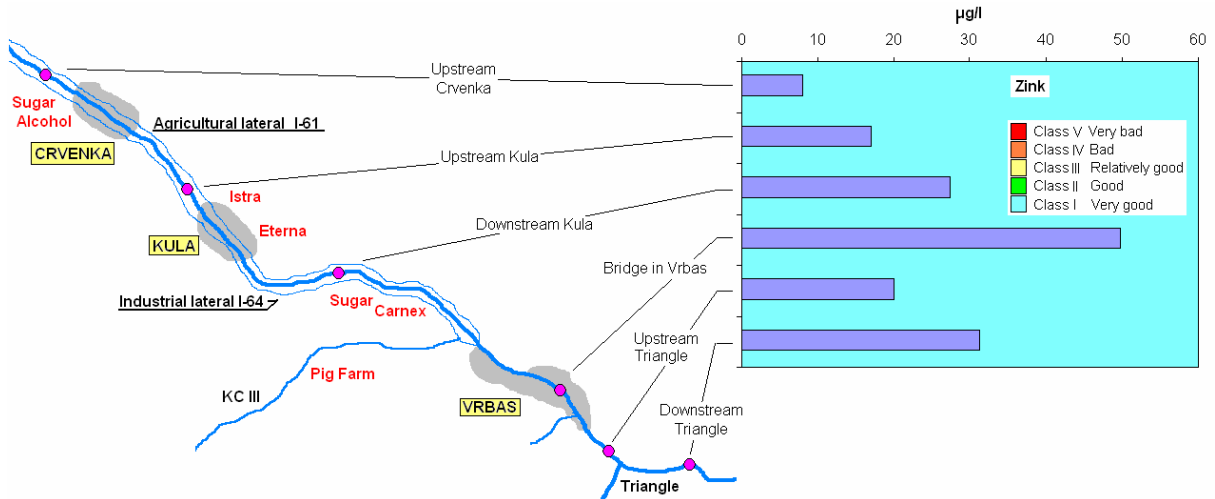


Figure 16. Mean concentrations of zinc at the different monitoring stations in the DTD-canal, compared with the water quality criteria recommended by The Danube River Commission

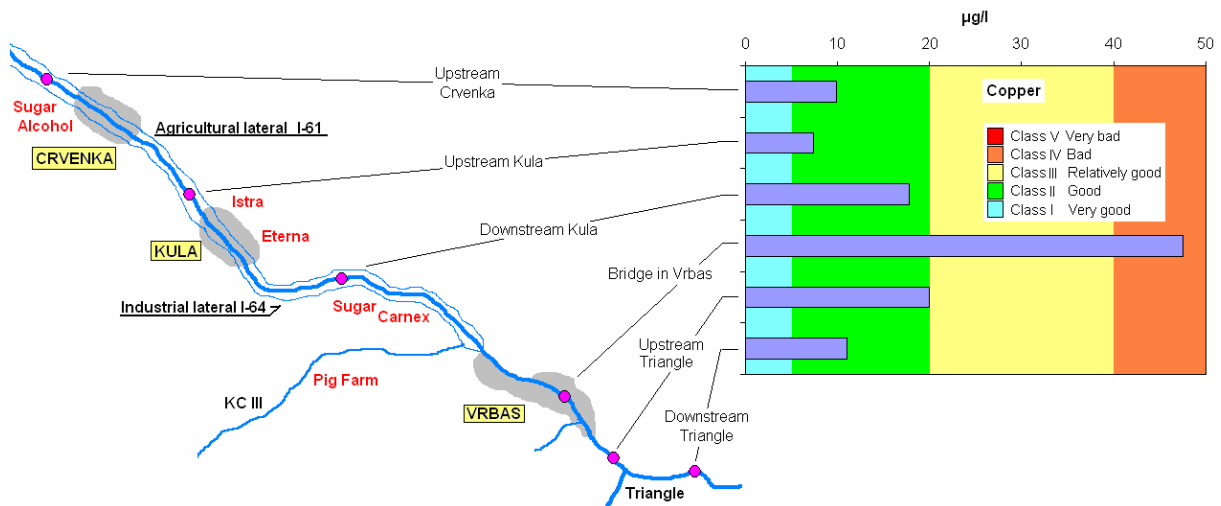


Figure 17. Mean concentrations of copper at the different monitoring stations in the DTD- canal, compared with the water quality criteria recommended by The Danube River Commission

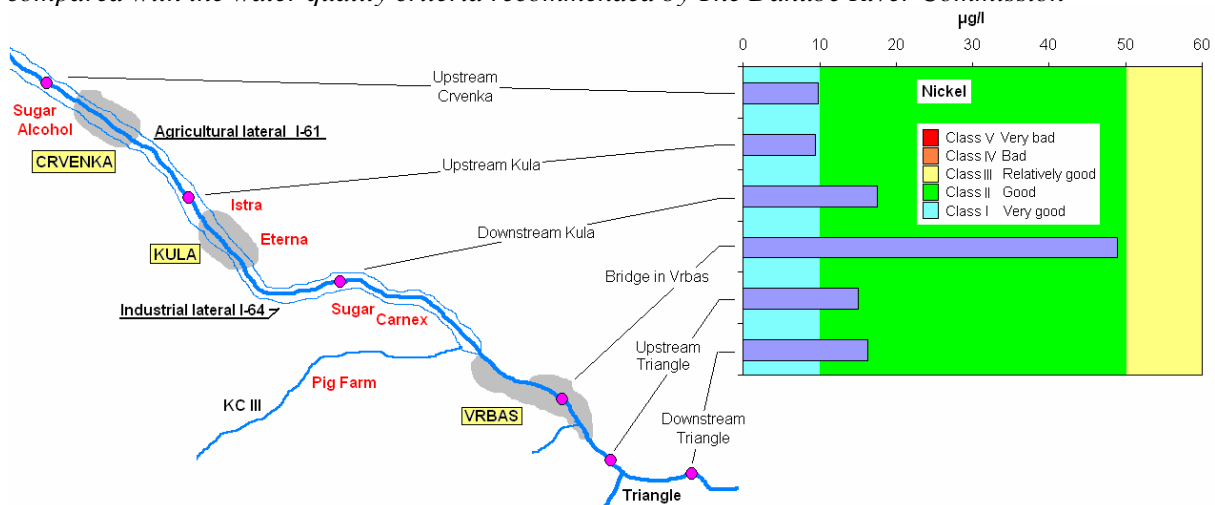


Figure 18. Mean concentrations of nickel at the different monitoring stations in the DTD- canal, compared with the water quality criteria recommended by The Danube River Commission

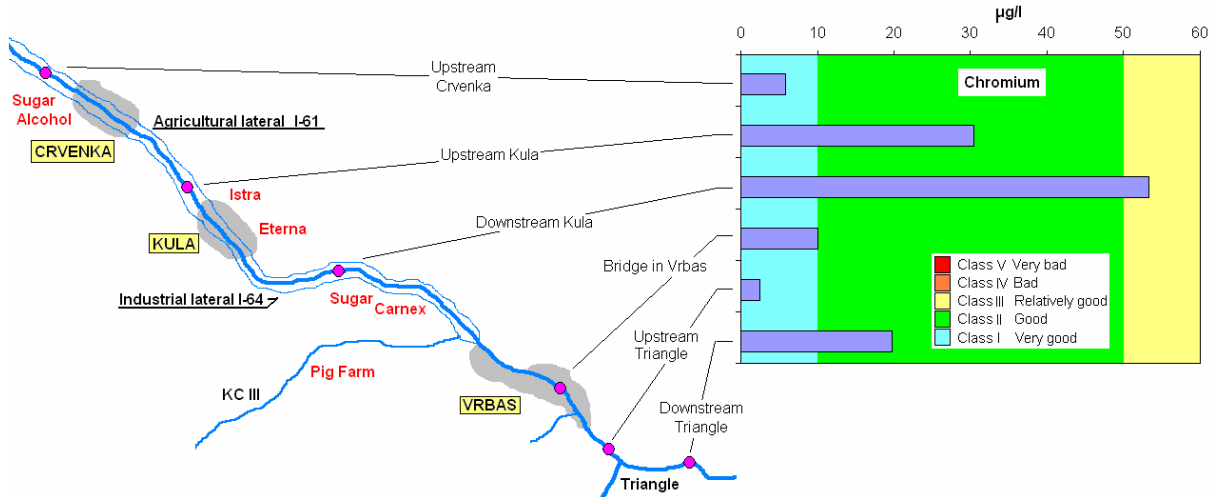


Figure 19. Mean concentrations of chromium at the different monitoring stations in the DTD-canal, compared with the water quality criteria recommended by The Danube River Commission

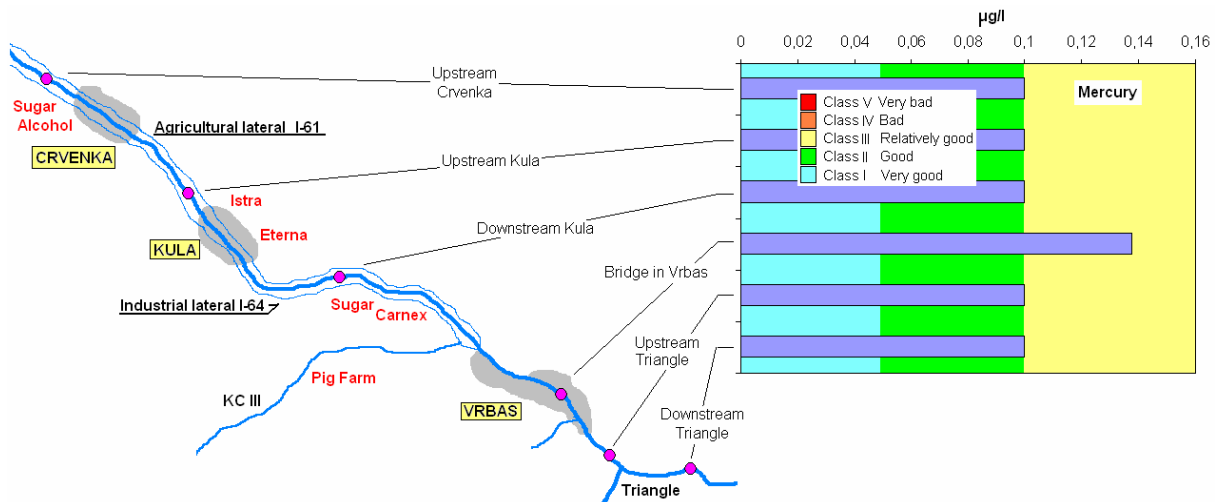


Figure 20. Mean concentrations of mercury at the different monitoring stations in the DTD-canal, compared with the water quality criteria recommended by The Danube River Commission

4.1.6 Organic micro pollutants

Mineral oil components

The concentrations of total mineral oil in the water samples from the canal are shown in **Figure 21**. The values upstream Vrbas were low, but at the Bridge of Vrbas they were very high. The highest observation was of 2800 µg/l. It was often seen oil layer on the top of the water and the water smelled of oil products.

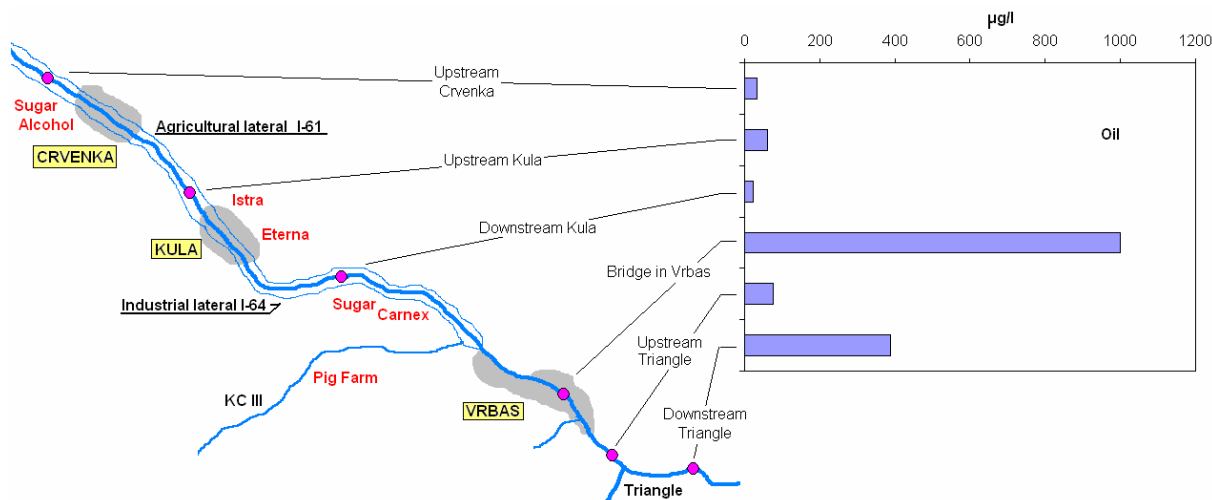


Figure 21. Concentration of total-mineral oil in the water samples at the different monitoring stations of the DTD-canal.

Polycyclic aromatic hydrocarbons (PAH)

PAH (polycyclic aromatic hydrocarbons) is a group of organic micro pollutants that occurs in many industrial processes that include burning, igniting, or glowing, of organic materials. Several of the compounds are known to be carcinogenic, of which the most known is Benzo-a-pyrene. The results from the analysis of Total-PAH in the water of the DTD-canal are shown in **Figure 22**. The values are low at all stations except for at the bridge in Vrbas. 34 ng/l tot-PAH is however, not considered as a high value. Inspecting this value more in detail revealed that it for the most part was made up of perylene, a compound that is known to be produced by micro organisms in anaerobic sediments, also in natural marsh-lands. The highly anaerobic conditions in the sediments in the Vrbas region of the canal, and laterals, are the most likely explanation. The results do not indicate any discharges of PAH.

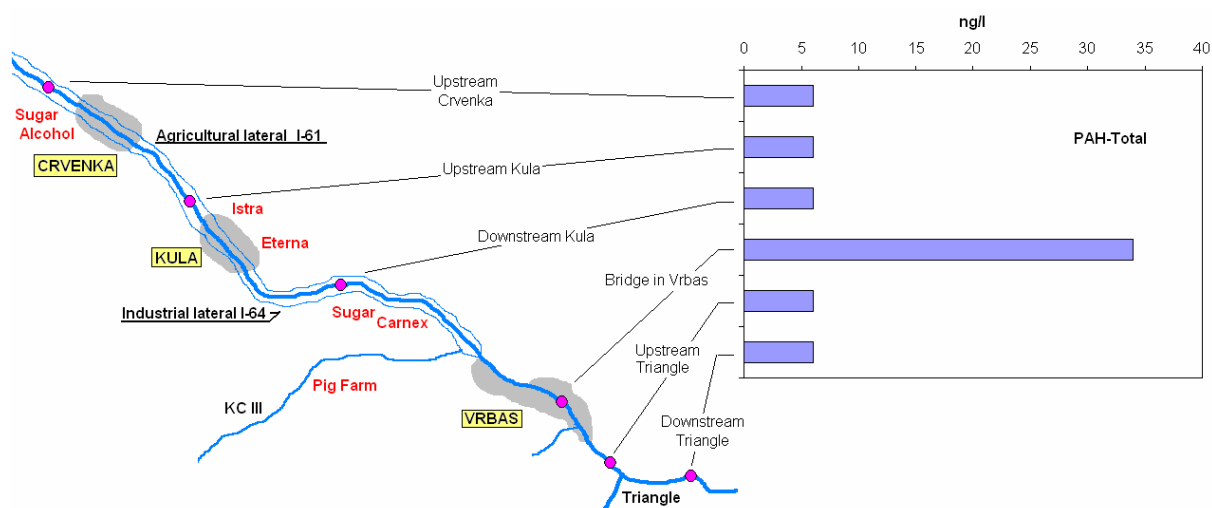


Figure 22. Concentrations of PAH-Total at the different monitoring stations in the DTD-Canal.

4.1.7 Hygienic pollution

Thermo tolerant Coliform Bacteria (TCB) is coming from the colon of warm blooded animals like humans and live stock animals, including also chicken. The content of these bacteria is an indicator on how infectious the water is with respect to transfer of water borne diseases. For example for drinking water, the content of TCB should be zero per 100 ml. Good bathing water should be below 100 bacteria per 100 ml, and above 1000 bacteria per 100 ml bathing is not recommended, i.e. there is then a great chance of getting some infections. **Figure 23** shows the concentrations of TCB at 3 different sites along the Great Canal.

The canal is very heavily loaded by faecal pollution, at the bridge of Vrbas the average concentration reached an incredible number of nearly 800 000 bacteria per 100 ml. This tremendously high number is to a large part due to the contribution from KC III which had an average concentration of 4 billion bacteria per 100 ml.

It should be noted, however, that even upstream Crvenka the canal is massively polluted by coliform bacteria, and the water quality is exceeding the limits for bathing, irrigation, and most human use categories even there. The lowest concentration recorded here were 500 bacteria per 100 ml, and even that is exceeding most human use categories. This indicates that the Grand Canal is receiving a considerable amount of faecal pollution (raw sewage, manure runoff, etc.) even upstream Crvenka.

It is confined with health hazards to use water from the canal for irrigation of products that are eaten without boiling, for example, salads and cabbage which trap irrigation water between the leaves, and for example strawberries, and other berries that are eaten directly without heat treatment.

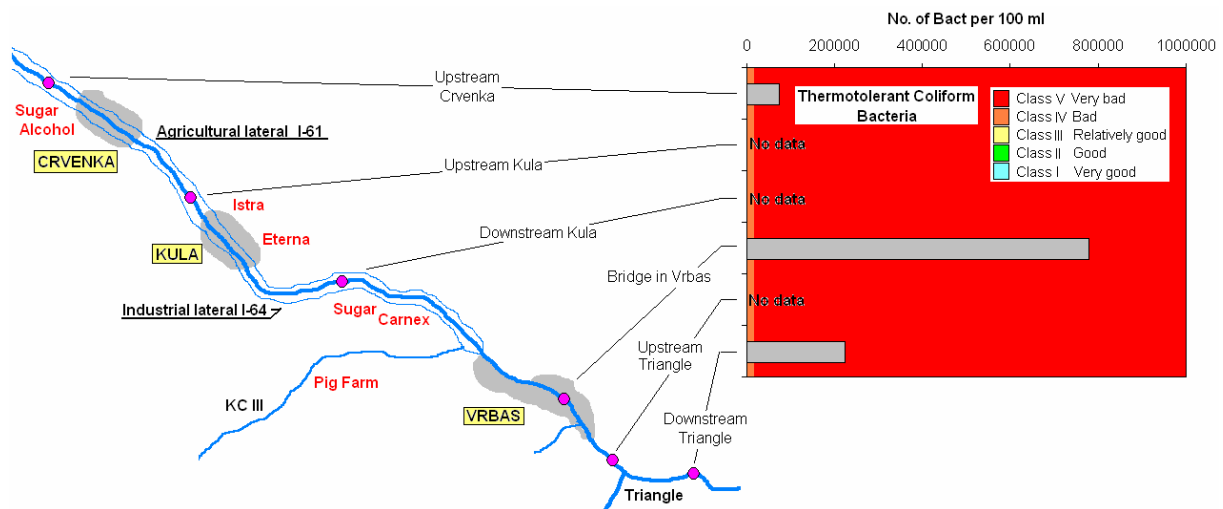


Figure 23. Faecal pollution in the Great Canal. Average concentrations of Thermo tolerant Coliform Bacteria (TCB) at three sites in the Grand Canal compared with the Serbian water quality guidelines.

4.2 Lateral monitoring

I-64 collects the industrial effluents south of the Grand Canal and I-61 the effluents and diffuse runoff from the agricultural land north of the Grand Canal. KC III collects the runoff and discharges from Farmakoop Pig Farm, and collects also runoff and discharges from a relative large semi-urban area between Kula and Vrbas which contains several small enterprises like for example several metal handling workshops, which also is handling oil products. **Figure 24** Shows the monitoring stations. It should be noted that the I-61 in Kula is lead into the GC, and starts over again downstream Kula. This means that the difference between the two monitoring stations in I-61 cannot be used as measure of what is coming from the agriculture on the stretch. The lowermost station in I-61 is representative for what is coming from the agriculture areas downstream Kula. The pollution from this agricultural area is also studied more in detail in a separate project (Cuvardic et al 2004, a summary of this is given in a later chapter in the report).

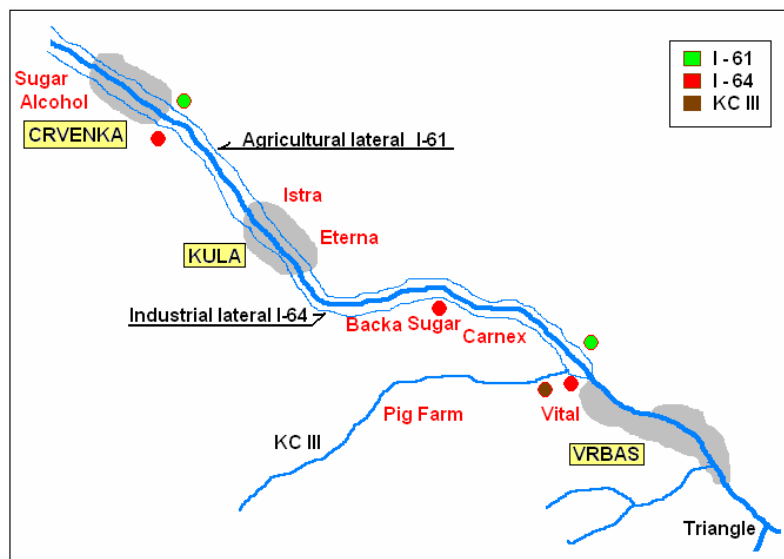


Figure 24. Monitoring stations in the laterals, I-64 (Industrial lateral), I-61 (Agricultural lateral) and KC III (Farm coop Pig Farm and several small enterprises).

From the monitoring of the GC it self it was evident that the main problems was discharges of 1) suspended particles which fill in the canal, 2) oxygen consuming organic matter which use up all the oxygen in the canal, 3) nutrients which increase growth of aquatic plants (plankton, periphyton, floating plants, and rooted macrophytes), and from Vrbas and downwards also some 4) heavy metals and 5) oil pollution. In the following paragraphs we present the results from the monitoring of these pollutant groups.

The Laterals are built to protect the canal from the pollution from the human activities, and to collect drainage water from the water soaked agricultural soil from Crvenka to Vrbas. In addition to receive effluent waters, it is fed by water from ground water seepage, as well as a certain leakage from the GC it self. In this way they are somewhat between ground water fed brooks and effluent collectors. It is not easy to relate the observed concentrations to any well established water quality standards.

4.2.1 Oxygen consuming organic material

The concentration of oxygen consuming material is monitored by Chemical Oxygen Demand (COD) using Dichromate as oxidiser. This gives a relative measure of the total amount of organic material in the water. In addition we have monitored the Biological Oxygen Demand (BOD₅) which is a measure of the amount of easily (biologically) degradable organic material. This analysis is most related to what steals the oxygen from rivers. The concentration of the two parameters at the different lateral monitoring stations is shown in **Figure 25** and **Figure 26**.

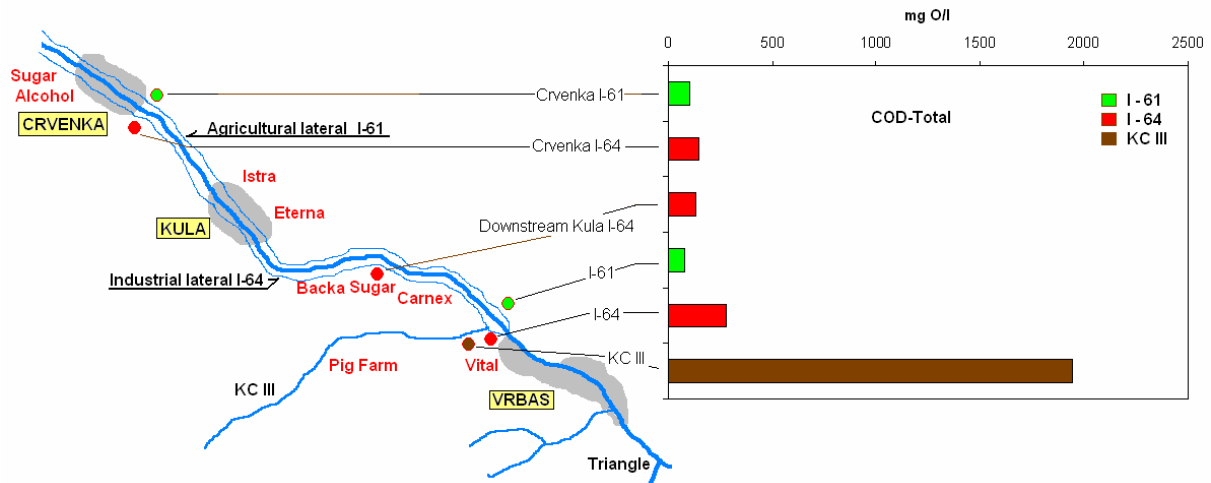


Figure 25. COD-total (chemical oxygen demand) in the water at the different lateral monitoring stations

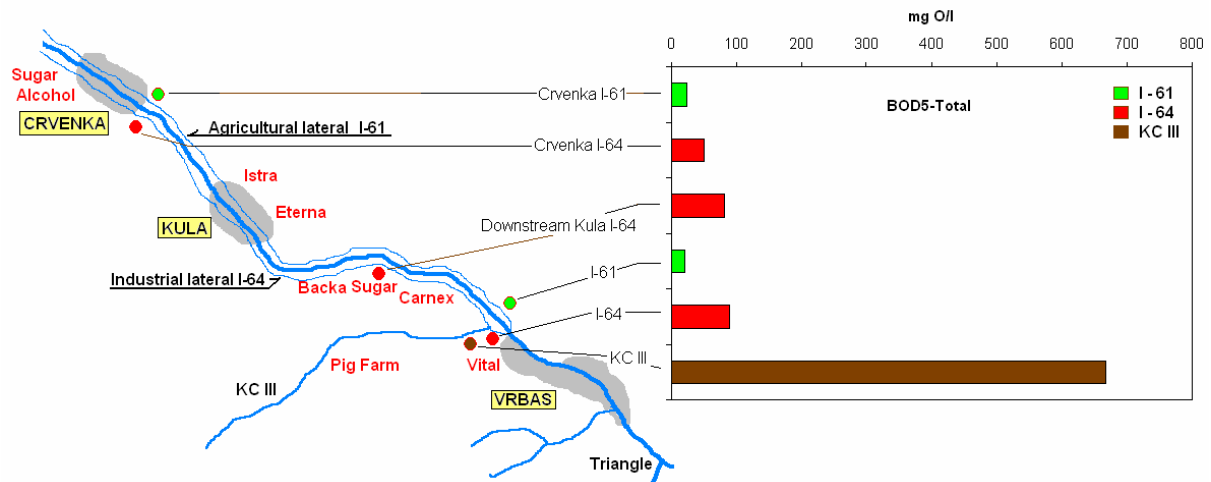


Figure 26. BOD₅-total in the water at the different lateral monitoring stations.

Both COD and BOD₅ showed high values at all stations. The lowest values were found in the agricultural lateral. In KC-III the values were extremely high. Natural concentrations of COD in unpolluted streams are from 4-50 mgO/l and BOD from 1-3 mg O/l.

In untreated raw sewage normal content of COD are 200-500 mg O/l, and BOD from 100-200 mg O/l. The KC-III is even worse than raw sewage. Most of the organic pollution in KC-III arises from the Farma-Coop pig farm.

4.2.2 Particulate material

The mean concentrations of particulate matter (>5 µm) at the different canal monitoring stations are given in **Figure 27**.

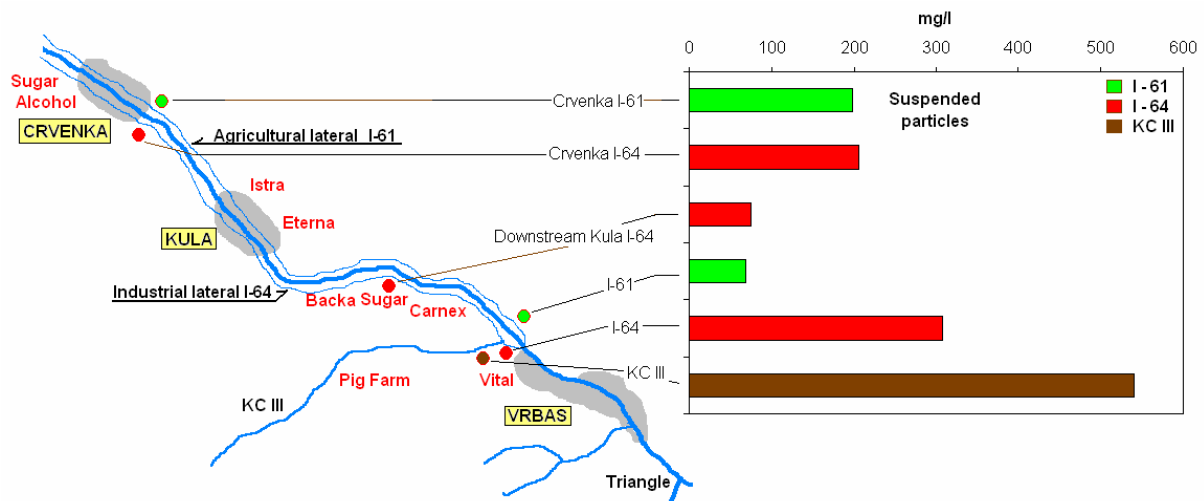


Figure 27. Concentration of suspended particles in the water at the different lateral monitoring stations

The content of particles in the laterals is partly a result of discharges and partly a result of erosion processes, both from the fields and from the lateral bed and banks. The relative high value in I-61 at Crvenka is most likely a result of erosion from the agricultural fields. This lateral is poured into GC in Kula. On the agricultural land that drains to lowermost station of I-61 there are only minor erosion processes taking place.

For I-64 there is a high concentration at Crvenka most likely due discharges from washing sugar beets at Crvenka sugar factory, it declines downwards until downstream the Backa sugar factory where it increases considerably due to discharges from sugar beet washing. In KC III the content of particles is very high. This is mainly organic particles arising from the Farmakoop Pig Farm.

4.2.3 Nutrients – Phosphorus and nitrogen

The concentrations of total nitrogen and total phosphorus are given in **Figure 28** and **Figure 29**.

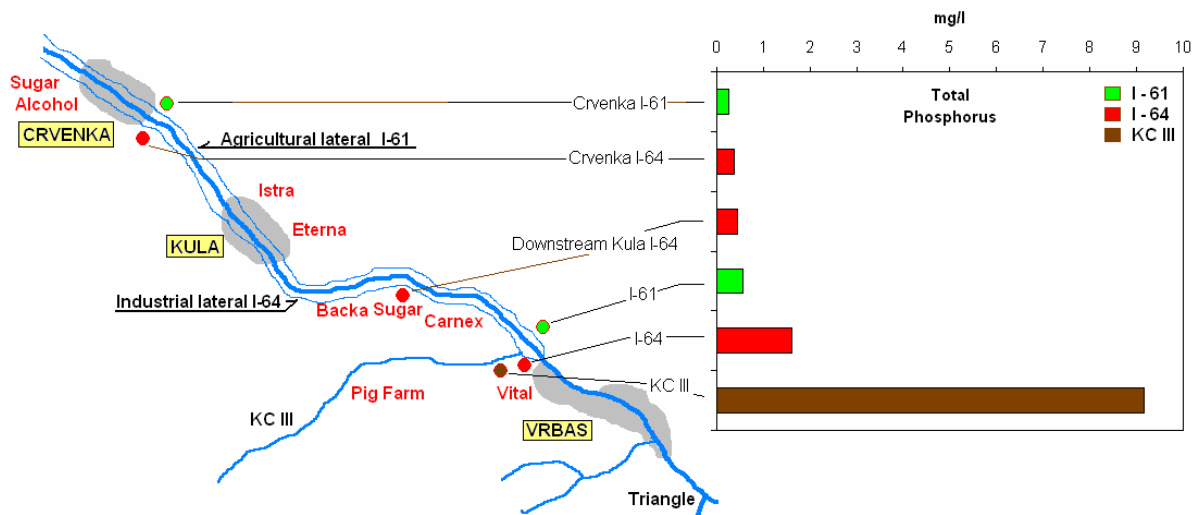


Figure 28. Concentrations of Total Phosphorus in the water at the different lateral monitoring stations.

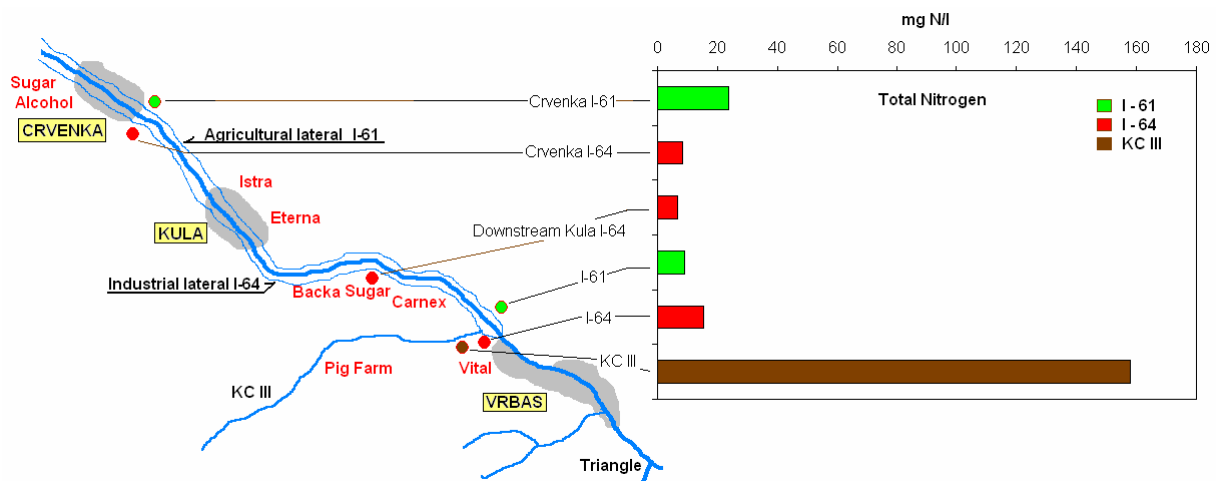


Figure 29. Concentrations of Total Nitrogen in the water at the different lateral monitoring stations

The concentration in KC-III is extremely high both with respect to P and N and is of the size normally found in the liquid part of in-door manure storages. Thus, the water in this canal can be characterized as concentrated manure storage leakage.

The concentrations in the agricultural lateral (I-61) are high for both elements. The N concentration at the Crvenka station is particularly high, about 25 mg N/l. The average concentration of N at the lowermost station in I-61 of about 10 mg N/l is more normally found in agricultural canals which only receive diffuse seepage from agricultural fields. The N concentration in the industrial lateral I-64 is of the same size as I-61. In the lower part of I-64 there is ongoing intense denitrification with loss of nitrogen to the atmosphere due to zero oxygen content and high concentrations of easily degradable organic material in the water.

The concentration of P in the I-61 and I-64 are high along the whole stretch from Crvenka to Vrbas, as compared to natural streams, even though they are small compared to KC-III.

The concentration in natural stream is from 0,005-0,020 mg P/l and from 0,060- 0,300 mg N/l. The concentration in untreated raw sewage is normally about from 4-10 mg P/l, and from 6-20 mg N/l.

4.2.4 Oil pollution

The mean concentrations at the different monitoring stations are given in **Figure 30**. The lower part of I-64 and the KC-III are both seriously contaminated with oil spills, and their pollution is also seriously impacting the Grand Canal. The I-61 and the upper stations in I-64 are not polluted by oil to any notable degree.

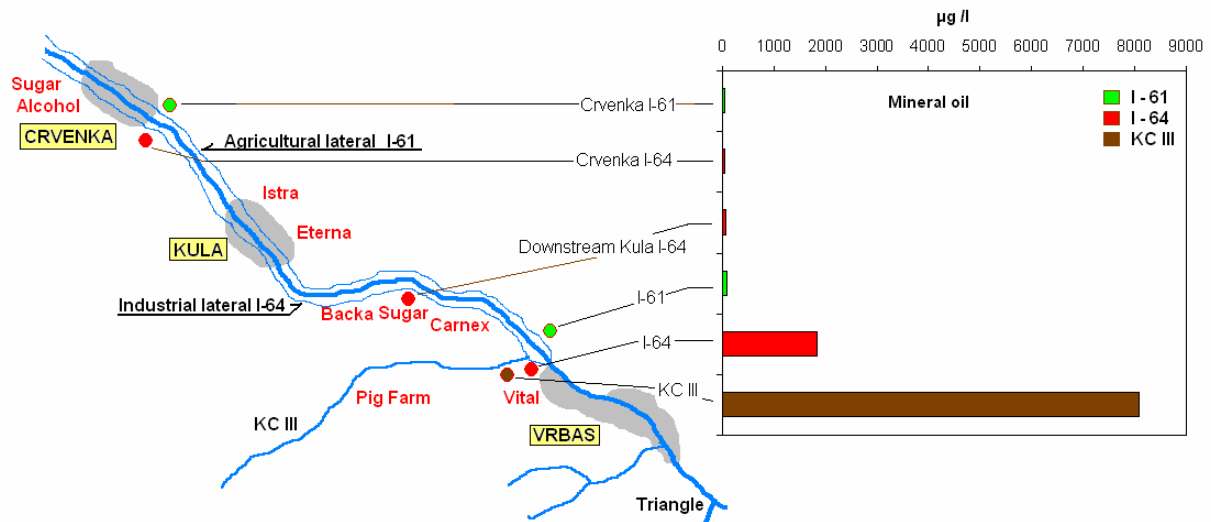


Figure 30. Concentration of Mineral oil in the water at the different lateral monitoring stations

4.2.5 Heavy metals

The mean concentrations of heavy metals at the different monitoring stations are given in **Figure 31**. It can be seen that particularly the KC-III and to somewhat less extent, the lower part of I-64, are heavily impacted by heavy metals.

The I-61 is somewhat impacted by heavy metals at the station in Crvenka, but little impacted at the lowermost station. As said earlier I-61 is entered into GC in Kula, and the pollution from upstream part are not influencing the lower parts.

Discharges from the metal processing/using industries Istra and Eterna can only explain a small part of the transport in lower I-64. In KC-III it was surprising to find high heavy metal concentrations, and it should be put effort in finding of the sources to this pollution.

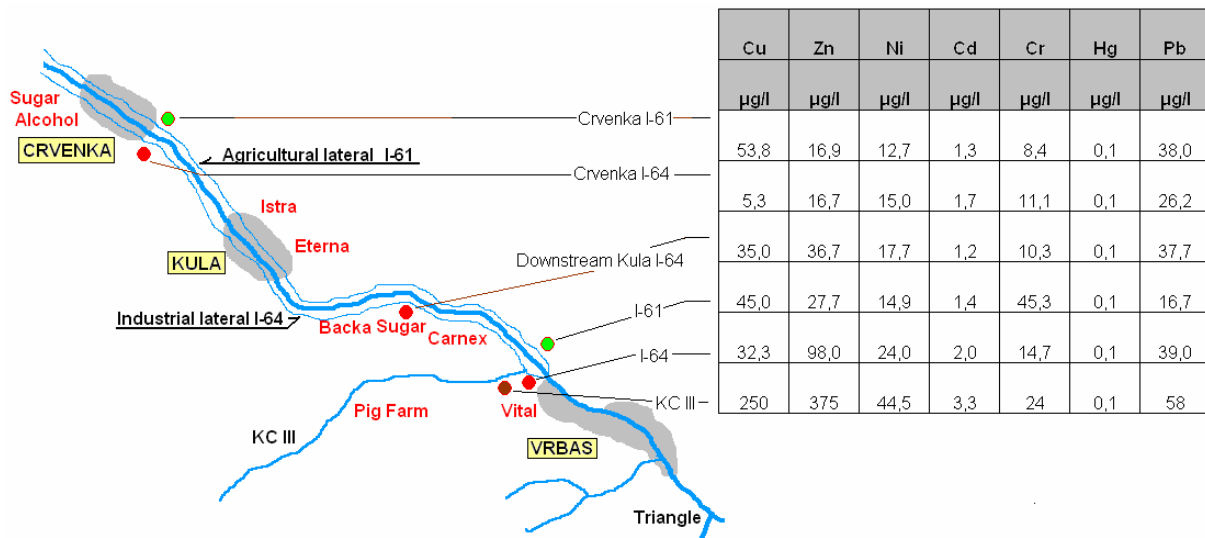


Figure 31. Mean concentrations of heavy metals in the water at the different lateral monitoring stations

4.2.6 Organic micro pollutants

Except for mineral oil components (see above) there was little evidence of any organic micro pollutants in the laterals. The PAH-total were down at detection limit of 6 ng/l, and industrial “thinners” and “de-fatters” like toluene, xylene, etc., were not detected at values of concern. It was, however, detected several industrial process chemicals, like phenols, ftalats, PAHs, benzene derivats, etc in a screening test, but none showed concentrations of concern, see the primary data in the Appendix for more details.

The only pollution of this kind is connected to bad use (and discharge) of mineral oils, see above.

4.2.7 Hygienic pollution

In chapter 4.1.7 it was shown that the Grand Canal was heavily polluted with coliform bacteria, and that the pollution was particularly massive downstream the entrance of the laterals. **Figure 32** shows the concentration of thermo tolerant coliform bacteria (TCB) at different sites in the different laterals. In I-64 the concentration is 1 billion TCB per 100 ml from Kula and downstream. In I-61 the concentration is low and does not represent any source of faecal pollution for the Grand Canal. The KC-III had an average concentration of 4 billion TCB per 100 ml which is almost the same concentration that is found in pure fresh faeces. Both the I-64 and KC-III is transporting so much coliform bacteria into the Great Canal that the canal will represent a health risk with respect to waterborne diseases. See chapter 4.1.7 for resulting concentrations in the Grand Canal and considerations with respect to water use and health risks.

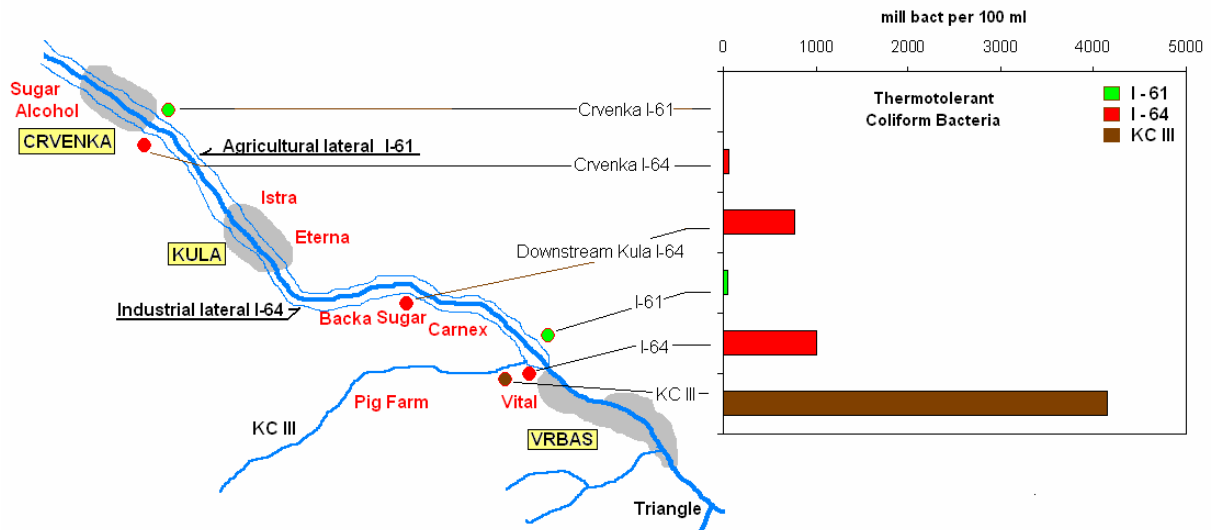


Figure 32. Faecal pollution in the laterals. Average concentrations of Thermo tolerant Coliforme Bacteria (TCB) at different sites in the laterals.

4.3 Main results from the sediment study (résumé from Dekonta 2004)

Originally, NIVA, together with Institute of Chemistry at the University of Novi Sad, had intended to perform a sediment study, to evaluate the necessity of, and the risk confined with dredging the sediments out of the Grand Canal, and how to dispose the dredged sediments. It was performed an initial small pilot test study the spring 2004. However, at the same time, the Czech company Deconta, had got funding from the Czech Republic to perform the same study. It was agreed that NIVA should focus more on mapping of the present pollution sources and how to control these, while Dekonta should focus on mapping the sediment pollution, the dredging and how to dispose the dredged material. NIVA should co-ordinate the joint study.

Therefore, as part of the co-ordinated rehabilitation study, Dekonta Inc., from the Czech Republic has performed the sediment study. The sediment study comprises:

- 1) Mapping the quantity of sediments from the Lateral entrances (6 km) to the Triangle (0 km), a distance of 6 kilometres.
- 2) Mapping the contamination of the sediments
- 3) Mapping the contamination of the old sediment deposit from a former dredging of polluted sediments.

In the following chapter the main findings of these studies are given.

4.3.1 Sediment thickness and volume

Figure 33 shows the sediment thickness at the different transects surveyed in the Dekonta study, where as **Figure 34** shows the average sediment thickness from the discharge point (lateral entrance) to the Triangle.

It is apparent that from 4 km and upstream the canal bed is more or less filled in with sediments. The sediment thickness is varying from year to year, and is partly depending on how the Vodo Vojvodina is flushing the canal during the spring high flow months. The volume of the sediment that were present in the last years sampling is based on thickness measurements done in this study combined with the canal width measurements performed by Bugarski and Bozidar from 1999.

This gives an estimated total sediment volume on the 6 km stretch of **402 772 m³**. Bugarski and Bozidar estimated the volume in 1999 to **355 376 m³**. **Table 1** shows the sediment quantity in the different sections from the lateral entrance and down to the Triangle (after Dekonta 2004),

Table 1. Sediment volume in the different canal sections from the lateral entrance (6 km) and down to the Triangle (0 km) (after dekonta 2004).

km	Data used from this study - 2004 (m ³)	Data used from study Bugarski and Bozidar - 1999 (m ³)
0 – 1	69 628	44 454
1 – 2	56 497	49 382
2 – 3	48 433	54 420
3 – 3.5	16 680	31 028
3.5 – 4	26 885	33 637
4 – 4.5	39 098	31 109
4.5 – 5	44 553	33 380
5 – 5.5	51 931	42 685
5.5 – 6	49 067	35 281
Total	402 772	355 376

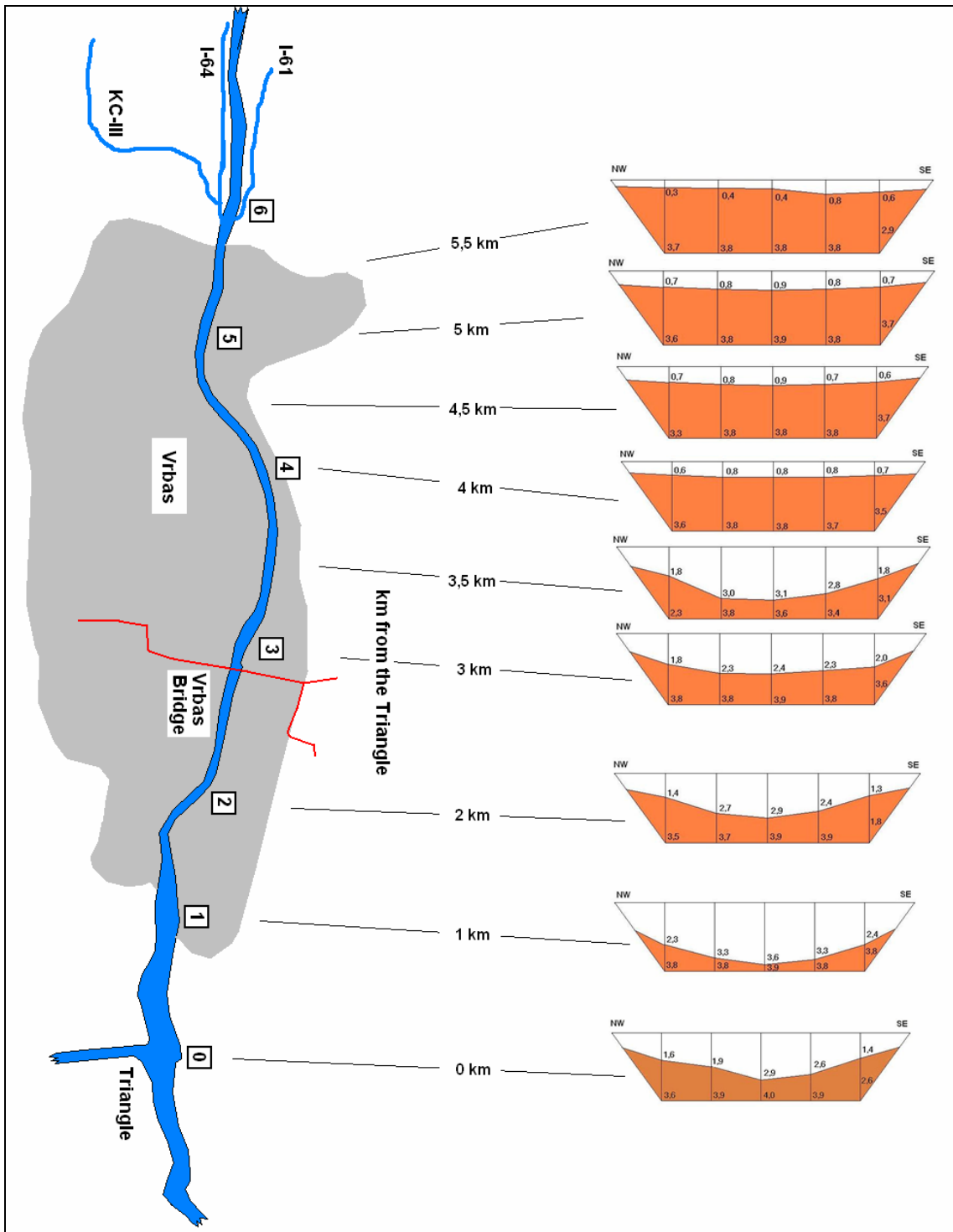


Figure 33. Sediment thickness at the different transects (data from Dekonta 2004).

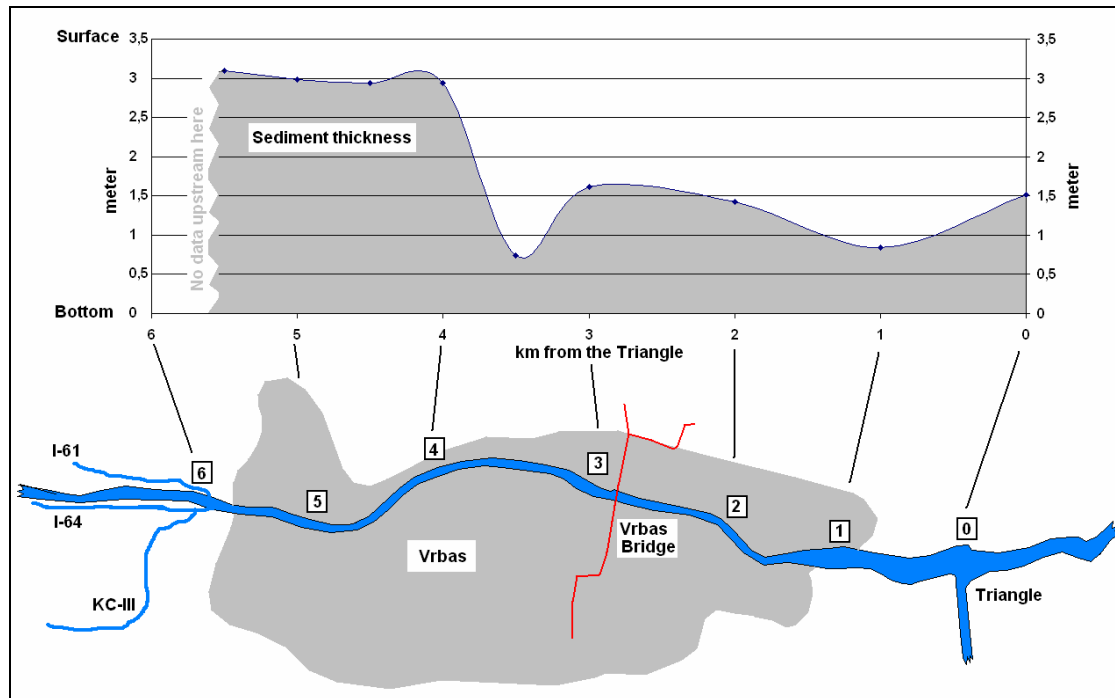


Figure 34. Average sediment thickness in the Grand Canal in varying distance from the discharge point (6 km) to the Triangle (0 km). Numbers in squares are kilometres from the Triangle. (data from Dekonta 2004).

4.3.2 Sediment contamination

In the former social republic of Czechoslovakia it was much heavy industry that created a lot of contaminated soils and sediments. Dekonta has for many years been involved in the rehabilitation of these areas, and thus has relevant experience both with respect to which contamination levels are dangerous, and how to dispose sediments of different degree of contamination. This experience is very relevant for the sediment actions to be taken in Vrbas. The analysis indicate that the vast bulk of the sediments are not more polluted than that they can be used as soil for park and recreation purposes. Therefore, the concentration of the different contaminants is compared with the Czech soil standards for soils used for recreational purposes. Landfills are often terminated as recreational and sport /park areas.

The results are extracted for the Dekonta study (2004).

Heavy metals

Figure 35 - Figure 37 shows concentrations of some heavy metals in the sediments (from Dekonta 2004). For a few samples (P8 and P9) Chromium reached values that exceeded the guidelines for soil used for parks and recreation areas. The other samples were well below these limits. Copper, Nickel and Zn did also show elevated levels, but they were, however, all below the recreation limits in the Czech soil guidelines.

The other heavy metals showed low values in the sediments.

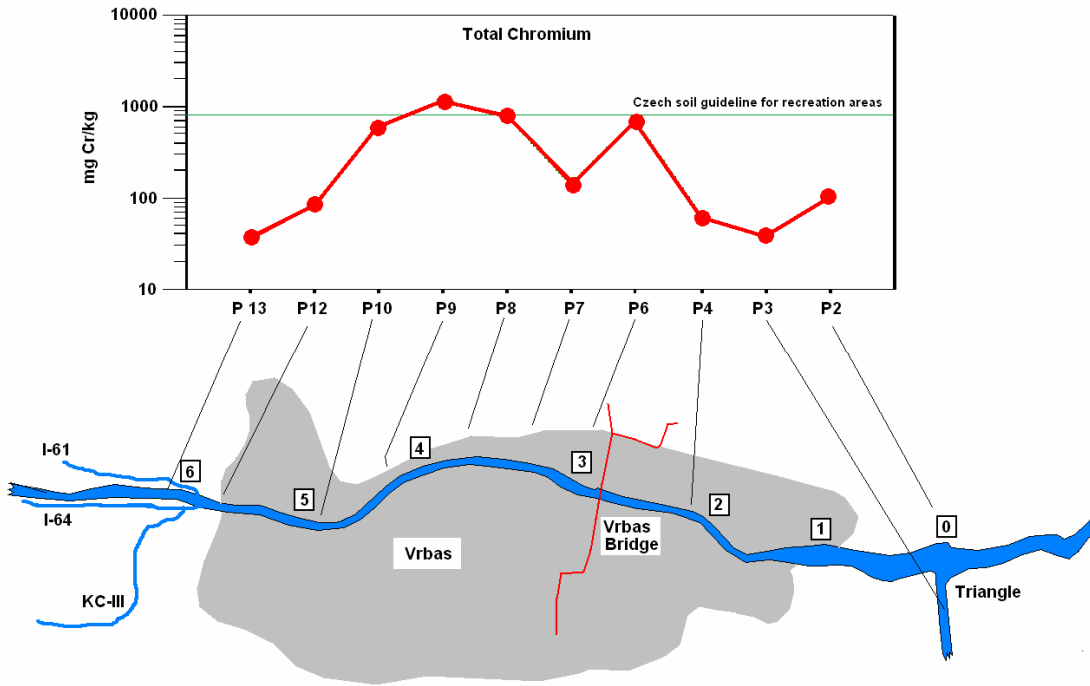


Figure 35. Concentration of total chromium in mixed sediment cores from the most polluted part of the Grand Canal (Data from Dekonta 2004)

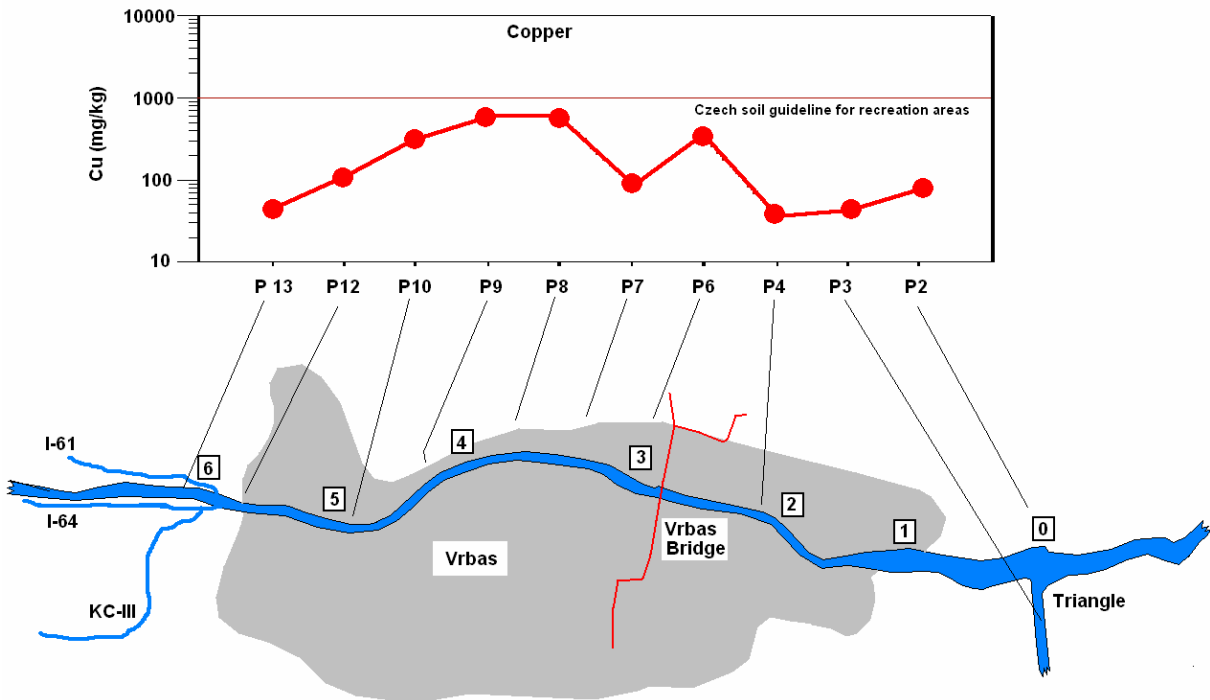


Figure 36. Concentration of copper in mixed sediment cores from the most polluted part of the canal (Data from Dekonta 2004).

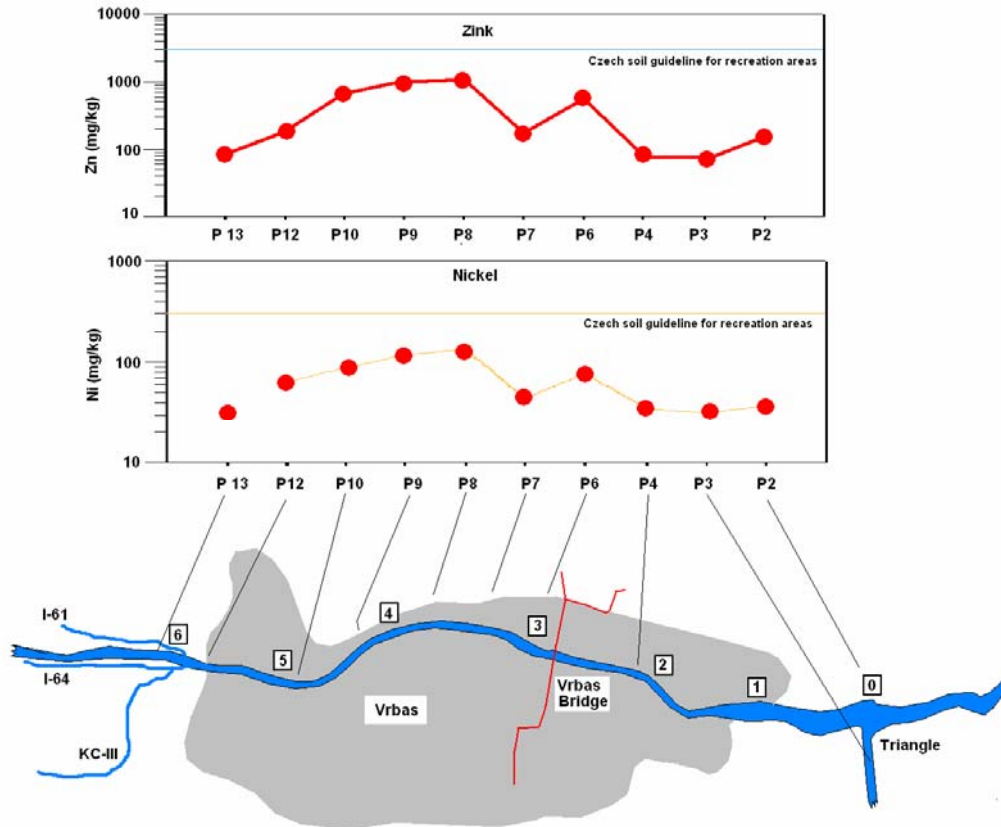


Figure 37. Concentration of zinc and nickel of mixed sediment cores from the most polluted part of the canal (data from Dekonta 2004).

Cyanides

The level of cyanide content in all the analysed samples was below the detection limit of the applied analyses technique, which was 1 mg/kg (1 ppm).

Organic environmental toxins

There was no evidence of serious contamination of sediment samples with organic micro pollutants. However, increased content of mineral oils (TPHs) and PCBs were recorded in a few samples, mainly in the area just downstream the entrance of the laterals, see **Figure 38**. Several of the samples exceeded the Czech pollution criteria for oil (TPH) content for soil used for recreational purposes. Only very few samples exceeded the limits for PCB content.

Levels of concentrations of all other analysed organic compounds (aliphatic chlorinated hydrocarbons, BTEX, PAHs, organochlorinated pesticides and chlorinated phenols) were below pollution criteria limits, and in most cases, even below detection limits.

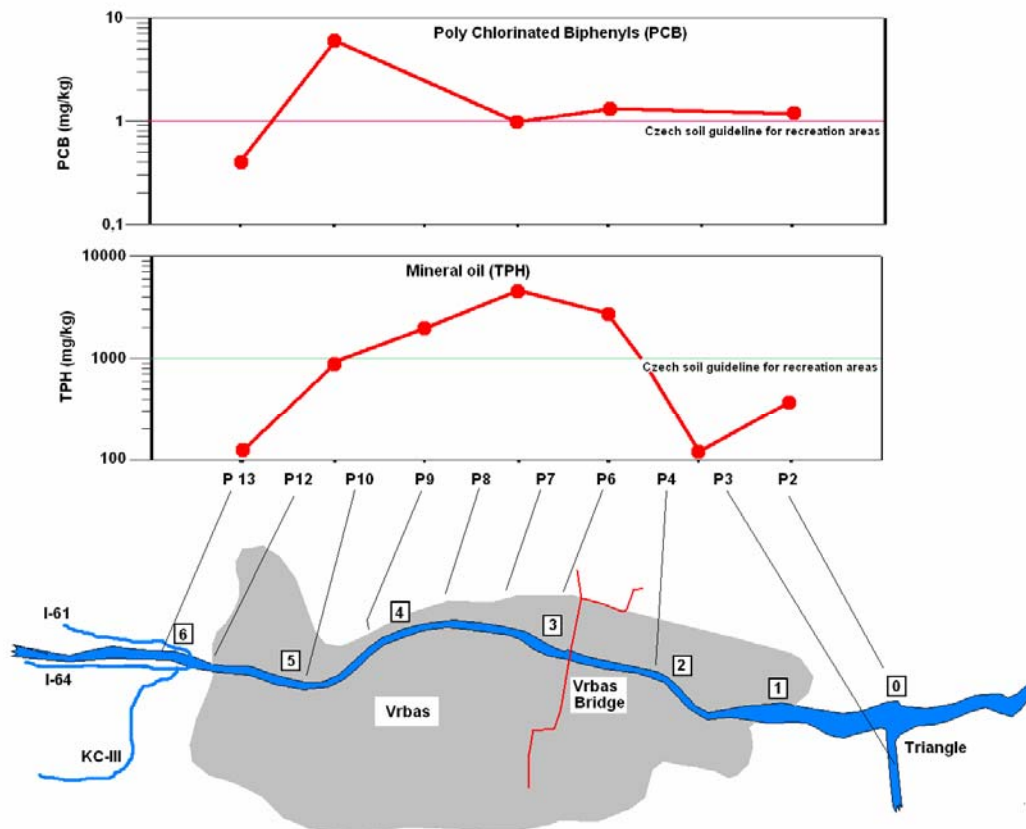


Figure 38. Concentrations of Poly-chlorinated biphenyls (PCBs) and Mineral oil (TPH) in mixed sediment cores from the most polluted part of the canal (Data from Dekonta 2004).

4.3.3 Evaluation of the sediment contamination results with reference to disposal

Most of the sediment volume seems to be made up by soil from the process of washing the sugar beets, and by organic waste from the pig farm. The sediments are mixed in with some heavy metals from Istra, from Eterna, and from different small metal treating/handling enterprises in the Vrbas region. There are also some organic micro pollutants present, like PCBs and mineral oil components, which has origin from several small sources.

Compared to Norwegian, Canadian and US sediment quality criteria, the sediments can be characterized as moderately polluted. In the most polluted stretch downstream the entrance of the 3 laterals (I-64, I-61 and KC III) the contaminants attain levels which will give negative impact on bottom living organisms according to the Canadian sediment guidelines. The anoxic conditions of the sediments are, however, the main problems for the living creatures, not the content of the environmental toxins.

None of the contaminants have such high concentrations that it will be risky to dredge the material. One problem is, however, that the sediments are often highly anaerobic and will release sulphide during the dredging operation. This might smell badly, and may also be a temporary health problem for the personnel performing the dredging. If strong smell of H_2S occurs, use gas protection equipment on board the dredging barge.

With respect to disposal of the dredged material, many elements exceed the acceptable concentration for agricultural soils. The soils can therefore not be spread onto agricultural land without any pre-treatment. However, only few sediment samples exceed the limits for soils used for parks and recreation

areas, and of course also for forest producing areas. Neither did they exceed concentrations which will impose a threat for ground water when placed in landfills. This means that the sediments do not need any advanced and expensive treatment prior to disposal.

The sediments could for example be placed on land along the canal on which it can be established a park, a golf course, or simply a riparian zone along the canal planted with forest for ecological and nutrient retaining purposes.

5. Pollution loading from different sources

5.1 Pollution Load from the laterals

5.1.1 Organic oxygen consuming pollutants

The main problem for the Grand Canal in the region is the discharge of particles (which fill in the canal with sediments), oxygen consuming compounds which steals the oxygen from the water, and of plant nutrients like Phosphorus and Nitrogen which stimulate growth of aquatic plants, both here and far downstream. The loading values of these compounds from the laterals, I-61 (agriculture lateral), I-64 (Industry lateral), and KC III (Fig Farm + + + +), into the Grand Canal are shown in **Figure 39**.

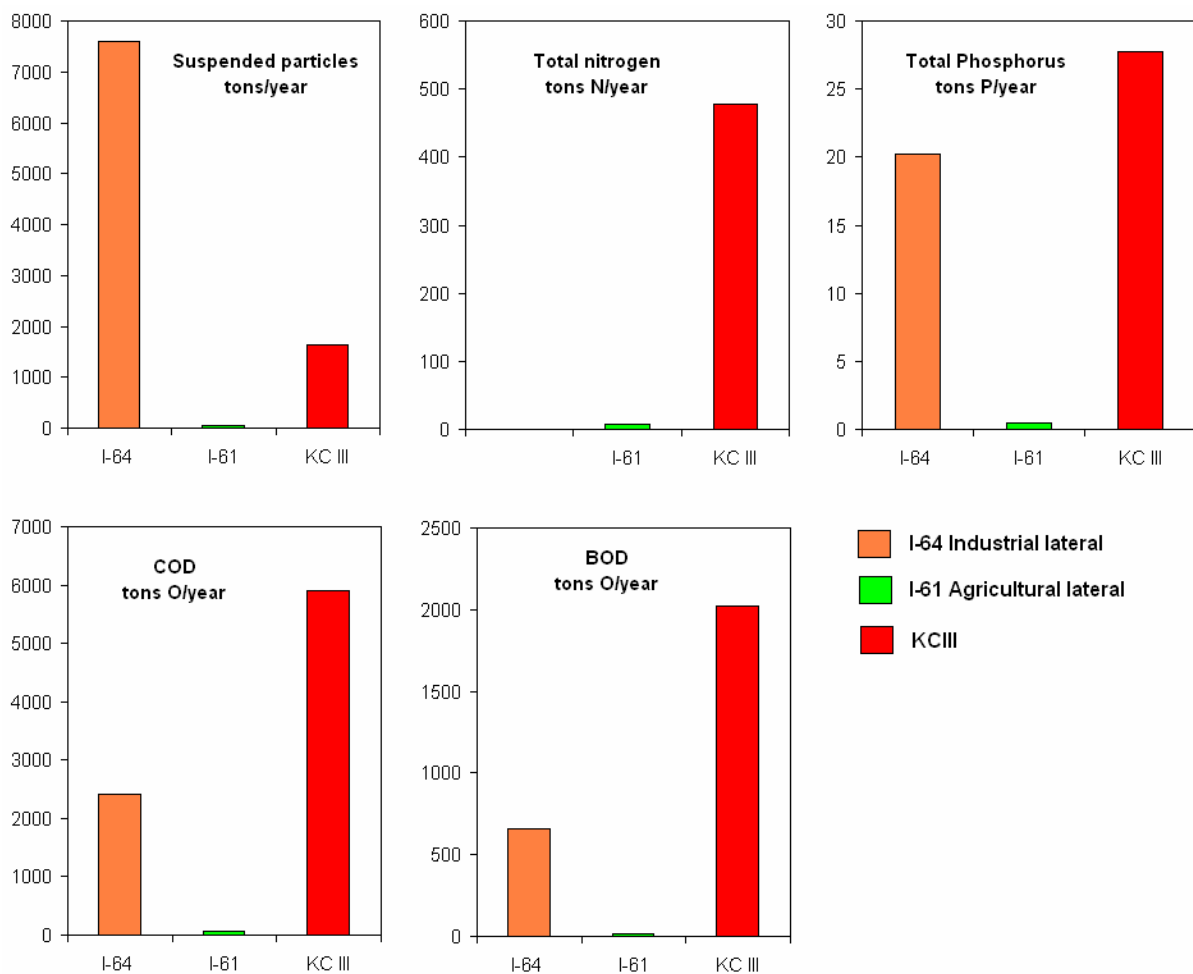


Figure 39. Transport of Oxygen consuming material and nutrients in the downstream part of the laterals, i.e. before discharge into the Great Canal.

It is quite clear that for these pollutants the I-64 and KC III is contributing with much more pollution than the I-61. KC III is the worst with respect to nutrients and oxygen consuming compounds, whereas I-64 is worst with respect to particles. The Pig Farm is the main source of these pollutants in KC III. In I-64 the sugar factories are the main contributor to the particle transport, while for nutrients and oxygen consuming organics, Carnex is also a significant contributor.

I-61 has only small transport values of these types of pollutants. This means that the runoff from agricultural fields is a relatively small contributor to the Grand Canal pollution in the stretch from Crvenka to the Triangle.

5.1.2 Heavy metals and mineral oil

The transport values of heavy metals, iron and manganese, and mineral oil is given in **Figure 40** and **Figure 41**.

It is quite clear that both KC III and I-64 are heavily contaminated by this type of pollution. From the earlier Chapter 4.2.5 it was demonstrated that KC III had the highest concentrations of these compounds. This type of pollution is not discharged from Pig Farm, so there must be other sources in the KC III. Small enterprises with metal processing activities like workshops, plumber, etc., may be contributors. These sources must be found and controlled.

Of the industries included in the study, only Istra was discharging considerable amount of heavy metals to day. They were originally discharging into I-61, but now they are discharging into I-64. The discharges from Istra, and Eterna, can however explain only part of the transport values in I-64. There must be considerable other sources as well.

Both in I-64 and KC III there are considerable discharges of mineral oil. The concentration, see chapter 4.2.4, are sometimes so large that it is smelling oil from the water and, when a water sample is stored a layer of oil of 1-2 mm is formed on top of the water in the bottle. The sources of this oil-pollution must be found and brought under control.

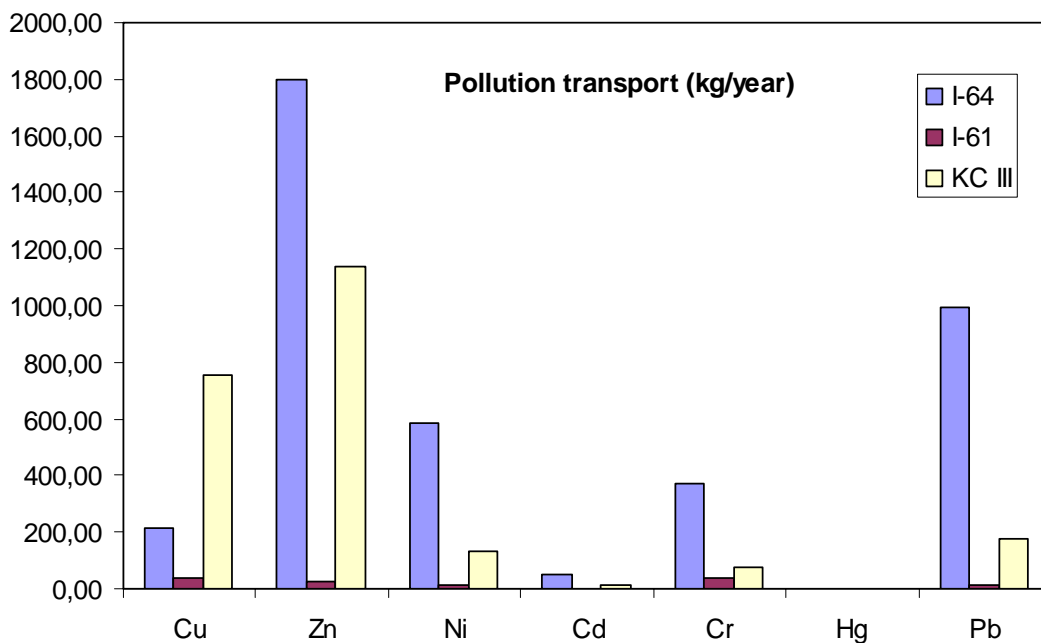


Figure 40. Transport values of heavy metals in the downstream part of the laterals, i.e. prior to discharge into the Great Canal.

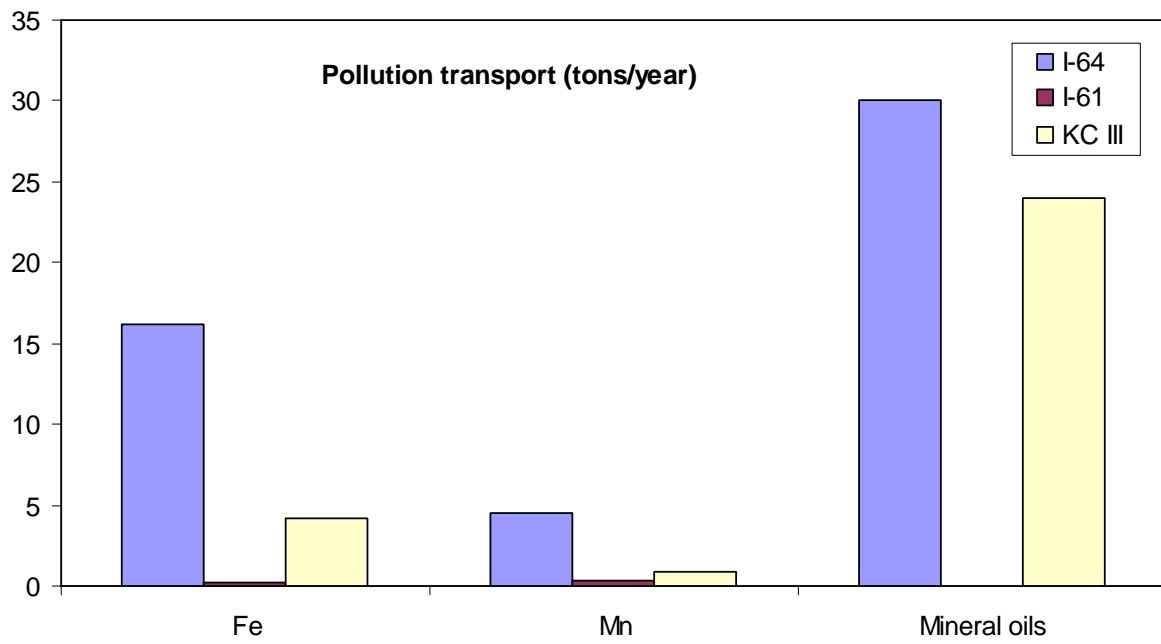


Figure 41. *Transport values of Fe, Mn and Mineral oil in the downstream part of the laterals, i.e. before discharging into the Grand Canal.*

5.2 Pollution Load from Industrial and Municipal Point Sources

To get an overview of the point discharges to the laterals, the anticipated 10 largest point sources have been monitored from autumn 2003 to the autumn 2004. These are 8 industries and the sewage facilities of Kula and Vrbas:

- Crvenka Sugar factory
- Alcohol fabric, Crvenka
- Istra Kula Faucet factory
- Eterna Leather factory
- JKB-Kula Municipality
- Backa Sugar factory
- Carnex slaughter house and meat factory
- Farmakoop Pig Farm
- Vital food oil factory
- JKB-Vrbas Municipality

From these industries the main effluent streams are monitored with respect to concentrations and flows during typical production periods. The daily load is thereafter multiplied with the number of production days per year to find the annual pollution load. From Carnex three effluent streams are monitored, from Istra two streams, whereas from the others only one effluent stream is monitored. The monitoring aims at quantifying the discharges into the lateral I-64 from these point sources.

In the next section the concentrations and amounts of pollutants discharged from each industry is presented, where as in section 5.2.2 the discharge from the different industries are compared quantitatively.

5.2.1 Effluent concentrations and loadings from the main industries and sewerage facilities

Effluents from Crvenka Sugar Factory

Only the main effluent stream is monitored for this industrial plant. The samples are taken where the effluent reach the lateral I-64. The factory operates for about 4 months a year, from August - November, but they use more than two months to empty their settling lagoons (Cassets), so there are effluents from this factory for about 200 days a year. The water flow measured was approximately 14500 m³/day. The effluent is highly concentrated with respect to nutrients and oxygen consuming, organic material, see **Table 2**.

Table 2. Crvenka sugar factory effluents. Flows and concentrations.

Parameter name	Shortname	Unit	Mean	Max
Flow adjusted	Q	m ³ /day	14500	
No of days with effluent	Days	days/y	200	
Suspended particles	SS	mg/L	94,8	240
Total Nitrogen	Total N	mg N/L	27,126	58
Total Phosphorus	Tot-P	mg P/L	3,284	11
Chemical Oxygen Demand	COD-tot.	mg O ₂ /L	2444	7600
Biological Oxygen Demand	BOD ₅ -tot.	mg O ₂ /L	1122,2	2972

Table 3 shows the loading of pollutants from the factory which is achieved through multiplying the average concentrations with the flow.

Table 3. Crvenka sugar factory. Total discharge (concentration x flow)

Parameter name	Shortname	Unit	Loading
Suspended particles	SS	tons/year	275
Total Nitrogen	Total N	tons N/y	79
Total Phosphorus	Tot-P	tons P/y	9,5
Chemical Oxygen Demand	COD-tot.	tons O/y	7088
Biological Oxygen Demand	BOD ₅ -tot.	tons O/y	3254

Effluents from Panon Alcohol Fabric in Crvenka

From the alcohol factory in Crvenka only the main effluent stream is monitored. The average flow in the effluent is about 2000 m³/day, and the discharge takes place for about 200 days per year. The concentrations of the different pollutants are given in **Table 4**, whereas the corresponding loadings that appear when the respective concentrations are multiplied by the flows are given in **Table 5**.

Table 4. Alcohol fabric effluent. Flows and concentrations.

Parameter name	Shortname	Unit	Mean	Max
Flow adjusted	Q	m ³ /day	2000	
No of days with effluents	Days	days/y	200	
Suspended particles	SS	mg/L	83	240
Total Nitrogen	Total N	mg N/L	1,48	2,43
Total Phosphorus	Tot-P	mg P/L	0,62	1,54
Chemical Oxygen Demand	COD-tot.	mg O ₂ /L	130	300
Biological Oxygen Demand	BOD ₅ -tot.	mg O ₂ /L	53	99

Table 5. Alcohol fabric. Total discharges based on effluent monitoring.

Parameter name	Short name	Unit	Loading
Suspended particles	SS	tons/y	33
Total Nitrogen	Total N	tons N/y	0,59
Total Phosphorus	Tot-P	tons P/y	0,25
Chemical Oxygen Demand	COD-tot.	tons O/y	52
Biological Oxygen Demand	BOD ₅ -tot.	tons O/y	21

Effluents from Istra Faucet factory in Kula

From this metal treating industry two effluent streams are monitored, called composite and electroplating, respectively. In addition to nutrients, particles and oxygen consuming compounds, this industry discharges a lot of heavy metals. The flows and concentrations of the different effluent streams are given in **Table 6** whereas the corresponding loading that appears when the different concentrations are multiplied by the respective flows are given in **Table 7**.

Table 6. Istra effluent monitoring. Flows and concentrations.

Parameter name	Short name	Unit	Composite		Electroplating	
			Mean	Max	Mean	max
Flow adjusted	Q	m ³ /day	1000		137	
No of days with effluent	Days	days/y	252		252	
Suspended particles	SS	mg/L	239	553	189	200
Total Nitrogen	Total N	mg N/L	36,7	60,3	32,0	46,4
Total Phosphorus	Tot-P	mg P/L	37,9	150	5,1	10
Chemical Oxygen Demand	COD-tot.	mg O ₂ /L	183	300	185	210
Biological Oxygen Demand	BOD ₅ -tot.	mg O ₂ /L	55	140	23	31
Iron	Fe	mg/L	0,10	0,15	0,18	0,18
Copper	Cu	µg/L	1,2	3,3	1968	3900
Zink	Zn	µg/L	1,2	3,4	1835	3500
Nickel	Ni	µg/L	4,5	8,1	5680	11300
Cadmium	Cd	µg/L	0,0089	0,025	10,045	11
Chromium	Cr	µg/L	2,1	5,8	2150	2600
Lead	Pb	µg/L	0,14	0,27	235	290

Table 7. Istra effluent monitoring. Total loading (conc x flow)

Parameter name	Short name	Unit	Composite	Electroplating	Sum
Suspended particles	SS	tons/y	60	6,5	67
Total Nitrogen	Total N	tons N/y	9,25	1,10	10
Total Phosphorus	Tot-P	tons P/y	9,55	0,18	9,7
Chemical Oxygen Demand	COD-tot.	tons O/y	46	6,39	52
Biological Oxygen Demand	BOD ₅ -tot.	tons O/y	13,8	0,79	14,6
Iron	Fe	tons/y	26	0,0060	25,6
Copper	Cu	kg/y	299	68	367
Zink	Zn	kg/y	299	63	362
Nickel	Ni	kg/y	1123	196	1319
Cadmium	Cd	kg/y	2,25	0,35	2,60
Chromium	Cr	kg/y	517	74	591
Lead	Pb	kg/y	36	8	44

Effluents from the Eterna Leather Factory

From the Eterna Leather Factory only the main effluent stream is monitored. The flow and concentrations for the different pollutants are given in **Table 8** whereas the loadings resulting from multiplying the concentrations by the flow is given in **Table 9**.

Table 8. Eterna effluent monitoring. Flows and concentrations.

Parameter name	Shortname	Unit	Mean	Max
Flow adjusted	Q	m ³ /day	120	
No of days with effluents	Days	days/y	240	
Suspended particles	SS	mg/L	1078,5	1570
Total Nitrogen	Total N	mg N/L	25,25	27,2
Total Phosphorus	Tot-P	mg P/L	5,035	10
Chemical Oxygen Demand	COD-tot.	mg O ₂ /L	730	1200
Biological Oxygen Demand	BOD ₅ -tot.	mg O ₂ /L	378	600
Chromium	Cr	mg/l	0,093	0,15

Table 9. Eterna effluent monitoring. Total discharges (concentration x flow)

Parameter name	Shortname	Unit	Loading
Suspended particles	SS	tons/y	31,06
Total Nitrogen	Total N	tons N/y	0,73
Total Phosphorus	Tot-P	tons P/y	0,15
Chemical Oxygen Demand	COD-tot.	tons O/y	21,02
Biological Oxygen Demand	BOD ₅ -tot.	tons O/y	10,89
Chromium	Cr	tons/y	0,003

Effluents from JKB-Kula Municipality Sewage Facility

The main effluent stream from JKB-Kula municipal sewage facility is monitored. The flow and concentrations for the different pollutants are given in **Table 10** whereas the loadings resulting from multiplying the concentrations by the flow is given in **Table 11**.

Table 10. JKB-Kula Municipality Sewerage Facility effluent monitoring. Flow and concentrations.

Parameter name	Shortname	Unit	Mean	Max
Flow adjusted	Q	m ³ /day	560	
No of days with effluents	Days	days/y	365	
Suspended particles	SS	mg/L	103	133
Total Nitrogen	Total N	mg N/L	64,3	87,8
Total Phosphorus	Tot-P	mg P/L	7,92	7,92
Chemical Oxygen Demand	COD-tot.	mg O ₂ /L	365	370
Biological Oxygen Demand	BOD ₅ -tot.	mg O ₂ /L	217	220

Table 11. JKB-Kula Municipality Sewerage Facility effluent monitoring. Total loading (conc x flow).

Parameter name	shortname	Unit	Loading
Suspended particles	SS	tons/y	21,05
Total Nitrogen	Total N	tons N/y	13,14
Total Phosphorus	Tot-P	tons P/y	1,62
Chemical Oxygen Demand	COD-tot.	tons O/y	74,61
Biological Oxygen Demand	BOD ₅ -tot.	tons O/y	44,35

Effluents from Backa Sugar Factory

From the Backa Sugar Factory only the main effluent stream is monitored. The flow and concentrations for the different pollutants are given in **Table 12** whereas the loadings resulting from multiplying the concentrations by the flow is given in **Table 13**.

Table 12. Backa Sugar factory effluents. Flows and concentrations.

Parameter name	Shortname	Unit	Mean	Max
Flow adjusted	Q	m ³ /day	25000	
No of days with effluents	Days	days/year	100	
Suspended particles	SS	mg/L	743	3120
Total Nitrogen	Total N	mg N/L	31	58,5
Total Phosphorus	Tot-P	mg P/L	2	11
Chemical Oxygen Demand	COD-tot.	mg O ₂ /L	1508	3400
Biological Oxygen Demand	BOD ₅ -tot.	mg O ₂ /L	746	1700

Table 13. Backa Sugar factory. Total effluents

Parameter name	Shortname	Unit	Loading
Suspended particles	SS	tons/yr	1857
Total Nitrogen	Total N	tons N/yr	78
Total Phosphorus	Tot-P	tons P/yr	6
Chemical Oxygen Demand	COD-tot.	tons O/yr	3771
Biological Oxygen Demand	BOD ₅ -tot.	tons O/yr	1866

Effluents from Carnex slaughter house and meat factory

From Carnex three effluent streams are monitored. These are called

- Composite
- Condensate
- Fat and oil

The flows and concentrations in the different effluent streams are given in **Table 14** whereas the loadings that appear from multiplying the concentrations by flows are given in **Table 15**.

Table 14. Carnex effluents. Flows and concentrations in the three effluent streams measured in 2004

Parameter	Shortname	Unit	Composite		Condensate		Fat and Oil	
			Mean	Max	Mean	Max	Mean	Max
Flow adjusted	Q	m ³ /day	2800		1600		10	
No of Days with effluents	Days	days/year	260		260		260	
Suspended particles	SS	mg/L	820	1807	112	313	787	787
Total Nitrogen	Total N	mg N/L	91	147	9	19,7	3581	6571
Total Phosphorus	Tot-P	mg P/L	21	88	0,36	1,1	170	330
Chemical Oxygen Demand	COD-tot.	mg O ₂ /L	1860	3000	223	520	31167	53000
Biological Oxygen Demand	BOD ₅ -tot.	mg O ₂ /L	972	1750	129	300	16850	31000

Table 15. Carnex effluents. Total discharges from the three effluent streams based on monitoring in 2004.

Parameter	Shortname	Unit	Composite	Condensate	Fat and Oil	Sum
Suspended particles	SS	tons/year	597	46	2,0	646
Total Nitrogen	Total N	Tons N/y	66	3,8	9,3	79
Total Phosphorus	Tot-P	tons P/y	15	0,15	0,44	16
Chemical Oxygen Demand	COD-tot.	tons O/y	1354	93	81	1528
Biological Oxygen Demand	BOD ₅ -tot.	tons O/y	707	54	44	805

Effluents from Farma-coop Pig Farm

From the pig farm Farma-coop only the main effluent stream is monitored. The flow and concentrations for the different pollutants are given in **Table 16** whereas the loadings resulting from multiplying the concentrations by the flow is given in **Table 17**.

Table 16. Pigfarm. Flows and concentrations in effluents

Parameter name	Shortname	Unit	Mean	Max
Average flow adjusted	Q	m ³ /day	2900	
No. of days with effluents	Days	days/y	365	
Suspended particles	SS	mg/L	1865	3990
Total Nitrogen	Total N	mg N/L	361	535,5
Total Phosphorus	Tot-P	mg P/L	155	660
Chemical Oxygen Demand	COD-tot.	mg O ₂ /L	5600	11500
Biological Oxygen Demand	BOD ₅ -tot.	mg O ₂ /L	2817	6000

Table 17. Pig farm. Annual discharges based on effluent monitoring.

Parameter name	Shortname	Unit	Loading
Suspended particles	SS	tons/y	1974
Total Nitrogen	Total N	tons N/y	383
Total Phosphorus	Tot-P	tons P/y	164
Chemical Oxygen Demand	COD-tot.	tons O/y	5928
Biological Oxygen Demand	BOD ₅ -tot.	tons O/y	2982

Effluents from Vital Food Oil Factory

From Vital Food Oil Factory only the main effluent stream is monitored. The flow and concentrations for the different pollutants are given in **Table 18** whereas the loadings resulting from multiplying the concentrations by the flow is given in **Table 19**.

Table 18. Vital effluent monitoring. Flows and concentrations.

Parameter name	Shortname	Unit	Mean	Max
Flow adjusted	Q	m ³ /day	4000	
No of days with effluents	Days	days/y	280	
Suspended particles	SS	mg/L	139	467
Total Nitrogen	Total N	mg N/L	2,48	3,6
Total Phosphorus	Tot-P	mg P/L	0,79	1,32
Chemical Oxygen Demand	COD-tot.	mg O ₂ /L	103	140
Biological Oxygen Demand	BOD ₅ -tot.	mg O ₂ /L	24	40

Table 19. Vital effluent monitoring. Total discharges (concentration x flow).

Parameter name	Shortname	Unit	Loading
Suspended particles	SS	tons/y	156
Total Nitrogen	Total N	tons N/y	2,77
Total Phosphorus	Tot-P	tons P/y	0,88
Chemical Oxygen Demand	COD-tot.	tons O/y	115
Biological Oxygen Demand	BOD ₅ -tot.	tons O/y	27

Effluents from JKB-Vrbas municipal sewage facility

The main effluent stream from JKB-Vrbas municipal sewage facility is monitored. The flow and concentrations for the different pollutants are given in **Table 20** whereas the loadings resulting from multiplying the concentrations by the flow is given in **Table 21**.

Table 20. JKB-Vrbas Municipal Sewerage Facility effluent monitoring. Flows and concentrations.

Parameter name	Shortname	Unit	Mean	Max
Flow adjusted		m ³ /day	4000	
No of days with effluents		days/y	365	
Suspended particles	SS	mg/L	205	340
Total Nitrogen	Total N	mg N/L	42,1	65,5
Total Phosphorus	Tot-P	mg P/L	3,25	5,72
Chemical Oxygen Demand	COD-tot.	mg O ₂ /L	280	350
Biological Oxygen Demand	BOD ₅ -tot.	mg O ₂ /L	123	143

Table 21. JKB-Vrbas Municipality Sewerage Facility effluent monitoring. Total loading (conc x flow).

Parameter name	Shortname	Unit	Loading
Suspended particles	SS	tons/y	299,30
Total Nitrogen	Total N	tons N/y	61,5
Total Phosphorus	Tot-P	tons P/y	4,75
Chemical Oxygen Demand	COD-tot.	tons O/y	409
Biological Oxygen Demand	BOD ₅ -tot.	tons O/y	180

5.2.2 Relative contribution to pollution load from the main point sources

In **Table 22** the loading data from the former section is compiled in one single table. In **Figure 42 - Figure 46**, the loading from the different main point sources is visualized for each type of pollution. This to get a clear pictures of which source are most important for the pollution of the canal.

Table 22. The pollution loading from the different sources (compiled)

Point source discharge	Suspended particles		Total P Total P tons P/y	Chemical Oxygen Demand, total COD-tot. tons O/y	BOD ₅ , total BOD ₅ -tot. tons O/y
	SS tons/y	Total N Total N tons N/y			
Crvenka Sugar	274,92	78,67	9,52	7087,60	3254,38
Alcohol Fabric	33,30	0,59	0,25	52,00	21,20
Istra	66,82	10,35	9,73	52,38	14,59
Eterna	31,06	0,73	0,15	21,02	10,89
Kula Municipality	21,05	13,14	1,62	74,61	44,35
Backa Sugar	1856,67	77,73	5,95	3770,83	1865,83
Carnex	645,53	79,12	15,59	1527,59	804,55
Pig Farm	1973,57	382,61	163,64	5927,60	2982,01
Vital	155,68	2,77	0,88	114,80	26,88
JKB Verbas Mun.	299,30	61,49	4,75	408,80	179,95

Loading with particulate matter

The loading with particulate matter from the 10 main point sources is given in **Figure 42**.

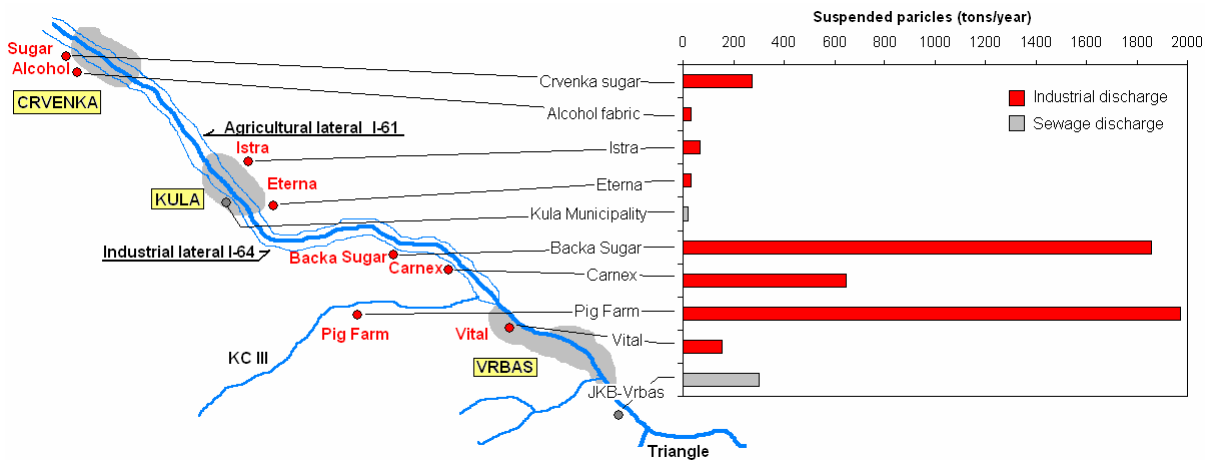


Figure 42. Loading of particulate matter from the main 10 point sources along the canal stretch comprised by the study.

With respect to particles the main source is the Backa sugar factory and the Farm coop Pig Farm. Then come Carnex, and then Crvenka sugar. The others are small in comparison. The Backa Sugar factory and the Pig farm are the main responsible for filling in the Grand Canal by sediments.

Nutrient loading

The loading of nutrient from the 10 main point sources is given in **Figure 43** and **Figure 44**.

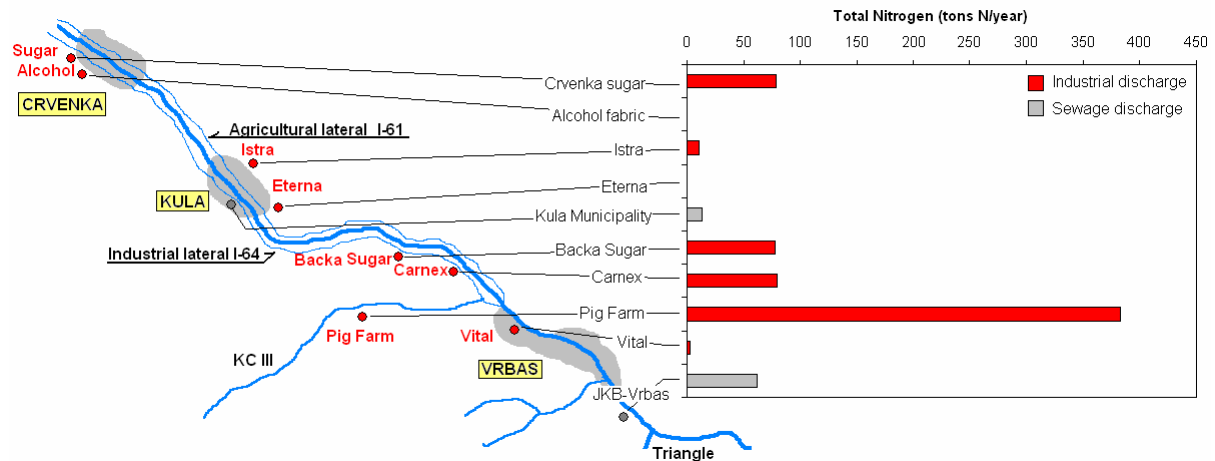


Figure 43. Loading of Total Nitrogen from the main 10 point sources along the canal stretch comprised by the study.

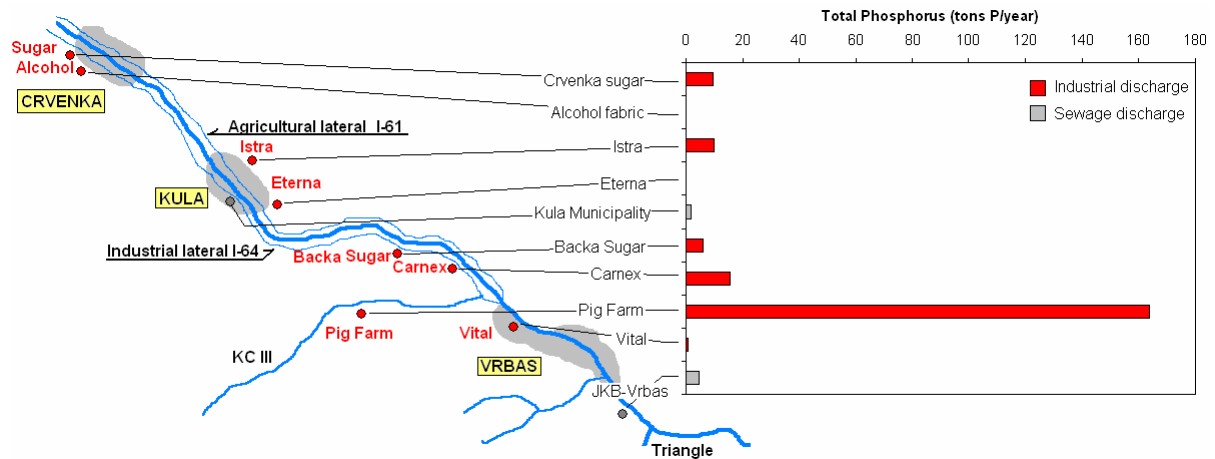


Figure 44. Loading of Total Phosphorus from the main 10 point sources along the canal stretch comprised by the study.

It is quite clear that the pig farm is the major contributor to the pollution of the canal with nutrients. But Carnex and the two sugar factories do also give significant contributions. JKB-Vrbas sewerage facility gives also a contribution, but minor compared to those mentioned above.

Loading of oxygen consuming organic material

The loading numbers for oxygen consuming material from the main point sources are given in **Figure 45** and **Figure 46**.

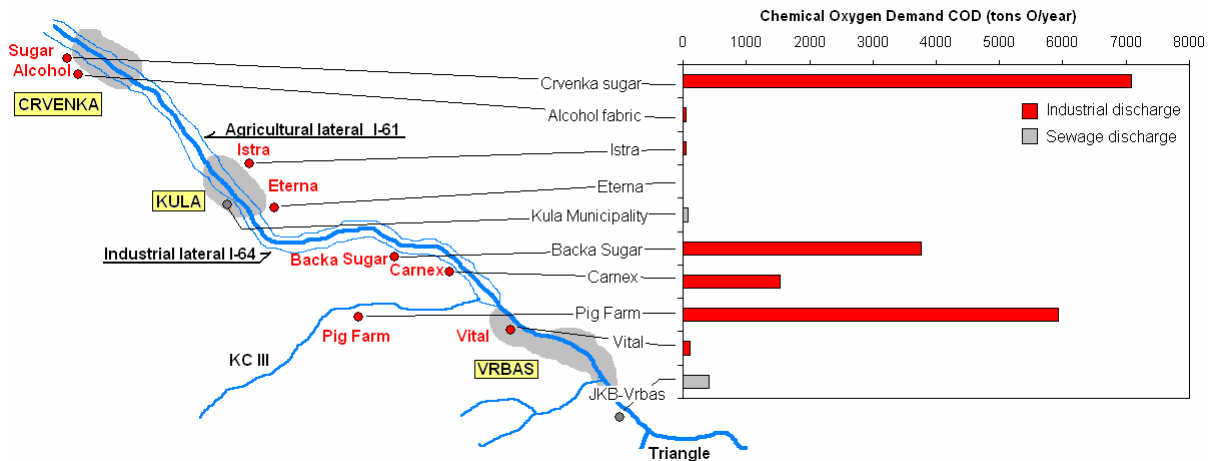


Figure 45. Loading of oxygen consuming matter from the main 10 point sources along the canal stretch comprised by the study (Given by the analysis COD_{Cr}).

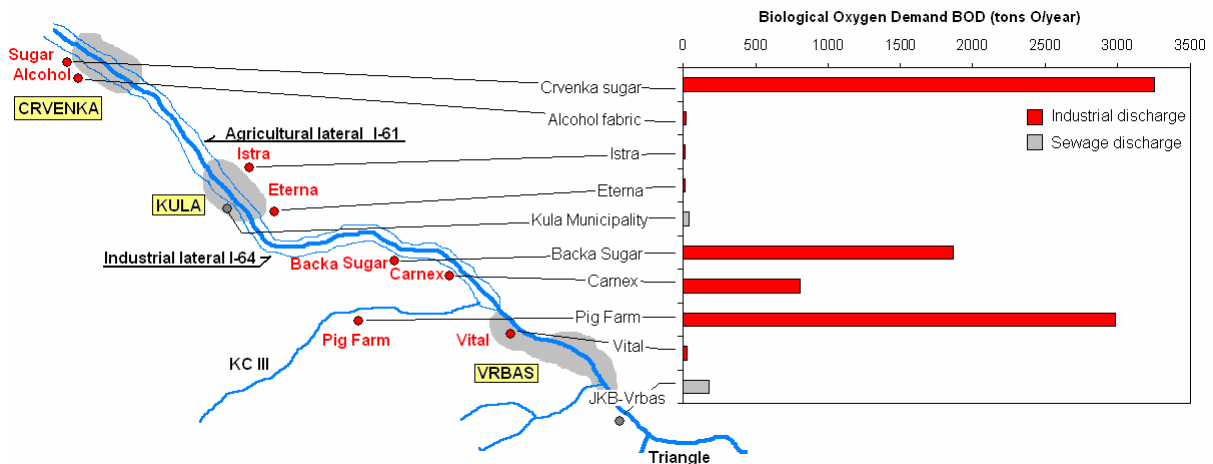


Figure 46. Loading of oxygen consuming matter from the main 10 point sources along the canal stretch comprised by the study (Given by the analysis BOD_5).

Both for COD and BOD the picture is the same; namely that the Pig Farm, the two sugar factories, together with Carnex are the main polluters. The others are minor to these four. These four are the main responsible for removing the oxygen from the Grand Canal.

Heavy metals

Istra and Eterna are the only ones out of the 10 main point sources that discharge heavy metals. Istra has much bigger discharge than Eterna, see the previous paragraph. As heavy metals are not monitored from the other sources no comparable discharge diagrams like those for the other pollutants can be made.

5.3 Pollution from agriculture

5.3.1 Indication of the Contribution from agriculture as measured from the lateral transport values

During the study period the transport of pollution has been monitored in the laterals:

- I-64 The lateral receiving effluents from industry
- I-61 The lateral receiving runoff from normal farms and farmland
- KC-III The lateral receiving effluents from i.a. large scale husbandry (Farmakoop Pig Farm)

As can be seen from **Figure 47** the contribution from the agricultural lateral (I-61) was very small compared to the two other laterals.

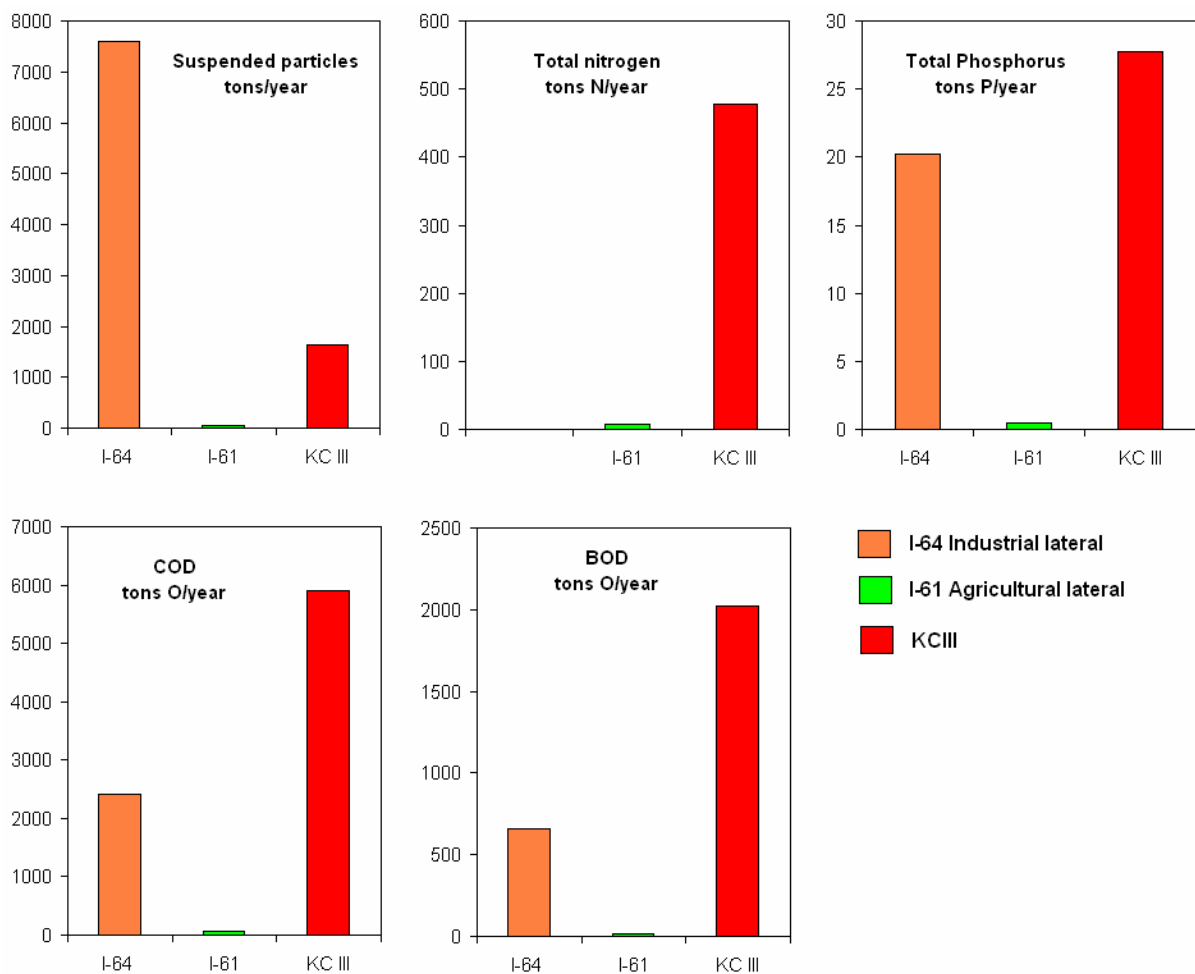


Figure 47. Transport of oxygen consuming material and nutrients in the downstream part of the laterals, i.e. before they discharge into the Grand Canal.

The reason why there is no nitrogen in I-64 is that it is lost by denitrification in the strictly anoxic lower part of the lateral. In chapter 5.1.2 the transport of other pollutants like heavy metals and mineral oil, are shown. Also for these parameters the I-61 shows low transport values compared to the other two.

5.3.2 Main findings from the study of diffuse runoff from agricultural areas

A desk study of the diffuse pollution from the agriculture areas draining to the lowermost part of the agricultural lateral I-61 was performed by the Agr. Faculty, Univ of Novi Sad as part of the rehabilitation plan (Cuvardic et al 2004). The area comprises 3890 ha of farmland, see **Figure 48**.

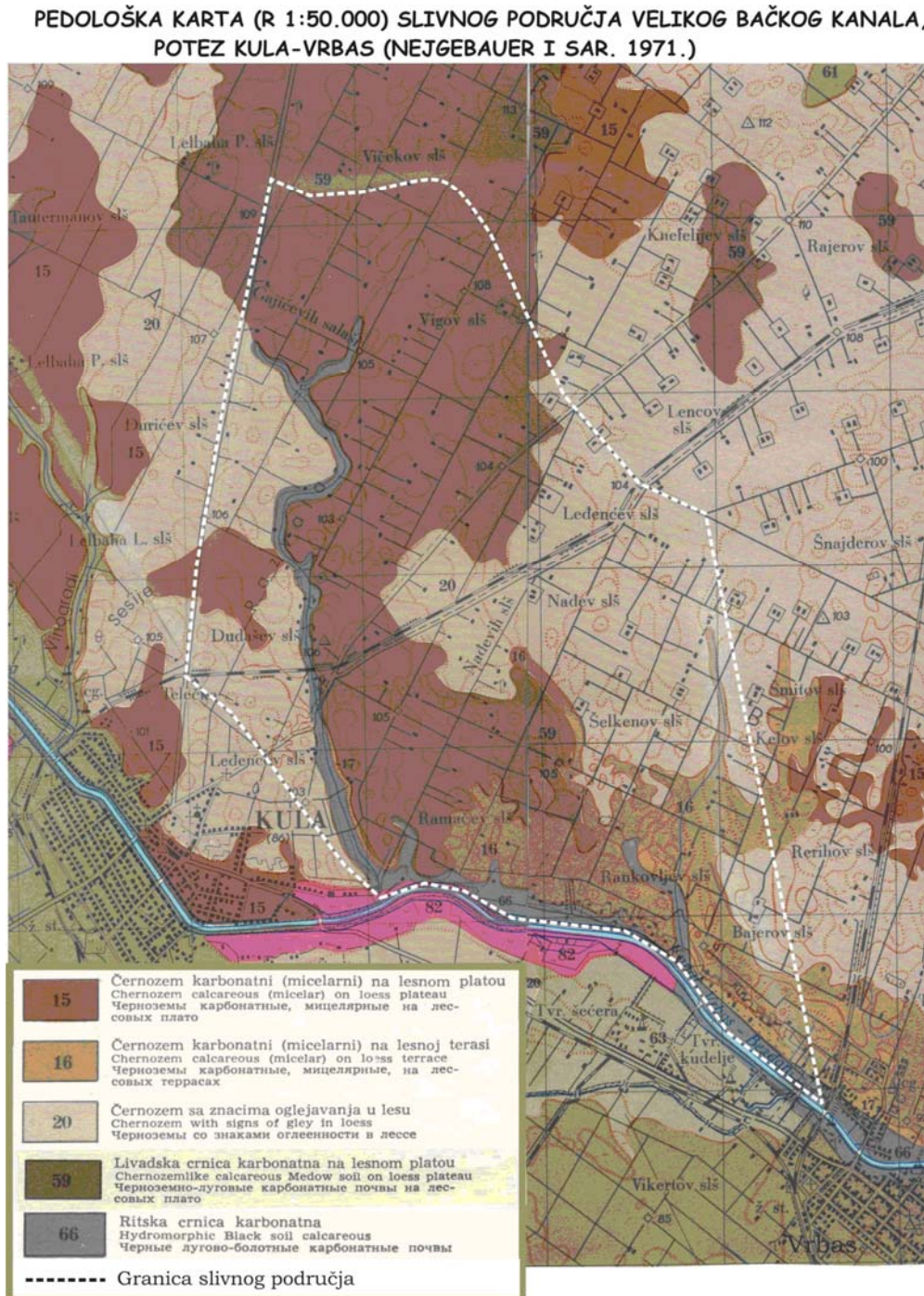


Figure 48. The agricultural area that has been studied for nutrient runoff to the lateral I-61. The area constitutes the catchment of the lowermost monitoring station in I-61.

Table 23 shows the land use in the study area. 87 % is fully cultivated, 4.4 % is pasture, the rest is water surface, urban areas and road sides, etc.

Table 23. *Percent share and areas per land utilization*

Land utilization	Share in total area (%)	Total Area (ha)
Pastures	4.40	171.35 ha
Cultivable	87.06	3386.7 ha
Unproductive (summer roads)	3.81	148.07 ha
Urban	1.75	68.19 ha
Water Area	2.36	91.98 ha
Total		3890 ha

Use of fertilizer

Table 24 shows the use of fertilizer for the most common crops in the area, whereas **Table 25** shows the balances of N and P.

Table 24. Use of fertilizers (with N:P:K-ratio) for the most common crops in the catchment area (from Cuvardic et al 2004)

	State owned farms without irrigation	State owned farms with irrigation	Private farms
Maize	15:15:15 300-400 kg/ha urea 200 kg/ha	15:15:15 300-400 kg/ha urea 200 kg/ha	15:15:15 200 kg/ha urea 100-150kg/ha
Wheat	15:15:15 300 kg/ha urea 150 kg/ha	15:15:15 300 kg/ha AN 300kg/ha	15:15:15 100 kg/ha urea 100 kg/ha
Sunflower	8:16:24 200 kg/ha urea 150 kg/ha		urea 100 kg/ha
Sugar beet	Manure 3 wagons/ha 8:24:16 500 kg/ha urea 100 kg/ha	Manure 5 wagons/ha 8:24:16 300-500 kg/ha urea 100 kg/ha	Manure 3 wagons/ha 8:24:16 300 kg/ha urea 100 kg/ha
alfalfa		15:15:15 200-250 kg/ha	

Table 25. Balance of N and P in the agriculture in the area, kg/ha (from Cuvardic et al 2004)

		Social sector without irrigation		Social sector with irrigation		Private sector without irrigation	
		N	P	N	P	N	P
Maize	input	137-152	45-60	137-152	45-60	76-100	30
	output	115	45	150	60	90	36
	surplus	+30	-	-	-	-	-6
Wheat**	input	114	45	145	45	60	15
	output	141	50	165	54	106	42
	surplus	-27	-5	-20	-10	-46	-25
Sunflower	input	85	32			46	0
	output	50	37			40	30
	surplus	+35	+35			+6	-30
Sugar beet**	input	96 + 50*	120+20*	96+83*	120+33*	70+50*	72+20*
	output	200	80	180	75	180	75
	surplus	-54	+60	-	78	-60	+17

In the private farms the use of fertilizer is rather low. In the state owned farms the level of fertilisation is much higher than in the private farms. For nitrogen the consumption is lower than in Western European agriculture, but for phosphorus it is comparable or even somewhat larger. Particularly in sugar beets the consumption of phosphorus is large.

Animal farms

Animal husbandry is normally run in large units. Most of them are still state owned. The animals produce large quantities of liquid manure which is only partly utilised as fertilizer. The manure is stored in depressions in the terrain, so called lagoons. They are leaking both to ground waters and to surface waters, and are a great source to water pollution. In the agricultural area in the study, see **Figure 48**, there are no large animal farms draining to the I-61, only a few animals on some farms. However, on the other side of the canal, there are large pig farms (Farmakoop) which drain more or less all its manure to the KC-III lateral and into the Grand Canal. See the former chapter. These animal farms constitute a large point source pollution problem, but is out of the scope of the agricultural study which concentrate on the diffuse runoff from agricultural fields.

In the total agricultural area draining to the Grand Canal from Bezdan to Vrbas, i.e. the municipalities of Sombor, Kula and Vrbas, the number of animals are given in **Table 26** and **Table 27**. It can be seen that for pigs, Vrbas has by far the highest density of pigs, which is due mainly to the Farmakoop Pig Farm. **Table 28** shows the number of household animals in the catchment of this agricultural study.

Table 26. The number of household animals in Sombor, Kula and Vrbas municipalities, (Municipalities in Serbia, 2003).

Municipality	NUMBER OF ANIMALS ON 15.01.2003.			
	Cattle	Pigs	Sheep	Poultry
Sombor	10791	95461	3217	415702
Kula	5484	11274	1961	270913
Vrbas	4438	69832	1169	113671

Table 27. The number of animals per ha of farmed land in Sombor, Kula and Vrbas in 2002 (Municipalities in Serbia, 2003).

Municipality	NUMBER OF ANIMALS PER HA OF FARMED LAND		
	Cattle	Pigs	Sheep
Sombor	0.11	1.00	0.03
Kula	0.13	0.26	0.05
Vrbas	0.13	2.10	0.04

Table 28. Household Animals in the catchment in study.

	Social sector without irrigation	Social sector with irrigation	Private sector bez irrigation
Cattle	Farm of milking cows (SK) 750 -1500 wagon/year of manure	Cattle farm (DS) 800 -1500-2000 wagon/year of manure	91 cows - 250 wagon/year of manure
Sheep	230		
Pigs	Small farm (SK), liquid manure, per land lots		78 pigs

Use of pesticides

Table 29 shows the consumption of pesticides in Sombor, Kula and Vrbas municipalities in 2003 (Provincial Secretariat for agriculture, Internal statistics data for the year 2003). Consumption of pesticides in private sector refers only to the pesticides purchased in our country. There are no statistical data on the consumption of pesticides purchased abroad. **Table 30** shows the use of pesticides in the catchment in study.

Table 29. The consumption of pesticides in the municipalities of Sombor, Kula and Vrbas in 2003 (Provincial Secretariat for agriculture, Internal statistics data for the year 2003).

	Consumption of pesticides (kg)			Consumption of pest. (kg ha ⁻¹ farmed land)		
	Total	Social	Private	Total	Social	Private
Sombor						
Fungicides	8838	7466	1372	0.09	0.19	0.02
Herbicides	12590	8579	4011	0.13	0.22	0.07
Insecticides	7273	6785	488	0.08	0.17	0.01
Other	3254	3235	19	0.03	0.08	0.00
Total	31955	26065	5890	0.33	0.67	0.10
Kula						
Fungicides	1731	1731	0	0.09	0.09	0.00
Herbicides	6611	6401	210	0.33	0.32	0.01
Insecticides	85	85	0	0.00	0.00	0.00
Other	1600	1600	0	0.08	0.08	0.00
Total	10027	9817	210	0.50	0.49	0.01
Vrbas						
Fungicides	3322	2967	355	0.22	0.20	0.02
Herbicides	24467	21225	3242	1.60	1.43	0.17
Insecticides	8380	7572	808	0.55	0.51	0.04
Other	206	206	0	0.01	0.01	0.00
Total	36379	31974	4405	2.38	2.15	0.24

Table 30. Use of pesticides in the catchment in study

	Social sector without irrigation	Social sector with irrigation	Private sector without irrigation
Maize	Atrazin 1l/ha + Merlin, Motivel,, Acetohlor 2l/ha	atrazin 1l/ha + Merlin, Motivel,, Acetohlor 1l/ha	Atrazin 1l/ha + Merlin ili Motivel,, Acetohlor 2l/ha
Wheat	-	-	Maton ili Monosan herby 1-1.5l/ha
Sunflower	Acetohlor 2l/ha Racer 2l/ha		Acetohlor 2l/ha Racer 2l/ha
Sugar beet	Betanal 3l/ha Lontrel 3l/ha Counter 20kg/ha trake	Betanal 3l/ha, Prestige, Safari 30-60 g/ha, Guardian 2-4 l/ha	Betanal 3l/ha Lontrel 3l/ha Counter 20kg/ha trake
alfalfa		Pivot 1l/ha , Basargram 1l/ha	Pivot 1l/ha , Basargram 1l/ha

Loss of phosphorus by diffuse runoff in the actual I-61 catchment

Table 31 shows the loss of phosphorus from diffuse runoff estimated by the Harp Guidline 6, (2000) Method (after Cuvardic et al 2004).

Table 31. Quantity of P that reaches the water stream in a year's time depending on land utilization and systematic soil unit (% , l), calculated on the basis of the average water balance for the period 1961-2003 (¹ surface drainage to pastures and fields) 0.13-0.46 kg P/ha/year (after Cuvardic et al 2004).

	Chernozem without irrigation (social)	Chernozem without irrigation (priv)	Chernozem with irrigation (social)	Marsh black earth without irrigation (priv)	Total
Total (ha)	1852	1353	284	407	
Pastures					
- surface flowing out	10.2kg	12 kg	2.4 kg	20 kg	
- drained water	0.56 kg	0.96 kg	0,1 kg	0.88 kg	
- naturally filtered water	-	-	-	-	
	10.76 kg P	12.96 kg P	2.50 kg P	20.88 kg P	36.34 kg P
kg P /ha/year	0.29	0.19	0.44	0.34	0.21
Cultivable					
- surface flowing out	100,5 kg	72,5 kg	22.2 kg	31,2 kg	
- drained water	74.34 kg	46.32 kg	14,8 kg	9.76 kg	
- naturally filtered water	92.89 kg	32.57 kg	16.61 kg	7.86 kg	
	267.73 kg P	151.39 kg P	53.61 kg P	48.82 kg P	521.55 kg
kg P /ha/year	0.16	0.13	0.21	0.17	0.15
Unproductive and urban ¹	-	-	-	-	
- deposition from atmosphere	8.52 kg P	12.45 kg P	2.62 kg P	18.72 kg P	42.31 kg P
kg P /ha/year	0.46	0.46	0.46	0.46	0.46
Total kg P	287.01	176.8	58.73	88.42	610.96
Total kg P/ha/year	0.16	0.13	0.21	0.22	0.16

In total the phosphorus runoff from agricultural field is estimated to 610 kg P/year. This is not very different from the transport of P (450 kg P/y) that was measured based on monitoring of flow and concentration in the lateral which drain this agricultural field, see chapter 5.1.

Loss of nitrogen by diffuse runoff in the actual I-61 catchment

Table 32 shows the loss of nitrogen from diffuse runoff from the agricultural fields in the actual I-61 catchment.

Table 32. Quantity of N that reaches the water stream in a year's time depending on land utilization and systematic soil unit (%), calculated on the basis of the average water balance for the period 1961-2003 (¹ surface drainage to pastures and fields) 1.91- 24.45 kg N/ha/god

	Chernozem without irrigation (social)	Chernozem without irrigation (private)	Chernozem with irrigation (social)	Marsh black earth without irrigation (priv)	Total
Total (ha)	1852	1353	284	407	
Pastures					
- surface flowing out	30,6 kg	32 kg	6 kg	50kg	
- drained water	35 kg	60 kg	6 kg	55 kg	
- naturally filtered water	43.2 kg	37.1 kg	12.3 kg	32 kg	
kg N /ha/year	108.8 kg N	129.1 kg N	24.3 kg N	137 kg N	399.2
kg N /ha/year	2.94	1.91	4.26	2.25	2.33
Pastures					
- surface flowing out	361.8 kg	232 kg	74 kg	104 kg	
- drained water	13216 kg	8685 kg	2960 kg	2074g	
- naturally filtered water	9289 kg	4559.1 kg	3322 kg	1571 kg	
kg N /ha/year	22866.8 kg N	13476.1kg N	6356kg N	3749 kg N	46447
kg N /ha/year	13.49	11.45	24.45	13.15	13.72
Unproductive and urban ¹					-
Deposition from atmosphere	185.2 kg	270.6 kg	57 kg	407 kg	919.8
kg N /ha/year	10	10	10	10	10
Total kg	23160.8	13875.8	6437.3	4293	47767
kg N /ha/year	12.51 kg/ha/year	10.25 kg /ha/year	22.67 kg/ha/year	10.55 kg/ha/year	12.28

The total quantity is estimated to 47 tons N/y. This is a much higher value than we measured (7.3 tons N/y) via monitoring of flow and concentration in the lateral at the outlet of this field. There may be many reasons for this discrepancy; both methods are not very accurate, there are relatively few samples in the monitoring, the soils in Vojvodina is relatively wet, which gives better conditions for denitrification loss and retention as ammonium in the soil, than in the area where the EUROHARP model for theoretical runoff estimates has been developed and tested.

5.3.3 Conclusion about pollution from agriculture

The results show clearly the pollution from diffuse runoff from agricultural fields is a small problem in the area, but that the pollution from the large scale animal husbandry causes a serious water pollution problem. Effective measures have to be taken against this pollution source.

For phosphorus the transport in the agricultural lateral I-61 is only 450-900 kg P/y, whereas the sum of I-64 (industrial lateral) and KC-III (pig-farm lateral) is close to 50 tons P/y. For nitrogen the transport in I-61 is 7-47 tons N/y whereas I-64 + KC-III transport 500 tons of N. The effluents from the pig-farm constitute a major part of this transport.

The use of pesticides is not very different from the use in Western Europe, despite that atrazine is still in use. Most countries in Europe have banned this compound (and other triazines) as they are very harmful to ground waters (atrazine is often called the “ground water killer”).

6. Pollution Abatement and Canal Rehabilitation Measures

6.1 Environmental status in the Grand Canal

The main problem in the Grand Canal on the stretch from Crvenka to the Triangle is saprobification and eutrophication as well as fill in with sediments, see **Figure 49** and **Figure 50**.

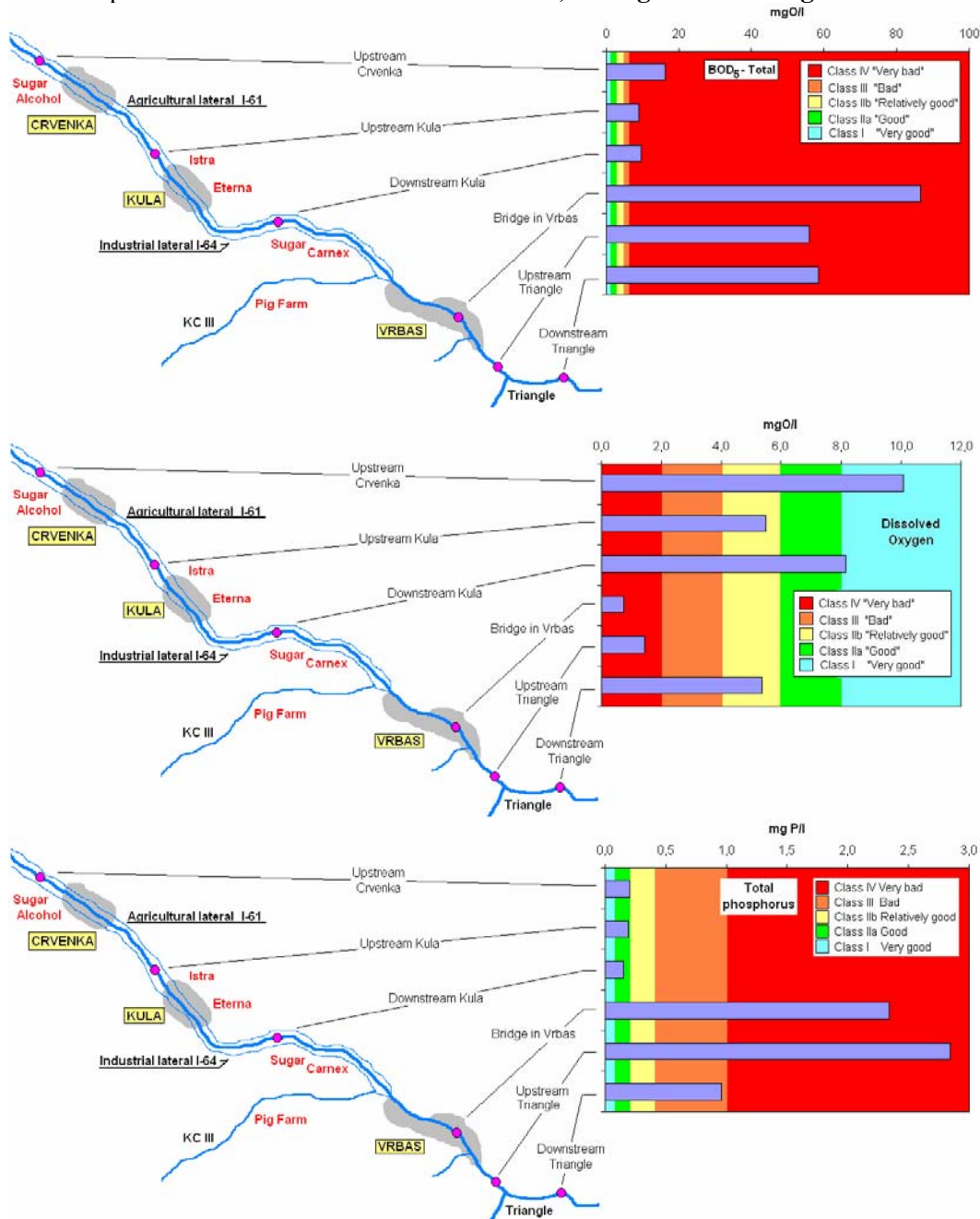


Figure 49. Data summarizing the environmental status in the Grand Canal from Crvenka to the Triangle given by Biological Oxygen Demand in the water, Oxygen Concentration in the water and the concentration of Total Phosphorus. All data are compared with the Serbian Water Quality Criteria.

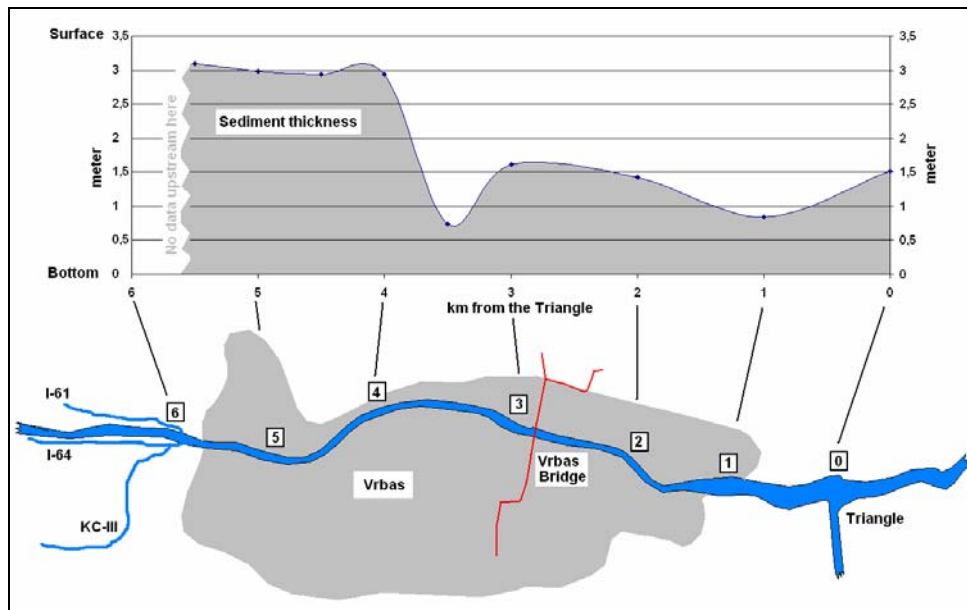


Figure 50. Average sediment thickness in the Grand Canal in varying distance from the discharge point (6 km) to the Triangle (0 km). Numbers in squares are kilometres from the Triangle. (Data from Dekonta 2004).

The whole stretch is impacted, but the situation is markedly deteriorated where the laterals enters the canal. Downstream the entrance of the “bypass canal” (Becej-Bogojevo Canal) the situation improves again. In the stretch from the lateral entrances to the Triangle the pollution is so bad that all criteria for aquatic ecology and water use is exceeded by many folds. Through Vrbas town the canal has the appearance of a stinky, bad looking sewage rotting tank where it is a great health risk confined with falling into the water. This is very negative for the thriving and prosperity of the people in Vrbas, and hampers the development of a modern society in Vrbas.

6.2 Pollution loading from laterals

The pollution loadings from the three laterals, I-64 (Industrial lateral), I-61 (Agricultural lateral) and KC-III (Pig Farm lateral) are given in **Figure 51**. It is quite clear that it is the loading from I-64 and KC-III that creates the problems for the Grand Canal. The diffuse agricultural runoff that enters via I-61 does not constitute any problem. Other pollutants like heavy metals and mineral oils also enter via I-64 and KC-III.

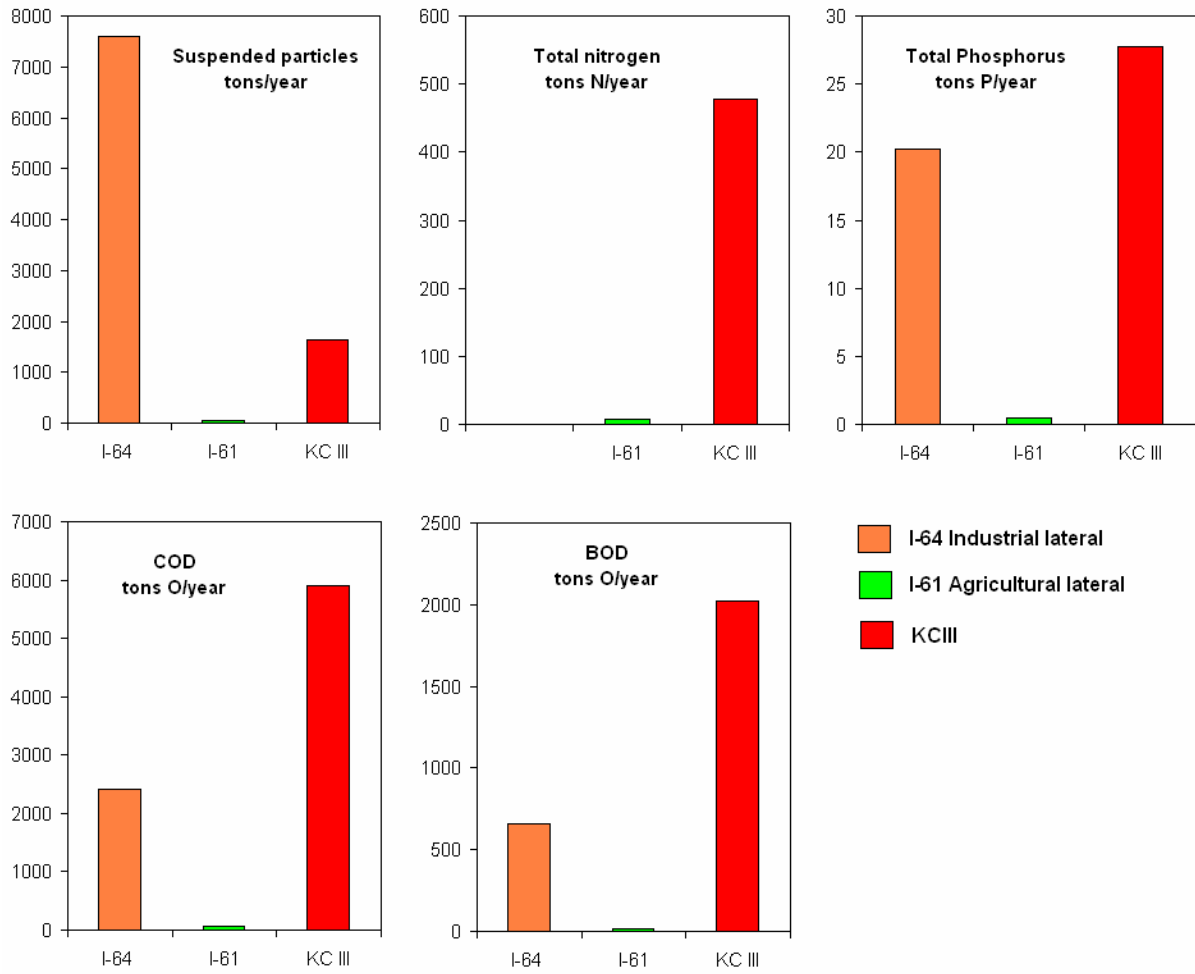


Figure 51. Loading of pollutants by the 3 laterals into the Grand Canal.

6.3 The most important pollution sources

6.3.1 Who is responsible for filling in the Grand Canal with sediments

With respect to fill in with sediments it is clearly shown in **Figure 52** that Farmakoop pig farm and Backa Sugar Factory, and to a somewhat smaller extent, Carnex, is the main discharger of suspended particles.

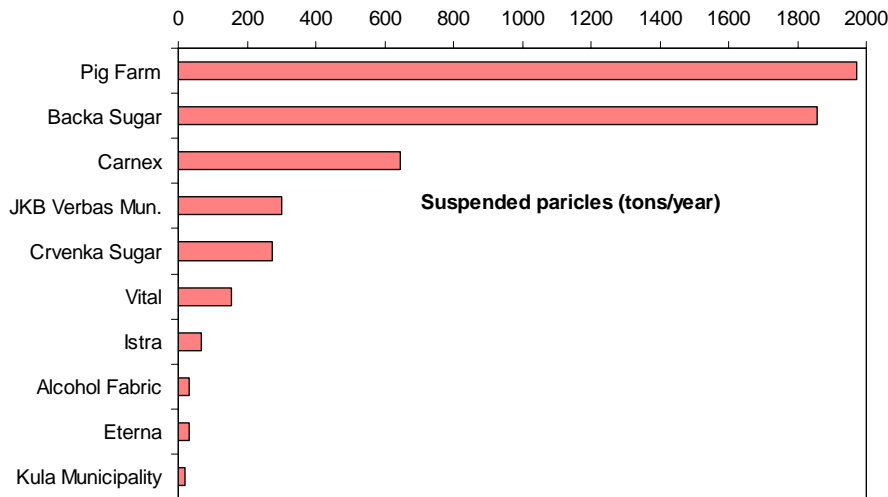


Figure 52. Loading of suspended particles by the different main polluters to the Grand Canal.

6.3.2 Who is responsible for stealing the oxygen from the canal water

Figure 53 shows in ranked order the discharge of easily degradable organic matter from the most important pollution sources. Crvenka Sugar Factory and the Farmakoop pig farm are stealing most oxygen from the Grand Canal water, followed by Backa Sugar factory and Carnex slaughter house and meat factory.

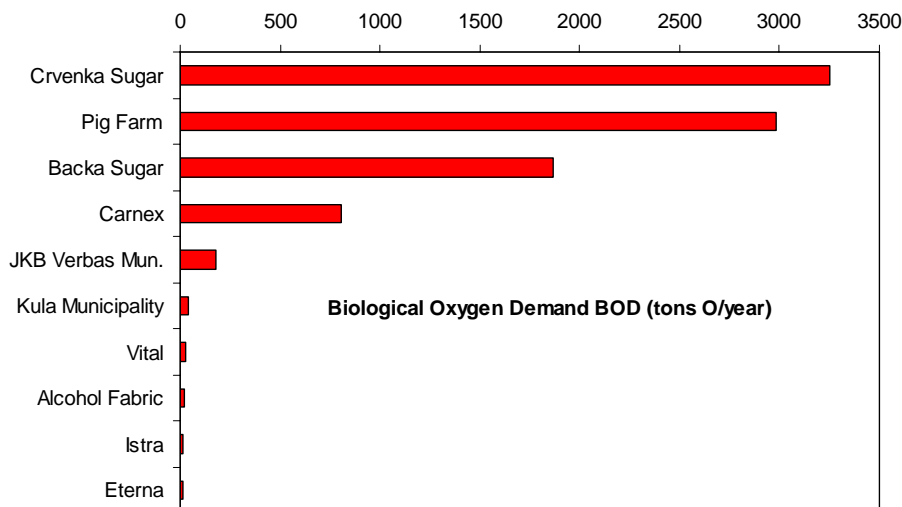


Figure 53. Loading with oxygen consuming organic material from different sources

6.3.3 Who is responsible for the eutrophication of the canal

The Farmakoop pig farm is by far the greatest discharger of nutrients in the region, see **Figure 54**. The other contributors are small compared to the pig farms discharge, but Carnex, Crvenka Sugar, Backa Sugar, and also the JKB Vrbas Municipality has discharges that are significant. For Phosphorus the metal processing plant Istra is using phosphoric acid for surface treatments, and the baths has to be renewed at intervals. This is a likely explanation for the relatively high P-transport that the monitoring revealed in their discharges.

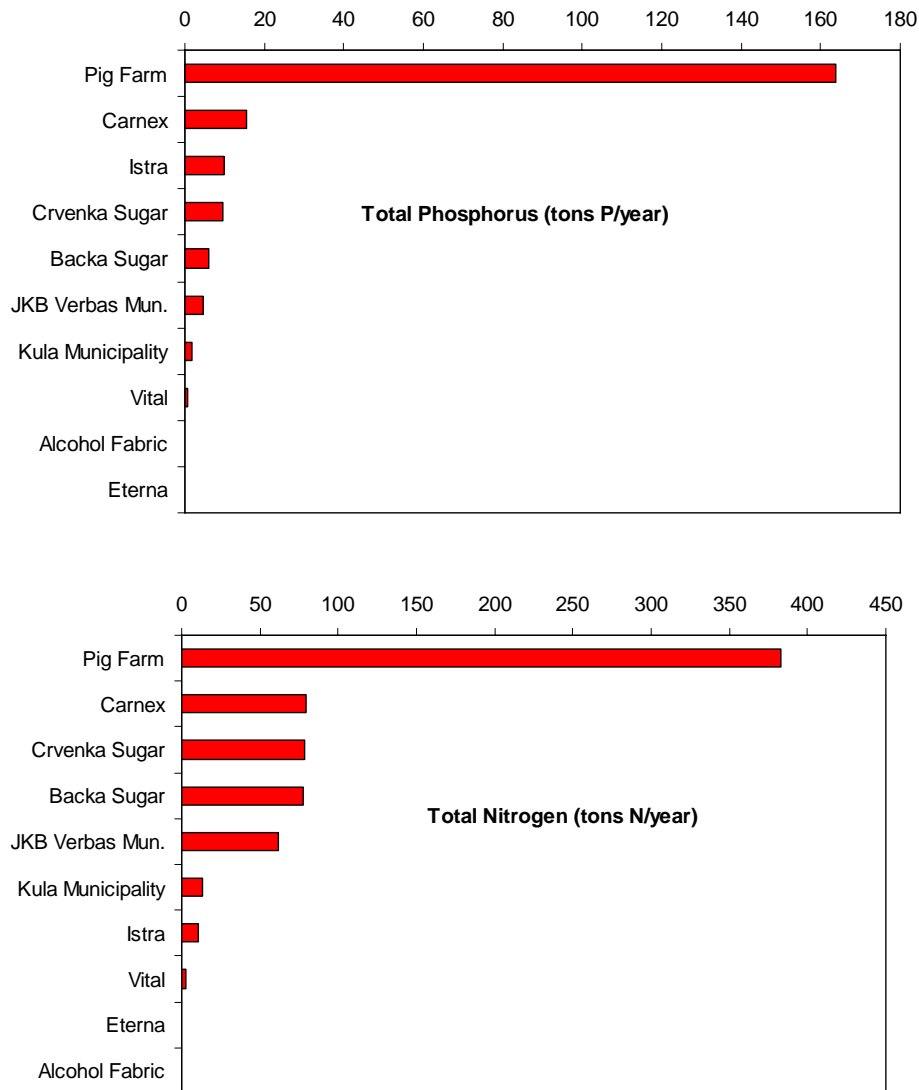


Figure 54. The loading of eutrophying nutrients Phosphorus and Nitrogen

6.3.4 Who is responsible for the heavy metal contamination

Istra faucet manufacturer is the main single source of metal discharges and their discharges revealed in the effluent monitoring is given in **Table 33**.

Table 33. Istra effluent monitoring. Total loading (conc. x flow)

Parameter name	Short name	Unit	Composite	Electroplating	Sum
Suspended particles	SS	tons/y	60	6,5	67
Total Nitrogen	Total N	tons N/y	9,25	1,10	10
Total Phosphorus	Tot-P	tons P/y	9,55	0,18	9,7
Chemical Oxygen Demand	COD-tot.	tons O/y	46	6,39	52
Biological Oxygen Demand	BOD ₅ -tot.	tons O/y	13,8	0,79	14,6
Iron	Fe	tons/y	26	0,0060	25,6
Copper	Cu	kg/y	299	68	367
Zink	Zn	kg/y	299	63	362
Nickel	Ni	kg/y	1123	196	1319
Cadmium	Cd	kg/y	2,25	0,35	2,60
Chromium	Cr	kg/y	517	74	591
Lead	Pb	kg/y	36	8	44

The metal discharges from **Eterna** were negligible in the monitoring period (2003-2004), which is partly a result of the low activity at that factory in that period.

It should be noted that there must be some metal discharging small enterprises along the KC-III as it was discovered high concentrations of metals in this lateral intermittently during the monitoring. A special surveillance should be undertaken to identify the sources of the metal pollution sources.

6.3.5 Who is responsible for the mineral oil contamination?

The monitoring revealed that both the Grand Canal itself in the Vrbas region, and the I-64 and KC-III periodically, have high concentrations of mineral oil. The sources are many, and the monitoring in this project has not been enough for mapping the sources. A special surveillance should be launched to identify the sources of oil pollution.

6.4 Pollution abatement measures

6.4.1 Main priorities

There is no chance of improving the environmental status of the Grand Canal without strongly reducing the discharges from four hot-spots: The Farma-Coop pig farm, the two sugar factories, and the slaughter house and meat factory Carnex. All the other polluters are minor compared to these 4.

Dredging the canal for sediment is also an essential measure, but this is of no value without controlling the 4 main discharges mentioned above. Otherwise the canal will be relatively rapidly filled in with new sediments.

The sewage from the two municipalities Kula and Vrbas should be collected and treated in a new sewage treatment plant. This plant could also take care of some of the industrial discharges from the smaller enterprises in the area.

The sources for the oil pollution of I-64 and KC-III, and the metal pollution in KC-III should be identified through special surveillances.

6.4.2 Crvenka Sugar Factory

Crvenka sugar factory takes relatively good care of the particle discharge by using the sedimentation cassettes. It is important to empty the cassettes for sludge at correct intervals.

However they have a large discharge of easily degradable organic material (BOD) stealing the oxygen from the water. Before entering the I-64 the discharge should be treated in a series of aerated lagoons to break down as much as possible of the oxygen consuming organic material.

6.4.3 Backa Sugar Factory

Backa Sugar Factory has to start using their cassettes for sediment removal. They must empty the cassettes at correct intervals. They also must install aerated lagoons to break down the BOD before discharging it into the I-64.

For both sugar factories, it can be a great help if the beets were washed in the agricultural fields before they were loaded on the truck, or washed on the trucks while still in the field. This would reduce the sediment problems and the sedimentation cassette area could be reduced.

6.4.4 Carnex slaughter house and meat factory

For Carnex the industrial process must be modernized to the type of clean technology used in Western Europe. This will utilize much more of the animals, like blood, bones, etc. and reduce the discharges considerably. There is given a separate report on these aspects (see Åsterud 2004). The rest-discharge from Carnex could possibly be lead into the new Central Waste Water Treatment Plant to receive an after polish there.

6.4.5 Farmakoop Pig Farm

This farm needs a major reconstruction and modernization. First of all the manure must be collected in a safe way and utilised as fertilizer on the fields in the start of the growing season. The pumping of manure into KC-III must be brought to a stop relatively rapidly.

There could be built prefabricated circular manure silos that could be placed at strategic sites in the agricultural areas around Vrbas and the liquid manure could be pumped to these regional storages. From there, at correct time the manure could be spread by tractors within acceptable transport distances. New spreading equipment, which allows for spreading of manure also after the seeds have sprouted without doing "burning" damage to the plants, exists and their use is increasing in Western Europe. In this way manure can be utilized as an effective fertilizer which will reduce the need for mineral fertilizer considerably, and much of the manure pollution problems will be solved.

6.4.6 The Istra Faucet Factory

This factory should build their own treatment systems as the metal containing effluents are not effectively treated in a conventional sewage treatment plant as is planned here (CWWTP). It will also introduce problems with disposal of the municipal sludge, which otherwise can be spread on agricultural fields.

The industry should be revised after the principles given in the IPPC-Directive in the EU, which includes BAT (Best Available Techniques) both with respect to the industrial process and the effluent handling.

6.4.7 Sewage from the municipalities (new CWWTP)

In the towns of Crvenka, Vrbas and Kula the population is 10000, 26000, and 19300 respectively. Approximately 35-40% of the population is connected to sewerage facilities. The treatment plants are old and degraded, and our monitoring results indicated that a considerable amount of sewage entered the Grand Canal. Even though the discharges of sewage were small compared to the 4 main industrial pollution sources, building of a new central wastewater treatment plant (CWWTP) will be an important step towards a clean Grand Canal. The CWWTP can also treat parts of the effluents from the food processing industry in the area. It should be considered to build a joint plant which could treat effluents both from Kula and Vrbas.

The planning for design of the CWWTP is going on at the moment.

6.4.8 Removal of sediment from the canal (dredging)

From the site where the laterals enters the Grand Canal and through most of Vrbas, the Grand Canal is almost filled in with sediments. Removal of these sediments is a necessary measure for restoring the canal. But the removal is of restricted value if not the sources of the sedimentation are controlled first.

Most of the sediment volume seems to be made up by soil from the process of washing the sugar beats, and by organic waste from the pig farm. The sediments are mixed in with some heavy metals from Istra, from Eterna, and from different small metal treating/handling enterprises in the Vrbas region. There are also some organic micro pollutants present, like PCBs and mineral oil components, which has origin from several small sources.

Compared to Norwegian, Canadian and US sediment quality criteria, the sediments can be characterized as moderately polluted. In the most polluted stretch downstream the entrance of the 3 laterals (I-64, I-61 and KC III) the contaminants attain levels which will give negative impact on bottom living organisms according to the Canadian sediment guidelines. The anoxic conditions of the sediments are, however, the main problems for the living creatures, not the content of the environmental toxins.

None of the contaminants have such high concentrations that it will be risky to dredge the material. One problem is, however, that the sediments are often highly anaerobic and will release sulphide during the dredging operation. This might smell badly, and may also be a temporary health problem for the personnel performing the dredging. If strong smell of H₂S occurs, use gas protection equipment on board the dredging barge.

With respect to disposal of the dredged material, many elements exceed the acceptable concentration for agricultural soils. The soils can therefore not be spread onto agricultural land without any pre-treatment. However, only few sediment samples exceed the limits for soils used for parks and recreation areas, and of course also for forest producing areas. Neither did they exceed concentrations which will impose a threat for ground water when placed in landfills. This means that the sediments do not need any advanced and expensive treatment prior to disposal.

The sediments could for example be placed on land along the canal on which it can be established a park, a golf course, or simply a riparian zone along the canal planted with forest for ecological and nutrient retaining purposes.

6.4.9 Diffuse runoff from agriculture

As this is a small source of pollution of the GC, it is not urgent to take measures against this source at the moment. However, Serbia having ratified the Danube Convention, and as member of the ICPDR (International Commission for the Protection of Danube River) they will adopt the BAP (Best Agricultural Practise) under the Common Agricultural Policy which is being introduced in the EU-countries at the moment. The BAP will include i.a. measures to reduce pollution from agriculture runoff. UNDP/GEF is undertaking such a study in the region right now (Danube Regional Project, Vienna).

The hot-spots in agriculture pollution in the catchment of the Grand Canal are the large scale animal husbandry, where the implementing of modern handling and disposal of the manure is the priority action. In the problem stretch of the canal from Crvenka to Vrbas, Farmakoop Pig Farm is in fact one of the largest single pollution sources. The actions against this pollution source are given in section 6.4.5 above.

6.4.10 Hydrological measures

During the sugar campaign the water in the Grand Canal is hold back around Vrbas by closing the Vrbas lock, the Becej lock, and Kucura lock. This is to prevent the pollution from the Vrbas area from flowing further downstream where i.a. is located fish farms and other pollution susceptible water use activities. This is one of the reasons why the pollution has been able to settle and fill in the canal with sediment. In periods with high water flow in the Danube, the DTD-canal Company flush the Grand Canal, and sometimes they manage to clean up the water in the canal for a short time and even manage to move some of the sediments.

Upstream the entrance of the laterals, where the canal should be relatively healthy, the canal is eutrophic and become filled in with aquatic plants, both rooted macrophytes and floating plants (duck weeds, etc). The growth conditions for this vegetation could be reduced considerably by letting more water flowing through the canal. Increased water flow will also improve the water quality downstream the lateral entrance. But before the pollution “hot-spot” sources are brought under control, the water flow cannot be increased on regular basis due to downstream spreading of the pollution. Afterwards, however, the flow through Vrbas should be increased.

6.4.11 Pollution surveillance in the whole DTD-canal system

The results from the monitoring station upstream Crvenka revealed that the Grand Canal was polluted even here, although much less than in the Vrbas region. The canal was heavily eutrophic indicating that it receives considerable amounts of nutrients and effluents on the stretch from Bezdán to Crvenka. The same is most likely true also downstream the stretch included in this study and for other parts of the canal systems as well. Therefore, it should be carried out a Recipient Surveillance in the whole DTD-Canal system to see if the recipient capacity is exceeded in some areas. The population in the area needs to use the Grand Canal as recipient for their wastewater, but recognising that the canal is their main watercourse, they will benefit from a healthy aquatic ecosystem that also will secure the fulfilment of the quality requirements of the water use interests.

7. Literature references

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8. Primary Data

8.1 Chemical analysis from the monitoring of the Grand Canal

Table 34. Chemical analysis from the Grand Canal upstream Crvenka

Upstr-crv-1

	Variabel	Water temp	Air temp	Visible particles	Colour	pH	Suspended particles	Dry residue	Ignited (glowed) residue	Turbidity	Conductivity	Thermotolerant coli. Bact	Ammonia	Nitrates	Nitrites	organic Kjeldahl N	Total N
Term		°C	°C	descr.	descr.		mg/L	mg/L	mg/L	NTU	µS/cm	no/100 mL	mg NH ₄ ⁺ /L	mg NO ₃ ⁻ /L	mg NO ₂ ⁻ /L	mg N/L	mg N/L
Cycle	Date																
1	24.09.2003	19	23	none	none	7,85	46	744	358	1,9	430		0,25	8	0,2	0,3	2,35
2	19.11.2003	9,7	5	none	none	8,3	150	250	80		524		0,125	0,65	0,01	0,1	0,2
3	16.01.2004.	1,5	3	small particles	none	8,46	53	117	28	11,6	510	500	0,15	10	0,04	3,76	6,21
4	10.03.2004.	3,6	3	none	none	8,5	95	410	280	1,57	639	500	0,2	6	0,06	1,3	2,83
5	12.05.2004.	18	19,5	none	none	8,2	233	800	320		858	101000	0,25	4	0,03	0,194	1,3
6	01.07.2004.	20	23	algae	none	7,79	60	1290	510	7,66	752	195000	0,2	0,65	0,002	2,76	2,91

Table 34 continued

Upstr-crv-2

	Variabel	dissolved phosphates	Total P	Chemical Oxygen Demand, total	Chemical Oxygen Demand, dissolved	COD-tot. - COD-diss	BOD ₅ , total	BOD ₅ , dissolved	BOD ₅ -tot. - BOD ₅ -diss	Dissolved Oxygen	Oxygen saturation				
Term	PO ₄ ³⁻	Tot-P	COD-tot.	COD-diss	CODdiff	BOD ₅ -tot.	BOD ₅ -diss	BOD ₅ diff.	left bank	right bank	middle	left bank	right bank	middle	
Unit	mg PO ₄ ³⁻ /L	mg P/L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	% sat.	% sat.	% sat.	
Cycle	Date														
1	24.09.2003	0,1	0,14	14		14	5		5	9,48	9,84	10,22	100	104	108
2	19.11.2003	0,1	0,035	10		10	2		2	10,1	10	10,1	89	88	89
3	16.01.2004.	0,1	0,035	140	20	120	50	10,4	39,6	14,1	14,3	14,5	100	100	100
4	10.03.2004.	0,1	0,035	50	26	24	7,1	2	5,1	12,9	13,1	13,4	99	100	100
5	12.05.2004.	0,67	0,106	50	20	30	20,8	11,5	9,3	7,2	7,3	7,4	76	77	78
6	01.07.2004.	2,01	0,88	30	20	10	12	8,9	3,1	4,5	4,3	4,8	49	47	53

Table 34 continued

Upstr-crv-3

	Variabel	UV-abs (254nm)	Alkalinity	Hardness	Phenols	PAH (Total)	Naftalen	Acenafitilen	Acenaften	Fluren	Fenantren	Antracen	Fluoranten	Piren	Benzo(a)antracen	Krisen	Benzo (b) fluoranten	Benzo (k) fluoranten	Benzo (a) piren	Dibenzo (a,h) antracen	Benzo (g,h,i) perilen	Indeno (1,2,3-c,d) piren
	Term	cm ⁻¹	mval/L	°dH	µg/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L
Cycle	Date																					
1	24.09.2003	0,038	3,4	12,3	0,25	6	2	2	2	2	6	6	6	6	2	6	2	2	2	2	2	2
2	19.11.2003	0,084																				
3	16.01.2004.	0,061																				
4	10.03.2004.	0,119																				
5	12.05.2004.	0,19																				
6	01.07.2004.	0,354																				

Table 34. Continued

Upstr-crv-4

	Variabel	Fe	Mn	Cu	Zn	Ni	Cd	Cr	Hg	Pb	Mineral oils	Benzene	Ethylbenzene	Toluol	Xylenes
	Term	Fe	Mn	Cu	Zn	Ni	Cd	Cr	Hg	Pb					
	Unit	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Cycle	Date														
1	24.09.2003	0,14	0,014	11	7,7	8,1	0,9	1,7	0,1	8,3	54	0,15	0,15	0,15	0,15
2	19.11.2003														
3	16.01.2004.	0,053	0,017	13	9,2	7,2	1,5	6,1	0,1	55	45				
4	10.03.2004.	0,033	0,013	5,5	7,1	14	1,1	9,6		12,4	22				
5	12.05.2004.														
6	01.07.2004.										11,02				

Table 35. Chemical analysis from the Grand Canal upsyteam Kula

Upstr-kula-1

	Variabel	Water temp	Air temp	Visible particles	Colour	pH	SS	Suspended particles	Dry residue	Ignited (glowed) residue	Turbidity	Conductivity	Thermotolerant coli bact	Ammonia	Nitrates	Nitrites	organic Kjeldahl N	Total N
Term	Unit	°C	°C	descr.	descr.	pH	mg/L	mg/L	mg/L	mg/L	NTU	µS/cm	no/100 mL?	mg NH ₄ ⁺ /L	mg NO ₃ ⁻ /L	mg NO ₂ ⁻ /L	mg N/L	mg N/L
Cycle	Date																	
1																		
2	18.11.2003	20	21	none	none	7,8	21	437	210	0,05	362			0,25	5	0,2	0,4	1,8
3																		
4																		
5	12.05.04.	19	19	small particles	none	8,48	593	700	290		927		100	0,3	6	0,09	0,737	2,35

Table 35 continued

Upstr-kula-2

	Variabel	dissolved phosphates	Total P	Chemical Oxygen Demand, total	Chemical Oxygen Demand, dissolved	COD-tot. - COD-diss	BOD ₅ -total	BOD ₅ -dissolved	BOD ₅ -tot. - BOD ₅ -diss	Dissolved Oxygen	Oxygen saturation				
Term	Unit	mg PO ₄ ³⁻ /L	mg P/L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L				
Cycle	Date									left bank	right bank	middle	left bank	right bank	middle
										% sat.	% sat.	% sat.	% sat.	% sat.	% sat.
1															
2	18.11.2003	0,21	0,28	15		15	4		4	4,2	4,1	4	46	45	44
3															
4															
5	12.05.04.	0,67	0,106	70	40	30	13,7	4	9	7,1	6,7	7	76	72	75

Table 35 Continued

Upstr-kula-3

	Variabel	UV-abs (254nm)	Alkalinity	Hardness	Phenols	PAH (Total)	Naftalen	Acenaffilen	Acenafften	Fluren	Fenantren	Antracen	Fluoranten	Piren	Benzo(a)antracen	Krisen	Benzo (b) fluoranten	Benzo (k) fluoranten	Benzo (a) piren	Dibenzo (a,h) antracen	Benzo (g,h,i) perilen	Indeno (1,2,3-c,d) piren
Term	Unit	cm ⁻¹	mval/L	°dH	µg/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L
Cycle	Date																					
1																						
2	18.11.2003	0,068	2,9	13,2	4,6	6	2	2	2	2	6	2	6	6	2	2	2	2	2	2	2	2
3																						
4																						
5	12.05.04.	0,235																				

Table 35 Continued
Upstr-kula-4

	Variabel	Fe	Mn	Cu	Zn	Ni	Cd	Cr	Hg	Pb	Mineral oils	Benzene	Ethylbenzene	Toluol	Xylenes
Term	Fe	Mn	Cu	Zn	Ni	Cd	Cr	Hg	Pb						
Unit	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Cycle	Date														
1															
2	18.11.2003	0,093	0,057	9,8	20	10	1,6	17	0,1	22	24	0,15	0,15	0,15	0,15
3															
4															
5	12.05.04.			5	14	9	1,2	44		12	97				

Table 36. Chemical analysis from the Grand Canal downstream Kula

Dstr-kula-1

	Variabel	Water temp	Air temp	Visible particles	Colour	pH	SS	Suspended particles	Dry residue	Ignited (glowed) residue	Turbidity	Conductivity	Thermotolerant coli bact	Ammonia	Nitrates	Nitrites	organicKjeldahl N
Term	Water temp	Air temp															
Unit	°C	°C	descr.	descr.			mg/L	mg/L	mg/L	mg/L	NTU	µS/cm	no/100 mL?	mg NH ₄ ⁺ /L	mg NO ₃ ⁻ /L	mg NO ₂ ⁻ /L	mg N/L
Cycle	Date																
1	22.09.2003	21,5	29,5	none	none	7,70	57	331	207	0,93	445			0,25	4	0,2	0,5
2																	
3																	
4																	
5	11.05.04.	13,0	18	algae, small particles	yellowish	9,30	507	1570	370		567		7500	0,25	0,65	0,08	0,78

Table 36 continued

Dstr-kula-2

	Variabel	Total N	PO ₄ ³⁻	dissolved phosphates	Total P	COD-tot.	Chemical Oxygen Demand, total	COD-diss	Chemical Oxygen Demand, dissolved	COD-tot. - COD-diss	BOD ₅ -total	BOD ₅ -dissolved	BOD ₅ -tot. - BOD ₅ -diss	Dissolved Oxygen		
	Term	Total N	PO ₄ ³⁻	Tot-P	COD-tot.	COD-diss	CODdiff	BOD ₅ -tot.	BOD ₅ -diss	BOD ₅ -tot.	BOD ₅ -diss	BOD ₅ -diff.	left bank	right bank	middle	
	Unit	mg N/L	mg PO ₄ ³⁻ /L	mg P/L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	
Cycle	Date															
1	22.09.2003	1,7	0,21	0,14	13		13	5		5			5,64	6,10	4,60	
2																
3																
4																
5	11.05.04.	0,99	0,67	0,16	80		50	30		14		6	8	11,40	11,50	11,70

Table 36 continued

Dstr-kula-3

	Variabel	Oxygen saturation			UV-abs (254nm)	Alkalinity	Hardness	Phenols	PAH (Total)	Nattalen	Acenatitlen	Acenafiten	Fluren	Fenantren	Antracen	Fluoranten	Piren	Benz(a)antracen	Krisen	Benzo (b) fluoranten	Benzo (k) fluoranten	Benzo (a) piren	Dibenzo (a,h) anracen	Benzo (g,h,i) perilen	Indeno (1,2,3-c-d) piren
	Term	left bank	right bank	middle																					
	Unit	% sat.	% sat.	% sat.	cm ⁻¹	mval/L	°dH	µg/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L
Cycle	Date																								
1	22.09.2003	65	70	53	0,071	3,3	14,9	4,6	6	2	2	2	2	6	2	6	6	2	2	2	2	2	2	2	2
2																									
3																									
4																									
5	11.05.04.	108,00	109,00	111,00	0,125																				

Table 36 continued

Dstr-kula-4

	Variabel	Fe	Mn	Cu	Zn	Ni	Cd	Cr	Hg	Pb	Mineral oils	Benzene	Ethylbenzene	Toluol	Xylenes
	Term	Fe	Mn	Cu	Zn	Ni	Cd	Cr	Hg	Pb					
	Unit	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Cycle	Date														
1	22.09.2003	0,065	0,012	5,5	33	11	3,3	5,5	0,1	11	38	0,15	0,15	0,15	0,15
2															
3															
4															
5	11.05.04.			30	22	24	1,5	101		12	9,7				

Table 37. Chemical analysi from the Grand Canal at the Bridge in Vrbas

br-vrb-1

Variabel	Water temp	Air temp	Visible particles	Colour	pH	SS	Suspended particles	Dry residue	Ignited (glowed) residue	Turbidity	Conductivity	Thermotolerant colif. Bact.	Ammonia	Nitrates	Nitrites
Term	°C	°C	descr.	descr.		mg/L	mg/L	mg/L	mg/L	NTU	µS/cm	no/100 mL?	mg NH ₄ ⁺ /L	mg NO ₃ ⁻ /L	mg NO ₂ ⁻ /L
Cycle	Date														
1	29.09.2003	22	28	film of oil on water surface		7,29	15	735	300	19,44	657		0,5		0,2
2	17.11.2003	13,3	6	film, fats, impurities	grey-milky	6,93	280	770	330		848		15	2	0,01
3	20.01.2003	5,2	1	fat	without	7,53	63	710	305	33	840	264000	11	4	0,1
4	11.03.2004	6,1	2	floating fat	yellowish	7,68	120	550	340	3	914	247000	10	0,65	0,002
5	11.05.2004.	18	18	floating fat	laight green	7,92	273	1000	370		1074	415000	0,38	0,65	0,002
6	02.07.2004.	20	24	fat	gray	7,4	687	2310	1960	2,35	1089	2195000	0,25	0,65	0,005

Table 37 continued

Br-vrb-2

Variabel	organic N per Kjeldahl	Total N	PO ₄ ³⁻	dissolved phosphates	Total P	Chemical Oxygen Demand, total	Chemical Oxygen Demand, dissolved	COD-tot. - COD-diss	BOD ₅ , total	BOD ₅ , dissolved	BOD ₅ -tot. - BOD ₅ -diss	Dissolved Oxygen
Term	mg N/L	mg N/L	mg PO ₄ ³⁻ /L	mg P/L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L
Cycle	Date											
1	29.09.2003	6,1	6,9	4,02	1,3	210		210	36		36	0,55
2	17.11.2003	3,8	16	0,1	5,9	360		360	230		230	0,70
3	20.01.2003	14	24	0,64	0,42	210	130	80	140	30	110	1,70
4	11.03.2004	89	97	0,1	3,5	60	40	20	44	24	20	0,00
5	11.05.2004.	5,6	5,8	1,5	0,7	220	80	140	20	9,8	10,2	0,10
6	02.07.2004.	8,5	8,7	7,4	2,2	100	80	20	50	37	13	0,80

Table 37 continued

Br-vrb-3

Variabel	Oxygen saturation	UV-abs (254nm)	Alkalinity	Hardness	Phenols	PAH (Total)	Naftalen	Acenafilen	Acenafiten	Fluren	Fenantren	Antracen	Fluoranten	Piren	Benzo(a)antracen	Krisen	Benzo (b) fluoranten	Benzo (k) fluoranten
Term	left bank	right bank	middle	cm ⁻¹	mval/L	°dH	µg/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L
Cycle	Date	% sat.	% sat.	% sat.														
1	29.09.2003	6	6	7	0,138	4,9	19,7	4,6	34	2	2	2	6	34	2	6	6	2
2	17.11.2003	7	6	8	0,660													
3	20.01.2003	14,00	13,00	15,00	0,466													
4	11.03.2004	0,00	0,00	0,00	0,175													
5	11.05.2004.	1,05	1,05	2,11	0,182													
6	02.07.2004.	8,80	8,80	11,00	0,431													

Table 37 continued
Br-vrb-4

	Variabel	Benzo (a) piren	Dibenzo (a,h) anracen	Benzo (g,h,i) perilen	Indeno (1,2,3-c,d) piren	Fe	Mn	Cu	Zn	Ni	Cd	Cr	Hg	Pb	Mineral oils	Benzene	Ethylbenzene	Toluol	Xylenes
Term						Fe	Mn	Cu	Zn	Ni	Cd	Cr	Hg	Pb					
Unit		ng/L	ng/L	ng/L	ng/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Cycle	Date																		
1	29.09.2003.	2	2	2	2	0,2	0,087	23	48	22	12	5,8	0,1	15	232	2	0,15	9,7	0,15
2	17.11.2003																		
3	20.01.2003						0,14		30	16	1,8	5	0,25	55	650				
4	11.03.2004					0,33	0,19	72	91	130	1,2	25	0,1	120	174				
5	11.05.2004.																		
6	02.07.2004.							26	30	28	18	4,2	0,1	34	2945				

Table 38. Chemical analysis from the Grand Canal Upstream the Triangle

Upstr-tria-1

	Variabel	Water temp	Air temp	Visible particles	Colour	pH	SS	Suspended particles	Dry residue	Ignited (glowed) residue	Turbidity	Conductivity	Thermotolerant coli. Bact.	Ammonia	Nitrates	Nitrites
Term		°C	°C	descr.	descr.	pH	SS				Turb.	Cond.		NH ₄ ⁺	NO ₃ ⁻	NO ₂ ⁻
Unit		°C	°C	descr.	descr.		mg/L	mg/L	mg/L	mg/L	NTU	µS/cm	no/100 mL?	mg NH ₄ ⁺ /L	mg NO ₃ ⁻ /L	mg NO ₂ ⁻ /L
Cycle	Date															
1	23.09.2003.	23	30	none	none	7,30	37	551	304	9,20	620		0,75	2	0,2	
2	17.11.2003	12,4	5	black balls of impurities	grey-milky	6,54	210	620	160		807		13	0,65	0,01	

Table 38 continued

Upstr-tria-2

	Variabel	organickjeldahl N	Total N	dissolved phosphates	Total P	Chemical Oxygen Demand, total	Chemical Oxygen Demand, dissolved	COD-tot. - COD-diss	BOD ₅ -total	BOD ₅ -dissolved	BOD ₅ -tot.- BOD ₅ -diss	Dissolved Oxygen		
Term		Total N	PO ₄ ³⁻	Tot-P	COD-tot.	COD-diss	CODdiff	BOD ₅ -tot.	BOD ₅ -diss	BOD ₅ diff.	left bank	right bank	middle	
Unit		mg N/L	mg PO ₄ ³⁻ /L	mg P/L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	
Cycle	Date													
1	23.09.2003.	3,8	4,9	2,68	0,88	150		150	32		32	2,83	3,25	2,46
2	17.11.2003	3	12,7	0,1	4,8	140		140	80		80	0,4	0,3	0,4

Table 38 continued

Upstr-tria-3

Cycle	Date	Oxygen saturation			UV-abs (254nm)	Alkalinity	Hardness	Phenols	PAH (Tctat)	Nafalen	Acenafilen	Acenaften	Fluren	Fenantrén	Antracén	Fluorantén	Piren	Benz(a)antracén	Krisén	Benz(o)fluorantén	Benz(o)k)fluorantén	Benz(o)piren	Dibenzo(a,h)antracén	Benz(o)g,h,i)perilen	Indeno(1,2,3-c-d)piren
		left bank	right bank	middle																					
Term	Unit	% sat.	% sat.	% sat.	cm ⁻¹	mval/L	°dH	µg/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	
1	23.09.2003.	33	38	29	0,119	5,3	18,4	0,25	6	2	2	2	2	6	2	6	6	2	2	2	2	2	2	2	
2	17.11.2003	4	3	4	0,504																				

Table 38 continued

Upstr-tria-4

Cycle	Date	Fe	Mn	Cu	Zn	Ni	Cd	Cr	Hg	Pb	Mineral oils	Benzene	Ethylbenzene	Toluol	Xylenes
1	23.09.2003.	0,096	0,075	20	20	15	1,2	2,5	0,1	10	76	0,15	0,15	0,15	0,15
2	17.11.2003														

Table 39. Chemical analysis from the Grand Canal downstream the Triangle

Dstr-tria-1

Cycle	Date	Water temp	Air temp	Visible particles	Colour	pH	Suspended particles	Dry residue	Ignited (glowed) residue	Turbidity	Conductivity	Thermotolerant coli. Bact.	Ammonia	Nitrates
1	23.09.2003	23,5	30,4	none	none	7,47	29	610	276	6,53	553		0,25	2,0
2	17.11.2003	10,6	5	dark broken film of fat	grey-milky	6,9	30	420	160		655		8,75	0,7
3	16.01.2003.	2,1	2	small particles, ice	light brown-green	7,7	55	470	256	18	741	300000	6,25	4,0
4	11.03.2003	3,7	0	small particles, ice	yellowish	8,64	147	510	220	0,82	536	36000	1,1	16,0
5	12.05.04.	17,9	18	small particles	none	8,2	380	1280	210		858	69800	1,25	13,0
6	02.07.2004.	21	23	small particles	green	7,54	540	1160	220	11,69	591	486500	2,25	3,0

Table 39 continued

Dstr-tria-2

Variabel	NO ₂ ⁻	Nitrites	organic Kjeldahl N	Total N	PO ₄ ³⁻	dissolved phosphates	Total P	Chemical Oxygen Demand, total	Chemical Oxygen Demand, dissolved	COD-tot. - COD-diss	BOD ₅ , total	BOD ₅ , dissolved	BOD ₅ -tot. - BOD ₅ -diss	Dissolved Oxygen		
Term	mg NO ₂ /L	mg N/L	mg N/L	mg PO ₄ ³⁻ /L	mg P/L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	left bank	right bank	middle
Cycle	Date															
1	23.09.2003	0,2	2,4	3,1	1,34	0,88	120		120		16		16	3,40	3,85	4,30
2	17.11.2003	0,02	2,8	9,6	0,1	2,1	130		130		90		90	1,10	1,10	1,20
3	16.01.2003	0,08	0,98	6,8	0,64	0,42	90	60	30	65	36		29	4,00	3,80	4,30
4	11.03.2003	0,06	0,019	4,5	0,1	0,88	480	480	0	164	160		4	13,00	12,90	13,30
5	12.05.04.	0,002	0,19	4,1	0,67	0,35	80	40	40	14,7	7		7,7	6,70	6,80	7,20
6	02.07.2004.	0,08	1,16	3,61	2,68	1,1	20	20	0	1	0,5		0,5	1,90	1,80	2,00

Table 39 continued

Dstr-tria-3

Variabel	Oxygen saturation			UV-abs (254nm)	Alkalinity	Hardness	Phenols	PAH (Total)	Nattalen	Acenafilen	Acenafiten	Fluren	Fenantren	Antracen	Fluoranten	Piren	Benzo(a)antracen	Krisen	Benzo (b) fluoranten	Benzo (k) fluoranten	Benzo (a) piren	Dibenzo (a,h) antracen
Term	left bank	right bank	middle	cm ⁻¹	mval/L	°dH	µg/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L
Cycle	Date	% sat.	% sat.	% sat.																		
1	23.09.2003	40	46	51	0,105	4,3	15,7	6,9	6	2	2	2	6	6	2	6	6	2	2	2	2	2
2	17.11.2003	10	10	11	0,409																	
3	16.01.2003	29,00	28,00	31,00	0,196																	
4	11.03.2003	99,20	99,00	100,00	0,094																	
5	12.05.04.	70,52	71,00	76,00	0,166																	
6	02.07.2004.	21,34	20,00	22,00	0,38																	

Table 39 continued

Dstr-tria-4

Variabel	Benzo (g,h,i) piren	Indeno (1,2,3-c-d) piren	Fe	Mn	Cu	Zn	Ni	Cd	Cr	Hg	Pb	Mineral oils	Benzene	Ethylbenzene	Toluol	Xylenes
Term	ng/L	ng/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Cycle	Date															
1	23.09.2003	2	2	0,12	0,15	19	52	14	1,6	41	0,1	15	68	0,15	0,15	0,15
2	17.11.2003															
3	16.01.2003			0,26	73	8,6	30	9,8	1,8	6,1	2,8	57	232			
4	11.03.2003			0,17	0,036	5,5	12	25	1,1	12	22	70				
5	12.05.04.															
6	02.07.2004.											1179				

8.2 Chemical analysis from the monitoring of the laterals

Table 40. Chemical analysis from the industrial lateral I-64 downstream of Crvenka

I-64-Crv-1

Variabel	Unit	Water temp °C	Air temp °C	descr.	Visible particles descr.	Colour	pH	Suspended particles mg/L	Dry residue mg/L	Ignited (glowed) residue mg/L	Conductivity µS/cm	Thermotolerant microorganisms no/100mL	Ammonia mg NH ₄ ⁺ /L	Nitrates mg NO ₃ ⁻ /L
Cycle	Date													
1	22.09.2003	19,5	23	none	none	7,6	59	471	209	425			1,5	3
2	19/11/2003	14,7	6	none	green-brown	6,51	440	770	290	919			20	0,75
3	20/01/2004	4,5	4	floatable particles	light brown	7,54	65	560	264	930		29100	7,5	0,75
4	10.03.2004.	6	3	small particles	gray	7,82	102	540	350	918		20000	4,8	0,75
5	12.04.2004.	16,5	20	whole animal, pig lot off different particles	green-gray	8,2	507	1220	390	108		12600	3,8	0,65
6	01.07.2004.	18,2	22	small particles	yellowish	7,83	62	720	500	1000		180000	5	0,65

Table 40 continued

I-64-crv-2

Variabel	Unit	organic Kjeldahl N mg N/L	Total N mg N/L	dissolved phosphates mg PO ₄ ³⁻ /L	Total P mg P/L	Chemical Oxygen Demand,dissolved mg O ₂ /L	Chemical Oxygen Demand, total mg O ₂ /L	COD-tot. - COD-diss mg O ₂ /L	BOD ₅ dissolved mg O ₂ /L	BOD ₅ total mg O ₂ /L	BOD ₅ -tot. - BOD ₅ -diss mg O ₂ /L	Dissolved Oxygen mg O ₂ /L	Oxygen saturation % sat.	UV-abs (254nm) cm ⁻¹	Alkalinity mval/L	Hardness °dH	Phenols µg/L
Cycle	Date																
1	22.09.2003	2	3,9	0,43	0,035		55			23		2,3	25	0,08	4,4	20,16	0,25
2	19/11/2003	0,9	1,7	0,1	0,035		390			37		0,9	9	0,43			
3	20/01/2004	3,9	9,8	0,1	0,035	150	210		71	105		2,2	17	0,416			
4	10.03.2004.	6	9,7	0,1	0,66	98	114		47,1	62		2,3	19	0,193			
5	12.04.2004.	1,9	4,9	0,67	0,21	50	60	10	15	28	13	2,1	21	0,21			
6	01.07.2004.	4,3	5,8	3,35	1,3	30	60	30	22	42	20	1,1	12	0,346			

Table 40 continued

I-64-crv-3

Variabel	Unit	Naftalen ng/L	Acenafitilen ng/L	Acenaften ng/L	Fluren ng/L	Fenantren ng/L	Antracen ng/L	Fluoranten ng/L	Piren ng/L	Benzo(a)antracen ng/L	Krisen ng/L	Benzo (b) fluoranten ng/L	Benzo (k) fluoranten ng/L	Benzo (a) piren ng/L	Dibenzo (a,h) amracen ng/L	Benzo (g,h,i) perilen ng/L	Indeno (1,2,3-c-d) piren ng/L	Fe mg/L	Mn mg/L	Cu µg/L	Zn µg/L	Ni µg/L	Cd µg/L	Cr µg/L	Hg µg/L	Pb µg/L
Cycle	Date																									
1	22.09.2003	2	2	2	2	6	2	6	6	2	2	2	2	2	2	2	2	0,11	0,093	13	23	11	1,6	11	0,1	20
2	19/11/2003																									
3	20/01/2004																	0,44	0,28	2	8	12	2	8,4	0,1	56
4	10.03.2004.																	0,35	0,12	0,86	19	22	1,4	14	0,1	2,5
5	12.04.2004.																									
6	01.07.2004.																									

Table 40 continued

I-64-crv-4

	Variabel	Benzene	Ethylbenzene	Toluol	Xylenes
	Unit	µg/L	µg/L	µg/L	µg/L
Cycle	Date				
1	22.09.2003	0,15	0,15	0,15	0,15
2	19/11/2003				
3	20/01/2004				
4	10.03.2004.				
5	12.04.2004.				
6	01.07.2004.				

Table 41. Chemical analysis from the industrial lateral I-64 downstream of Kula

34-Kula-1

Variabel	Water temp	Air temp	Visible particles	Colour	pH	Suspended particles	Dry residue	Ignited (glowed) residue	Conductivity	Thermotolerant microorganisms	Ammonia	Nitrates	Nitrites	Organic Kjeldahl N	Total N
Unit	°C	°C	descr.	descr.		mg/L	mg/L	mg/L	µS/cm	no/100mL	mg NH ₄ ⁺ /L	mg NO ₃ ⁻ /L	mg NO ₂ ⁻ /L	mg N/L	mg N/L
24/09/2003	19	23	none	none	7,4	51	672	416	570		1,5	2	0,02	2,4	4,02
18/11/2003	12	7	none	none	6,9	100	710	290	852		15	0,75	0,0025	1,5	13
16/01/2004	3,2	2	small particles	light brown	7,37	64	483	263	733	130500	3,8	4	0,06	4,9	8,7
03.10.2004	5,7	3	small particles	brown-green	7,9	113	480	350	842	885000	3,3	3	0,3	2,3	5,6
11.05.2004.	16,8	19	small particles	none	8,5	47	890	360	680	312500	3	0,65	0,2	1,6	3,9
01.07.2004.	18	22	small particles	yellowish	7,79	73	820	510	720	1765000	2,3	0,65	0,002	2,1	3,9

Table 41 continued

I-64-Kula-2

Variabel	dissolved phosphates	Total P	Chemical Oxygen Demand, total	Chemical Oxygen Demand, dissolved	COD-tot. - COD-diss	BOD ₅ , total	BOD ₅ , dissolved	BOD ₅ -tot. - BOD ₅ -diss	Dissolved Oxygen	Oxygen saturation	UV-abs (254nm)	Alkalinity	Hardness	Phenols
Unit	mg PO ₄ ³⁻ /L	mg P/L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	% sat.	cm ⁻¹	mval/L	°dH	µg/L
1 24/09/2003	0,21	0,14	55			27					0,184	2,9	19	0,25
2 18/11/2003	0,21	0,035	330			260			1,73	16	0,386			
3 16/01/2004	0,11	0,035	140	140		120	78,3		6,3	48	0,383			
4 03.10.2004	1,34	1,1	92	82		25	12		4,5	36	0,132			
5 11.05.2004.	0,43	0,52	80	70	10	8	7,6	0,4	35	372	0,111			
6 01.07.2004.	0,86	0,88	90	20	70	43,8	43,2	0,6	1,4	14,7	0,415			

Table 41 continued
I-64-Kula-3

	Variabel	PAH (Total)	Naftalen	Acenaftilen	Acenaften	Fluren	Fenantren	Antracen	Fluoranten	Piren	Benzo(a)antracen	Krisen	Benzo (b) fluoranten	Benzo (k) fluoranten	Benzo (a) piren	Dibenzo (a,h) anracen	Benzo (g,h,i) perilen	Indeno (1,2,3-c.d) piren
	Unit	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L
1	24/09/2003	6	2	2	2	2	6	2	6	6	2	2	2	2	2	2	2	2
2	18/11/2003																	
3	16/01/2004																	
4	03.10.2004																	
5	11.05.2004.																	
6	01.07.2004.																	

Table 41 continued
I-64-Kula-4

	Variabel	Fe	Mn	Cu	Zn	Ni	Cd	Cr	Hg	Pb	Mineral oils	Benzene	Ethylbenzene	Toluol	Xylenes
	Unit	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
1	24/09/2003	0,31	0,095	19	17	13	1,2	5,8	0,1	10	62	0,15	0,15	0,15	0,15
2	18/11/2003														
3	16/01/2004	0,37	0,17	75	74	18	1,5	11	0,1	13	191				
4	03.10.2004	0,34	0,12	11	19	22	0,92	14		90	88				
5	11.05.2004.														
6	01.07.2004.										38,9				

Table 42. Chemical analysis from the industrial lateral I-64 just before it enters the Grand Canal.
I-64-GC-1

Cycle	Variabel	Unit	Water temp °C	Air temp °C	descr.	Visible particles	descr.	Colour	pH	Flow (weighted average) m3/day	No days with effluent days	Suspended particles mg/L	Total N mg N/L	Total P mg P/L	Chemical Oxygen Demand, total mg O ₂ /L	BOD ₅ , total mg O ₂ /L	Fe mg/L	Mn mg/L	Cu µg/L	Zn µg/L	Ni µg/L
1	24.09.2003.		21	28	none	none	7,25					72	4,9	1,32	75	44	0,71	0,24	55	100	21
2	19.11.2003.		15,9	8	none	brown	7,25					710	16	0,14	550	74					
3	16.01.2004.		4,9	1	blood, small particles	brown	7,51					72	25	1,1	430	240		0,16	22	95	29
4	10.03.2004.		6,1	3	small particles	gray	7,6					480	24	3,52	290	80	0,65	0,14	20	99	22
5	11.5.204.		17,6	18	small particles	browngreen	7,76					447	8,7	1,32	150	42					
6	01.07.2004.		21	24	small particles	yellow-gray	7,32					67	15	2,2	170	57					
	Average									82080	365	308	15,6	1,6	277,5	89,5	0,68	0,18	32	98	24

Table 42 continued

I-64-GC-2

Cycle	Variabel	Unit	Cd µg/L	Cr µg/L	Hg µg/L	Pb µg/L	Mineral oils µg/L	Dry residue mg/L	Ignited (glowed) residue mg/L	Conductivity µS/cm	Thermotolerant microorganisms no/100mL	Ammonia mg NH ₄ ⁺ /L	Nitrates mg NO ₃ /L	Nitrites mg NO ₂ /L	organic Kjeldahl N mg N/L	mg PO ₄ ³⁻ /L	dissolved phosphates mg O ₂ /L	Chemical Oxygen Demand, dissolved mg O ₂ /L	COD-tot. - COD-diss mg O ₂ /L
1	24.09.2003.		2,7	25	0,1	40	444	744	358	660		1	2	0,2	3,6	4,02			
2	19.11.2003.						1700	1100	891			19	0,75	0,01	1,1	0,25			
3	16.01.2004.		1,8	7,2	0,1	55	6300			834	550000	13	2	0,02	15	0,84	250		
4	10.03.2004.		1,4	12		22	350	580	320	900	970000	18	0,65	0,002	11	8,04	140		
5	11.5.204.						1480	490	1327	585000		10	0,65	0,002	1	1,5	140	10	
6	01.07.2004.						203,2	1440	1160	1180	1910000	13	0,65	0,002	4,9	8,04	70	100	
	Average		2,0	14,7	0,1	39	1824,3												

Table 42 continued

I-64-GC-3

Cycle	Variabel	Unit	BOD ₅ , dissolved mg O ₂ /L	BOD ₅ -tot.- BOD ₅ -diss mg O ₂ /L	Dissolved Oxygen mg O ₂ /L	Oxygen saturation % sat.	UV-abs (254nm) cm ⁻¹	Alkalinity mval/L	Hardness °dH	Phenols µg/L	PAH (Total) ng/L	Naftalen ng/L	Acenafilen ng/L	Acenafiten ng/L	Fluren ng/L	Fenantren ng/L	Antracen ng/L	
1	24.09.2003.				2,23	2,23	25	25	25	0,184	5,5	20,7	6,9	6	2	2	2	2
2	19.11.2003.				1,9	1,9	19	19	19	0,746								
3	16.01.2004.		60			5,6				43								
4	10.03.2004.		67			2,2				18	0,29							
5	11.5.204.		4,3	37,7		1,1				12	0,273							
6	01.07.2004.		14	43		0,5				6	0,398							
	Average																	

Table 42 continued

I-64-GC-4

	Variabel	Fluoranten	Piren	Benzo(a)antracen	Krisen	Benzo (b) fluoranten	Benzo (k) fluoranten	Benzo (a) piren	Dibenzo (a,h) antracen	Benzo (g,h,i) piren	Indeno (1,2,3-c,d) piren	Fe	Mn	Cu	Zn	Ni	Cd	Cr	Hg	Pb	Mineral oils	Benzene	Ethylbenzene	Toluol	Xylenes	
Cycle	Unit	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	
1	24.09.2003.	6	6	2	2	2	2	2	2	2	2	0,71	0,24	55	100	21	2,7	25	0,1	40	444	0,3	0,15	0,15	0,15	
2	19.11.2003.																									
3	16.01.2004.													0,16	22	95	29	1,8	7,2	0,1	55	6300				
4	10.03.2004.											0,65	0,14	20	99	22	1,4	12		22	350					
5	11.5.204.																									
6	01.07.2004.																				203,2					
	Average																									

Table 43. Chemical analysis from the agricultural lateral I-61 downstream Crvenka

I-61-crv-1

	Variabel	Water temp	Air temp	Visible particles	Colour	pH	Suspended particles	Dry residue	Ignited (glowed) residue	Conductivity	Thermotolerant microorganisms	Ammonia	Nitrates	Nitrites	organic Kjeldahl N	Total N
Cycle	Unit	°C	°C	descr.	descr.		mg/L	mg/L	mg/L	µS/cm	no/100mL	mg NH ₄ ⁺ /L	mg NO ₃ ⁻ /L	mg NO ₂ ⁻ /L	mg N/L	mg N/L
2	19.11.2003	8	5	none	none	8,34	110	460	310	650		0,25	16	0,01	85	89
3	16.01.2004	1,4	3	soil	brown	8,19	57	190	71	497	300	0,1	10	0,08	3,8	6,2
4	10.03.2003	5,1	3	small particles	gray-green	8,5	113	720	610	1128	19500	0,05	18	0,02	9,7	14
5	12.04.2004.	16,9	19	small particles	none	8,7	627	1440	540	1319	1000	0,2	14	0,07	2	4,9
6	01.07.2004.	17,4	23	none	none	8,2	80	1130	830	1494	25000	0,2	0,65	0,005	3,7	3,9

Table 43 continued

I-61-crv-2

	Variabel	dissolved phosphates	Total P	Chemical Oxygen Demand, total	Chemical Oxygen Demand, dissolved	COD-tot. - COD-diss	BOD ₅ , total	BOD ₅ , dissolved	BOD ₅ -tot. - BOD ₅ -diss	Dissolved Oxygen	Oxygen saturation	UV-abs (254nm)	Fe
Cycle	Unit	mg PO ₄ ³⁻ /L	mg P/L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	% sat.	cm ⁻¹	mg/L
2	19.11.2003	54	18	20			10			7,2	7,2	81	650
3	16.01.2004	0,1	0,035	50	30	20	30	14					0,129
4	10.03.2003	0,1	0,035	50	40	10	10	4			8,2	66	0,12
5	12.04.2004.	0,7	0,035	280	60	220	14,2	10,4	3,8		9,5	104	0,146
6	01.07.2004.	0,1	0,88	100	40	60	49,7	39,4	10,3		8,2	86	0,302

Table 43 continued
I-61-crv-3

	Variabel	Mn	Cu	Zn	Ni	Cd	Cr	Hg	Pb	Mineral oils
Cycle	Unit	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
2	19.11.2003									
3	16.01.2004	0,017	100	28	6,3	1,1	8,4	0,1	64	65
4	10.03.2003	0,015	7,5	5,8	19	1,4			12	32
5	12.04.2004.									
6	01.07.2004.									8,64

Table 44. Chemical analysis from the agricultural lateral I-61 downstream of Kula

I-61-dstr kula-1																	
Cycle	Variabel	Water temp	Air temp	Visible particles	Colour	pH	Flow (average)	No of days with effluent	Suspended particles	Total N	Total P	Chemical Oxygen Demand, total	BOD ₅ , total	Fe	Mn	Cu	Zn
Term	Unit	°C	°C	descr.	descr.	pH	m3/day	days/y	mg/L	mg N/L	mg P/L	mg O ₂ /L	mg O ₂ /L	mg/L	mg/L	µg/L	µg/L
1	23/09/2003	18,8	25	small floatable particles	gray	7,6			65	5,7	0,35	125	20	0,17	0,15	13	21
2	18/11/2003	7,7	7	none	gray	7,6			33	2,1	0,07	40	17				
3	16/01/2004	4	1	none	none	7,7			28	8,8	0,035	70	30	0,24	0,1	110	21
4	11.03.2004.	4,6	3	none	yellowish	7,8			107	16	0,035	160	14	0,21	0,92	12	41
5	05.05.2004.	19	21	small particles	green	8,67			118	15	1,5	30	22,4				
6	01.07.2004.	16	21	smol particles	yellowish	7,96			60	5,4	1,32	40	15				
	average						2246	365	68,5	8,8	0,55	77,5	19,73	0,207	0,39	45	28

Table 44. continued

I-61-dstr kula-2																
Cycle	Variabel	Ni	Cd	Cr	Hg	Pb	Mineral oils	Dry residue	Ignited (glowed) residue	Conductivity	Thermotolerant microorganisms	Ammonia	Nitrates	Nitrites	organic Kjeldahl N	dissolved phosphates
Term	Unit	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	mg/L	µS/cm	no/100mL	mg NH ₄ ⁺ /L	mg NO ₃ ⁻ /L	mg NO ₂ ⁻ /L	mg N/L	mg PO ₄ ³⁻ /L
1	23/09/2003	14	1,2	92	0,1	13	70	942	355	690		0,37	2	0,2		4,9
2	18/11/2003							490	220	1003		2,5	0,75	0,03		0,1
3	16/01/2004	9,8	1,6	11	0,1	17	122	450	190	910	1000	7,5	6	0,2		1,5
4	11.03.2004.	21	1,4	33		20	32	530	360	894	4300	3,3	6	0,4		12
5	05.05.2004.							750	470	1150	100	2,5	3	0,03		13
6	01.07.2004.						24,45	1220	920	1036	161000	4,5	2	0,3		1,4
	average	15	1,4	45	0,1	17	62	730	419	947						

Table 44 continued

I-61-dstr kula-3																				
Cycle	Variabel	Chemical Oxygen Demand, dissolved	COD-tot. - COD-diss	BOD ₅ , dissolved	BOD ₅ -tot. - BOD ₅ -diss	Dissolved Oxygen	Oxygen saturation	UV-abs (254nm)	Alkalinity	Hardness	Phenols	PAH (Total)	Naftalen	Acenafitilen	Acenaften	Fluren	Fenantren	Antracen	Fluoranten	
	Term	COD-diss	CODdiff	BOD ₅ -diss	BOD ₅ diff.	middle	middle													
	Unit	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	% sat.	cm ⁻¹	mval/L	°dH	µg/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L
1	23/09/2003					2,2	24	0,184	5,5	16,8	6,9	34	2	2	2	34	6	2	2	
2	18/11/2003					5	43	1,03												
3	16/01/2004	50		19		6,9	53	0,156												
4	11.03.2004.	106		14		7,6	58	0,102												
5	05.05.2004.	20	10	12,2	10,2	10	108	0,182												
6	01.07.2004.	40	0	23	8	5,3	54	0,315												

Table 44 continued

I-61-dstr kula-4																				
Cycle	Variabel	Piren	Benzo(a)antracen	Krisen	Benzo (b) fluoranten	Benzo (k) fluoranten	Benzo (a) piren	Dibenzo (a,h) antracen	Benzo (g,h,i) perilen	Indeno (1,2,3-c,d) piren	Benzene	Ethylbenzene	Toluol	Xylenes						
	Term																			
	Unit	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	µg/L	µg/L	µg/L	µg/L						
1	23/09/2003	2	2	2	2	2	2	2	2	2	0,15	0,15	0,15	0,15						
2	18/11/2003																			
3	16/01/2004																			
4	11.03.2004.																			
5	05.05.2004.																			
6	01.07.2004.																			

Table 45. Chemical analyses of the Pig Farm lateral KC-III

KC-III-1

	Variabel	Water temp C	Air temp C	descr.	Visible particles	Colour	pH	Flow (Weighted average) m3/day	Number of days with effluents days/y	Suspended particles mg/L	Total N mg N/L	Total P mg P/L	Chemical Oxygen Demand, total mg O ₂ /L
Cycle	Date												
1	18/11/2003	7,9	7	covered by core			7,58			1200	313	0,07	1000
	14/01/2004						7,29			260	98	7,3	2100
2	16/01/2004	3,5	4	floatable small particles	brown		7,61			320	196	13,2	3200
3	11.03.2004.	5,2	3	small particles	gray-green		7,92			633	132		3200
4	12.04.2004.	18	20	particles	brown-green		7,52			413	128,13	9,9	1200
5	02.06.2004.	21	23	at the surface of the canal there is a core	gray		6,8			413	79,83	15,3	980
	Average							8294	365	540	158	9,2	1947

Table 45 continued

KC-III-2

	Variabel	BOD ₅ , total mg O ₂ /L	Fe mg/L	Mn mg/L	Cu µg/L	Zn µg/L	Ni µg/L	Cd µg/L	Cr µg/L	Hg µg/L	Pb µg/L	Mineral oils µg/L	Dry residue mg/L	Ignited (glowed) residue mg/L	Conductivity µS/cm	Thermotolerant microorganisms no/100mL	Ammonia mg NH ₄ ⁺ /L	Nitrates mg NO ₃ ⁻ /L	
Cycle	Date																		
1	18/11/2003	215											21000	540	1705		288	22	
	14/01/2004	400										1120	870	630			59	0,75	
2	16/01/2004	1100	0,84	0,23	240	200	26	2,6	12	0,1	43	31000	960	710	1343	3305000	75	2	
3	11.03.2004.	1480	1,9	0,33	260	550	63	4	36		73	108	970	510	1589	4815000	110	6	
4	12.04.2004.	470											1720	530	1796	1086000	49	52	
5	02.06.2004.	344											83	1830	1130	1600	7400000	50	9,7
	Average	668	1,37	0,28	250	375	44,5	3,3	24	0,1	58	8078							

Table 45 continued

KC-III-3

	Variabel	Nitrates mg NO ₂ ⁻ /L	organic Kjeldahl N mg N/L	dissolved phosphates mg PO ₄ ³⁻ /L	Chemical Oxygen Demand, dissolved mg O ₂ /L	COD-tot. - COD-diss mg O ₂ /L	BOD ₅ , dissolved mg O ₂ /L	BOD ₅ -tot. - BOD ₅ -diss mg O ₂ /L	Dissolved Oxygen mg O ₂ /L	Oxygen saturation % sat.	UV-abs (254nm) cm ⁻¹	Fe mg/L	Mn mg/L	Cu µg/L	Zn µg/L	Ni µg/L	Cd µg/L	Cr µg/L	Hg µg/L	Pb µg/L	Mineral oils µg/L	
Cycle	Date																					
1	18/11/2003	0,01	85	0,1					1,06	9	2,67											
	14/01/2004	0,088	52	9	1100		50															1120
2	16/01/2004	0,1	136,5	20	900		450		4,6	35	3	0,84	0,23	240	200	26	2,6	12	0,1	43	31000	
3	11.03.2004.	0,002	45,6	0,1	1200		700		5,2	42	0,971	1,9	0,33	260	550	63	4	36		73	108	
4	12.04.2004.		67,95	32,16	1000		360	110	0,3	3,16	1,13											
5	02.06.2004.		38,82	32,16	380		600	234	-110	0,4	4,49	2,27									83	
	Average																					

8.3 Chemical analysis from the monitoring of the industrial and municipal effluents (point sources)

Table 46. Chemical analysis of the discharges from Crvenka Sugar Factory

Crvenka-fin-1

	Variabel	Water temp	Air temp	Colour	Odour	Visible particles	pH	Dry residue	Ignited (glowed) residue	Loss at ignition	settleable solids	Turbidity	Flow (Ivana)	Flow adjusted
	Term	°C	°C	descr.	descr.	descr.		mg/L	mg/L	mg/L	ml/L	descr.	m3/day	m3/day
Cycle	Date													
1	18.11.2003	8	14	grey-yellow	of molasses	none	7,6	1847	437	1410	0	opalscent	13734	
2	04.12.2003	12	7	yellow	of molasses	none	4,55	2150	510	1640	0,3	opalscent	14000	
3	04.10.2004.	20	24	yellow	of molasses	none	6,72	1820	670	1150	0,2	opalscent		
4	22.10.2004.						6,58	2400	1090	1310	0	opalscent		
	08.11.2004	6	4				6,56						8000	
	Average												11911,33333	14500
	Max													

Table 46 continued

Crvenka-fin-2

	Variabel	No of days with effluent	Suspended particles	Total N	Total P	Chemical Oxygen Demand, total	BOD ₅ , total	Chemical Oxygen Demand, dissolved	BOD ₅ , dissolved	m-alc
	Term	SS	Total N	Tot-P	COD-tot.	BOD ₅ -tot.	COD-diss	BOD ₅ -diss	m-alc	
	Unit	days/y	mg/L	mg N/L	mg P/L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mVal/L
Cycle	Date									
1	18.11.2003		97	53,3	0,07	1800	950			6,39
2	04.12.2003		50	4,02	0,07	1400	650			0,47
3	04.10.2004.		20	10,54	2,64	340	179	180	105	8,68
4	22.10.2004.		240	9,77	2,64	1080	860	650	360	22,7
	08.11.2004		67	58	11	7600	2972			
	Average	200	94,8	27,126	3,284	2444	1122,2			
	Max		240	58	11	7600	2972			

Table 47. Chemical analysis from the discharges from the Panon alcohol factory in Crevenka

Alcohol-fabric-fin-1

	Variabel	Water temp °C	Air temp °C	Colour descr.	Odour descr.	Visible particles descr.	pH	Suspended particles mg/L	Dry residue mg/L	Ignited (glowed) residue mg/L	Loss at ignition mg/L	settleable solids ml/L	Turbidity descr.	Flow (Ivana) m3/day	Flow adjusted m3/day	No of days with effluents days/y	Suspended particles mg/L
Cycle	Unit	°C	°C	descr.	descr.	descr.		mg/L	mg/L	mg/L	mg/L	ml/L	descr.	m3/day	m3/day	days/y	mg/L
1	10.12.2003	25	1	none	none	none	7,24	30	300	230	70	0	clear	2640			30
2	12.03.2004.	18	5	none	none	small black particles	7,05	240	870	200	670	0,03	clear	4440			240
3	13.07.2004.	38	22	none	none	none	7,63	53	390	270	120	0,2	clear	2160			53
4	28.09.2004.	34	15	none	none	none	7,3	10	390	140	250	0,3	clear	4406			10
	Average													3411,5	2000	200	83,25
	Max																240

Table 47 continued

Alcohol-fabric-fin-2

	Variabel	Total N	Total P	Chemical Oxygen Demand, total	BOD ₅ , total	Sulphates	Ammonia	Nitrates	Nitrites	organicKjeldahl N	Chemical Oxygen Demand, dissolved	COD-tot. - COD-diss	BOD ₅ , dissolved	BOD ₅ -tot. - BOD ₅ -diss
Term	Total N	Tot-P	COD-tot.	BOD ₅ -tot.		NH ₄ ⁺	NO ₃ ⁻	NO ₂ ⁻			COD-diss	CODdiff	BOD ₅ -diss	BOD ₅ diff.
Unit	mg N/L	mg P/L	mg O ₂ /L	mg O ₂ /L	mg SO ₄ ²⁻ /L	mg NH ₄ ⁺ /L	mg NO ₃ ⁻ /L	mg NO ₂ ⁻ /L	mg N/L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L
Cycle	Date													
1	10.12.2003	0,9	0,035	300	99	6,5								
2	12.03.2004.	2,43	0,035	60	54	14,1	0,25	0,75	0,002	2,23	60	0	40	14
3	13.07.2004.	0,24	0,88	80	10	0,28					80	0	10	0
4	28.09.2004.	2,36	1,54	80	49	9,3								
	Average	1,4825	0,6225	130	53							#REF!		#REF!
	Max	2,43	1,54	300	99							#REF!		#REF!

Table 48. Chemical analysis from the effluents (composite stream) of the Istra faucet factory in Kula

Istra-comp-fin-1

	Variabel	Water temp °C	Air temp °C	Colour descr.	Odour descr.	Visible particles descr.	pH	Dry residue mg/L	Ignited (glowed) residue mg/L	Loss at ignition mg/L	settleable solids ml/L	Turbidity descr.	Flow (Ivana) m3/day	Flow (Tanja) average m3/day	Flow adjusted m3/day	No of days with effluent days/y	Suspended particles mg/L
Cycle	Unit	°C	°C	descr.	descr.	descr.		mg/L	mg/L	mg/L	ml/L	descr.	m3/day	m3/day	m3/day	days/y	mg/L
1	30.10.2003	16	13	none	none	none	9,25	1472	955	517	0,1	slightly turbid	226				238
2	11.03.2004	15	4	yellowish	none	none	9,1	580	350	230	0,2	slightly turbid	237				133
3	28.05.2004	19	21	blue-green	none	none	8,9	1530	580	770	0,5	slightly turbid	1209				553
4	14.07.2004.	31,2	21,7	yalow-green	none	none	7,42	790	590	200	0,5	slightly turbid	468				33
Composite	Mean												535	1000	1000	252	239,25
	Max																553

Table 48 continued

Istra-komp-fin-2

	Variabel	Total N	Total P	Chemical Oxygen Demand, total	BOD ₅ , total	Fe	Cu	Zn	Ni	Cd	Cr	Pb
	Unit	mg N/L	mg P/L	mg O ₂ /L	mg O ₂ /L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Cycle	Date											
1	30.10.2003	49,8	150	300	140	0,11	0,8	0,15	0,13	0,006	5,8	0,27
2	11.03.2004	32,8	0,28	140	35	0,1	3,3	3,4	6,6	0,0031	0,97	0,16
3	28.05.2004	3,88	0,49	30	21	0,046	0,2	0,51	3	0,0016	1,2	0,027
4	14.07.2004.	60,3	0,88	260	23	0,15	0,44	0,68	8,1	0,025	0,23	0,12
Composite	Mean	36,695	37,9125	182,5	54,75	0,1015	1,185	1,185	4,4575	0,008925	2,05	0,14425
	Max	60,3	150	300	140	0,15	3,3	3,4	8,1	0,025	5,8	0,27

Table 48 continued

Istra-komp-fin-3

	Variabel	Ammonia	Nitrates	Nitrites	organic Kjeldahl N	dissolved phosphates	Chemical Oxygen Demand, dissolved	COD-tot. - COD-diss	BOD ₅ , dissolved	BOD ₅ -tot. - BOD ₅ -diss	p-alkalinity	m-alkalinity
	Unit	mg NH ₄ ⁺ /L	mg NO ₃ ⁻ /L	mg NO ₂ ⁻ /L	mg N/L	mg PO ₄ ³⁻ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mval/L	mVal/L
Cycle	Date											
1	30.10.2003										3,84	1,35
2	11.03.2004	10	80	0,4	6,8		20	120	8	27	0	8,45
3	28.05.2004					0,86	20	10	14,1	6,7	0	8,3
4	14.07.2004.					2,68	70	190	21,3	1,7	0	9,1
Composite	Mean											
	Max											

Table 49. Chemical analysis from the effluents (electroplating stream) of the Istra faucet factory in Kula.

Istra-el-fin-1

	Variabel	Water temp	Air temp	Colour	Odour	Visible particles	pH	Dry residue	Ignited (glowed) residue	Loss at ignition	settleable solids	Turbidity
	Unit	°C	°C	descr.	descr.	descr.		mg/L	mg/L	mg/L	ml/L	NTU
Cycle	Date											
1	30.10.2003	16	13	none	none	none	8,35	582	379	202	0,1	slightly turbid
2	11.03.2004	15	4	light blue-g	none	none		810	530	280	0,2	slightly turbid
	Average											
	Max											

Table 49 continued

Istra-el-fin-2

	Variabel	Flow (Ivana)	Flow adjusted	No of days with effluent	Suspended particles	Total N	Total P	Chemical Oxygen Demand, total	BOD ₅ , total	Fe	Cu	Zn	Ni
	Unit	m3/day	m3/day	days/y	mg/L	mg N/L	mg P/L	mg O ₂ /L	mg O ₂ /L	mg/L	µg/L	µg/L	µg/L
Cycle	Date												
1	30.10.2003	157			178	17,5	10	210	15	0,18	36	170	59
2	11.03.2004	117			200	46,4	0,28	160	31	0,17	3900	3500	11300
	Average	137	137	252	189	31,95	5,14	185	23	0,175	1968	1835	5679,5
	Max				200	46,4	10	210	31	0,18	3900	3500	11300

Table 49 continued

Istra-el-fin-3

	Variabel	Cd	Cr	Pb	Ammonia	Nitrates	Nitrites	Kjeldahl N	dissolved phosphates	Chemical Oxygen Demand, dissolved	BOD ₅ , dissolved	p-alkalinity	m-alkalinity
	Unit	µg/L	µg/L	µg/L	mg NH ₄ ⁺ /L	mg NO ₃ /L	mg NO ₂ /L	mg N/L	mg PO ₄ ⁻³ /L	mg O ₂ /L	mg O ₂ /L	mval/L	mVal/L
Cycle	Date												
1	30.10.2003		11	1700	180				6			0,62	1,14
2	11.03.2004		9,09	2600	290	7	140	0,8	9,12	60	10	0	7,85
	Average		10,045	2150	235								
	Max		11	2600	290								

Table 50. Chemical analysis of the effluents of the Eterna leather factory in Kula.

Eterna-fin-1

	Variabel	Water temp	Air temp	Colour	Odour	Visible particles	pH	Dry residue	Ignited (glowed) residue	Loss at ignition	settleable solids	Turbidity	oil and fats	Sulphides	Flow (Ivana)	Flow adjusted	No of days with effluents
	Term	°C	°C	descr.	descr.	descr.		mg/L	mg/L	mg/L	ml/L	descr.	mg/L	mg/L	m3/day	m3/day	days/y
Cycle	Date																
1	05.11.2003	19	9,5	white	slight smell of fat	grey-white particle	9,5	3612	2374	1238	19	very turbid	1,6	23,6	260		
2	10.03.2004	11	4	red	none	pieces of leather, oil	9,2	1280	1000	280	1,5	very turbid	48	0,2	60		
	Average														160	120	240
	Max																

Table 50 continued

Eterna-fin-2

	Variabel	Suspended particles	Total N	Total P	Chemical Oxygen Demand, total	BOD ₅ , total	Cr	Ammonia	Nitrates	Nitrites	organic Kjeldahl N	Chemical Oxygen Demand, dissolved	COD-tot. - COD-diss	BOD ₅ , dissolved	p-alc	m-alc	Cr
Term	SS	Total N	Tot-P	COD-tot.	BOD ₅ -tot.	Cr	NH ₄ ⁺	NO ₃	NO ₂		COD-diss	CODdiff	BOD ₅ -diss	p-alc	m-alc	Cr	
Unit	mg/L	mg N/L	mg P/L	mg O ₂ /L	mg O ₂ /L	mg/l	mg NH ₄ ⁺ /L	mg NO ₃ /L	mg NO ₂ /L	mg N/L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mval/L	mVal/L	g/L	
Cycle	Date																
1	05.11.2003	1570	23,3	10	1200	600	0,15							1,47	5,46	150	
2	10.03.2004	587	27,2	0,07	260	156	0,036	3	3	1	26,21	140	45	2,1	7,7	36	
	Average	1078,5	25,25	5,035	730	378	0,093										
	Max	1570	27,2	10	1200	600	0,15										

Table 51. Chemical analysis from the municipal effluent system in Kula at station CS-fecalna

Kula-mun-fec-1

	Variabel	Water temp	Air temp	Colour	Odour	Visible particles	pH	Dry residue	Ignited (glowed) residue	Loss at ignition	Settleable solids	Turbidity	Flow (Vara)
Unit	°C	°C	descr.	descr.	descr.		mg/L	mg/L	mg/L	ml/L	descr.	m3/day	
Cycle	Date												
1	15.07.2004.	12,8	18	dark brown	fekal	particles	7,64	1030	620	410	6 very turbid	55,5	
2	17.08.2004.	18	26,5	gray	fekal	none	7,7	2330	1370	960	5 very turbid	52,9	
3													
4	Average												
	Max												

Table 51 continued

Kula-mun-fec-2

	Variabel	Flow adjusted	No of days with effluents	Suspended particles	Total N	Total P	Chemical Oxygen Demand, total	BOD ₅ , total	Chemical Oxygen Demand, dissolved	COD-tot. - COD-diss	BOD ₅ , dissolved	BOD ₅ -tot. - BOD ₅ -diss
Unit				mg/L	mg N/L	mg P/L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L
Cycle	Date											
1	15.07.2004.			133	40,8	7,92	370	214	140	230	55	159
2	17.08.2004.	560	365	73	87,8	7,92	360	220	300	60	175	45
3												
4	Average	560	365	103	64,3	7,92	365	217				
	Max			133	87,8	7,92	370	220				

Table 52. Chemical analysis from the municipal effluent system in Kula at station Njegoseva street

Kula-mun-njeg-1

	Variabel	Water temp	Air temp	Colour	Odour	Visible particles	pH	Suspended particles	Dry residue	Ignited (glowed) residue	Loss at ignition	settleable solids	Turbidity
	Unit	°C	°C	descr.	descr.	descr.		mg/L	mg/L	mg/L	mg/L	ml/L	descr.
Cycle	Date												
1	15.07.2004.	20,5	20	yellow-brown	amonia, H2S	small particles	7,69	100	990	600	390	3	very turbid
2	17.08.2004.	19,5	26	gray	fekal	small particles	7,65	73	1620	890	730	1,8	very turbid

Table 52 continued

Kula-mun-njeg-2

	Variabel	Flow (Ivana)	Total N	Total P	Chemical Oxygen Demand, total	Chemical Oxygen Demand, dissolved	COD-tot. - COD-diss	BOD5, total	BOD5, dissolved	BOD5-tot. - BOD5-diss
	Unit	m3/day	mg N/L	mg P/L	mg O2/L	mg O2/L	mg O2/L	mg O2/L	mg O2/L	mg O2/L
Cycle	Date									
1	15.07.2004.	1009	58,72	7,92	310	210	100	146	123	23
2	17.08.2004.	1012	102,4	9,24	460	420	40	252	218	24

Table 53. Chemical analysis from the effluents of Backa Sugar Factory in Vrbas

Backa-sugar-chem-fin-1

	Variabel	Water temp	Air temp	Colour	Odour	Visible particles	pH	p-acidity	m-acidity	Dry residue	Ignited (glowed) residue	Loss at ignition	settleable solids	Turbidity
	Term	°C	°C	descr.	descr.	descr.	pH	p-acidity	m-acidity	mg/L	mg/L	mg/L	ml/L	descr.
Cycle	Date													
1	24.10.2003	25	6	yellow brown	of molasses	a lot of suspended particles	2,63	0,49	0,33	1400	734	666	4,5	very turbid
2	27.11.2003								6,7	4600	3100	1500		
3	01.12.2003	24	5	yellow brown	of molasses	a lot of suspended particles	7,3	0	0	4850	3360	1490	2,1	very turbid
4	04.10.2004.	43	24	brown	of molasses	a lot of suspended particles	5,83			1180	250	930	15	very turbid
5	22.10.2004.	36	14	yellow brown	of molasses	a lot of suspended particles	5,75			750	200	550	10	very turbid
	08.11.2004													
	Average													
	Max													

Table 53 continued

Backa-Sugar-chem-fin-2

Variabel	Flow (Ivana)	Flow (Tanja) average	Flow adjusted	No of days with effluents	Suspended particles	Total N	Total P	Chemical Oxygen Demand, total	BOD ₅ , total	Total N	PO ₄ ³⁻	dissolved phosphates	Chemical Oxygen Demand, dissolved	BOD ₅ , dissolved	p-alc	m-alc
Term	Unit	m3/day	m3/day		SS	Total N	Tot-P	COD-tot.	BOD ₅ -tot.	Total N	PO ₄ ³⁻	COD-diss	BOD ₅ -diss	p-alc	m-alc	
Cycle	Date				mg/L	mg N/L	mg P/L	mg O ₂ /L	mg O ₂ /L	mg N/L	mg PO ₄ ³⁻ /L	mg O ₂ /L	mg O ₂ /L	mval/L	mVal/L	
1	24.10.2003				251	30,8	0,07	280	140	30,8						
2	27.11.2003	29200	24000		3120	28,1	0,07	3400	1700	28,1						
3	01.12.2003				251	58,5	0,07	1100	328	58,5						
4	04.10.2004.				80	47,2	1,32	2200	1173	47,2	40,2	1600	737	0	4,92	
5	22.10.2004.				587	4,95	1,76	470	360	4,95				0	5,93	
	08.11.2004				167	17	11	1600	777	17						
Average		29200	24000	25000	100	743	31	2	1508	746						
Max					3120	58,5	11	3400	1700							

Table 54. Chemical analysi of the effluents from Carnex slaughter house and meat factory in Vrbas, effluent stream composite.

Carnex Vrbas-composite-fin-1

Variabel	Water temp	Air temp	Colour	Odour	Visible particles	pH	SS	Suspended particles	Dry residue	Ignited (glowed) residue	Loss at ignition	settleable solids	Turbidity	oil and fats	Flow (Ivana)	Flow adjusted
Term	Unit	°C	°C	descr.	descr.	pH	SS	mg/L	mg/L	mg/L	mg/L	m/L	descr.	mg/L	m3/day	m3/day
Cycle	Date															
1	14.01.2004					7,38	843	1415	600	815				533	3100	
2	12.03.2004	15	4	red	blood	large particles, skin, blood, meat	7,35	933	2120	830	1290	20	very turbid	1430	3050	
3	02.07.2004.	20	21	red	blood	large particles, skin, blood, meat	7,3	1807	2310	1960	250	8	very turbid	762	2750	
4	12.08.2004.	18	31	red	blood	large particles, skin, blood, meat	7,25	50	1970	1290	680		very turbid	680	2700	
5	04.11.2003.	19	15,5	yellow	blood	large particles, skin, blood, meat	7,2	469	1764	1074	689	10	very turbid	6	2800	
Average															2880	2800
Max															3100	

Table 54 continued.

Carnex Vrbas-composite-fin-2

Variabel	No of Days with effluents	Suspended particles	Total N	Total P	Chemical Oxygen Demand, total	BOD ₅ , total	Detergents	Ammonia	Nitrates	Nitrites	organic Kjeldahl N	dissolved phosphates	Chemical Oxygen Demand, dissolved	COD-tot. - COD-diss	BOD ₅ , dissolved	BOD ₂ -tot. - BOD ₂ -diss	p-alc	m-alc
Term	Unit	SS	Total N	Tot-P	COD-tot.	BOD ₅ -tot.	mg DBS/L	NH ₄ ⁺	NO ₃ ⁻	NO ₂ ⁻	mg N/L	PO ₄ ³⁻	COD-diss	CODdiff	BOD ₅ -diss	BOD ₂ diff.	p-alc	m-alc
Cycle	Date	mg/L	mg N/L	mg P/L	mg O ₂ /L	mg O ₂ /L		mg NH ₄ ⁺ /L	mg NO ₃ ⁻ /L	mg NO ₂ ⁻ /L	mg N/L	mg PO ₄ ³⁻ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mval/L	mVal/L
1	14.01.2004	843	147	2,4	1000	578		29	0,75	0,12	124	3,7	200		68		0	12,01
2	12.03.2004	933	117	5,3	2500	1750		35	0,75	0,02	89,3		1200		800		0,198	3,36
3	02.07.2004.	1807	71,8	88	3000	1600						24,12	1320	1680	500	1100	0	16
4	12.08.2004.	50	100,2	5,28	1200	770	0,65	25	100	0,002	58,24	16,08	700	500	295	475	0	13
5	04.11.2003.	469	18,4	1,98	1600	160	6,23	4,49	3	0,015	13,7	12					0	8,21
Average		260	820,4	90,88	20,592	1860												
Max		1807	147	88	3000	1750												

Table 55. Chemical analysi of the effluents from Carnex slaughter house and meat factory in Vrbas, effluent stream condensate.

Carnex-cond-fin-1

Variabel	Water temp	Air temp	Colour	Odour	Visible particles	pH	Dry residue	Ignited (glowed) residue	Loss at ignition	settleable solids	Turbidity	oil and fats	Flow (Ivana)	Flow adjusted	No of days with effluents	Suspended particles	Total N	Total P	
Term	°C	°C	descr.	descr.	descr.		mg/L	mg/L	mg/L	ml/L	descr.	mg/L	m3/day	m3/day	days/y	SS	Total N	Tot-P	
Unit	°C	°C	descr.	descr.	descr.		mg/L	mg/L	mg/L	ml/L	descr.	mg/L	m3/day	m3/day	days/y	mg/L	mg N/L	mg P/L	
Date																			
1	14.01.2004					7,7	574	403	171			2,5	1600			68	19,7	0,07	
2	12.03.2004	16	2	none	none	7,8	1460	370	1090	0,1		100	1700			313	1,19	0,14	
3	02.07.2004.	18	20	none	none	7,9	1240	720	520	6	clear	6,2	1700			16	4,8	1,1	
4	12.08.2004.	29,5	32	none	none	7,62	980	730	250	0	clear	5,5	1600			50	10,9	0,14	
average													1650	1600	260	111,75	9,1475	0,3625	
Max														0	0	313	19,7	1,1	

Table 55 continued.

arnex-cond-fin-2

Variabel	Chemical Oxygen Demand, total	BOD ₅ , total	Detergents	Ammonia	Nitrates	Nitrites	Kjeldahl organic N	dissolved phosphates	Chemical Oxygen Demand, dissolved	COD-tot. - COD-diss	BOD ₅ , dissolved	BOD ₅ -tot. - BOD ₅ -diss	p-alc	m-alc	
Term	COD-tot.	BOD ₅ -tot.		NH ₄ ⁺	NO ₃ ⁻	NO ₂ ⁻		PO ₄ ³⁻	COD-diss	CODdiff	BOD ₅ -diss	BOD ₅ diff.	p-alc	m-alc	
Unit	mg O ₂ /L	mg O ₂ /L	mg DBS/L	mg NH ₄ ⁺ /L	mg NO ₃ ⁻ /L	mg NO ₂ ⁻ /L	mg N/L	mg PO ₄ ³⁻ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mval/L	mVal/L	
Date															
14.01.2004	280	175		25	0,75	0,69	0,12	0,1	70		34			0	9,36
12.03.2004	520	300		0,19	3	0,08	0,34		40		20			0	10,3
02.07.2004.	30	22	0,04					2,68	30	0	22	0		0	9,8
12.08.2004.	60	19,7	0,16	3	12	0,04	5,8	0,32	50	10	4,5	15,2		0	10,2
average	222,5	129,175													
Max	520	300													

Table 56. Chemical analysi of the effluents from Carnex slaughter house and meat factory in Vrbas, effluent stream “fat and oil”.

carnex-fat-fin-1

Variabel	Water temp	Air temp	Colour	Odour	Visible particles	Dry residue	Ignited (glowed) residue	Loss at ignition	settleable solids	Turbidity	oil and fats	Flow (Ivana)	Flow adjusted	No of days with effluent	Suspended particles
Term	°C	°C	descr.	descr.	descr.	mg/L	mg/L	mg/L	ml/L	descr.	mg/L	m3/day	m3/day	days/year	SS
Unit	°C	°C	descr.	descr.	descr.	mg/L	mg/L	mg/L	ml/L	descr.	mg/L	m3/day	m3/day	days/year	mg/L
Cycle	Date														
1	14.01.2004.											342000	10		
2	12.03.2004	54	2	light brown	fat	floatable fat, foam	3880		5	very turbid	140000	10			
3	02.07.2004.	50	20	brown	fat	floatable fat	1240	720	520	6	very turbid	230000	10		787
Average												10	10	260	787
Max												0	0	0	787

Table 56 continued

Carnex-fat-fin-2

Variabel	Total N	Total P	Chemical Oxygen Demand, total	BOD ₅ , total	Detergents	Ammonia	Nitrates	Nitrites	Kjeldahl N	dissolved phosphates	Chemical Oxygen Demand, dissolved	COD-tot. - COD-diss	BOD ₅ , dissolved	BOD ₅ -tot. - BOD ₅ -diss	p-alc	m-alc
Unit	mg N/L	mg P/L	mg O ₂ /L	mg O ₂ /L	mg DBS/L	mg NH ₄ ⁺ /L	mg NO ₃ ⁻ /L	mg NO ₂ ⁻ /L	mg N/L	mg PO ₄ ³⁻ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mval/L	mVal/L
Cycle	Date															
1	14.01.2004			53000												
2	12.03.2004	591	9,18	36500	31000		9,38	40	0,002	575		25500		19200		
3	02.07.2004	6571	330	4000	2700	0,04					643	3600	400	2000	700	0 200
	Average	3581	169,59	31166,66667	16850											
	Max	6571	330	53000	31000											

Table 57. Chemical analysis from the effluent stream from the Farma-coop Pig Farm

Pig-farm-fin-1

Variabel	Water temp	Air temp	Colour	Odour	Visible particles	pH	Dry residue	Ignited (glowed) residue	Loss at ignition	settleable solids	Turbidity	oil and fats	Flow (l/vana)	Flow (Tanja) average	Average flow adjusted	No. of days with effluents
Unit	°C	°C	descr.	descr.	descr.		mg/L	mg/L	mg/L	ml/L	descr.	mg/L	m3/day	m3/day	m3/day	days/y
Cycle	Date															
1	24.10.2003	13,5	5	grey-yellow	of pigs	a lot of suspended solids	6,92	1903	1046	857	110	very turbid	0,4	480	4147	2500
2	14.01.2004						6,94	1050	820	230			23,8		4147	
3	11.03.2004	10	4	grey- green	fekal	food, fecal	6,8	6950			110	very turbid		530	4147	
4	12.05.2004	14	18	grey-green	of pigs	a lot of suspended solids	8,44	2830	910	1920	150	very turbid		415	4147	
5	15.07.2004	14	21	dark-gray	of pigs		6,86	5820				very turbid		600	4147	
	Average													4147	2900	365
	Max															

Table 57 continued

Pig-farm-fin-2

Variabel	Suspended particles	Total N	Total P	Chemical Oxygen Demand, total	BOD ₅ , total	Nitrates	Nitrites	organic Kjeldahl N	Chemical Oxygen Demand, dissolved	COD-tot. - COD-diss	BOD ₅ , dissolved	BOD ₅ -tot. - BOD ₅ -diss	p-alc	m-alc
Unit	mg/L	mg N/L	mg P/L	mg O ₂ /L	mg O ₂ /L	mg NO ₃ ⁻ /L	mg NO ₂ ⁻ /L	mg N/L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mval/L	mVal/L
Cycle	Date													
1	24.10.2003	2215	535,5	20	4000	1800								0,62 1,14
2	14.01.2004	400	341	12	5100	2050	0,75	0,12	238	1100		590		
3	11.03.2004		511	46	11500	6000	4	0,002	505	8000		1800		
4	12.05.2004	853	388	35	2900	1636				2600	300	500	1136	
5	15.07.2004	3990	31,8	660	4500	2600				2000	2500	1557	1043	
	Average	1865	361	155	5600	2817								
	Max	3990	535,5	660	11500	6000								

Table 58. Chemical analysis of the effluents from the Vital food oil factory in Vrbas

Vital-fin-1

	Variabel	Water temp	Air temp	Colour	Odour	Visible particles	pH	Dry residue	Ignited (glowed) residue	Loss at ignition	settleable solids	Turbidity	oil and fats	Flow (lvana)	Flow adjusted	No of days with effluents	Suspended particles	Total N	Total P	
	Unit	°C	°C	descr.	descr.	descr.		mg/L	mg/L	mg/L	ml/L	descr.	mg/L	m3/day	m3/day	days/y	mg/L	mg N/L	mg P/L	
Cycle	Date																			
1	25.10.2003	16	6,5	none	of rancid oil	none	7,07	308	168	140	0,1	opalscent	1,1	3500			36	3,6	0,07	
2	09.03.2004	12	0	yellowish	fatty	none		400	320	80	0,2	opalscent	28	2500			20	1,94	0,88	
3	29.4.2004.	14	15	yellowish	fatty	none	7,3	1230	690	540	0,5	opalscent	17,6	18144			33	0,97	0,88	
4	30.06.2004.	17,7	23	yellow	fatty	none		1660	1360	300	0,8	opalscent	12,9	3200			467	3,4	1,32	
	Average													6836	4000	280	139	2,4775	0,7875	
	Max																467	3,6	1,32	

Table 58 continued

Vital-fin-2

	Variabel	Chemical Oxygen Demand, total	BOD ₅ , total	Sulphates	Detergents	Ammonia	Nitrates	Nitrites	organic Kjeldahl N	Chemical Oxygen Demand, dissolved	COD-rot. - COD-diss	BOD ₅ , dissolved	BOD ₅ -tot. - BOD ₅ -diss	m-alkalicy
	Unit	mg O ₂ /L	mg O ₂ /L	mg SO ₄ ²⁻ /L	mg DBS/L	mg NH ₄ ⁺ /L	mg NO ₃ /L	mg NO ₂ /L	mg N/L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mg O ₂ /L	mVal/L
Cycle	Date													
1	25.10.2003	90	40	142	1,8									1,47
2	09.03.2004	110	10	141		0,125	4	0,025	1,84	110		2,9		
3	29.4.2004.	70	28	186		0,25	0,65	0,002	0,77	70	0	26	2	
4	30.06.2004.	140	18							120	20	17	0	
	Average	102,5	24											
	Max	140	40											

Table 59. Chemical analysis of the effluents of the sewage treatment system in Vrbas (JKB-Vrbas)

JKB-fin-1

	Variabel	Water temp	Air temp	Colour	Odour	Visible particles	pH	Dry residue	Ignited (glowed) residue	Loss at ignition	settleable solids	Turbidity	Flow (lvana)
	Unit	°C	°C	descr.	descr.	descr.		mg/L	mg/L	mg/L	ml/L	NTU	m3/day
Cycle	Date												
1	10.03.2004	7	4	gray	fekal	small particles	7,15	810	520	290	0,5	slightly turbid	3888
2	05.05.2004	19,5	21	gray-yellow	fekal	small particles	8,65	870	540	330	4	slightly turbid	4493
3	30.06.2004.	18	24	gray	fekal	small particles	8	1920	750	1170	2	slightly turbid	2160
4	12.08.2004.	21	32	gray-green	fekal	none	7,12	1580	740	840	0,1	slightly turbid	2592
	Average												3283,25
	max												

Table 59 continued

JKB-fin-2

	Variabel	Flow adjusted m ³ /day	No of days with effluents days/y	Suspended particles mg/L	Total N mg N/L	Total P mg P/L	Chemical Oxygen Demand, total mg O ₂ /L	BOD ₅ , total mg O ₂ /L	Ammonia mg NH ₄ ⁺ /L	Nitrates mg NO ₃ /L	Nitrites mg NO ₂ /L	mg N/L	organic Kjeldahl N mg PO ₄ ³⁻ /L	dissolved phosphates
Cycle	Date													
1	10.03.2004			187	65,5	1,8	260	114	1,1	0,75	0,002		64,7	
2	05.05.2004			173	38,8	4,6	250	131						
3	30.06.2004.			340	29,3	0,88	350	105	37,5	0,65	0,002		0	
4	12.08.2004.			120	34,86	5,72	260	143						
	Average	4000	365	205	42,115	3,25	280	123,25						
	max			340	65,5	5,72	350	143						

Table 59 continued

JKB-fin-3

	Variabel	Chemical Oxygen Demand, dissolved mg O ₂ /L	COD-tot. - COD-diss mg O ₂ /L	BOD ₅ , dissolved mg O ₂ /L	BOD ₅ -tot. - BOD ₅ -diss mg O ₂ /L
Cycle	Date				
1	10.03.2004	140		82	
2	05.05.2004	120	130	91	40
3	30.06.2004.	180	170	51,5	53,5
4	12.08.2004.	80	180	75	68
	Average				
	max				

8.4 Water flow measurements

Table 60. Water flow measurements at different sites in the laterals and selected effluent streams

Sites		Measuring period			Flow rate [l/s]		
		Date-installed	Date-taken off	Number of days	Minimum	Maximum	Average
Lateral canal I-64	Period out of sugar factory campagne	15.des.03	15.jun.04	183	212 (17.05.2004.)	1306 (28.05.2004.)	779
		15.jun.04	03.aug.04	49	Construction of a new bridge - no measuring		
		03.aug.04	14.sep.04	42	651 (21.08.2004.)	1353 (17.09.2004.)	969
		25.des.04	28.feb.05	65	356 (5.02.2004.)	1223 (28.02.2004.)	656
	Period during sugar factory campagne	15.sep.04	25.des.04	101	890 (24.12.2004)	2072 (14.10.2004.)	1386
Lateral canal I-64 upstream		04.mar.04	08.apr.04	35	101 (12.03.2004.)	1701 (7.04.2004.)	410
Lateral canal I-64 upstream (II)		27.okt.04	04.mar.05	128	103 (31.01.2005.)	1795 (1.03.2005.)	571
Lateral canal I-61		08.apr.04	15.jun.04	68	1 (end of april, begin. of may)	284 (12.04.2004.)	57
Lateral canal I-61 (II)		14.okt.04	14.des.04	61	15 (21.10.2004.)	303 (9.11.2004.)	103
Lateral canal KC-III		25.des.03	03.mar.04	69	48 (23.02.2004.)	136 (6.02.2004.)	84
Standard		29.apr.04	17.mai.04	18	0,9 (8.05.2004.)	126 (29.04.2004.)	49
Farmacoop		10.mai.04	28.mai.04	18	21 (10.05.2004.)	133 (12.05.2004.)	48
Farmacoop (II)		16.des.04	23.jan.05	38	19 (16.12.2004.)	70 (6.01.2005.)	42
Vital		21.apr.04	29.apr.04	8	167 (24.04.2004.)	236 (23.04.2004.)	213
Panon		23.sep.04	04.okt.04	11	4 (4.10.2004.)	72 (23.09.2004.)	32
Sugar Factory "Backa" Vrbas		25.nov.03	15.des.03	20	38 (15.12.2004.)	416 (30.11.2003.)	327
Istra		17.mai.04	28.mai.04	11	3 (18.05.2004.)	25 (25.05.2004.)	12

8.5 Pilot sediment analysis

Sediment sampling was done on 17.04.04 on the profile 3.300 as previously agreed upon. In total 16 samples were taken, 5 from the surface, 2 from the middle and 5 from the bottom. In addition 4 more samples were taken upstream (300 m) from 4 different depths on the places where more sediment was detected (about 1 m).

Table 61 shows the results of the analyses of metal and cyanide content. **Table 62** refers to pesticides and PCB contents and **Table 63** gives the results of radioactivity measurements.

GC-multiscreening was done after all extracts from the surface, from the middle and from the bottom were mixed together (three analysis in total) for the profile 3.300. Mass spectra of the compound were compared with the commercial base Wiley and the report gives only compounds with confirmed identification with the result for software PBM search higher than 70%. These results are given in **Table 64**.

NB! It should be noted that the description of the sediment pollution given in the text part of this report is taken from the Dekonta (2004) study, as they took over this part of the project.

Table 61. Metal content in sediment samples

Location	Sample mark	Mn (mg/kg)	Ni (mg/kg)	Zn (mg/kg)	Cd (mg/kg)	Cr-total (mg/kg)	Cu (mg/kg)	Pb (mg/kg)	Hg ($\mu\text{g/kg}$)	Fe (mg/kg)	CN ⁻ (mg/kg)
Left bank – surface	1P	160	130	650	5.2	570	590	130	600	23500	8200
Left bank - middle(20-60cm)	1S	220	110	170	2.8	510	220	64	<0.2	26100	-
Left bank – bottom (60-80cm)	1D	430	58	94	2.9	91	69	48	630	22800	7.7
Left bank quarter - surface (0-20cm)	2P	110	97	320	3.4	110	210	54	<0.2	26000	-
Left bank quarter-bottom (20-40 cm)	2D	340	34	66	2.7	40	26	25	200	16800	-
Mid canal – surface (0-20cm)	3P	300	34	79	2.9	40	25	35	1200	16000	7.2
Mid canal – bottom (20-40cm)	3D	310	33	46	2.2	32	21	24	320	15500	<1mg/kg
Right bank quarter-surface (0-20cm)	4P	110	140	540	3.5	120	810	73	10	27200	-
Right bank quarter-bottom (20-40cm)	4D	400	28	49	1.4	27	23	22	<0.2	20000	-
Right bank – surface (0-20cm)	5P	76	110	480	3.0	100	360	72	3500	20300	9700
Right bank – middle (20-50cm)	5S	260	80	360	1.9	290	370	65	590	20200	
Right bank – bottom (50-70 cm)	5D	310	26	47	1.9	36	19	18	<0.2	13700	2.3
300 m upstream ferry (0-20 cm)	6.1	320	110	430	2.3	77	340	73	<0.2	32400	5100
300 m upstream ferry (20-50 cm)	6.2	130	100	470	3.5	430	500	66	<0.2	19100	-
300 m upstream ferry (50-80 cm)	6.3	230	64	270	2.5	680	440	57	<0.2	18900	-
300 m upstream ferry - bottom (80-100 cm)	6.4	420	40	120	2.3	58	45	36	<0.2	17900	4.8

Table 62. Pesticides and PCB content on the profile 3.300

Sampling spot	Sample mark	µg/kg											PCB				
		α-BHC	γ-BHC	β-BHC	heptahlor	δ-BHC	aldrin	heptahloreposid	4,4'-DDE	dieldrin	endrin	4,4'-DDD		4,4'-DDT	endrinaldehid	endosulfansulfat	
Left bank surface	1P	<0.2	<0.5 ¹	<0.2	<0.2	<0.2	<0.2	<0.5 ¹	<0.5 ¹	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Left bank middle	1S	<0.5 ¹	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5 ¹	<0.5 ¹	<0.2	<0.2	<0.5 ¹	<0.2	<0.2	<0.2	<0.2	<0.2
Left bank bottom	1D	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5 ¹	<0.5 ¹	<0.2	<0.2	<0.5 ¹	<0.2	<0.2	<0.2	<0.2	<0.2
Left bank quarter - sruface	2P	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5 ¹	<0.5 ¹	<0.2	<0.2	<0.5 ¹	<0.2	<0.2	<0.2	<0.2	<0.2 ²
Left bank quarter – bottom	2D	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5 ¹	<0.5 ¹	<0.2	<0.2	<0.5 ¹	<0.2	<0.2	<0.2	<0.2	<0.2
Mid Canal - surface	3P	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Mid Canal - bottom	3D	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5 ¹	<0.5 ¹	<0.2	<0.2	<0.5 ¹	<0.2	<0.2	<0.2	<0.2	<0.2 ²
Right bank quarter surface	4P	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5 ¹	<0.5 ¹	<0.2	<0.2	<0.5 ¹	<0.2	<0.2	<0.2	<0.2	<0.2
Right bank quarter bottom	4D	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5 ¹	<0.5 ¹	<0.2	<0.2	<0.5 ¹	<0.2	<0.2	<0.2	<0.2	<0.2
Right bank surface	5P	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5 ¹	<0.5 ¹	<0.2	<0.2	<0.5 ¹	<0.2	<0.2	<0.2	<0.2	<0.2 ²
Right bank middle	5S	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5 ¹	<0.5 ¹	<0.2	<0.2	<0.5 ¹	<0.2	<0.2	<0.2	<0.2	<0.2
Right bank bottom	5D	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5 ¹	<0.5 ¹	<0.2	<0.2	<0.5 ¹	<0.2	<0.2	<0.2	<0.2	<0.2
300 m upstream ferry surface	6.1	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2 ²
300 m upstream ferry (20-50 cm)	6.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	1.4	<0.5 ¹	0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2 ²
300 m upstream ferry (50-80 cm)	6.3	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5 ¹	<0.5 ¹	<0.2	<0.2	<0.5 ¹	<0.2	<0.2	<0.2	<0.2	<0.2 ²
300 m upstream ferry bottom	6.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2

¹ components detected in traces, could not be quantified within the scope of 0.2-0.5 µg/kg.

² normal procedure of sample cleaning we could not obtain sufficient extract cleanliness to claim that PCB is not present.

Table 63. Concentration of radionuclides in sediment samples from the Canal near Vrbas

Radionuclide	Sludge 2P 2973	Sludge 3P 2975	Sludge 4P 2977	Sludge 5P 2979	Sludge 1P 2970
	LSM8A	MSM1A	LSM12A	LSM15A	LSM10A
	A[Bq/kg]				
⁷⁵ Se	<0.23	<0.11	<0.13	<0.22	<0.16
¹⁴⁴ Ce	<1.5	<2.3	<1.2	<1.3	<1.6
¹⁴¹ Ce	<0.6	<0.6	<0.5	<0.5	<0.7
¹²⁵ Sb	<1.2	<0.9	<0.7	<0.7	<1.1
⁷ Be	8±3	<3	3.3±2.6	<3.7	4.4±2.7
¹⁰³ Ru	<0.4	<0.4	<0.5	<0.5	<0.29
¹³⁴ Cs	<1.0	<1.1	<0.39	<0.26	<0.6
¹²⁴ Sb	<0.4	<0.4	<0.19	<0.4	<0.33
¹⁰⁶ Ru	<6	<3.0	<3.5	<2.2	<2.7
^{110m} Ag	<0.8	<0.45	<0.26	<0.29	<0.39
¹³⁷ Cs	10.3±1.3	2.6±0.7	8.2±0.9	5.8±0.6	16.2±1.2
⁹⁵ Zr	<1.2	<1.6	<0.8	<0.8	<0.5
⁹⁵ Nb	<0.6	<0.7	<0.4	<0.6	<0.9
⁵⁸ Co	<0.9	<0.4	<0.4	<0.25	<0.3
¹⁶⁰ Tb	<1.2	<1.8	<0.6	<0.9	<0.4
⁶⁰ Co	<0.4	<0.29	<0.31	<0.23	<0.30
²³⁸ U	115±28	60±50	131±28	150±30	250±50
²³⁵ U	2.7±1.6	<2	2.4±1.1	3.5±1.3	4.4±1.4
²²⁶ Ra	31±3	30.7±1.4	30±3	32±4	29±4
²³² Th	43.2±2.5	36.7±2.0	40.7±2.3	39.2±2.2	39.6±2.0
⁴⁰ K	520±40	477±29	481±25	425±20	420±22

Table 64. GC/MS screening on the profile 3.300

	sediment surface	sediment middle	sediment bottom
Phthalates			
Bis(2-ethylhexyl)phtalate	+	+	+
Phenols			
Nonyl phenol	+	+	+
Nonyl phenol isomer	+	+	+
Phenol 4-(2,2,3,3 tetramethylbutyl)	+	+	+
Phenol,5-methyl-2-(1-methylethyl)	+		
Phenol, 2,6-bis (1,1-dimethylethyl)		+	
Benzene Derivates			
Benzene (1-Butylheptyl)	+		
Benzene (1-Butyloctyl)	+		
Hydrocarbons			
Tridecane	+		
Hexadecane	+		
Octadecane	+		
Nonadecane	+		+
Docosane			+
Tricosane	+	+	+
Tetracosane		+	
Pentacosane	+		
Heptacosane			+
Octacosane		+	
Nonacosane			+
Eicosane	+	+	+
3-Eicosene	+		+
Heneicosane			+
2,6,10,15-tetramethyl heptadecane			+
2,6,10,-trimethyl pentadecane			+
2,6,10,-trimethyl hexadecane		+	
2,6,10,15-tetramethyl hexadecane	+	+	+
2,Hexadecene-3,7,11,15 tetramethyl	+		
Hexadecanoic acid methylester	+	+	+
13 -Octadecanoic acid methylester	+		
Octadecanoic acid methylester	+		
Heneicosanoic acid 18-propyl methylester	+		
Polynuclear Aromatic Hydrocarbons			
2,3-dimethyl phenanthrene	+		
2,5-dimethyl phenanthrene		+	
2,3,5- trimethyl phenanthrene			+
9-methyl phenanthrene		+	
Methyl phenantrene		+	
Fluorantene			+
Antracene -9-dodecyltetrahydro			+
<hr/>			
Calarene	+		
Cadinal-1(10),6,8-triene	+		
Kaur-16-ene	+		
Dihydrocholesterol	+		
Cholestan-3-one	+		
Cyclobutendion,1,2-diphenyl		+	
6-methylnaphto(2,1-b) thiophene		+	
Baccharane			
29-nor-(17alpha.H21,betaH)-hopane		+	
Ethyl trans-13,14-dihydro-13,14-methylenetionates		+	

Lanosterol	+	
Isopropyl myristate		+
4-methylnaphtho(2,1-b)thiophene	+	+
5-ethyl-9,9-dimethyl-5H,9H-quinolizino(3,2,1-de)phenazine		+
11-phenyl-1H-indolo(3,2-c)quinoline-6(5H)-one		+
29-methyl-(17 α ,21 β)-hopane		+
