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*

Norwegian Institute for Water Research
– an institute in the Environmental Research Alliance of Norway

# REPORT

| **Main Office** | **Regional Office, Sørlandet** | **Regional Office, Østlandet** | **Regional Office, Vestlandet** | **Akvaplan-NIVA A/S** |
|---|---|---|---|---|
| P.O. Box 173, Kjelsås | Televeien 3 | Sandvikaveien 41 | Nordnesboder 5 | |
| N-0411 Oslo, Norway | N-4879 Grimstad, Norway | N-2312 Ottestad, Norway | N-5008 Bergen, Norway | N-9005 Tromsø, Norway |
| Phone (47) 22 18 51 00 | Phone (47) 37 29 50 55 | Phone (47) 62 57 64 00 | Phone (47) 55 30 22 50 | Phone (47) 77 68 52 80 |
| Telefax (47) 22 18 52 00 | Telefax (47) 37 04 45 13 | Telefax (47) 62 57 66 53 | Telefax (47) 55 30 22 51 | Telefax (47) 77 68 05 09 |
| Internet: www.niva.no | | | | |

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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.

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Finn Medbø Harsha Ratnaweera

*Finn Medbø*
Project manager

*Harsha Ratnaweera*
Research Manager

*Øivind Sørensen*
Research Management Director

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Norwegian Institute for Water Research
Oslo

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# Rehabilitation of the DTD-Canal in the Vrbas region

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

Novi Sad 2005-09-07

| | | |
|---|---|---|
| Project leader: | Finn Medbø | NIVA |
| Co-Workers: | Dag Berge | NIVA |
| | Bozo Dalmacija | Chem.Inst. Univ. Novi Sad |
| | Ivana Ivancev Tumbas | ” |
| | Milan Barackov | NECW Renesansa |
| | Tanja Bosnjak | “ |
| | Vera Cvejic | “ |
| | Bojana Susa | “ |
| | Snezana Sokolovic | Interpreter |
| | Vladimir Hadzic | Agr. Inst. Univ. Novi Sad |
| | Maja Cuvardic | ” |
| | Ondrej Urban | Dekonta |
| | Bjørnar Noreide | ICG |

# 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*

# Contents

# 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 the 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 Bezdan 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)

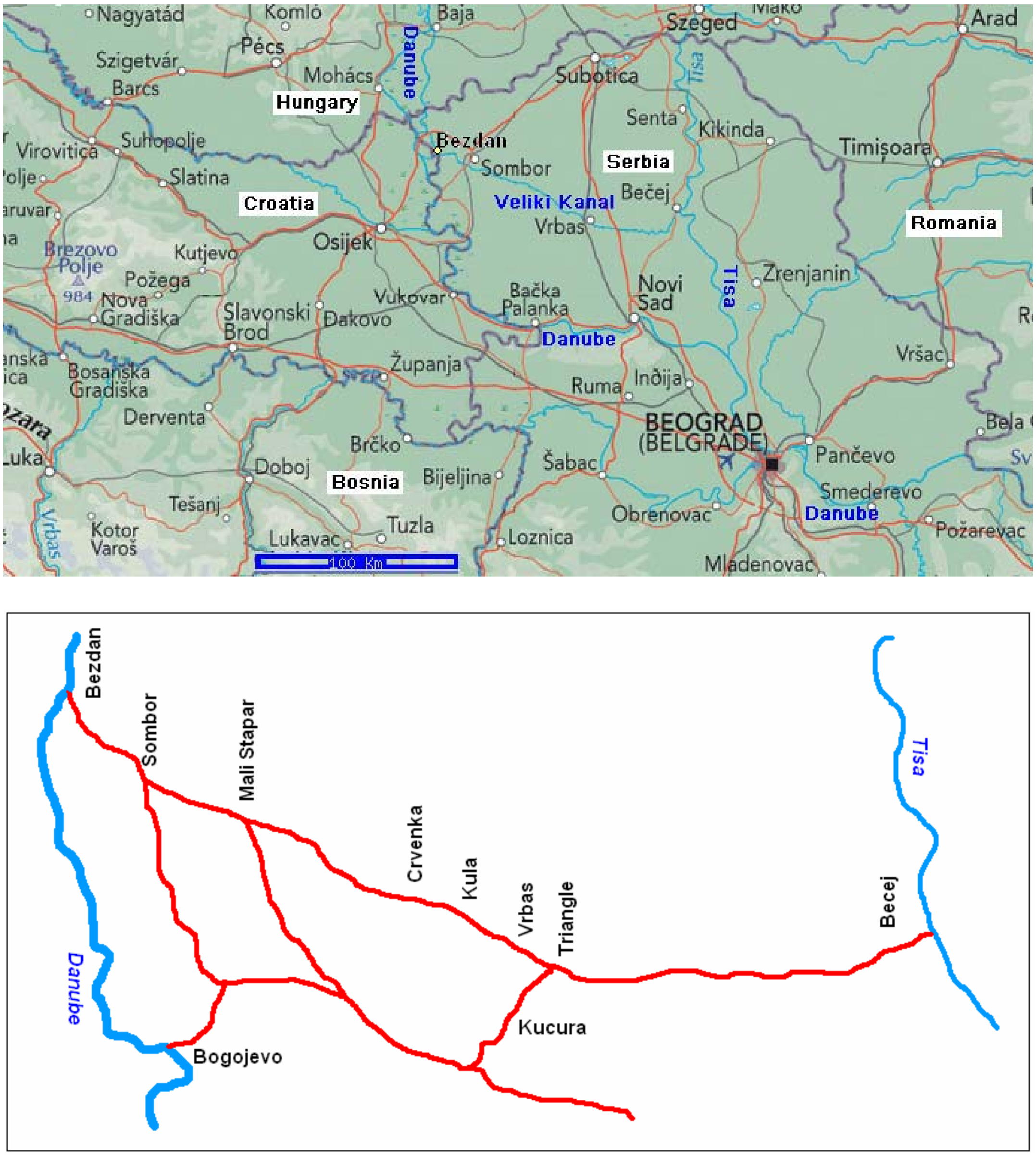


**Figure 1.** The DTD-canal system connecting Danube and Tisa.

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 Bezdan, pump-station Bezdan 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 hydrotehnical entity: basin no. 1 gets water from the Danube, basin 2 gets water from basin 1, and it empties into basin 5.

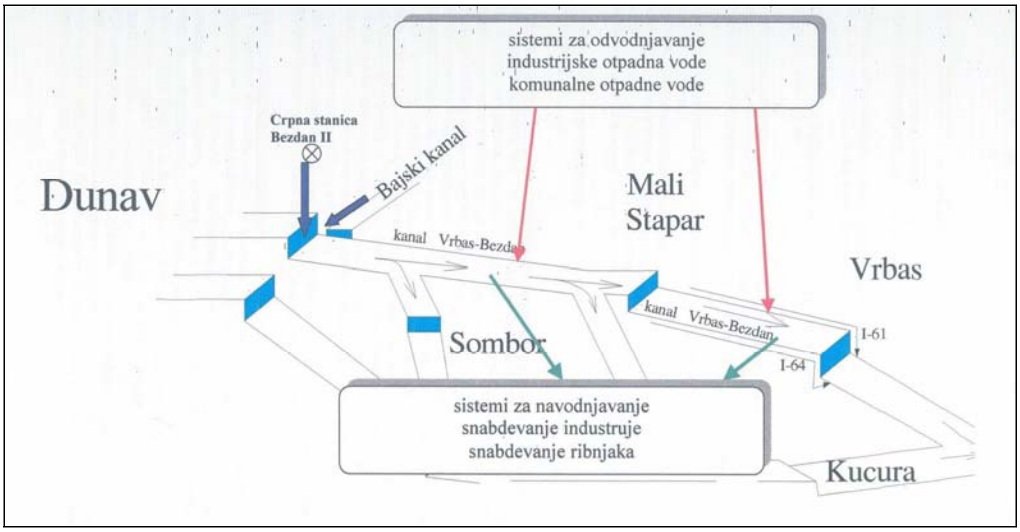


**Figure 2.** The DTD-canal system with the main locks in the Vrbas region

## 2.2 Quantity of water taken from the Danube

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

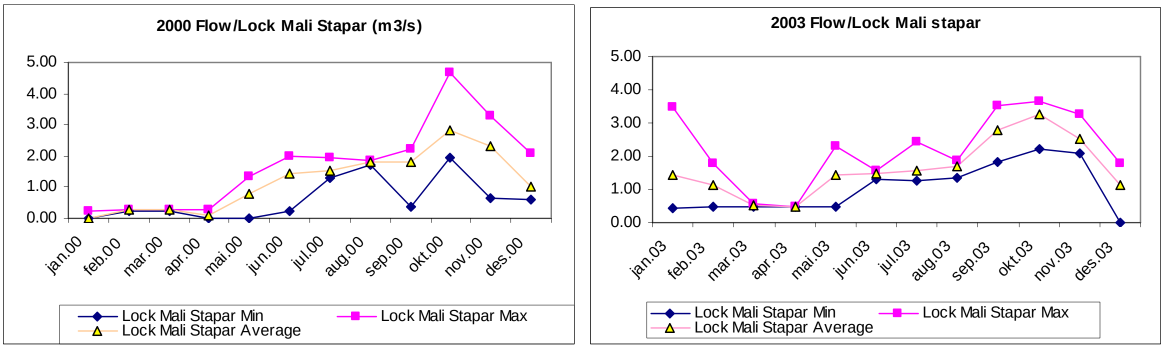


**Figure 3.** Water flow ($m^3$/s) through Mali Stapar Lock in a rainy year (left panel) and a dry year (right panel)

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

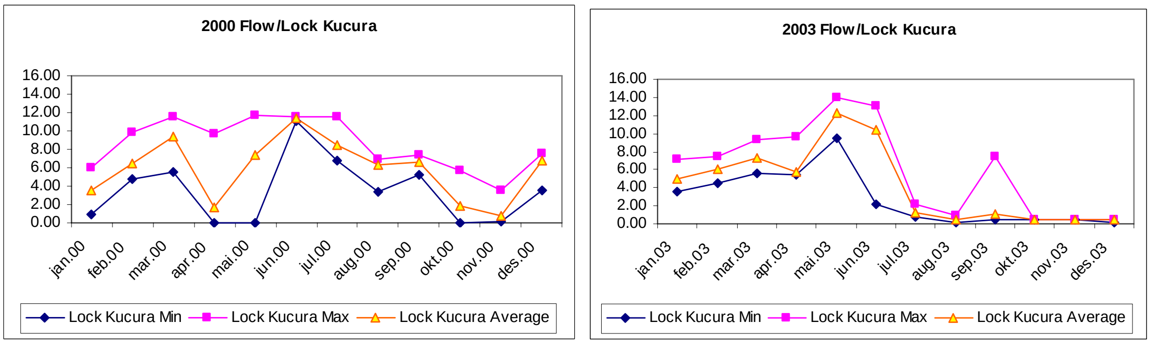


**Figure 4.** Water flow ($m^3/s$) through Kucura lock in a rainy year (left panel) and a dry year (right panel)

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

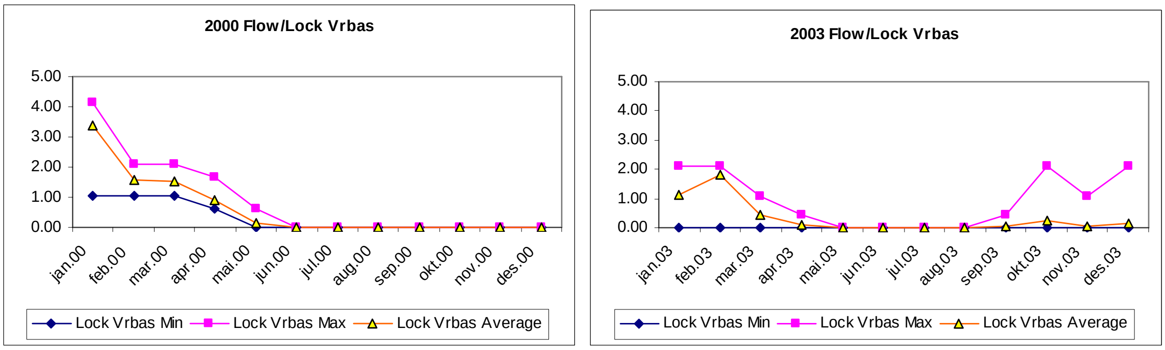


**Figure 5.** Water flow ($m^3/s$) through Vrbas lock in a wet year (left panel) and a dry year (right panel)

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

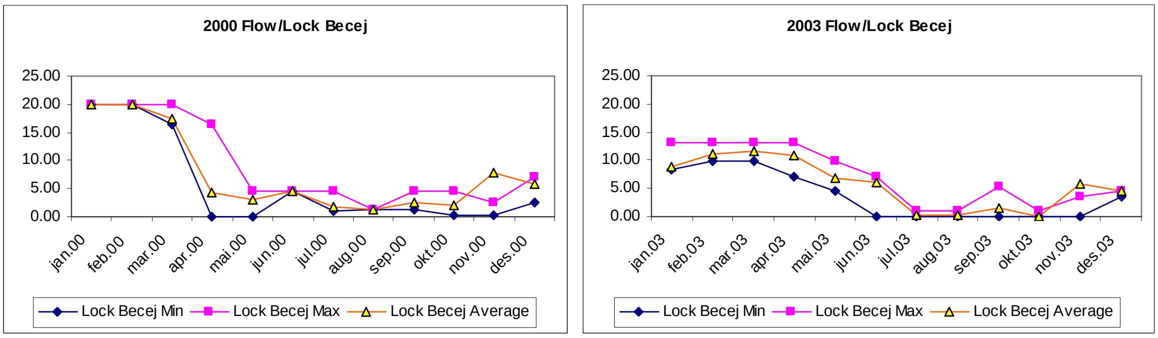


**Figure 6.** Water flow ($m^3/s$) through Becej Lock in a wet year (left panel) and a dry year (right panel)

## 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 Bezdan- 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 Bečej is thus prolonged. The oxygen consuming polluted plume would also have created eclogical 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 Vojovodina, 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-61are 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 $m^3/s$ 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 $m^3$ of water for irrigation of 4,000 hectares of land, and in 2004 they used about 1.7 million $m^3$ 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 ($NaCO_3$) 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 $m^3$ 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 $m^3$. Annual deposit of sludge is some 20,000 $m^3$ 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 $m^3/s$. The fish farm consumes 12.5 million $m^3$ 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, $BOD_5$ less then 8 $mgO_2/l$, $CO_2$ 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 $BOD_5$ 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.

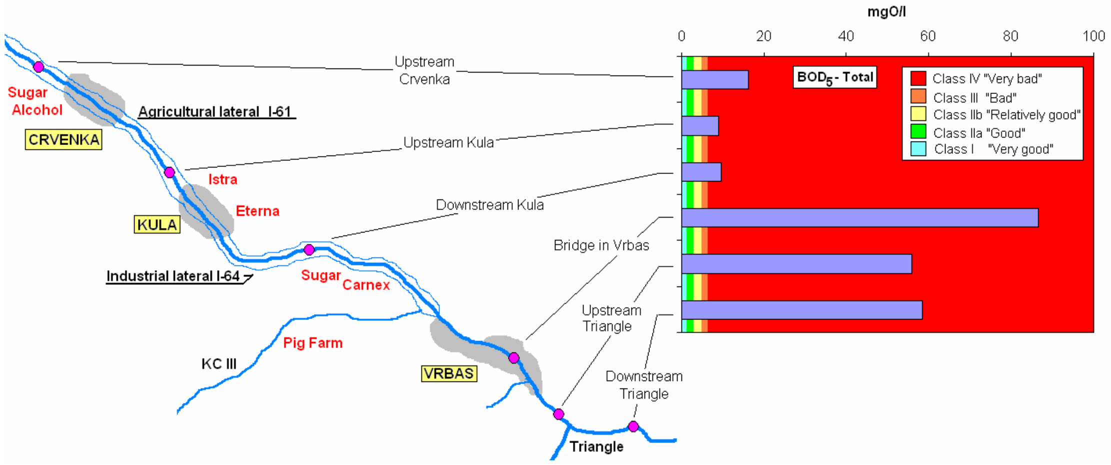


**Figure 8.** *BOD5-total. Mean values of the 6 observations at the different monitoring stations in the DTD-canal in 2003-2004, as compared with the Serbian water quality criteria.*

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

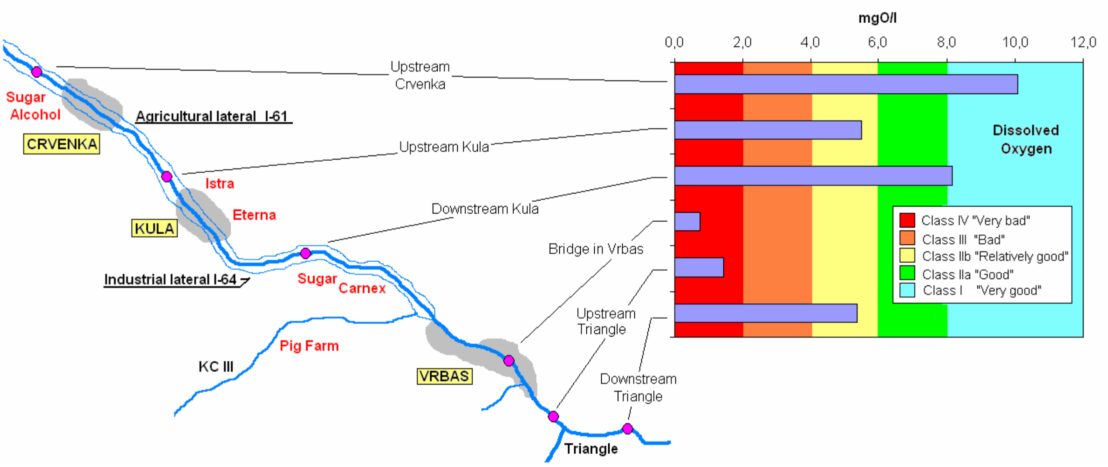


**Figure 9.** *Concentration of dissolved oxygen. Mean values of the 6 observations at the different monitoring stations in the DTD-canal in 2003-2004, as compared with the Serbian water quality criteria.*

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.

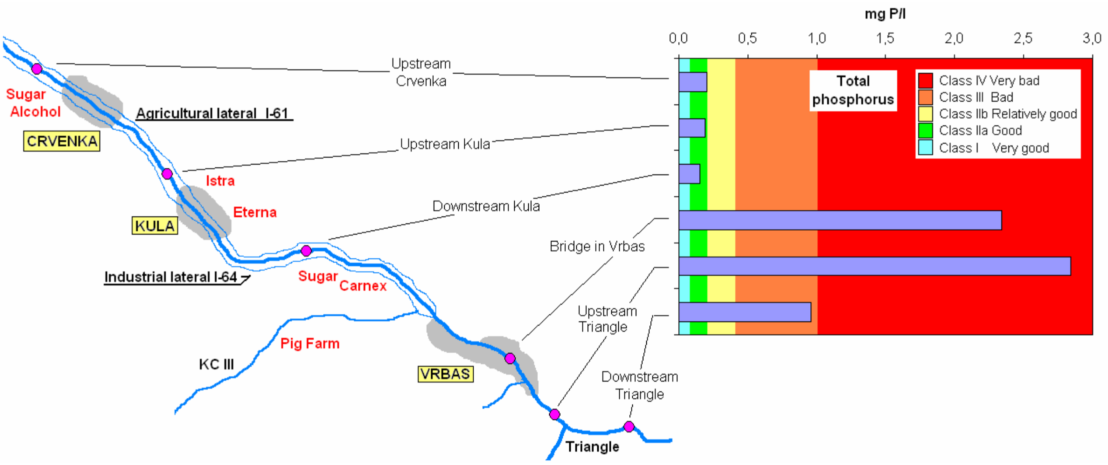


**Figure 10.** *Concentration of Total Phosphorus. Mean values of the 6 observations at the different monitoring stations in the DTD-canal in 2003-2004, as compared with the water quality criteria recommended by the Danube River Commission.*

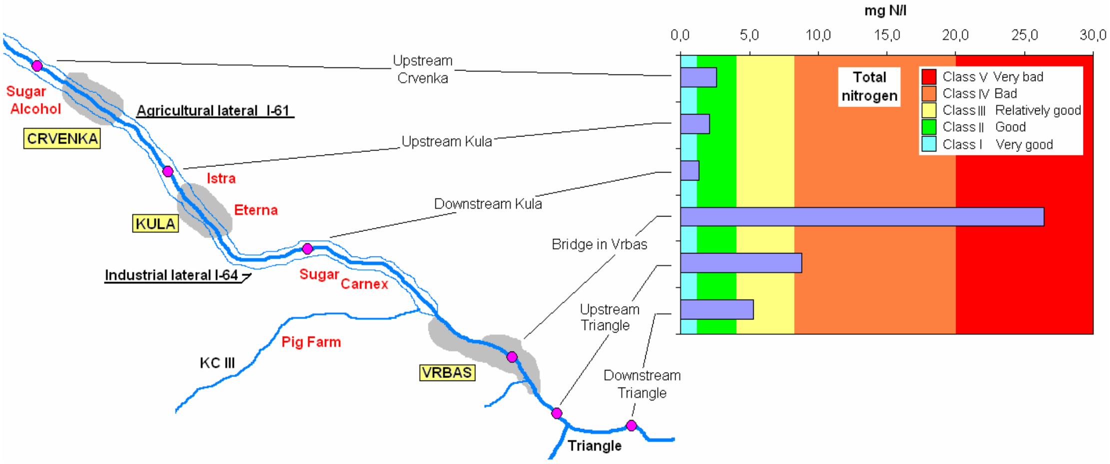


**Figure 11.** *Concentration of Total Nitrogen. Mean values of the 6 observations at the different monitoring stations in the DTD-canal in 2003-2004, as compared with the water quality criteria recommended by the Danube River Commission.*

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.

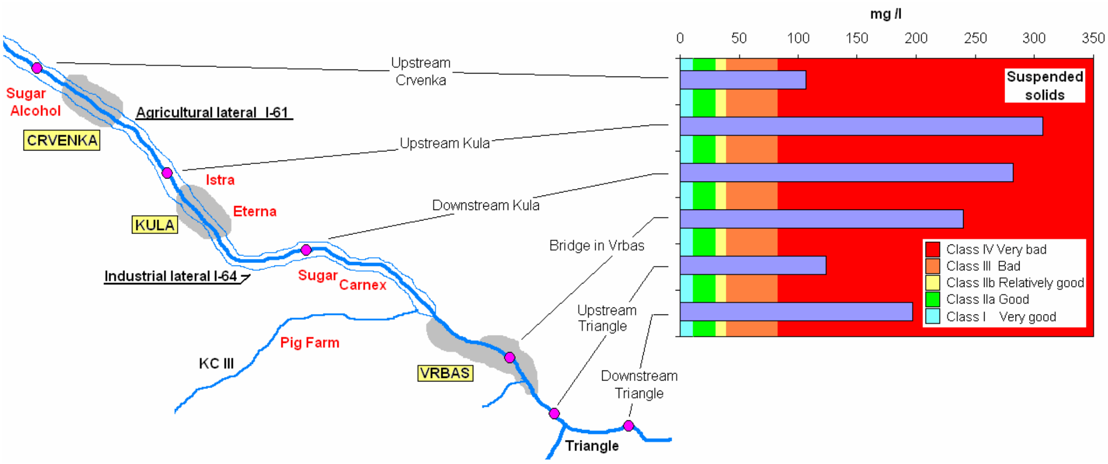


**Figure 12.** *Concentration of suspended solids. Mean values of the 6 observations at the different monitoring stations in the DTD-canal in 2003-2004, as compared with the Serbian water quality criteria.*

## 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, $SO_4$, and $HCO_3$. Therefore, the results can not be related directly to pollution.

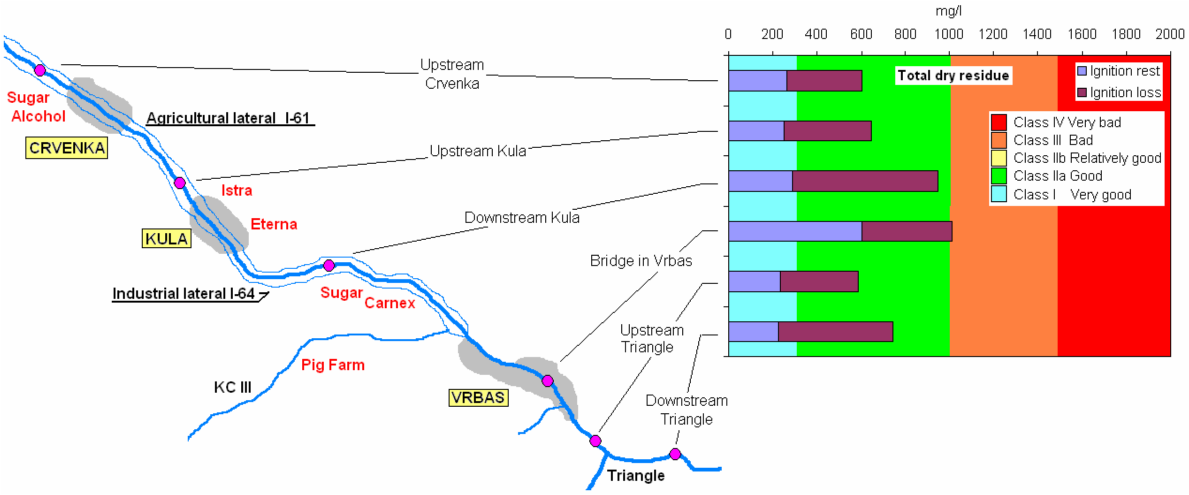


**Figure 13.** *Total particulate matter (dry residue) in the canal at the different monitoring stations. Mean values divided into inorganic and organic fraction.*

### 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.

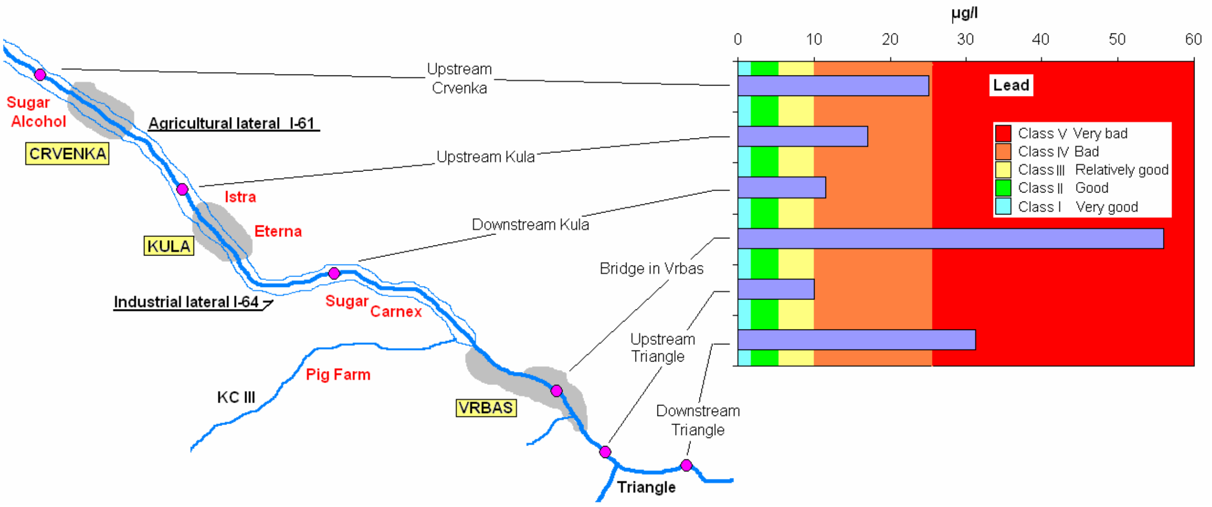


**Figure 14.** *Mean concentrations of lead at the different monitoring stations in the DTD-canal, compared with the water quality criteria recommended by The Danube River Commission.*

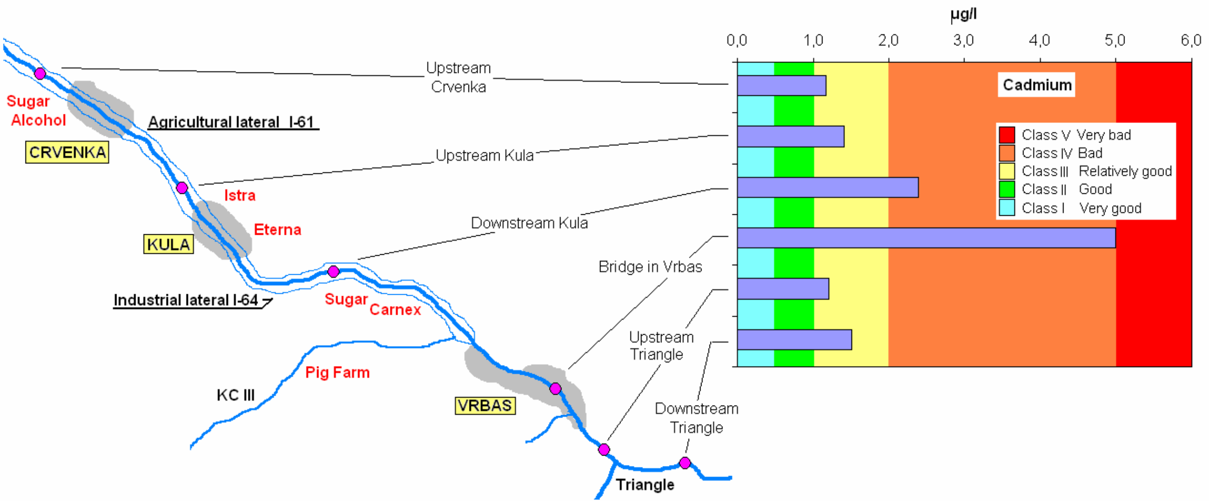


**Figure 15.** *Mean concentrations of cadmium at the different monitoring stations in the DTD-canal, compared with the water quality criteria recommended by The Danube River Commission*

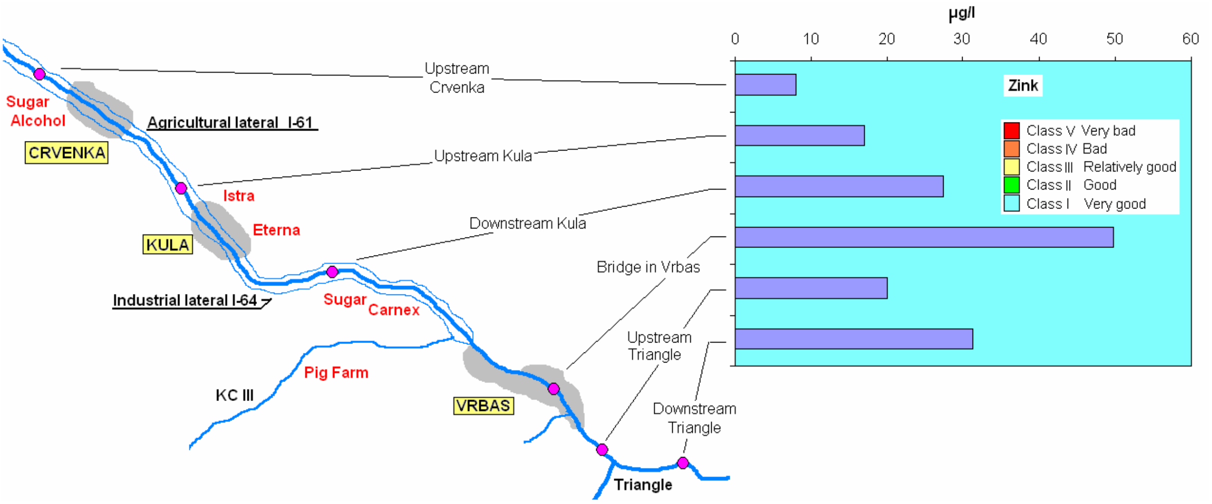


**Figure 16.** *Mean concentrations of zinc at the different monitoring stations in the DTD-canal, compared with the water quality criteria recommended by The Danube River Commission*

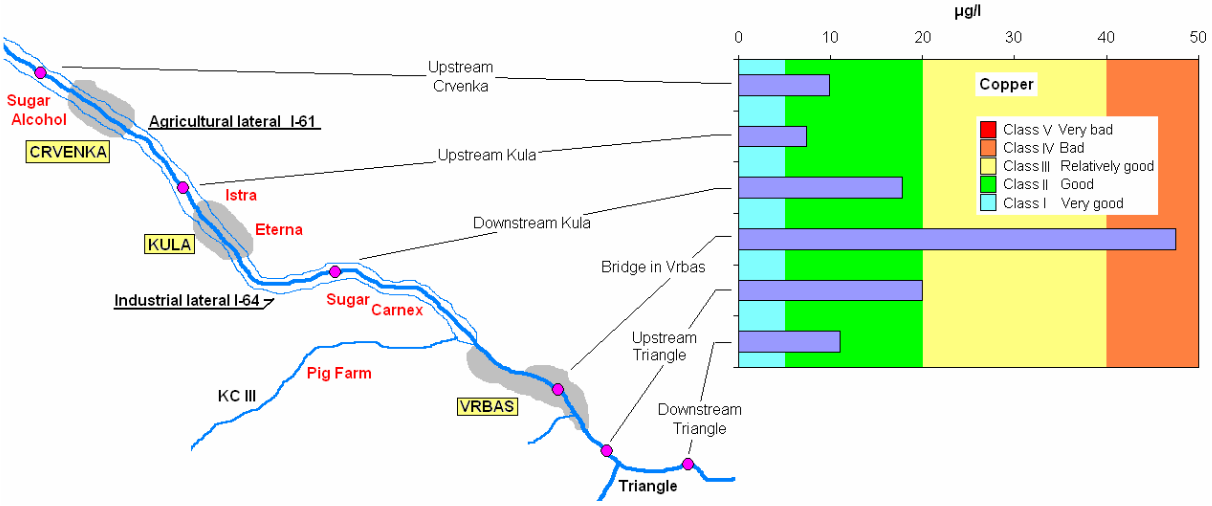


**Figure 17.** *Mean concentrations of copper at the different monitoring stations in the DTD-* canal, *compared with the water quality criteria recommended by The Danube River Commission*

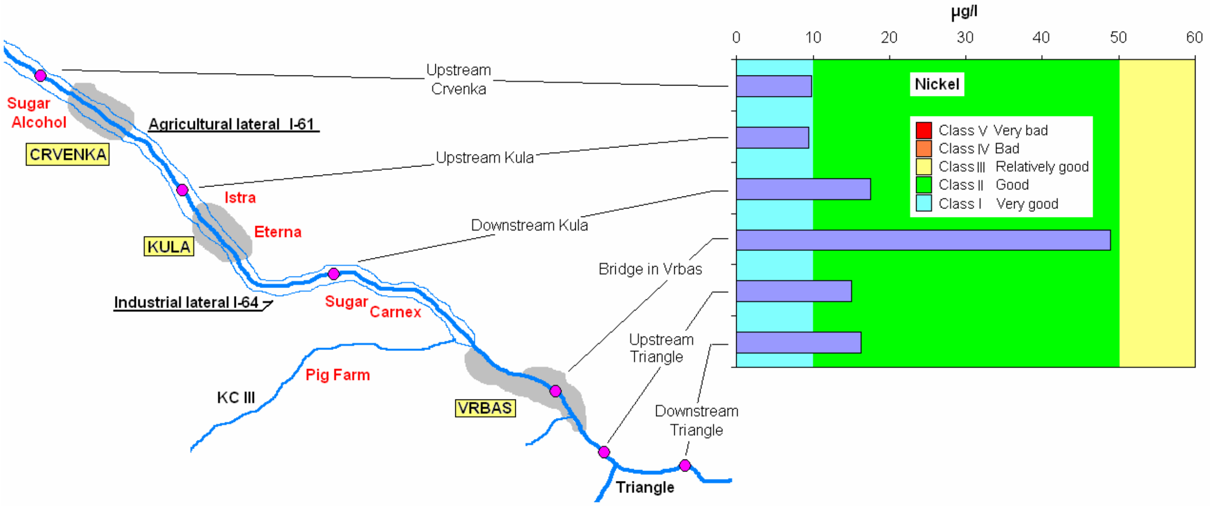


**Figure 18.** *Mean concentrations of nickel at the different monitoring stations in the DTD-* canal, *compared with the water quality criteria recommended by The Danube River Commission*

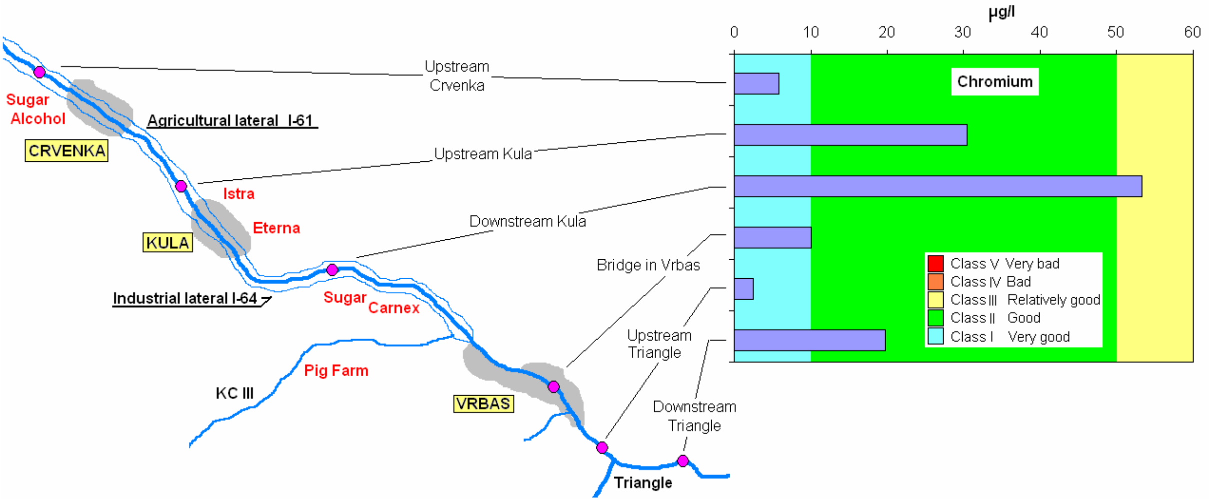


**Figure 19.** *Mean concentrations of chromium at the different monitoring stations in the DTD-canal, compared with the water quality criteria recommended by The Danube River Commission*

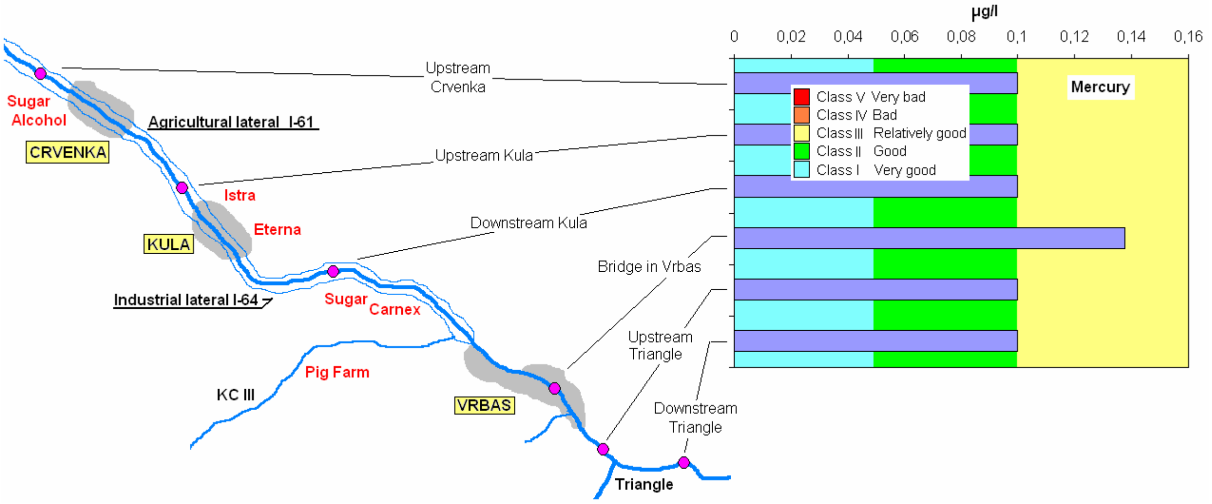


**Figure 20.** *Mean concentrations of mercury at the different monitoring stations in the DTD-canal, compared with the water quality criteria recommended by The Danube River Commission*

### 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.

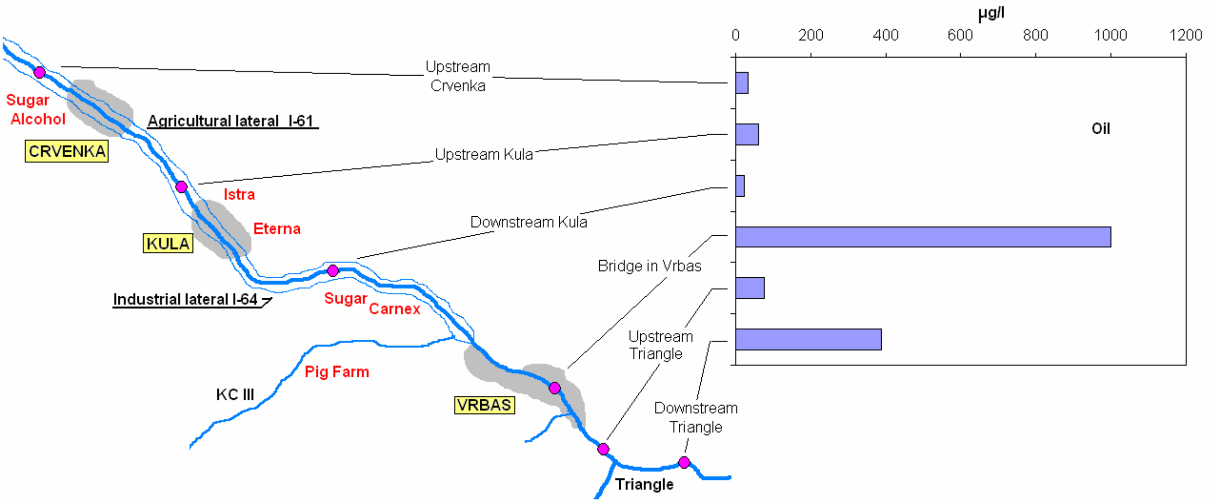


**Figure 21.** *Concentration of total-mineral oil in the water samples at the different monitoring stations of the DTD-canal.*

## ***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.

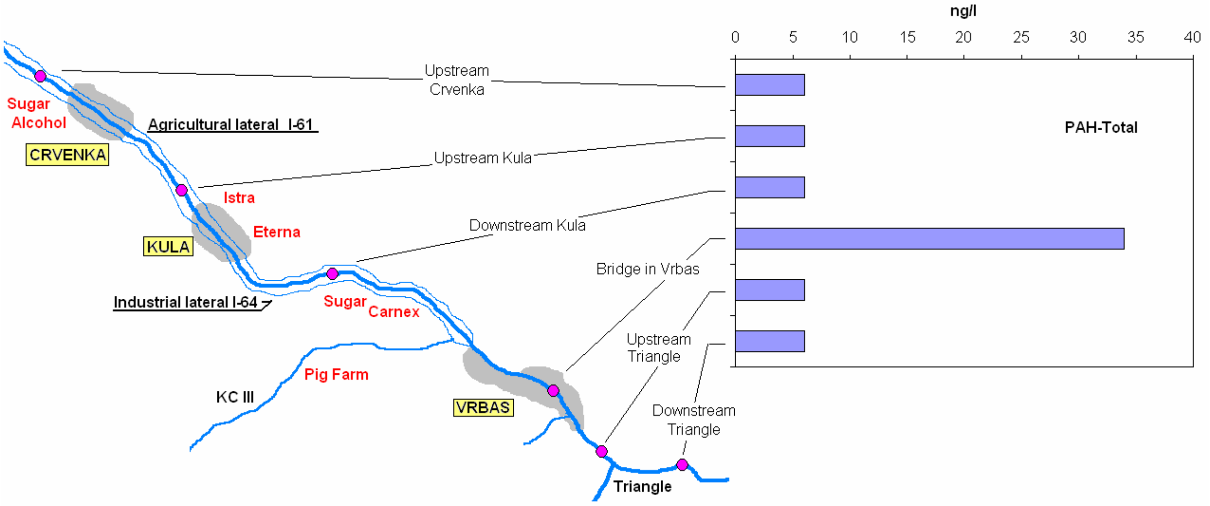


**Figure 22.** *Concentrations of PAH-Total at the different monitoring stations in the DTD-Canal.*

### 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.

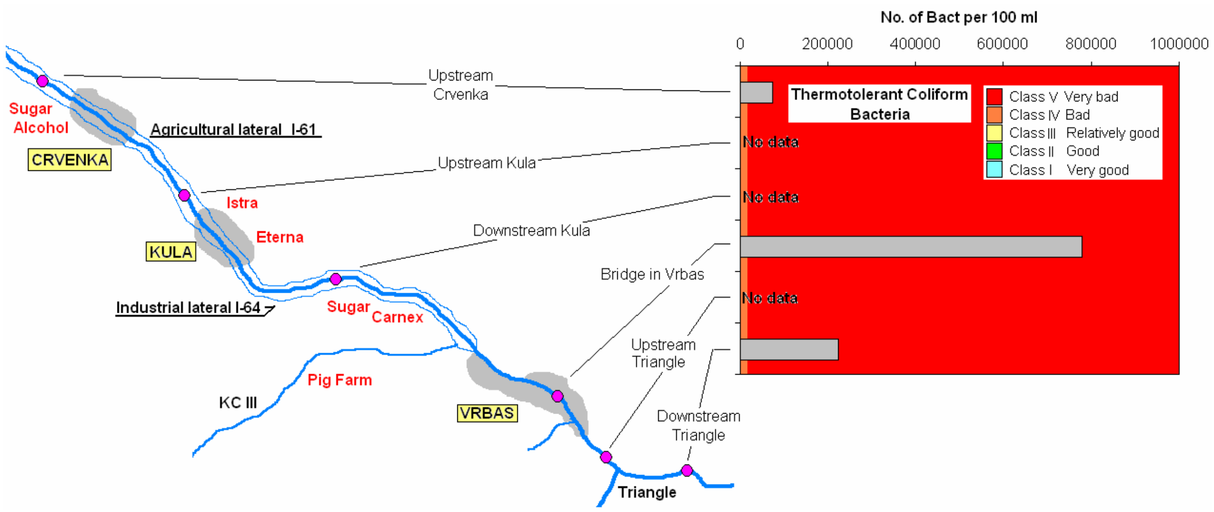


**Figure 23.** *Faecal pollution in the Great Canal. Average concentrations of Thermo tolerant Coliform Bacteria (TCB) at three sites in the Grand Canal compared with the Serbian water quality guidelines.*

## 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).

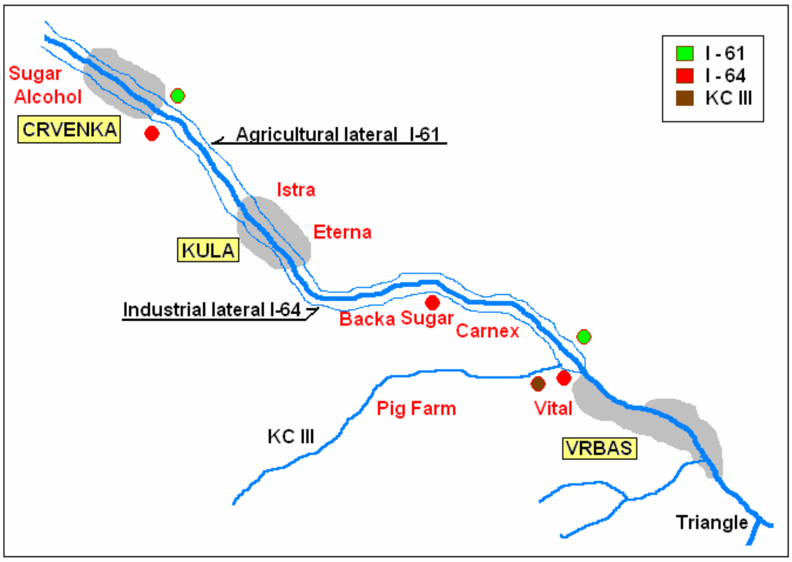


**Figure 24.** *Monitoring stations in the laterals, I-64 (Industrial lateral), I-61 (Agricultural lateral) and KC III (Farm coop Pig Farm and several small enterprises).*

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 ($BOD_5$) 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**.

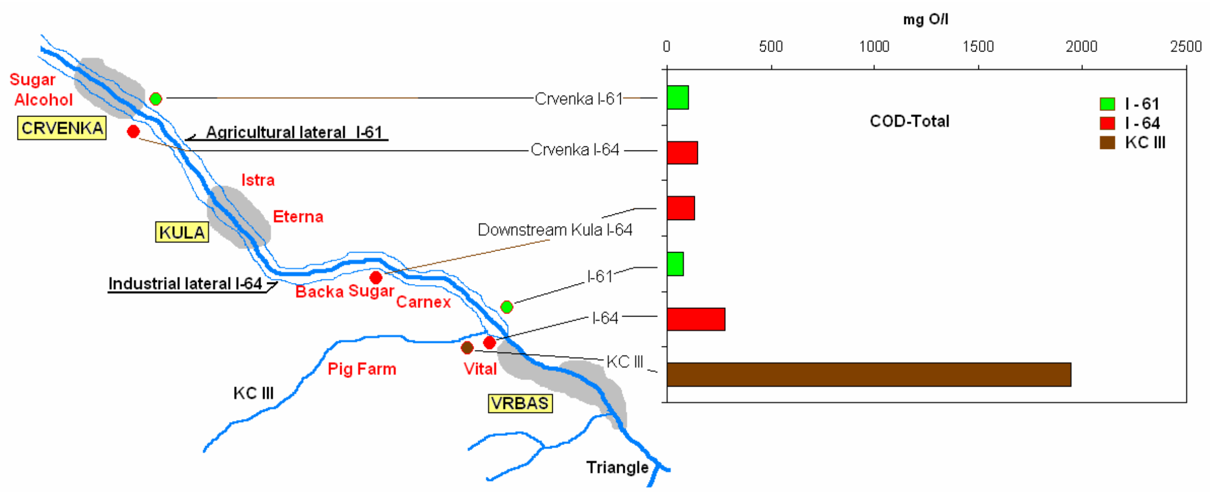


**Figure 25.** *COD-total (chemical oxygen demand) in the water at the different lateral monitoring stations*

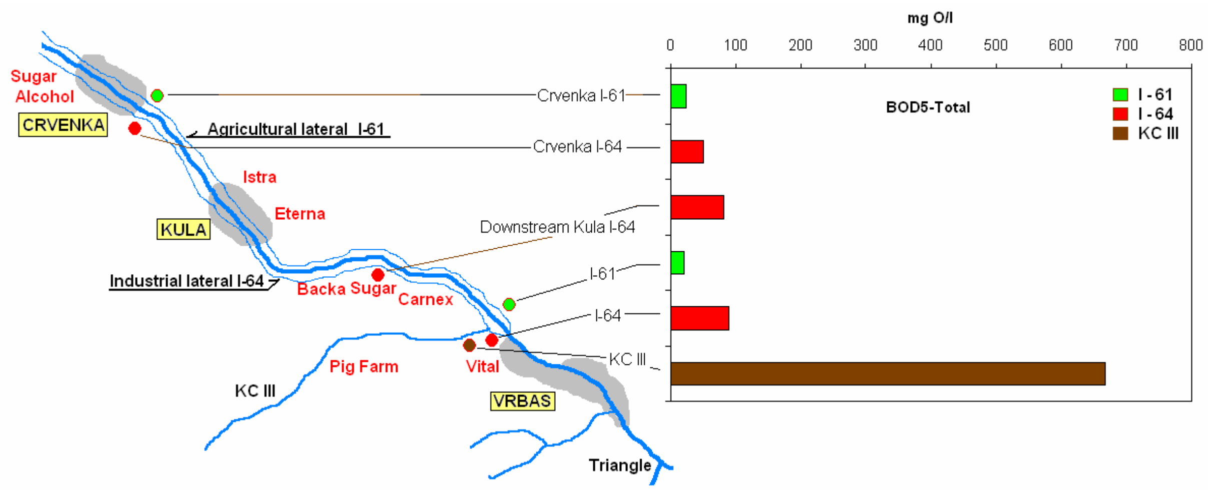


**Figure 26.** *$BOD_5$-total in the water at the different lateral monitoring stations.*

Both COD and $BOD_5$ 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**.

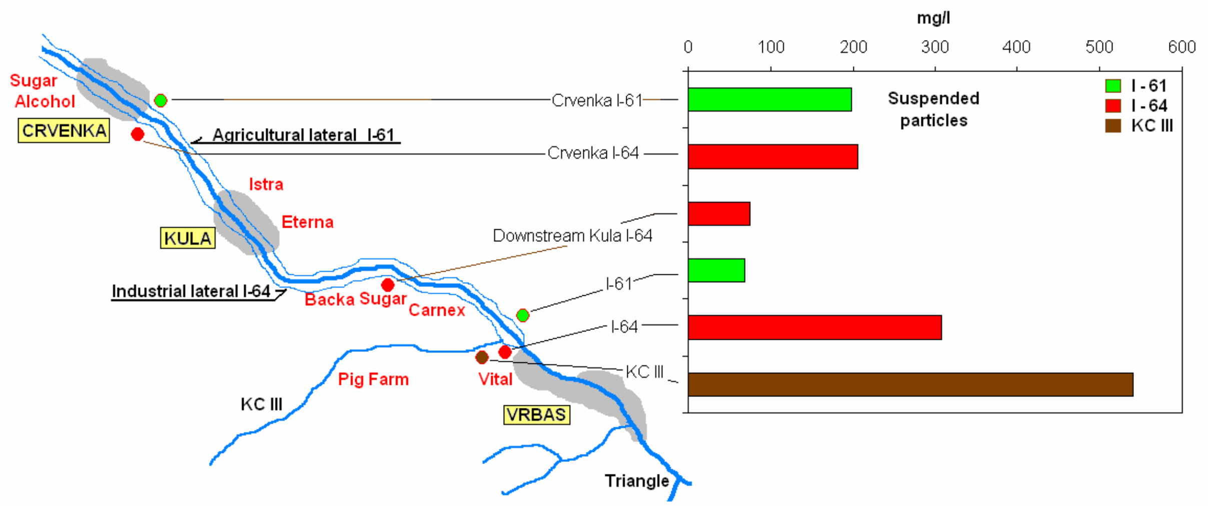


**Figure 27.** *Concentration of suspended particles in the water at the different lateral monitoring stations*

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**.

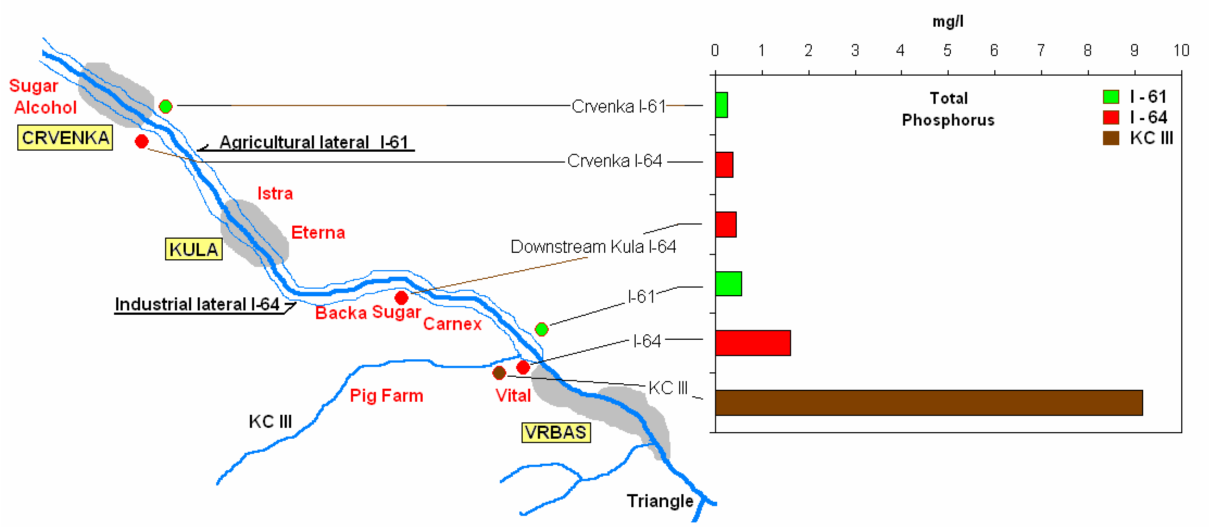


**Figure 28.** Concentrations of Total Phosphorus in the water at the different lateral monitoring stations.

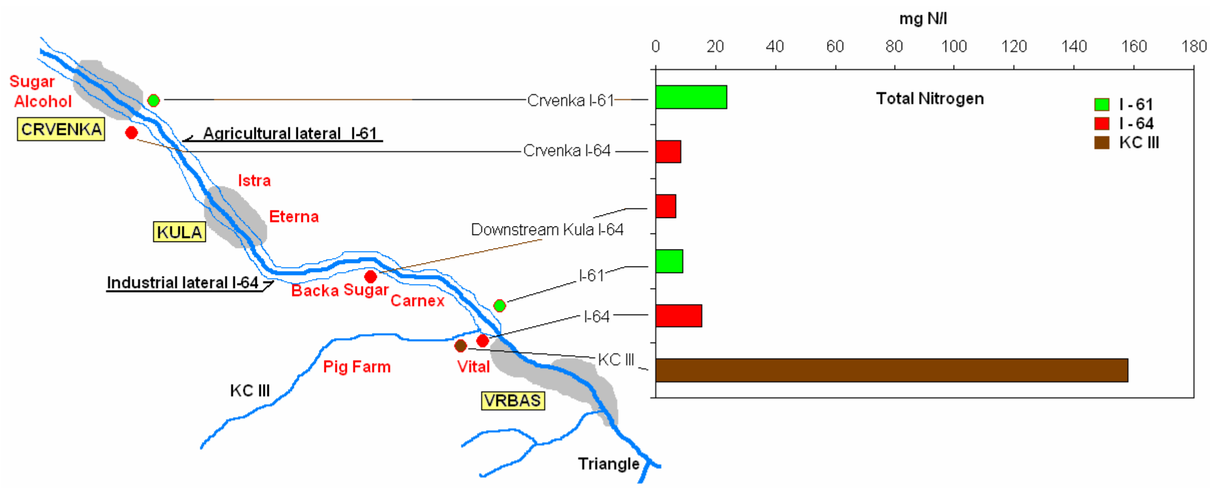


**Figure 29.** *Concentrations of Total Nitrogen in the water at the different lateral monitoring stations*

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.

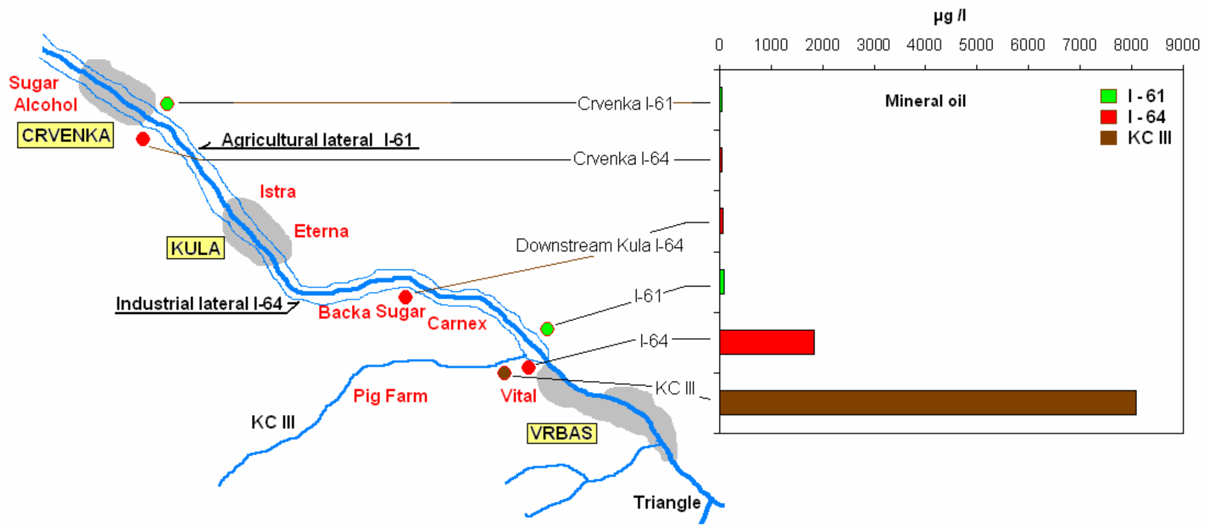


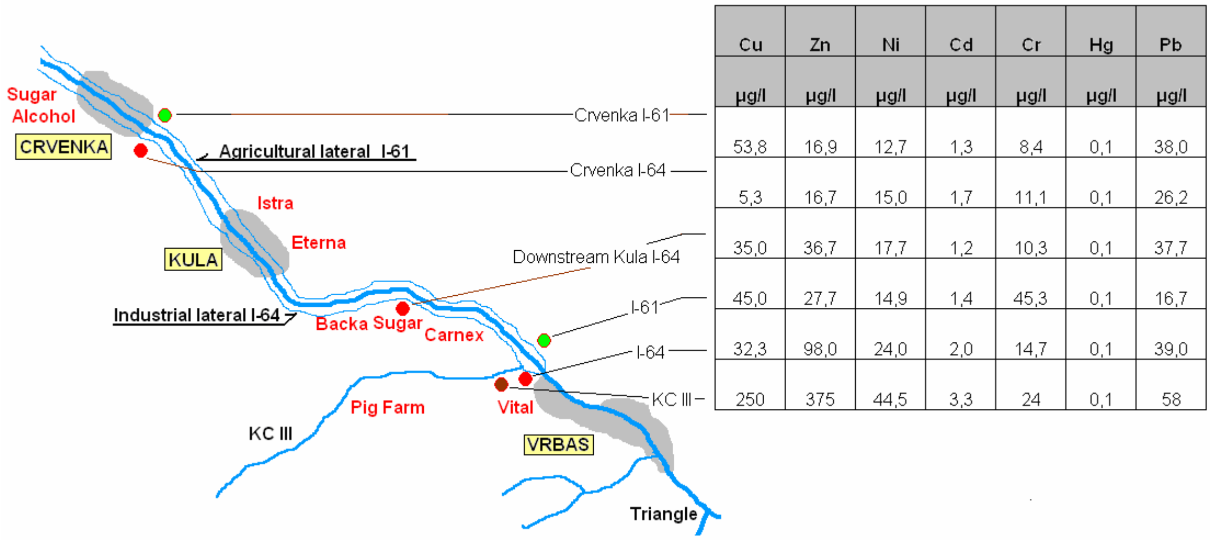
**Figure 30.** *Concentration of Mineral oil in the water at the different lateral monitoring stations*

### 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.



| | Cu | Zn | Ni | Cd | Cr | Hg | Pb |
|---|---|---|---|---|---|---|---|
| | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l | µg/l |
| Crvenka I-61 | 53,8 | 16,9 | 12,7 | 1,3 | 8,4 | 0,1 | 38,0 |
| Crvenka I-64 | 5,3 | 16,7 | 15,0 | 1,7 | 11,1 | 0,1 | 26,2 |
| Downstream Kula I-64 | 35,0 | 36,7 | 17,7 | 1,2 | 10,3 | 0,1 | 37,7 |
| I-61 | 45,0 | 27,7 | 14,9 | 1,4 | 45,3 | 0,1 | 16,7 |
| I-64 | 32,3 | 98,0 | 24,0 | 2,0 | 14,7 | 0,1 | 39,0 |
| KC III | 250 | 375 | 44,5 | 3,3 | 24 | 0,1 | 58 |

**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 touluene, 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.

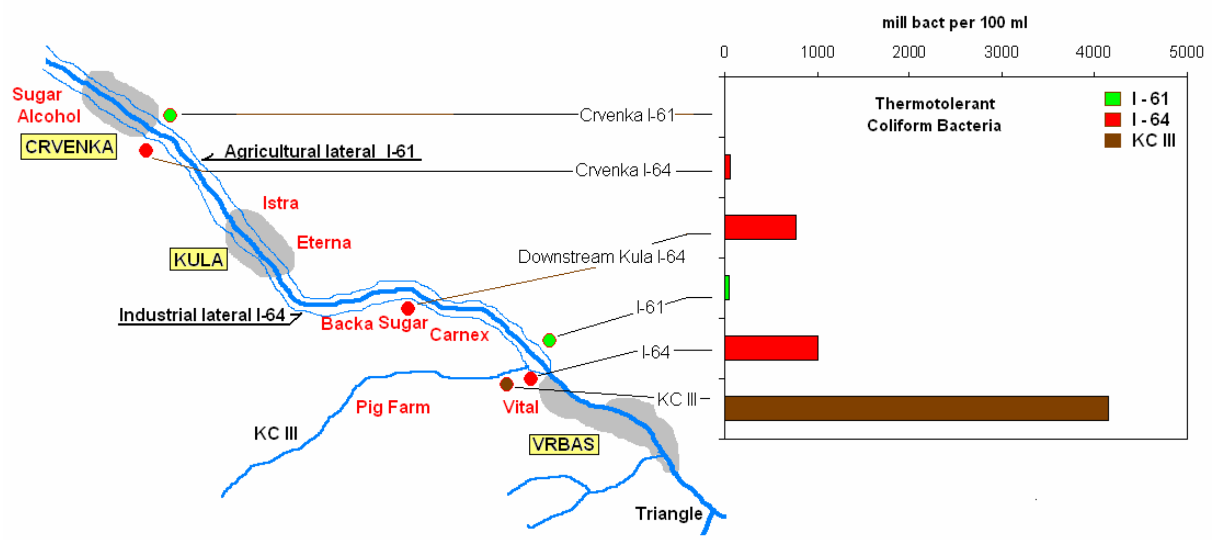


**Figure 32.** *Faecal pollution in the laterals. Average concentrations of Thermo tolerant Coliforme Bacteria (TCB) at different sites in the laterals.*

## 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** $m^3$. Bugarski and Bozidar estimated the volume in 1999 to **355 376** $m^3$. **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** |

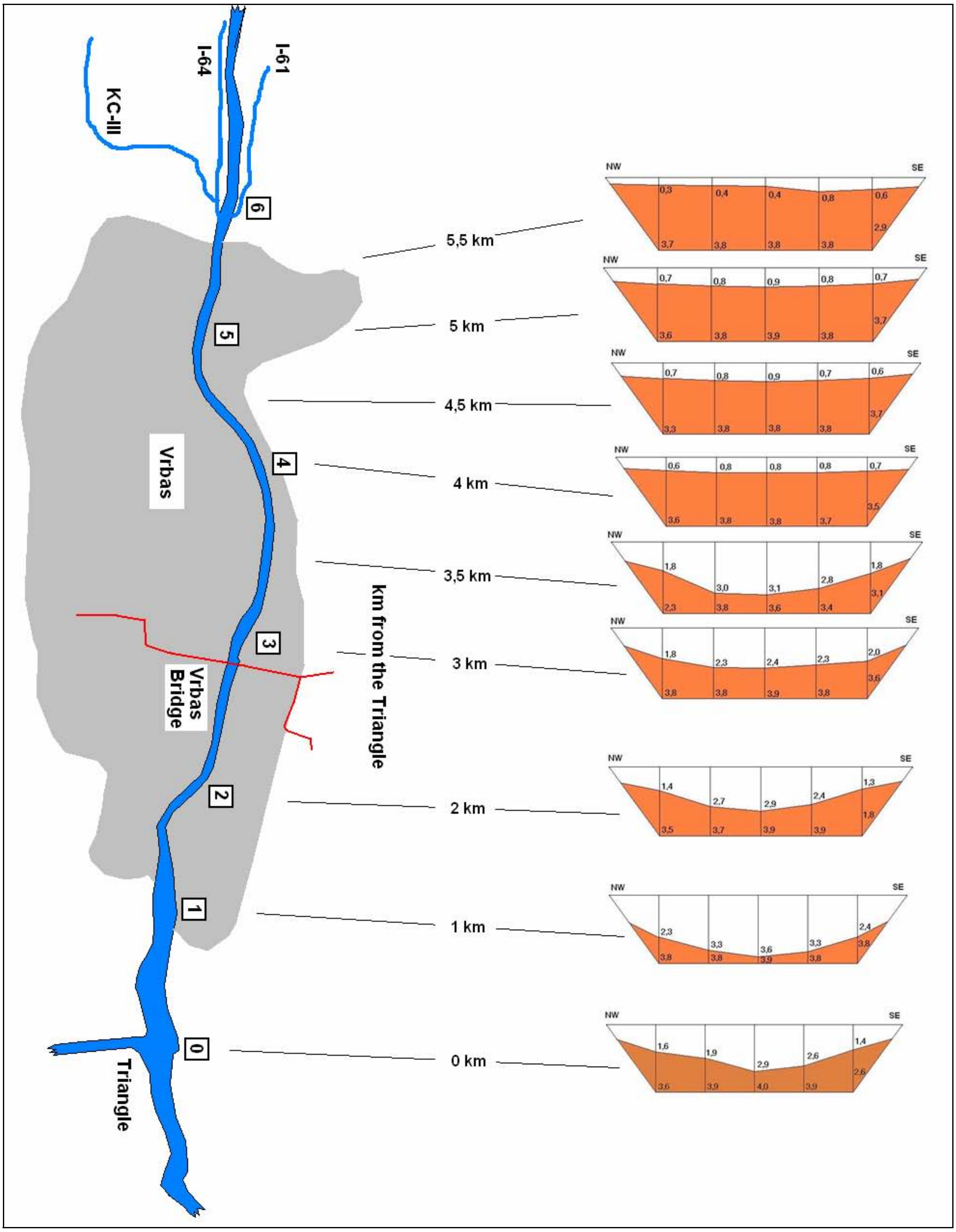


**Figure 33.** *Sediment thickness at the different transects (data from Dekonta 2004).*

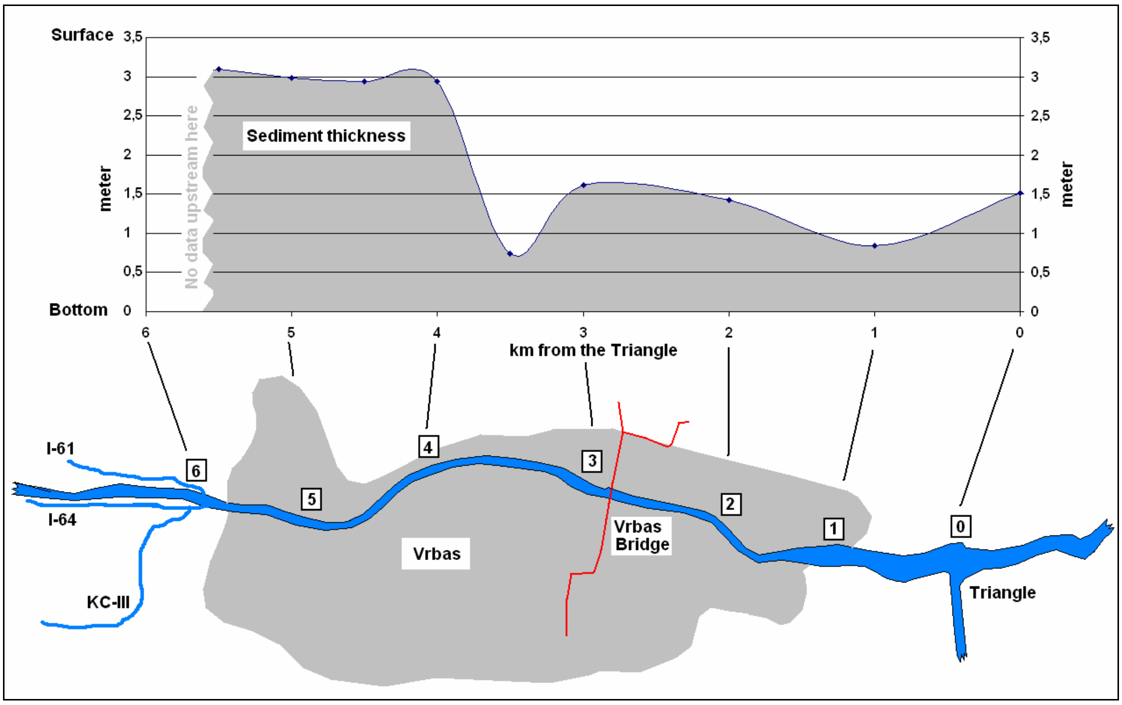


**Figure 34.** *Average sediment thickness in the Grand Canal in varying distance from the discharge point (6 km) to the Triangle (0 km). Numbers in squares are kilometres from the Triangle. (data from Dekonta 2004).*

## 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).

***<u>Heavy metals</u>***

**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.

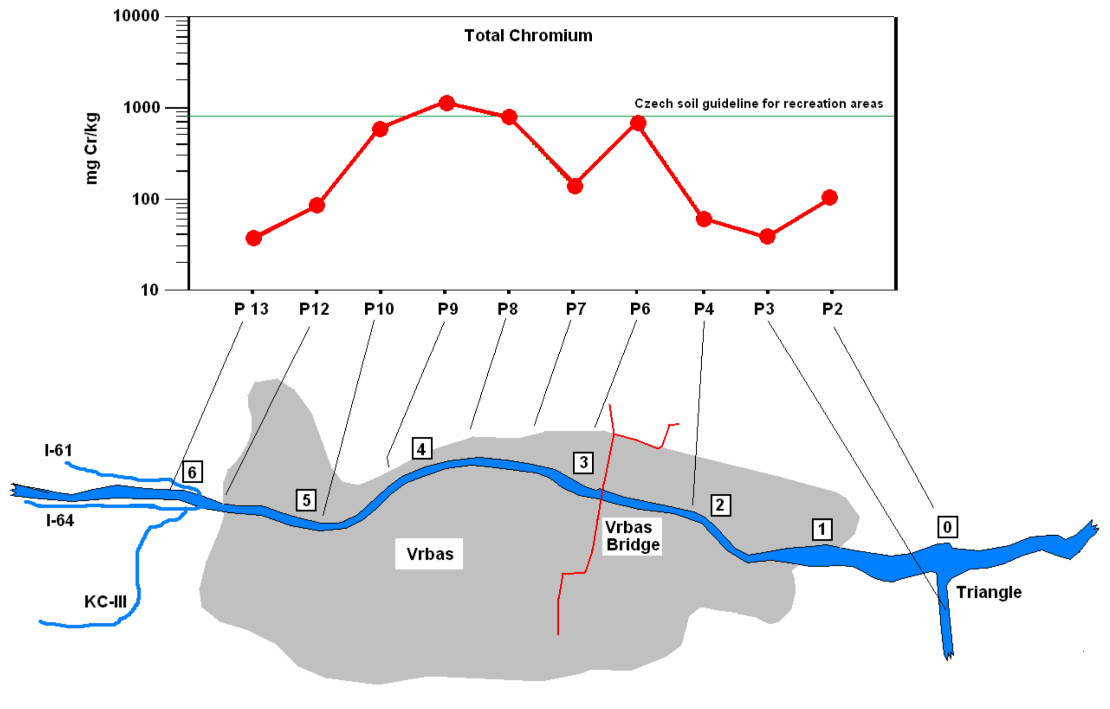


**Figure 35.** *Concentration of total chromium in mixed sediment cores from the most polluted part of the Grand Canal (Data from Dekonta 2004)*

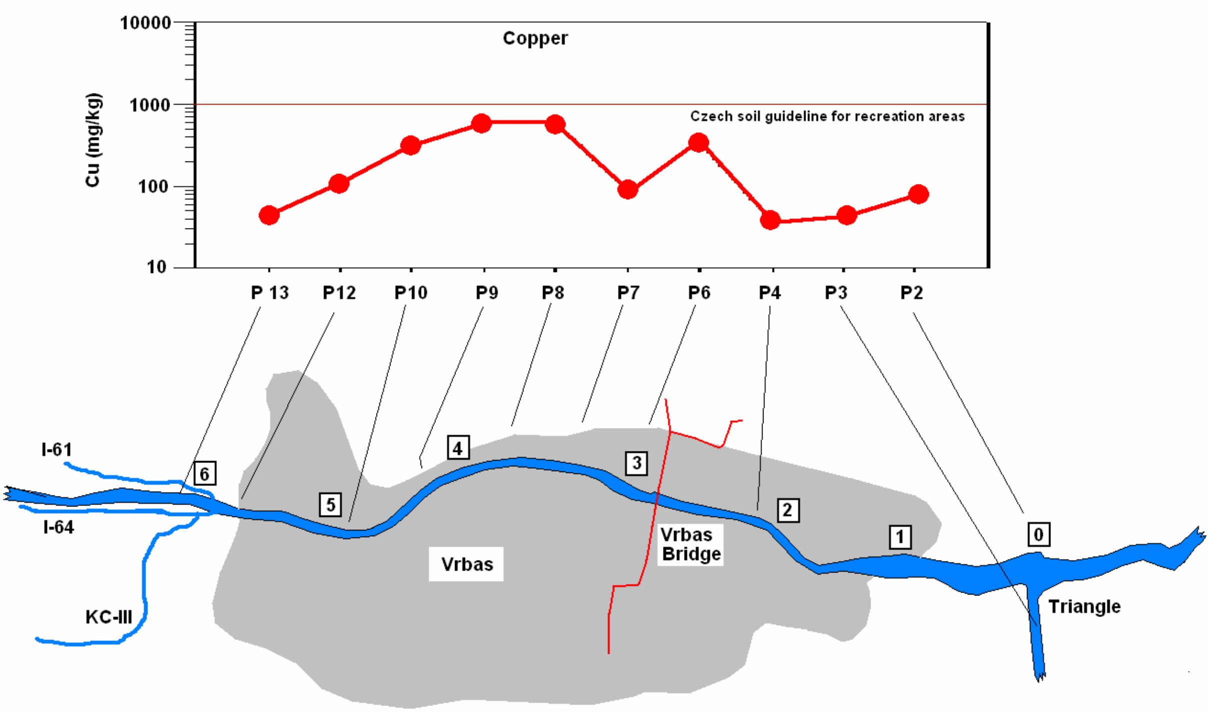


**Figure 36.** *Concentration of copper in mixed sediment cores from the most polluted part of the canal (Data from Dekonta 2004).*

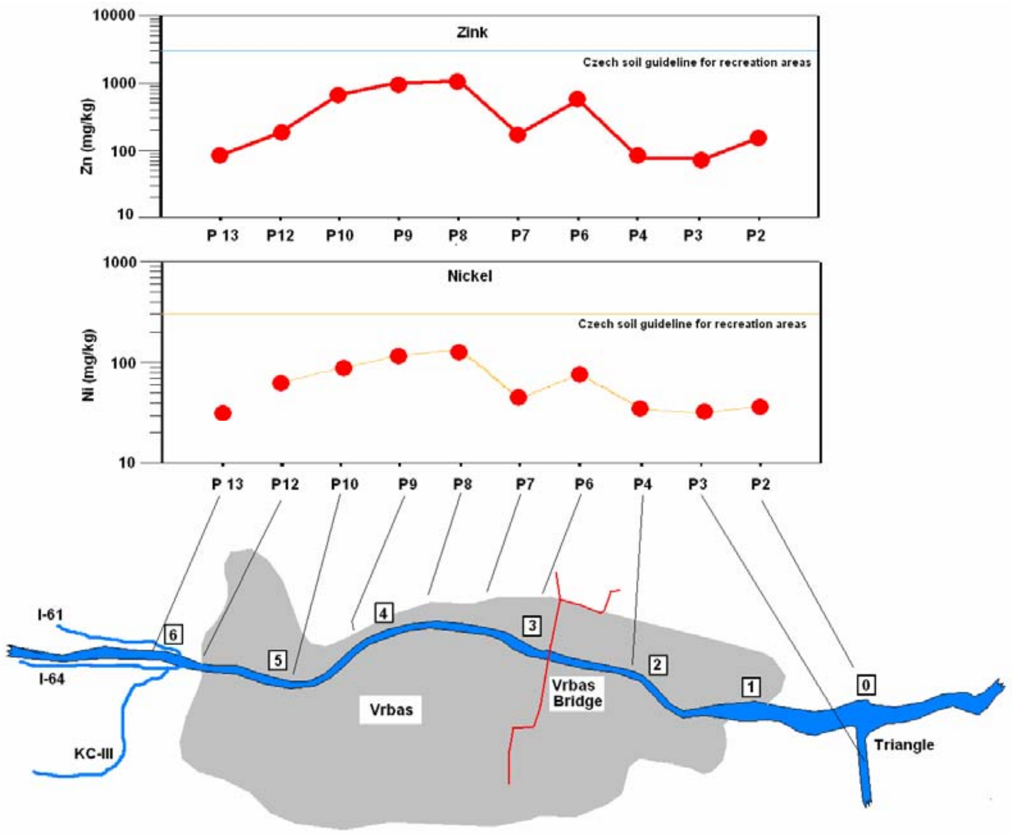


**Figure 37.** *Concentration of zinc and nickel of mixed sediment cores from the most polluted part of the canal (data from Dekonta 2004).*

## *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 compoundes (aliphatic chlorinated hydrocarbons, BTEX, PAHs, organochlorinated pesticides and chlorinated phenols) were below pollution criteria limits, and in most cases, even below detection limits.

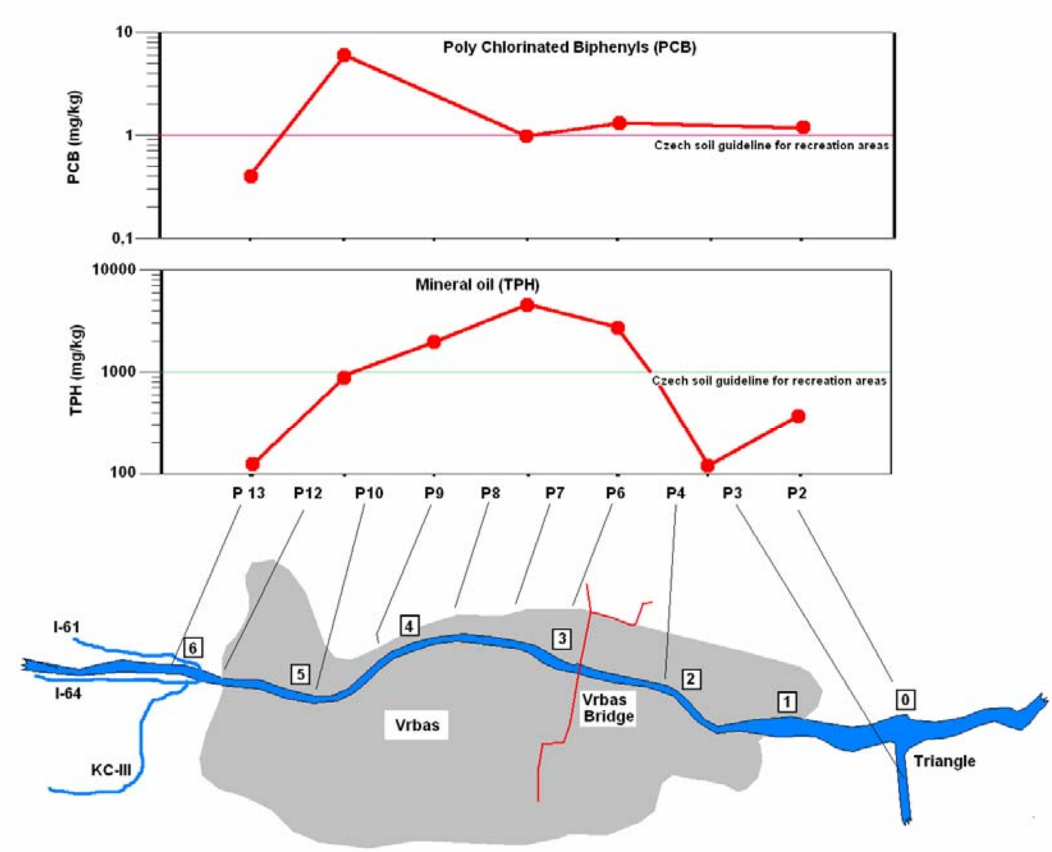


**Figure 38.** *Concentrations of Poly-chlorinated biphenyls (PCBs) and Mineral oil (TPH) in mixed sediment cores from the most polluted part of the canal (Data from Dekonta 2004).*

### 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**.

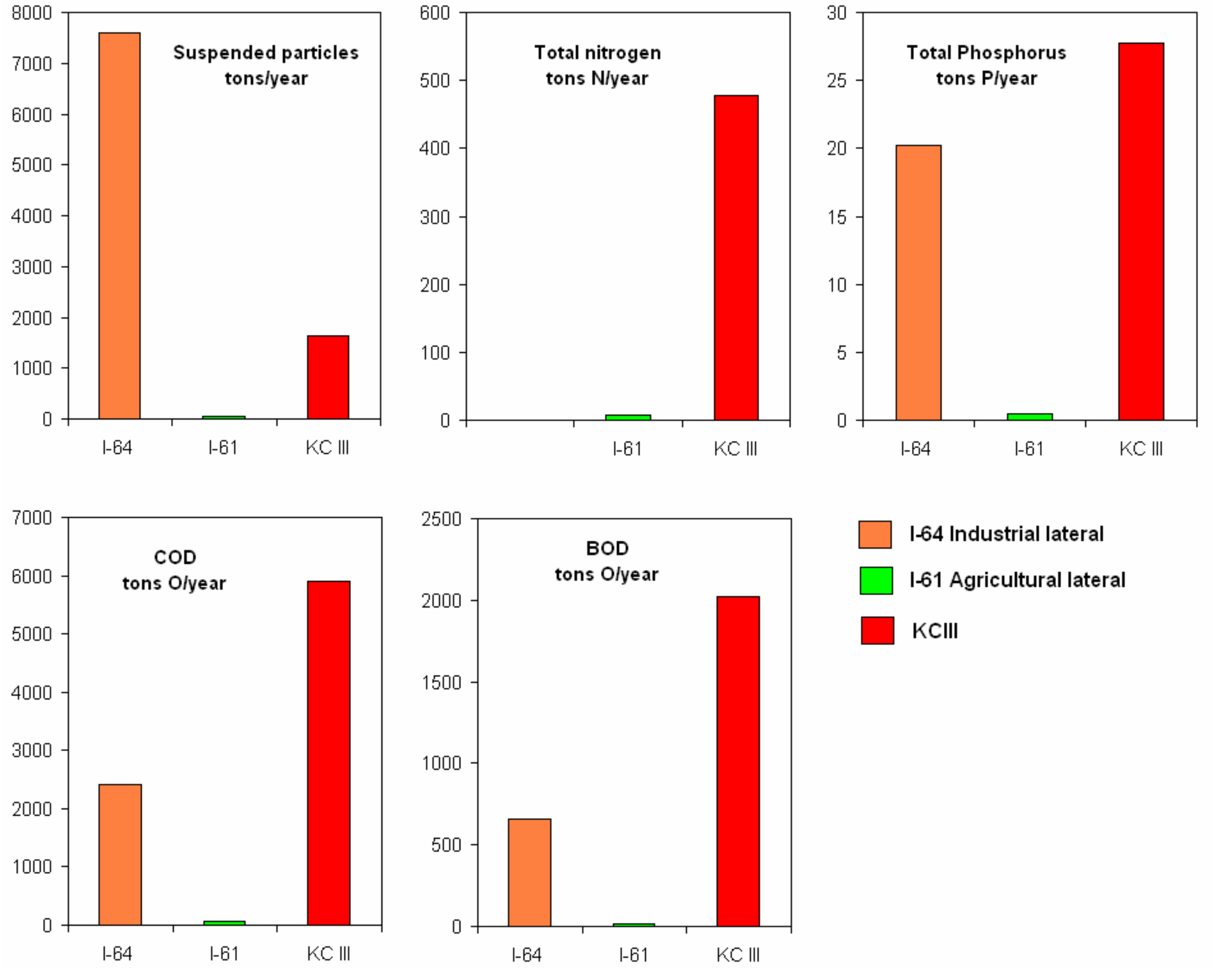


**Figure 39.** *Transport of Oxygen consuming material and nutrients in the downstream part of the laterals, i.e. before discharge into the Great Canal.*

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.

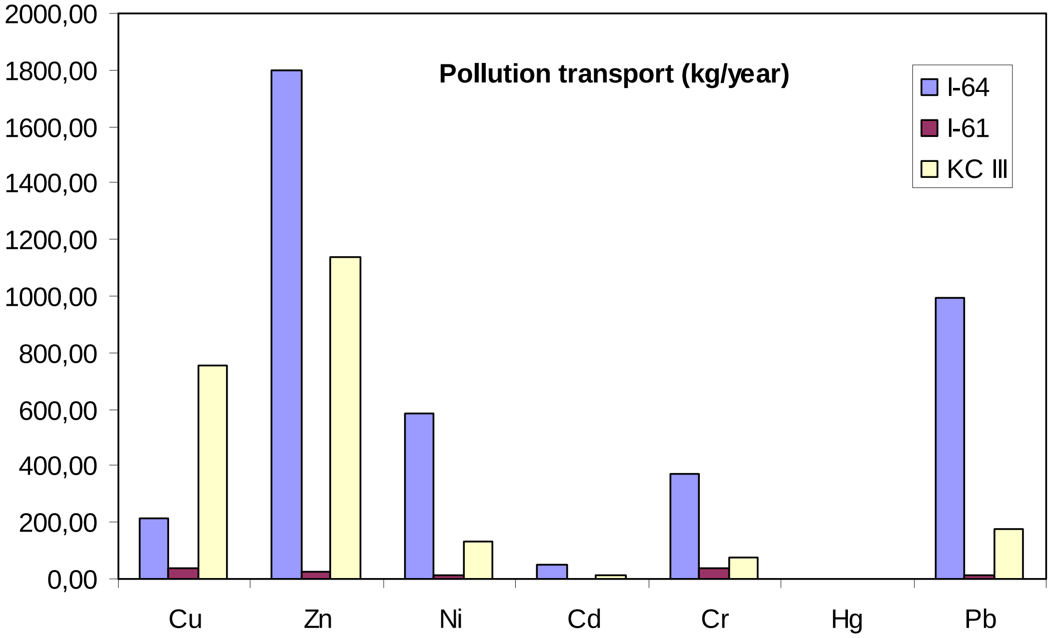


**Figure 40.** *Transport values of heavy metals in the downstream part of the laterals, i.e. prior to discharge into the Great Canal.*

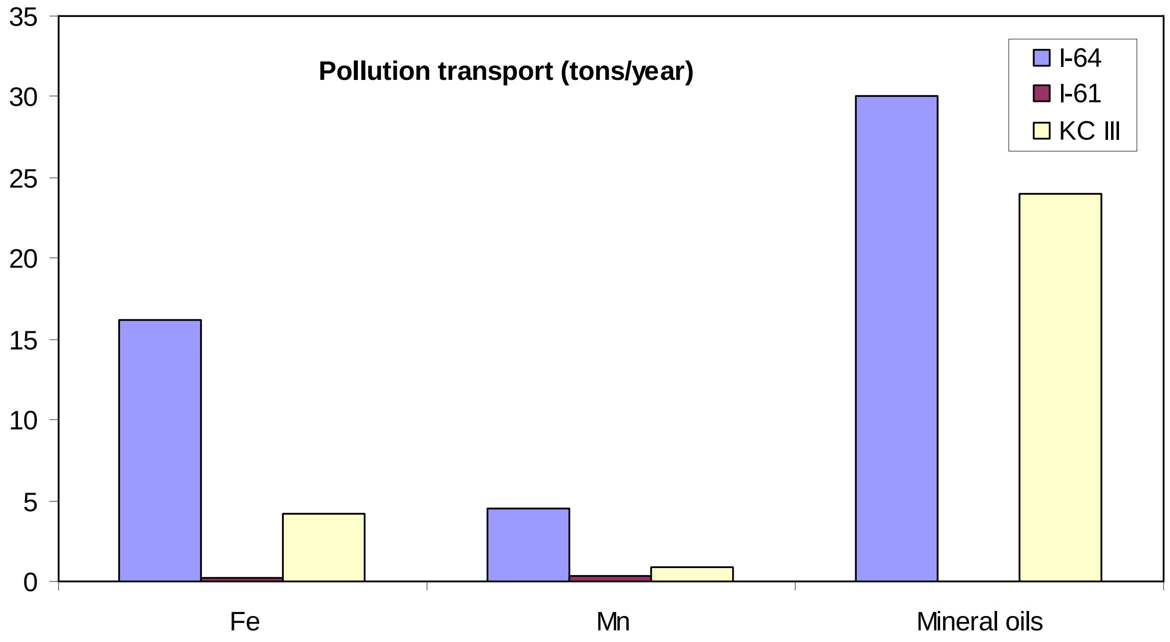


**Figure 41.** *Transport values of Fe, Mn and Mineral oil in the downstream part of the laterals, i.e. before discharging into the Grand Canal.*

## 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 $m^3$/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 | m3/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 $m^3$/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 | m3/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 | m3/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 | m3/day | **120** | |
| No of days with effluents | Days | days/y | **240** | |
| Suspended paricles | 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 paricles | 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 | m3/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 | m3/day | **25000** | |
| No of days with effluents | Days | days/year | **100** | |
| Suspended paricles | 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 paricles | 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 | m3/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 | m3/day | **2900** | |
| No. of days with effluents | Days | days/y | **365** | |
| Suspended paricles | 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 | m3/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 | | m3/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)

| | Suspended paricles | Total N | Total P | Chemical Oxygen Demand, total | $BOD_5$, total |
|---|---|---|---|---|---|
| **Point source discharge** | **SS tons/y** | **Total N tons N/y** | **Tot-P tons P/y** | **COD-tot. tons O/y** | **$BOD_5$-tot. tons O/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**.

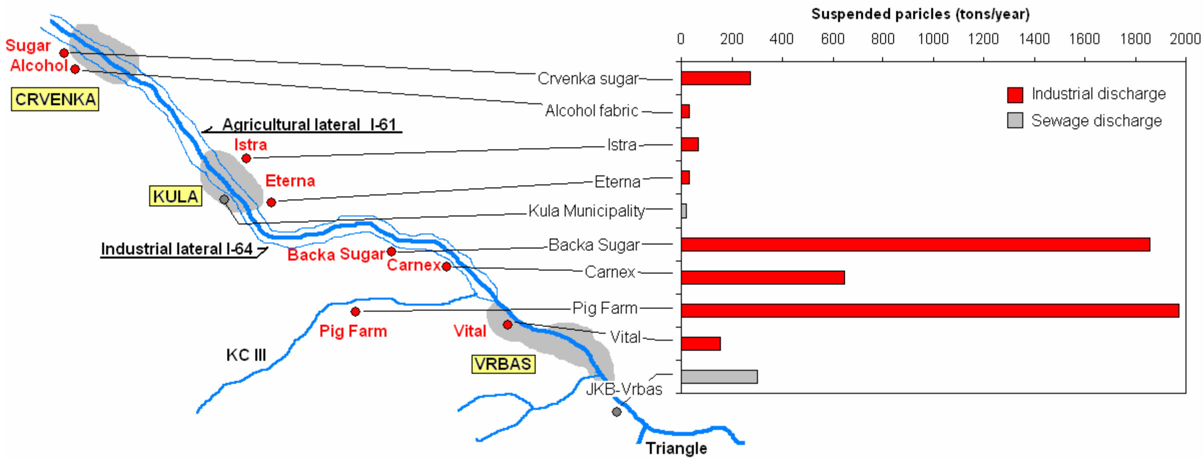


**Figure 42.** *Loading of particulate matter from the main 10 point sources along the canal stretch comprised by the study.*

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**.

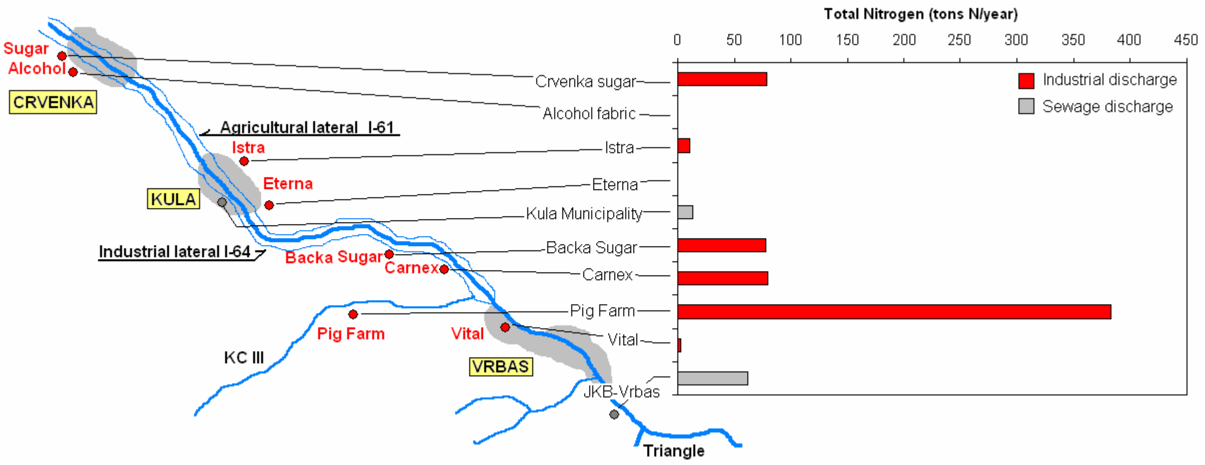


**Figure 43.** *Loading of Total Nitrogen from the main 10 point sources along the canal stretch comprised by the study.*

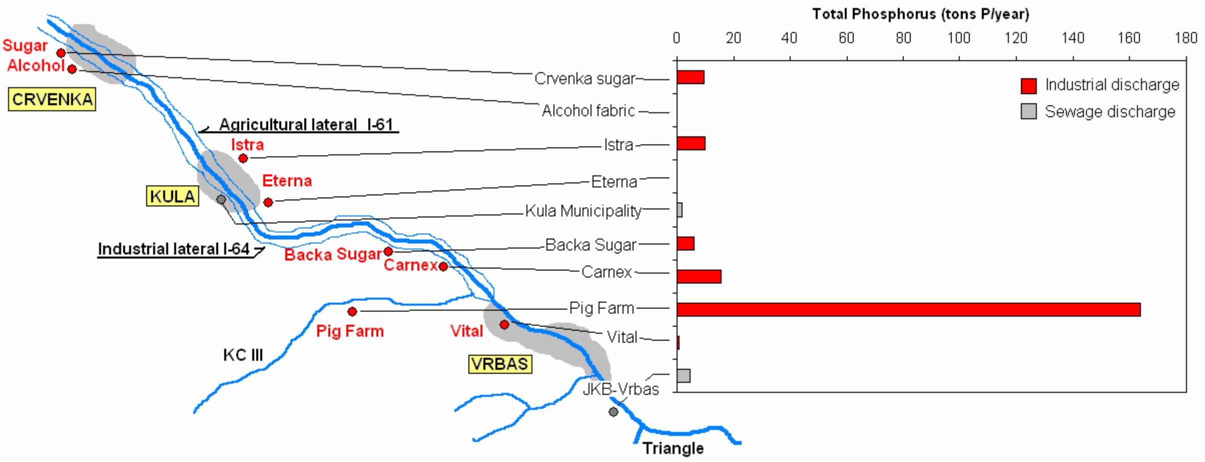


**Figure 44.** *Loading of Total Phosphorus from the main 10 point sources along the canal stretch comprised by the study.*

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 facilty 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**.

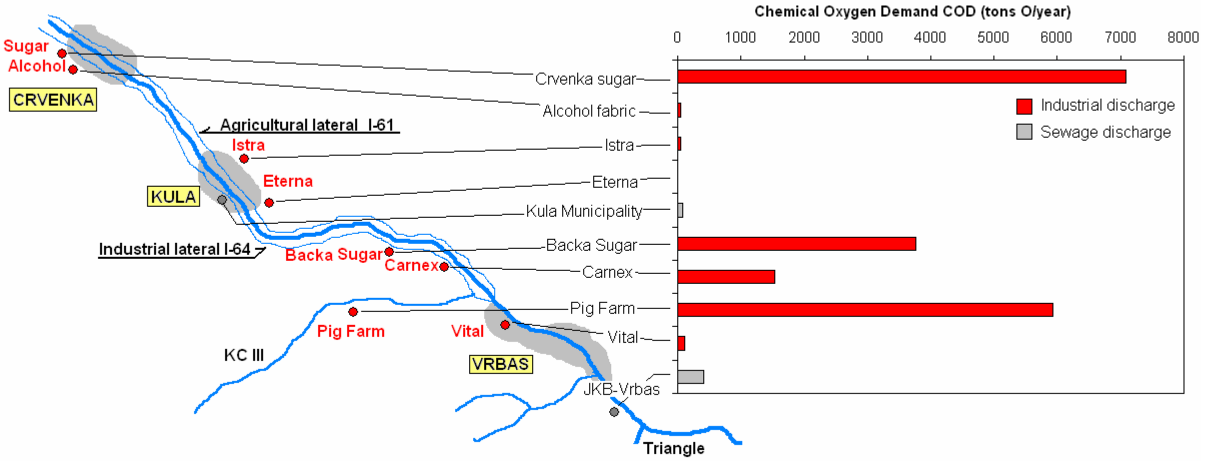


**Figure 45.** *Loading of oxygen consuming matter from the main 10 point sources along the canal stretch comprised by the study (Given by the analysis* $COD_{Cr}$*).*

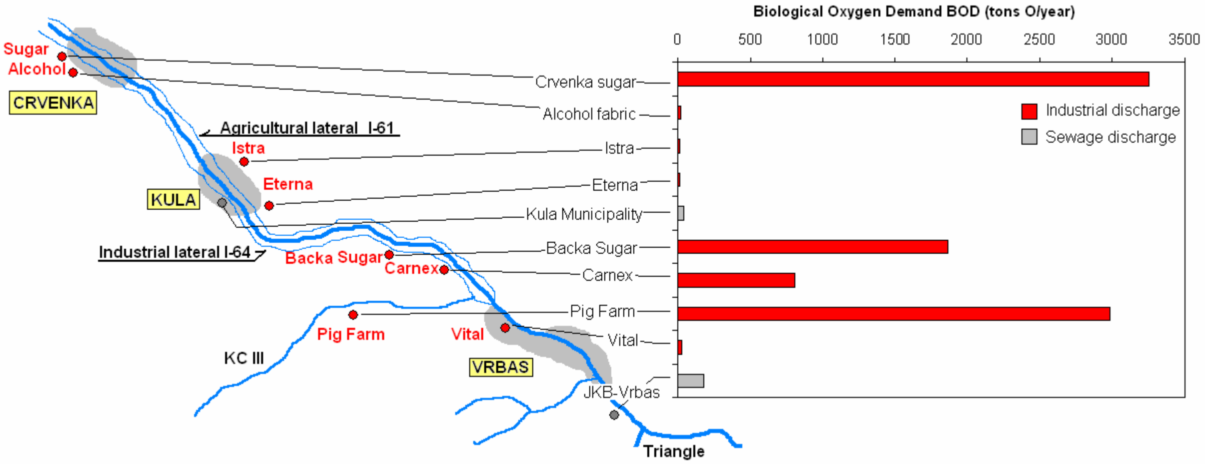


**Figure 46.** *Loading of oxygen consuming matter from the main 10 point sources along the canal stretch comprised by the study (Given by the analysis* $BOD_5$*).*

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.

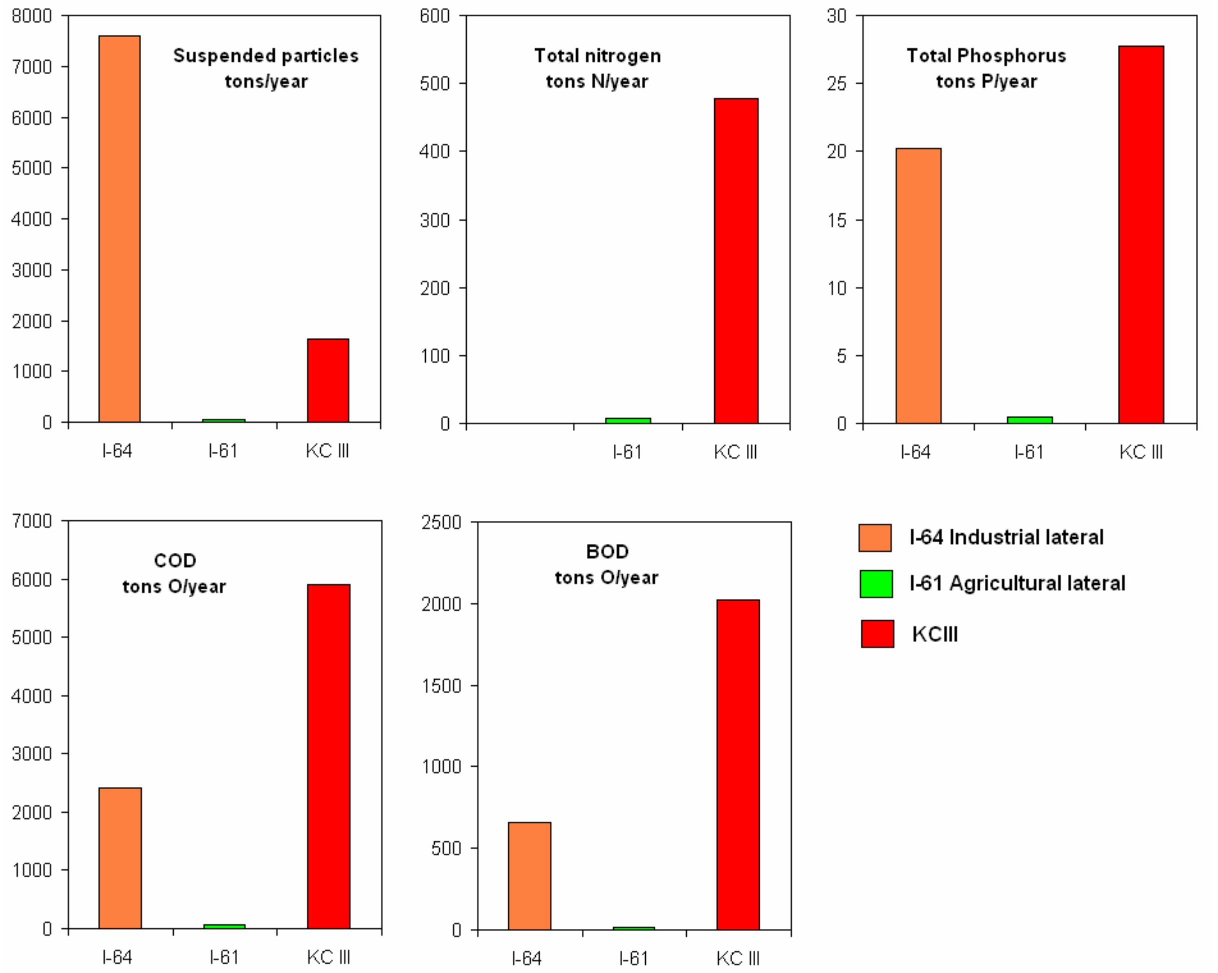


**Figure 47.** *Transport of oxygen consuming material and nutrients in the downstream part of the laterals, i.e. before they discharge into the Grand Canal.*

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**.

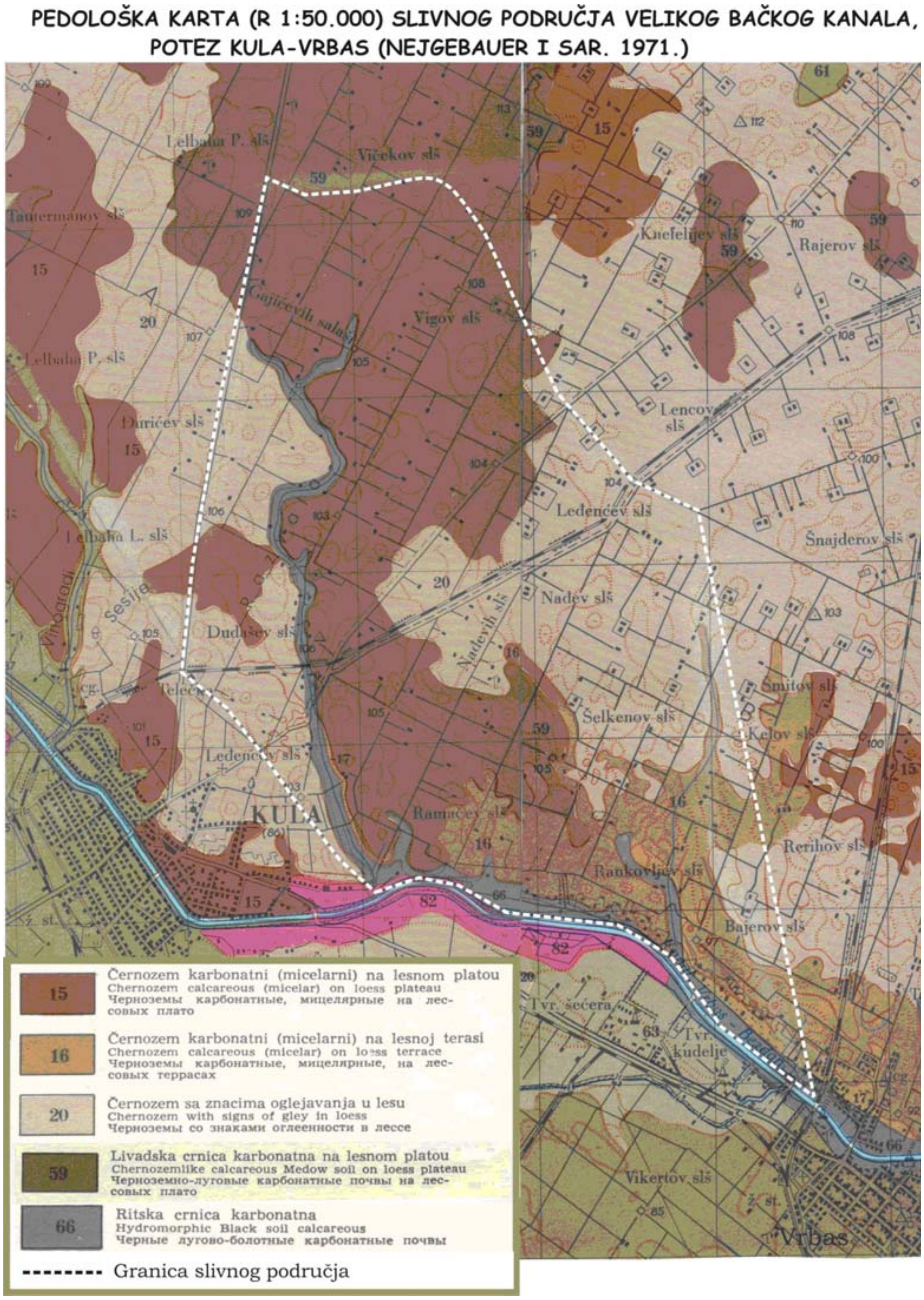

PEDOLOŠKA KARTA (R 1:50.000) SLIVNOG PODRUČJA VELIKOG BAČKOG KANALA, POTEZ KULA-VRBAS (NEJGEBAUER I SAR. 1971.)

**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 s*hare 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<br>urea 200 kg/ha | 15:15:15 300-400 kg/ha<br>urea 200 kg/ha | 15:15:15 200 kg/ha<br>urea 100-150kg/ha |
| Wheat | 15:15:15 300 kg/ha<br>urea 150 kg/ha | 15:15:15 300 kg/ha<br>AN 300kg/ha | 15:15:15 100 kg/ha<br>urea 100 kg/ha |
| Sunflower | 8:16:24 200 kg/ha<br>urea 150 kg/ha | | urea 100 kg/ha |
| Sugar beet | Manure 3 wagons/ha<br>8:24:16 500 kg/ha<br>urea 100 kg/ha | Manure 5 wagons/ha<br>8:24:16 300-500 kg/ha<br>urea 100 kg/ha | Manure 3 wagons/ha<br>8:24:16 300 kg/ha<br>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).

| | NUMBER OF ANIMALS ON 15.01.2003. | | | |
|---|---|---|---|---|
| Municipality | 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).

| | NUMBER OF ANIMALS PER HA OF FARMED LAND | | |
|---|---|---|---|
| Municipality | 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<br>-1500 wagon/year of manure | Cattle farm (ĐS) 800<br>-1500-2000 wagon/year of manure | 91 cows<br>- 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<br>Racer 2l/ha | | Acetohlor 2l/ha<br>Racer 2l/ha |
| Sugar beet | Betanal 3l/ha<br>Lontrel 3l/ha<br>Counter 20kg/ha trake | Betanal 3l/ha, Prestige, Safari 30-60 g/ha, Guardian 2-4 l/ha | Betanal 3l/ha<br>Lontrel 3l/ha<br>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<br>- surface flowing out<br>- drained water<br>- naturally filtered water | 10.2kg<br>0.56 kg<br>-<br>10.76 kg P | 12 kg<br>0.96 kg<br>-<br>12.96 kg P | 2.4 kg<br>0,1 kg<br>-<br>2.50 kg P | 20 kg<br>0.88 kg<br>-<br>20.88 kg P | 36.34 kg P |
| kg P /ha/year | 0.29 | 0.19 | 0.44 | 0.34 | 0.21 |
| Cultivable<br>- surface flowing out<br>- drained water<br>- naturally filtered water | 100,5 kg<br>74.34 kg<br>92.89 kg<br>267.73 kg P | 72,5 kg<br>46.32 kg<br>32.57 kg<br>151.39 kg P | 22.2 kg<br>14,8 kg<br>16.61 kg<br>53.61 kg P | 31,2 kg<br>9.76 kg<br>7.86 kg<br>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 (%, l), 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<br>- surface flowing out<br>- drained water<br>- naturally filtered water | 30,6 kg<br>35 kg<br>43.2 kg<br>108.8 kg N | 32 kg<br>60 kg<br>37.1 kg<br>129.1 kg N | 6 kg<br>6 kg<br>12.3 kg<br>24.3 kg N | 50kg<br>55 kg<br>32 kg<br>137 kg N | 399.2 |
| kg N /ha/year | 2.94 | 1.91 | 4.26 | 2.25 | 2.33 |
| Pastures<br>- surface flowing out<br>- drained water<br>- naturally filtered water | 361.8 kg<br>13216 kg<br>9289 kg<br>22866.8 kg N | 232 kg<br>8685 kg<br>4559.1 kg<br>13476.1kg N | 74 kg<br>2960 kg<br>3322 kg<br>6356kg N | 104 kg<br>2074g<br>1571 kg<br>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**.

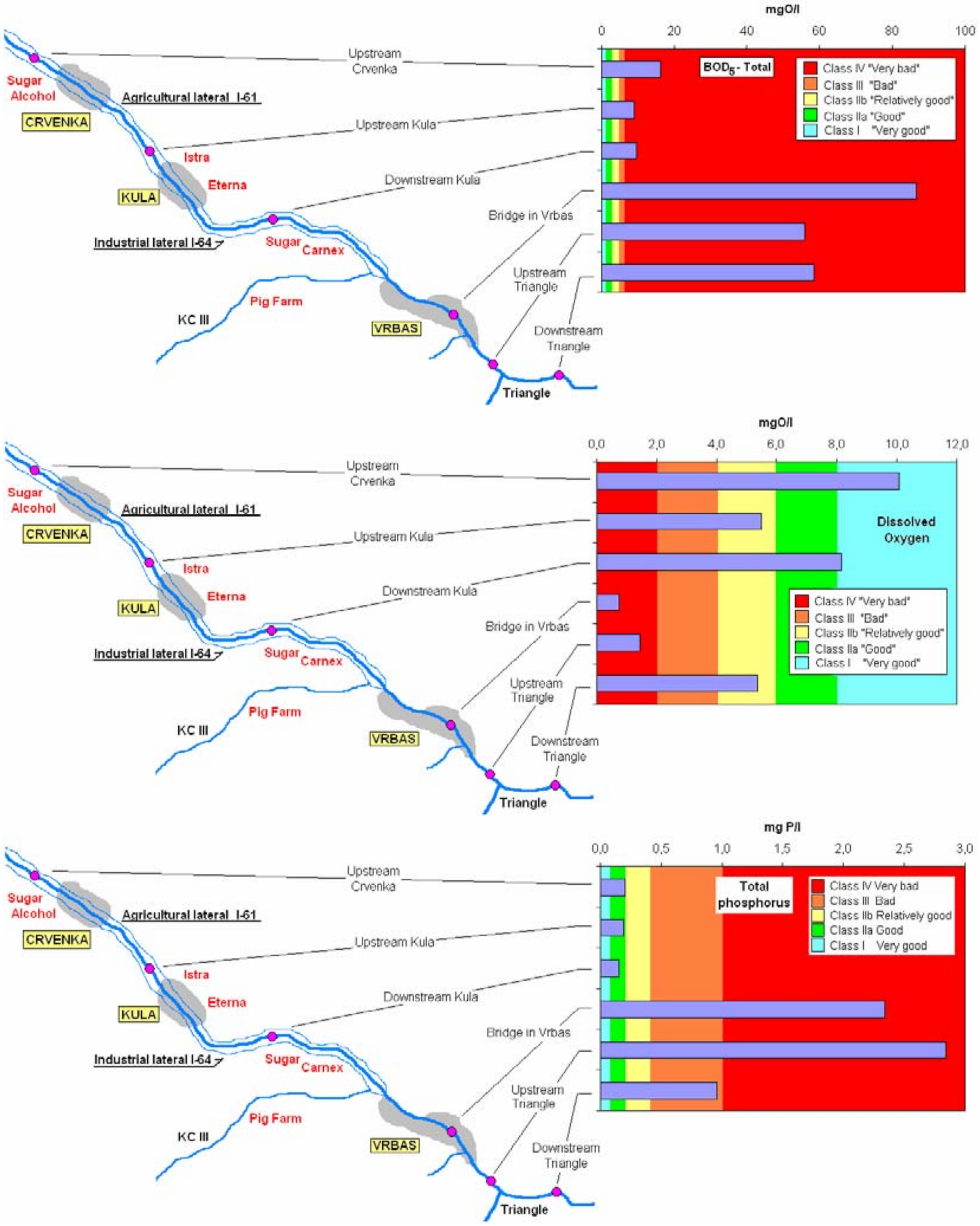


**Figure 49.** Data summarizing the environmental status in the Grand Canal from Crvenka to the Triangle given by Biological Oxygen Demand in the water, Oxygen Concentration in the water and the concentration of Total Phosphorus. All data are compared with the Serbian Water Quality Criteria.

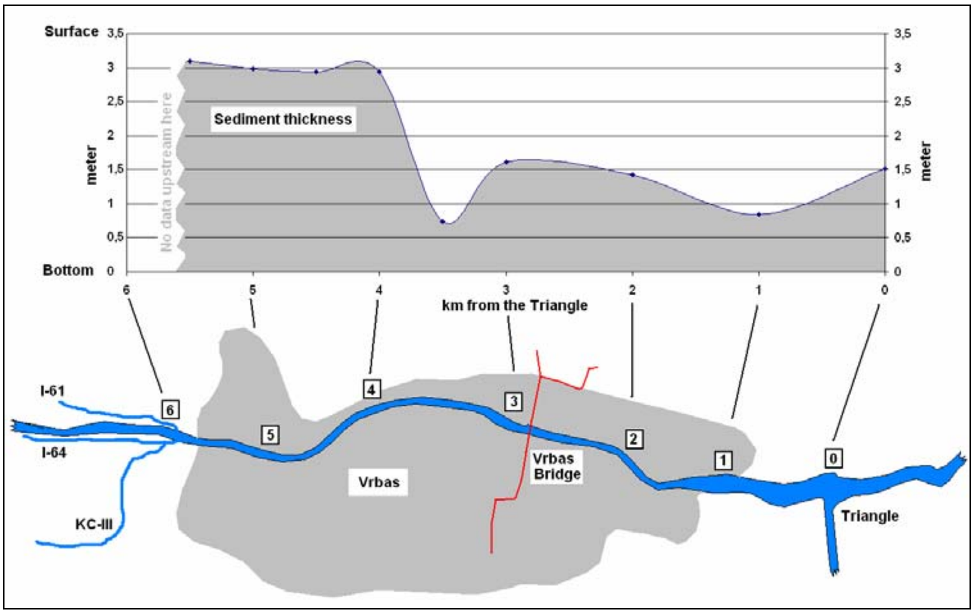


**Figure 50.** *Average sediment thickness in the Grand Canal in varying distance from the discharge point (6 km) to the Triangle (0 km). Numbers in squares are kilometres from the Triangle. (Data from Dekonta 2004).*

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.

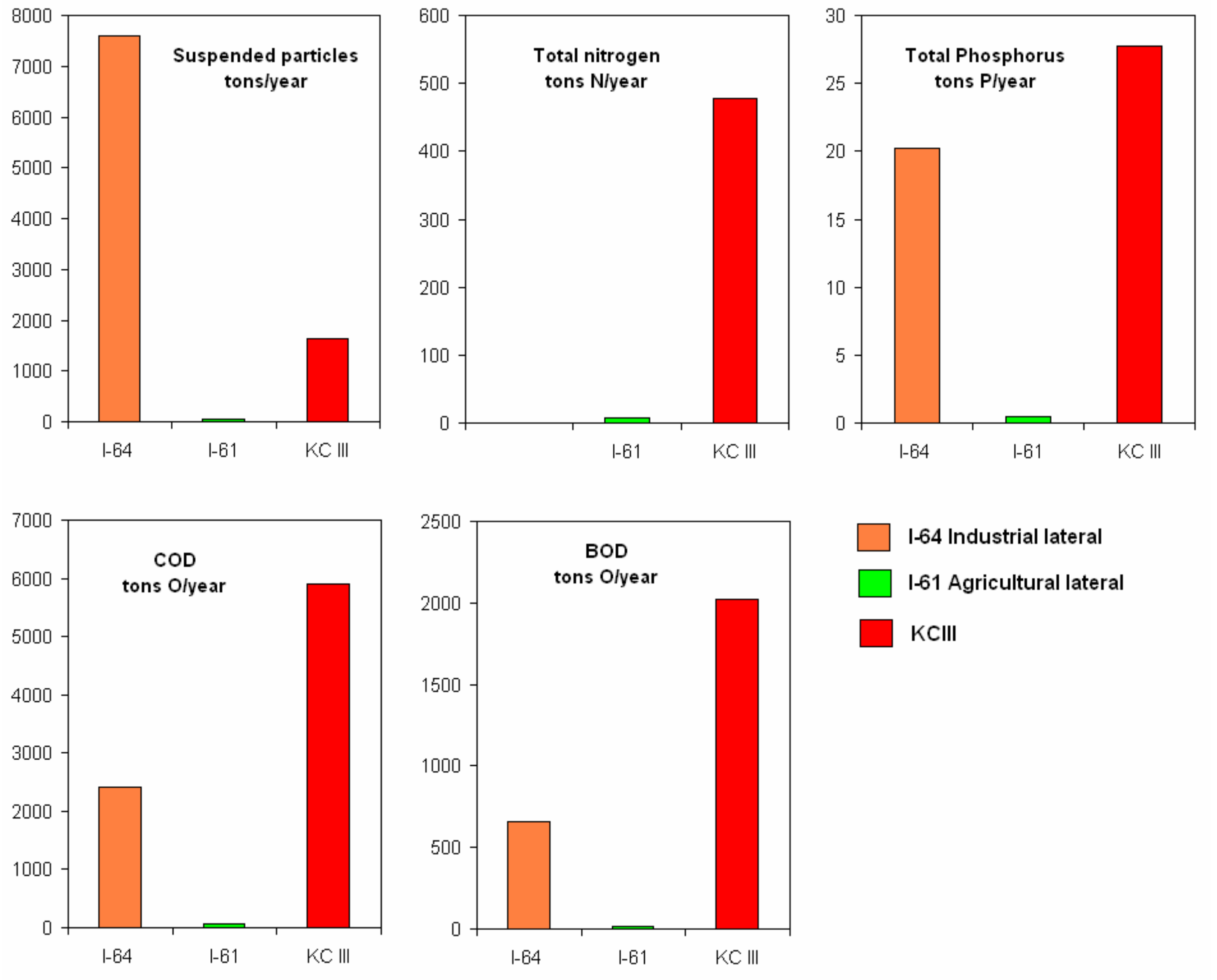


**Figure 51.** *Loading of pollutants by the 3 laterals into the Grand Canal.*

## 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.

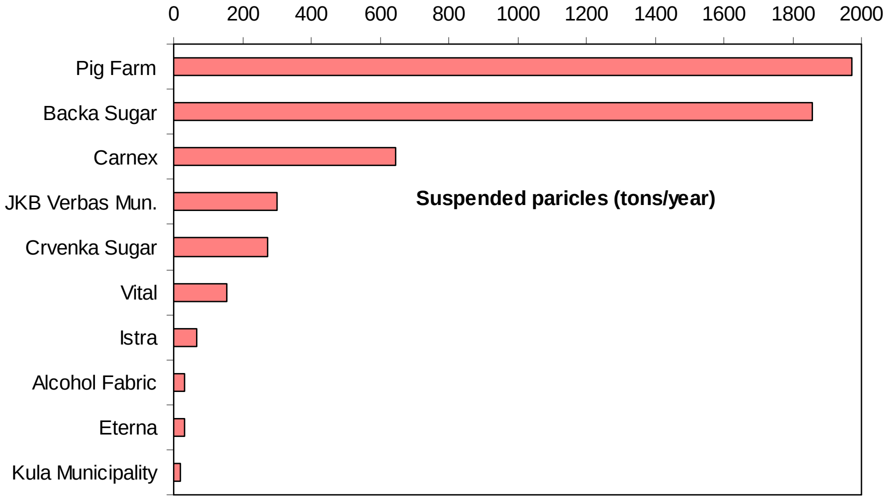


**Figure 52.** *Loading of suspended particles by the different main polluters to the Grand Canal.*

### 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.

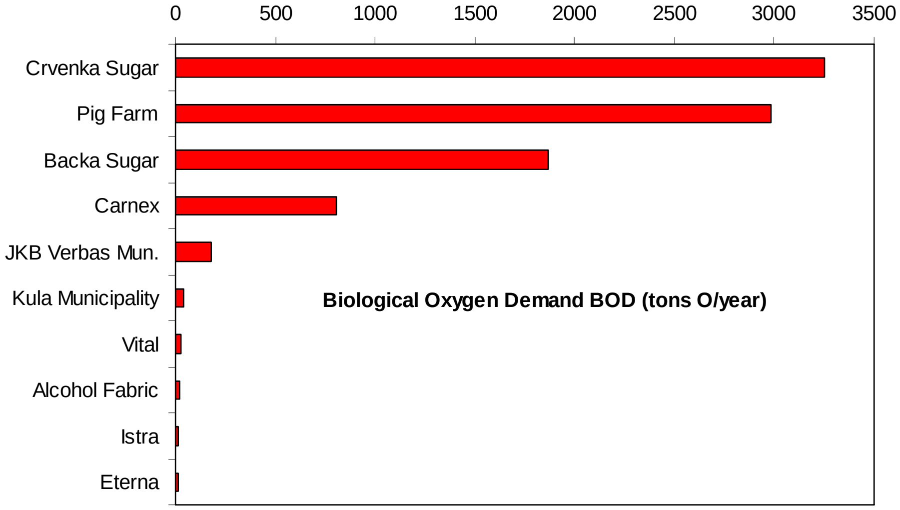


**Figure 53.** *Loading with oxygen consuming organic material from different sources*

### 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.

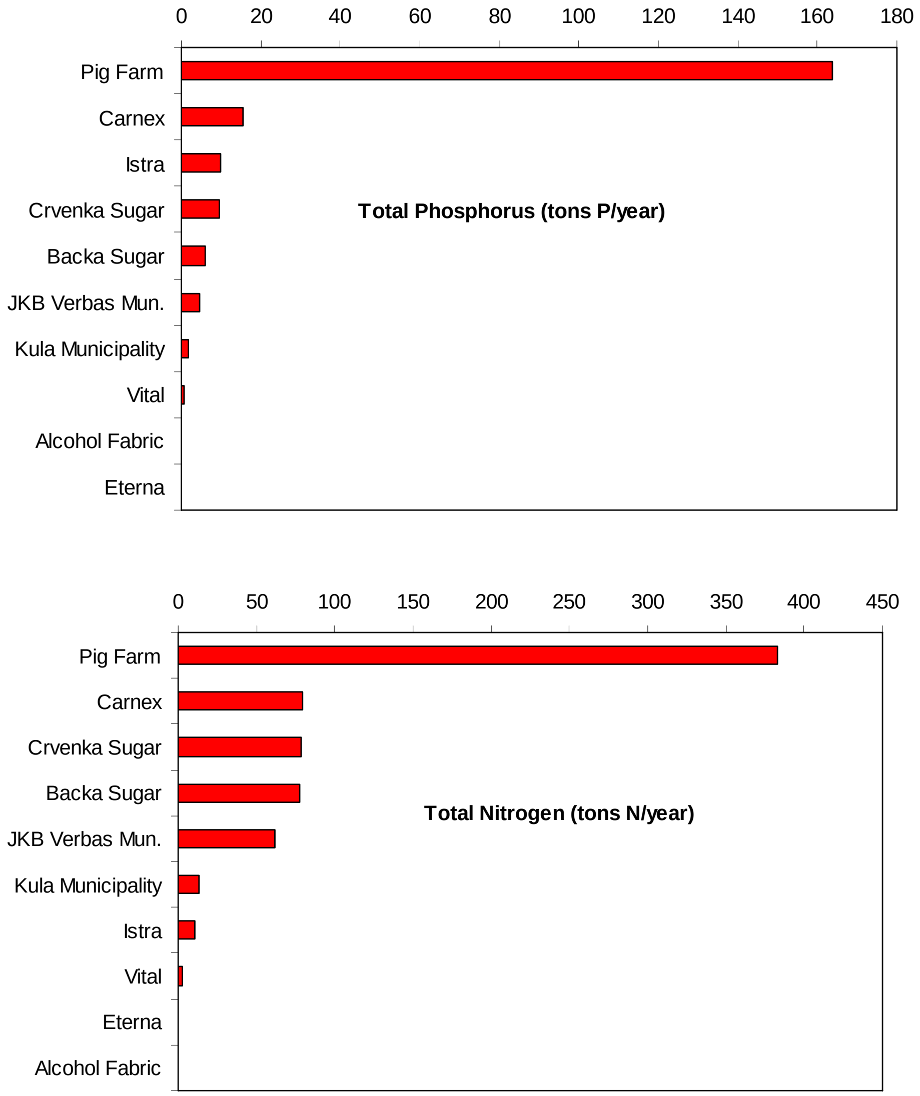


**Figure 54.** The loading of eutrophying nutrients Phosphorus and Nitrogen

### 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 form 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 $H_2S$ 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.

### 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 Bezdan 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.

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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 paricles | Dry residue | Ignited (glowed) residue | Turbidity | Conductivity | Thermotolerant coli. Bact | Ammonia | Nitrates | Nitrites | organic Kjeldahl N | Total N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Term | | | | | pH | SS | | | Turb. | Cond. | | $NH_4^+$ | $NO_3^-$ | $NO_2^-$ | | Total N |
| | Unit | °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 | 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,l) perilen | Indeno (1,2,3-c.d) piren |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Term | | | | | | | | | | | | | | | | | | | | | |
| | Unit | $cm^{-1}$ | mval/L | $^{o}$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 | Suspended paricles | Dry residue | Ignited (glowed) residue | Turbidity | Conductivity | Thermotolerant coli bact | Ammonia | Nitrates | Nitrites | organic Kjeldahl N | Total N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Term | | | | | pH | SS | | | Turb. | Cond. | | $NH_4^+$ | $NO_3^-$ | $NO_2^-$ | | Total N |
| | Unit | $^oC$ | $^oC$ | 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 | | | | | | | | | | | | | | | | | |
| 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 | $PO_4^{3-}$ | 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 | | | | | | | | | | | | | | | |
| 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 | 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,l) perilen | Indeno (1,2,3-c.d) piren |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Term | | | | | | | | | | | | | | | | | | | | | |
| | Unit | $cm^{-1}$ | mval/L | $^odH$ | 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 |
| 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 | Suspended paricles | Dry residue | Ignited (glowed) residue | Turbidity | Conductivity | Thermotolerant coli bact | Ammonia | Nitrates | Nitrites | organicKjeldahl N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Term | | | | | pH | SS | | | Turb. | Cond. | | $NH_4^+$ | $NO_3^-$ | $NO_2^-$ | |
| | Unit | °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 |
| 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 | yelowish | 9,30 | 507 | 1570 | 370 | | 567 | 7500 | 0,25 | 0,65 | 0,08 | 0,78 |

## Table 36 continued

Dstr-kula-2

|  | Variabel | 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 | 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) | 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,l) 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 | Suspended paricles | Dry residue | Ignited (glowed) residue | Turbidity | Conductivity | Thermotolerant colif. Bact. | Ammonia | Nitrates | Nitrites |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Term | | | | | pH | SS | | | Turb. | Cond. | | $NH_4^+$ | $NO_3^-$ | $NO_2^-$ |
| | Unit | °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 |
| Cycle | Date | | | | | | | | | | | | | | |
| 1 | 29.09.2003 | 22 | 28 | film of oil on water surface | | 7,29 | 15 | 735 | 300 | 19,44 | 657 | | 0,5 | 2 | 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 | yelowish | 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 Kjeldahl 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 | organic N per Kjedahl | | 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 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 | 29.09.2003 | | 6,1 | 6,9 | 4,02 | 1,3 | 210 | | 210 | 36 | | 36 | 0,55 | 0,54 | 0,60 |
| 2 | 17.11.2003 | | 3,8 | 16 | 0,1 | 5,9 | 360 | | 360 | 230 | | 230 | 0,70 | 0,60 | 0,80 |
| 3 | 20.01.2003 | | 14 | 24 | 0,64 | 0,42 | 210 | 130 | 80 | 140 | 30 | 110 | 1,70 | 1,60 | 1,90 |
| 4 | 11.03.2004 | | 89 | 97 | 0,1 | 3,5 | 60 | 40 | 20 | 44 | 24 | 20 | 0,00 | 0,00 | 0,00 |
| 5 | 11.05.2004. | | 5,6 | 5,8 | 1,5 | 0,7 | 220 | 80 | 140 | 20 | 9,8 | 10,2 | 0,10 | 0,10 | 0,20 |
| 6 | 02.07.2004. | | 8,5 | 8,7 | 7,4 | 2,2 | 100 | 80 | 20 | 50 | 37 | 13 | 0,80 | 0,80 | 1,00 |

## Table 37 continued

Br-vrb-3

| | Variabel | Oxygen saturation | | | UV-abs (254nm) | Alkalinity | Hardness | Phenols | PAH (Total) | Naftalen | Acenaftilen | Acenaften | Fluren | Fenantren | Antracen | Fluoranten | Piren | Benzo(a)antracen | Krisen | Benzo (b) fluoranten | Benzo (k) fluoranten |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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 |
| Cycle | Date | | | | | | | | | | | | | | | | | | | | |
| 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 | 2 | 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 | Suspended paricles | Dry residue | Ignited (glowed) residue | Turbidity | Conductivity | Thermotolerant coli. Bact. | Ammonia | Nitrates | Nitrites |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Term | | | | | pH | SS | | | Turb. | Cond. | | $NH_4^+$ | $NO_3^-$ | $NO_2^-$ |
| | Unit | °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 |
| 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 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

| | Variabel | Oxygen saturation | | | UV-abs (254nm) | Alkalinity | Hardness | Phenols | 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,l) perilen | Indeno (1,2,3-c,d) piren |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Term | left bank | right bank | middle | | | | | | | | | | | | | | | | | | | | | |
| | Unit | % sat. | % sat. | % sat. | $cm^{-1}$ | mval/L | $^{o}$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 | 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 |
| 2 | 17.11.2003 | 4 | 3 | 4 | 0,504 | | | | | | | | | | | | | | | | | | | | |

Table 38 continued

Upstr-tria-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 | 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

| | Variabel | Water temp | Air temp | Visible particles | Colour | pH | Suspended particles | Dry residue | Ignited (glowed) residue | Turbidity | Conductivity | Thermotolerant coli. Bact. | Ammonia | Nitrates |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Term | | | | | pH | SS | | | Turb. | Cond. | | $NH_4^+$ | $NO_3^-$ |
| | Unit | $^{o}$C | $^{o}$C | descr. | descr. | | mg/L | mg/L | mg/L | NTU | µS/cm | no/100 mL? | mg $NH_4^+$/L | mg $NO_3^-$/L |
| Cycle | Date | | | | | | | | | | | | | |
| 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 | yelowish | 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 | Nitrites | organic Kjeldahl 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 | $NO_2^-$ | | 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 $NO_2^-$/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 | mg $O_2$/L |
| 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) | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Term | left bank | right bank | middle | | | | | | | | | | | | | | | | | | | |
| | Unit | % sat. | % sat. | % sat. | $cm^{-1}$ | mval/L | $^o$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 | | | | | | | | | | | | | | | | | | | | | | |
| 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 |
| 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) 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 | 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 | 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 | Water temp | Air temp | Visible particles | Colour | pH | Suspended paricles | Dry residue | Ignited (glowed) residue | Conductivity | Thermotolerant microorganisms | Ammonia | Nitrates |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | Unit | °C | °C | descr. | descr. |  | mg/L | mg/L | mg/L | µS/cm | no/100mL | mg $NH_4^+$/L | 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 animall, pig lot off diferent particles | green-gray | 8,2 | 507 | 1220 | 390 | 108 | 12600 | 3,8 | 0,65 |
| 6 | 01.07.2004. | 18,2 | 22 | small particles | yelowish | 7,83 | 62 | 720 | 500 | 1000 | 180000 | 5 | 0,65 |

Table 40 continued

I-64-crv-2

|  | Variabel | organic Kjeldahl N | Total N | dissolved phosphates | Total P | Chemical Oxygen Demand,dissolved | Chemical Oxygen Demand, total | COD-tot. - COD-diss | $BOD_5$,dissolved | $BOD_5$, total | $BOD_5$-tot.- $BOD_5$-diss | Dissolved Oxygen | Oxygen saturation | UV-abs (254nm) | Alkalinity | Hardness | Phenols |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | Unit | 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 | % sat. | $cm^{-1}$ | mval/L | °dH | 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 | 17 | 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 | 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,l) perilen | Indeno (1,2,3-c,d) piren | Fe | Mn | Cu | Zn | Ni | Cd | Cr | Hg | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | 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 | mg/L | mg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | 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

4-Kula-1

| Variabel | Water temp | Air temp | Visible particles | Colour | pH | Suspended paricles | 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 | yelowish | 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,l) 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

| | Variabel | Water temp | Air temp | Visible particles | Colour | pH | Flow (weighted average) | No days with effluent | Suspended paricles | Total N | Total P | Chemical Oxygen Demand, total | BOD$_5$, total | Fe | Mn | Cu | Zn | Ni |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cycle | Unit | °C | °C | descr. | descr. | | m3/day | days | mg/L | mg N/L | mg P/L | mg O$_2$/L | mg O$_2$/L | mg/L | mg/L | µg/L | µg/L | 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, smal 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 | yelow-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

| | Variabel | Cd | Cr | Hg | Pb | Mineral oils | Dry residue | Ignited (glowed) residue | Conductivity | Thermotolerant microorganisms | Ammonia | Nitrates | Nitrites | organic Kjeldahl N | dissolved phosphates | Chemical Oxygen Demand, dissolved | COD-tot. - COD-diss |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cycle | Unit | 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 | mg O$_2$/L | 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

| | Variabel | BOD$_5$, dissolved | BOD$_5$-tot.- BOD$_5$-diss | Dissolved Oxygen | | | Oxygen saturation | | | UV-abs (254nm) | Alkalinity | Hardness | Phenols | PAH (Total) | Naftalen | Acenaftilen | Acenaften | Fluren | Fenantren | Antracen |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cycle | Unit | mg O$_2$/L | mg O$_2$/L | mg O$_2$/L | mg O$_2$/L | mg O$_2$/L | % sat. | % sat. | % sat. | cm$^{-1}$ | mval/L | °dH | µg/L | ng/L | ng/L | ng/L | ng/L | ng/L | ng/L | ng/L |
| 1 | 24.09.2003. | | | 2,23 | 2,23 | 2,23 | 25 | 25 | 25 | 0,184 | 5,5 | 20,7 | 6,9 | 6 | 2 | 2 | 2 | 6 | 6 | 2 |
| 2 | 19.11.2003. | | | 1,9 | 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) anracen | Benzo (g,h,l) perilen | 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

| I- | Variabel | Water temp | Air temp | Visible particles | Colour | pH | Suspended paricles | 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, dissolvec | 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 | mg $O_2$/L | mg $O_2$/L | % sat. | % sat. | % sat. | $cm^{-1}$ | mg/L |
| 2 | 19.11.2003 | 54 | 18 | 20 | | | 10 | | | 7,2 | 7,2 | 7,2 | 81 | 81 | 81 | 650 | |
| 3 | 16.01.2004 | 0,1 | 0,035 | 50 | 30 | 20 | 30 | 14 | | | | | | | | 0,129 | 0,38 |
| 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 paricles | Total N | Total P | Chemical Oxygen Demand, total | $BOD_5$, total | Fe | Mn | Cu | Zn |
| | Term | | | | | pH | | | SS | Total N | Tot-P | COD-tot. | $BOD_5$-tot. | Fe | Mn | Cu | Zn |
| | Unit | °C | °C | descr. | descr. | | 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 | yelowish | 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 | yelowish | 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. contiued

| 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 | Ni | Cd | Cr | Hg | Pb | | | | Cond. | | $NH_4^+$ | $NO_3^-$ | $NO_2^-$ | organic N per Kjedahl | $PO_4^{3-}$ |
| | 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 | 1,07 |
| | | | | | | | | | | | | | | | | |
| 2 | 18/11/2003 | | | | | | | 490 | 220 | 1003 | | 2,5 | 0,75 | 0,03 | 0,1 | 0,21 |
| 3 | 16/01/2004 | 9,8 | 1,6 | 11 | 0,1 | 17 | 122 | 450 | 190 | 910 | 1000 | 7,5 | 6 | 0,2 | 1,5 | 0,1 |
| 4 | 11.03.2004. | 21 | 1,4 | 33 | | 20 | 32 | 530 | 360 | 894 | 4300 | 3,3 | 6 | 0,4 | 12 | 0,1 |
| 5 | 05.05.2004. | | | | | | | 750 | 470 | 1150 | 100 | 2,5 | 3 | 0,03 | 13 | 0,1 |
| 6 | 01.07.2004. | | | | | | 24,45 | 1220 | 920 | 1036 | 161000 | 4,5 | 2 | 0,3 | 1,4 | 0,1 |
| | | | | | | | | | | | | | | | | |
| | 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 | Acenaftilen | 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 | $^o$dH | µg/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) anracen | Benzo (g,h,l) 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 | Air temp | Visible particles | Colour | pH | Flow (Weighted average) | Number of days with effluents | Suspended paricles | Total N | Total P | Chemical Oxygen Demand, total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Unit | $^oC$ | $^oC$ | descr. | descr. | | m3/day | days/y | mg/L | mg N/L | mg P/L | 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 | Fe | Mn | Cu | Zn | Ni | Cd | Cr | Hg | Pb | Mineral oils | Dry residue | Ignited (glowed) residue | Conductivity | Thermotolerant microorganisms | Ammonia | Nitrates |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Unit | mg $O_2$/L | mg/L | mg/L | µg/L | µg/L | 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 |
| 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 | Nitrites | organic Kjeldahl N | dissolved phosphates | Chemical Oxygen Demand, dissolved | COD-tot. - COD-diss | $BOD_5$, dissolved | $BOD_5$-tot.- $BOD_5$-diss | Dissolved Oxygen | Oxygen saturation | UV-abs (254nm) | Fe | Mn | Cu | Zn | Ni | Cd | Cr | Hg | Pb | Mineral oils |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Unit | 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 | mg $O_2$/L | % sat. | $cm^{-1}$ | mg/L | mg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | 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 | 200 | 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 | | | | | | pH | | | | | | | |
| | Unit | $^{o}$C | $^{o}$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 paricles | Total N | Total P | Chemical Oxygen Demand, total | BOD$_5$, total | Chemical Oxygen Demand, dissolved | BOD$_5$, dissolved | m-alcality |
|---|---|---|---|---|---|---|---|---|---|---|
| | 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 | Air temp | Colour | Odour | Visible particles | pH | Suspended paricles | Dry residue | Ignited (glowed) residue | Loss at ignition | settleable solids | Turbidity | Flow (Ivana) | Flow adjusted | No of days with effluents | Suspended paricles |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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 |
| Cycle | Date | | | | | | | | | | | | | | | | |
| 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, dissolve | 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 |
| 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 | | | | | | | | |
| | | | | | | | | | | | | #REF! | | #REF! |
| | Average | 1,4825 | 0,6225 | 130 | 53 | | | | | | | #REF! | | #REF! |
| | Max | 2,43 | 1,54 | 300 | 99 | | | | | | | | | |

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

Istra-comp-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 (Tanja) average | Flow adjusted | No of days with effluent | Suspended paricles |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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 |
| Cycle | Date | | | | | | | | | | | | | | | | |
| 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 | yelowish | 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, dissolve | COD-tot. - COD-diss | BOD$_5$, dissolved | BOD$_5$-tot. - BOD$_5$-diss | p-alcality | m-alcality |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Unit | mg $NH_4^+$/L | mg $NO_3^-$/L | mg $NO_2^-$/L | mg N/L | mg $PO_4$ $^{3-}$/ | 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 paricles | 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-alcality | m-alcality |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | Unit | µg/L | µg/L | µg/L | mg $NH_4^+$/L | mg $NO_3^-$/L | mg $NO_2^-$/L | mg N/L | mg $PO_4^{3-}$/ | 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 |  |  |  |  |  | pH |  |  |  |  |  |  |  |  |  |  |
|  | Unit | °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 paricles | 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-alcality | m-alcality | 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 | 0g/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 (Ivana) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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 paricles | 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 paricles | Dry residue | Ignited (glowed) residue | Loss at ignition | settleable solids | Turbidity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Unit | $^{o}$C | $^{o}$C | descr. | descr. | descr. | | mg/L | mg/L | mg/L | mg/L | ml/L | descr. |
| Cycle | Date | | | | | | | | | | | | |
| 1 | 15.07.2004. | 20,5 | 20 | yelow-brown | amonia, $H_2S$ | 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 | | | | | | pH | p-acidity | m-acidity | | | | | |
| | Unit | $^{o}$C | $^{o}$C | descr. | descr. | descr. | | | | 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 paricles | Total N | Total P | Chemical Oxygen Demand, total | $BOD_5$, total | Total N | dissolved phosphates | Chemical Oxygen Demand, dissolved | $BOD_5$, dissolved | p-alcality | m-alcality |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Term | | | | | SS | Total N | Tot-P | COD-tot. | $BOD_5$-tot. | Total N | $PO_4^{3-}$ | COD-diss | $BOD_5$-diss | p-alc | m-alc |
| | Unit | m3/day | m3/day | m3/day | | 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 |
| Cycle | Date | | | | | | | | | | | | | | | |
| 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 | Suspended paricles | Dry residue | Ignited (glowed) residue | Loss at ignition | settleable solids | Turbidity | oil and fats | Flow (Ivana) | Flow adjusted |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Term | | | | | | pH | SS | | | | | | | | |
| | Unit | °C | °C | descr. | descr. | descr. | | mg/L | mg/L | mg/L | mg/L | ml/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 | verry turbid | 1430 | 3050 | |
| 3 | 02.07.2004. | 20 | 21 | red | blood | large particles, skin, blood, meat | 7,3 | 1807 | 2310 | 1960 | 250 | 8 | verry turbid | 762 | 2750 | |
| 4 | 12.08.2004. | 18 | 31 | red | blood | large particles, skin, blood, meat | 7,25 | 50 | 1970 | 1290 | 680 | | verry turbid | 680 | 2700 | |
| 5 | 04.11.2003. | 19 | 15,5 | yelow | blood | large particles, skin, blood, meat | 7,2 | 469 | 1764 | 1074 | 689 | 10 | verry turbid | 6 | 2800 | |
| | | | | | | | | | | | | | | | | |
| | Average | | | | | | | | | | | | | | 2880 | 2800 |
| | Max | | | | | | | | | | | | | | 3100 | |

Table 54 continued.

Carnex Vrbas-composite-fin-2

| | Variabel | No of Days with effluents | Suspended paricles | 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 | $BOD_5$-tot.- $BOD_5$-diss | p-alcality | m-alcality |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Term | | SS | Total N | Tot-P | 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 | days/year | mg/L | 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 | | 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 | 971,6 | | | | | | | | | | | | |
| | 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 paricles | Total N | Total P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Term | | | | | | pH | | | | | | | | | | 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 | none | 7,8 | 1460 | 370 | 1090 | 0,1 | | 100 | 1700 | | | 313 | 1,19 | 0,14 |
| 3 | 02.07.2004. | 18 | 20 | none | 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 | 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, dissolve | COD-tot. - COD-diss | BOD$_5$, dissolved | BOD$_5$-tot.- BOD$_5$-diss | p-alcality | m-alcality |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 $PO_4^{3-}$/ | 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 paricles |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Term | | | | | | | | | | | | | | | 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 | 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, dissolve | COD-tot. - COD-diss | BOD$_5$, dissolved | BOD$_5$-tot.- BOD$_5$-diss | p-alcality | m-alcality |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Term | Total N | Tot-P | 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 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 (Ivana) | 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 paricles | Total N | Total P | Chemical Oxygen Demand, total | BOD$_5$, total | Nitrates | Nitrites | organic Kjeldahl N | Chemical Oxygen Demand, dissolve | COD-tot. - COD-diss | BOD$_5$, dissolved | BOD$_5$-tot.- BOD$_5$-diss | p-alcality | m-alcality |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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 (Ivana) | Flow adjusted | No of days with effluents | Suspended paricles | 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 | yelowish | fatty | none | | 400 | 320 | 80 | 0,2 | opalscent | 28 | 2500 | | | 20 | 1,94 | 0,88 |
| 3 | 29.4.2004. | 14 | 15 | yelowish | 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 | yelow | 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-tot. - COD-diss | $BOD_5$, dissolved | $BOD_5$-tot.- $BOD_5$-diss | m-alcality |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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 (Ivana) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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 | No of days with effluents | Suspended paricles | Total N | Total P | Chemical Oxygen Demand, total | $BOD_5$, total | Ammonia | Nitrates | Nitrites | organic Kjeldahl N | dissolved phosphates |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Unit | m3/day | days/y | 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 |
| 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 | COD-tot. - COD-diss | $BOD_5$, dissolved | $BOD_5$-tot. - $BOD_5$-diss |
|---|---|---|---|---|---|
| | Unit | mg $O_2$/L | mg $O_2$/L | mg $O_2$/L | 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

**Flow rate in laterals and industries (l/s) - Vrbas & Kula municipalities**

| Sites | | Measuring period | | Number of days | Flow rate [l/s] | | |
|---|---|---|---|---|---|---|---|
| | | Date- installed | Date- taken off | | 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 ws done after all extracts from the surface, from the middle and from the bottom were mixed together (three analysis in total) for the profice 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 (µg/kg) | Fe (mg/kg) | CN$^-$ (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Left bank – sruface | 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 - sruface (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 | α-BHC | γ-BHC | β-BHC | heptahlor | δ-BHC | aldrin | heptahlorepoksid | 4,4'-DDE | dieldrin | endrin | 4,4'-DDD | 4,4'-DDT | endrinaldehid | endosulfansulfat | PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | µg/kg | | | | | | | | | | | | | | |
| Left bank surface | 1P | <0.2 | <0.5[1] | <0.2 | <0.2 | <0.2 | <0.2 | <0.5[1] | <0.5[1] | <0.5[1] | <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] | <0.5[1] | <0.2 | <0.5[1] | <0.2 | <0.2 | <0.2 | <0.2 |
| Left bank bottom | 1D | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.5[1] | <0.2 | <0.2 | <0.5[1] | <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] | <0.2 | 0.5[1] | <0.2 | <0.5[1] | <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 | <0.2 | <0.5[1] | <0.5[1] | <0.2 | <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 |
| Mid Canal - bottom | 3D | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.5[1] | <0.2 | <0.2 | <0.5[1] | <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 | <0.2 | <0.5[1] | <0.5[1] | <0.2 | <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 | <0.2 | <0.5[1] | <0.2 | <0.2 | <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] | <0.2 | <0.2 | <0.2 | <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] | <0.2 | <0.5[1] | <0.2 | <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 | <0.2 | <0.5[1] | <0.2 | <0.2 | <0.5[1] | <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[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[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] | <0.5[1] | <0.2 | <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 |

[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 |
|---|---|---|---|
| **Phtalates** | | | |
| Bis(2-ethylhexyl)phtalate | + | + | + |
| **Phenols** | | | |
| Nonyl phenol | + | + | + |
| Nonyl phenol isomer | + | + | + |
| Phenol 4-(2,2,3,3 tetramethylbutul) | + | + | + |
| 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 | | | + |
| Calarene | + | | |
| Cadina1-1(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-methylnaphto(2,1-b)thiophene | + | + |
| 5-ethyl-9,9-dimethyl-5H,9H-quino(3,2,1-de)phenazine | | + |
| 11,phenyl-11H-indolo(3,2-c)quinoline-6(5H)-one | | + |
| 29-methyl -(17alpha.H21,betaH)-hopane | | + |