The physical and chemical characteristics of Danube water quality near Kovin (Vojvodina) in Serbia

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This work represents a summary of the Danube river water quality in the vicinity of one of the largest spirit producing plants in Serbia and indicates the necessity for a wastewater treatment facility for maintaining acceptable river water quality in the area.

Keywords: Water quality, Danube river, Kovin, Vojvodina

Introduction

The length of the Danube river flowing through Serbia is 558 km, starting from Bezdan at the north-west, to Djerdap at the south-east (Fig. 1). Near the town of Kovin, located in the southern part of Vojvodina (Fig. 2). There the section of the Danube has a length of around 50 km and numerous smaller tributaries enter the Danube River. The characteristic of the river bed is a wide riverbed, sand dunes, and frequent river islands.

Figure 1. Danube in Vojvodina, Serbia

Figure 2. Danube near the town of Kovin

The depth of Danube near Kovin ranges anywhere from 2 m up to 18 m, and the annual water levels fluctuate anywhere from the Fall minimum of 69 cm (October) to the Spring maximum of 408 cm (April).

Near Kovin the Danube has a very high average annual temperature: 12.3 ºC. This is most likely due to its wide and shallow riverbed, and the warm water of its tributaries. The highest temperature observed was in June (24 ºC), and the lowest in January (1.6 ºC).

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When it comes to flooding, most of the communities along the Danube, including Kovin, have been protected against this natural disaster. The flood regulation plan established in 1867, which included building high floodwalls along most of Danube's length and completed in 1909, has successfully protected Kovin against floods for over a century. However, more recently, the town of Kovin has had more issues with Danube river water pollution rather than with flooding: the water quality of the Danube river near Kovin has deteriorated mainly due to pollutants from the alchol producing plant Alpis, the incomplete sewage infrastructure of the Kovin community, animal husbandries and agriculture (due to common use of fertilizers).

This study represents a summary of physical and chemical parameters determined for Alpis's technology cooling water and its wastewater (both delivered into the Danube either directly or indirectly), and their impact on Danube river water quality.

Methods

The Danube water quality monitoring program included two pollution sources:

a) technology cooling water and b) wastewater, both produced by the spirit plant Alpis. All of the measurements and analyses were conducted according to the Standard Methods [1], and the Yugoslavian Water Pollution Control Directive (YWPCD) [2].

The inland water quality classifications according to the selected parameters, following YWPCD, are presented in Table 1. The parameters describing Yugoslavian water quality classes are given below Table.1.

Table 1. YWPCD: Water quality classification levels

Water Quality Parameters		**Water Quality Classes**			
		I	**II**	**III**	**IV**
Dissolved oxygen	(mg/l)	8.0	6.0	4.0	>3.0
PH		6.0-8.5	6.8-8.5	6.0-9.0	6.0-9.0
Electroconductivity	(µS/cm)	-	-	-	-
Dry residue	(mg/l)	350	1000	1500	>1500
Suspended matter	(mg/l)	10	30	80	>100
COD	(mg O_2/l)	10	12	20	>40
BOD_5	(mg O_2/l)	2.0	4.0	7.0	>20
$KMnO_4$	(mg/l)	10	20	30	>40
Amonia - NH_3	(mg/l)	0.1	0.1	0.5	>0.5
Total - N	(mg/l)	10.0	10.0	15.0	>15
Total - P	(mg/l)	0.03	0.03	1.5	>1.5

- **Class I:** *Very clean water* (requires only disinfection in order to be used for water supply, suitable for recreational activities, trout production)
- **Class II:** *Slightly polluted water* (requires adequate treatment in order to be used for water supply, suitable for recreational activities, not suitable for trout production, may be used as irrigation water if important standards are met)
- **Class III:** *Polluted water* (requires adequate treatment in order to be used for industrial supply - except for food and textile industries; not suitable for recreational activities)
- **Class IV:** *Very polluted water* (describes a water quality class being worse than the classes mentioned above, banned for recreational activities).

The analyses of the Alpis technology cooling water were done throughout the year 2005 (Table 2). The Alpis plant delivers its technology cooling water into the Danube via a discharge canal (2.5 km long). The effluent samples were analyzed for physical-chemical characteristics and compared to the YWPCD standards to determine the extent of water pollution. During the last week of Fall 2005 the technology cooling water from the discharge canal and Danube river water were sampled over three days: the 1st, 2nd, and 6th day so that the effect of increasing concentration of technology cooling water discharged into the Danube could be observed. The technology cooling water samples were analyzed for: temperature, pH value, water electroconductivity, dry residue, suspended matter, chemical and biological oxygen demand (COD and BOD_5, respectively), content of NH_4^+, and Total-N and Total-P concentrations (Table 3). Parameters determined for river water samples taken at the same time were: pH value, COD, BOD_5, and $KMnO_4$ (Table 4).

Alpis-produced wastewater is collected in four large basins in the vicinity of the plant by means of a wastewater pipeline close to the Danube river dam. Parameters determined for discharged wastewater collected in these four basins are shown in Table 5.

Results and Discussion

The water quality of the technology cooling water, the Danube river, and that of Alpis plant produced wastewater was determined based on comparing the pH value, conductivity, COD, BOD_5, Total-N, Total-P, and $KMnO_4$ parameters with those given by the YWPCD. These are summarized in Tables 2-5.

Physical and chemical parameters of technology cooling water sampled in seasons of 2005 are given in Table 2. The temperature of examined water was in the range of 44-49 ºC, and pH value was determined to be from 7.45 to 7.90. The mean recorded values of COD ($KMnO_4$), BOD_5, phosphate, and nitrate levels were found to be 7.95 - 27.0 mg/l (11.87-37.7 mg/l), 4.35 – 10.5 mg/l, 0.44 – 1.0 mg/l and 0.01-4.20 mg/l, respectively. Parameters shown in Table 2 indicate that the quality of technology cooling water is a "Class II" during the autumn season and "Class IV" during the remaining three seasons with respect to values determined for BOD_5.

Table 2. Physical and chemical parameters of technology cooling water sampled per season in 2005.

Water Quality Parameters		Samples			
		Spring	**Summer**	**Fall**	**Winter**
Temperature	(^oC)	46	49	47	44
pH		7.73	7.45	7.75	7.90
Electroconductivity	(µS/cm)	897.0	775.2	1028	759.6
Dry residue	(mg/l)	0.650	0.560	0.620	0.585
Suspended matter	(mg/l)	0.043	0.040	0.035	0.041
COD	(mg O_2/l)	27.0	13.7	7.95	9.43
BOD_5	(mg O_2/l)	10.5	13	4.35	8.02
$KMnO_4$	(mg/l)	20.10	11.87	15.6	37.7
Amonia – NH_3	(mg/l)	<0.010	<0.010	0.009	1.20
Total - N	(mg/l)	3.54	0.40	0.0092	4.20
Total - P	(mg/l)	<0.010	<0.010	0.44	1.0

Parameters shown in Table 3 indicate that the quality of technology cooling water in the discharge canal is a "Class IV " prior to reaching the Danube. Water quality parameters were determined to be poor overall, especially on the sixt day after prolonged cooling water discharge. All parameters varied during the investigation period, except dry residue (0.565- 0.660 mg/l) and suspended matter (0.0355- 0.043 mg/l).

Table 3. Parameters for technology cooling water sampled from the collecting discharge canal during the last week of Fall 2005

Water Quality Parameters		First day	Second day	Sixth day	Mean value from discharge canal
pH		7.65	7.78	7.41	7.61
Electroconductivity	(µS/cm)	650	700.0	1400	916.7
Dry residue	(mg/l)	0.565	0.660	0.620	0.617
Suspended matter	(mg/l)	0.043	0.040	0.035	0.039
COD	(mg O_2/l)	27.0	45	275	115.7
BOD_5	(mg O_2/l)	7.31	16	150	57.8
$KMnO_4$	(mg O_2/l)	8.30	15.2	104	42.5
Amonia – NH_3	(mg/l)	2.80	6.50	72	27.1
Total - N	(mg/l)	3.20	9.60	75	29.3
Total - P	(mg/l)	1.70	2.35	7.50	3.85

An attempt to ascertain the present water quality of the Danube river affected by Alpis plant technology cooling water discharge has been made. Samples of river water were collected at locations upstream and downstream to the discharge canal delivery point. Table 4 indicates that Danube river water quality near Kovin is a "Class I" according to the YWPCD classification scale with respect to parameters obtained for COD, BOD_5 and $KMnO_4$ prior to the discharge of technology cooling water into the river. The high degree of water quality degradation is reflected by the changes in values of BOD_5, COD, and nitrogen contents determined for water samples downstream to the discharge canal delivery point into the Danube. However, after prolonged discharge of technology cooling water (day six) the Danube river water is a "Class II - IV " – a direct consequence of higher concentrations found for organic matter: COD increased by 89%, and BOD_5 by 319% .

Table 4. Parameters for Danube river water sampled during the last week of Fall 2005.

Water Quality Parameters		Danube water sampled before the discharge canal	Second day	Sixth day
PH		7.92	7.97	7.70
COD	(mg O_2/l)	9	10	17
BOD_5	(mg O_2/l)	3.46	4.50	14.50
$KMnO_4$	(mg O_2/l)	6.40	7.20	10.94
Amonia - NH_3	(mg/l)	-	-	1.96

Even though the technology cooling water discharged does significantly deteriorate Danube water quality, the bigger problem is the Alpis plant produced wastewater. This water is accumulated in four open-air basins, not far away from the Danube dam, and at only 0.5 km from the riverbank. The measured parameters of the Alpis plant wastewater are given in Table 5.

The results clearly indicate that the wastewater coming throughout the overflow pipe into the basins is severely polluted. The wastewater determined temperature was 57ºC, pH of the effluent was 7.41 and the observed concentrations for COD and BOD were 74490 mg/l and 21826 mg/l, respectively. Total-N, Total-P, dry residue, and suspended solid concentrations were also considerably high. If we compare parameter values obtained for samples from basins 2 and 4, results from basin 2 are similar to those obtained for the overflow pipe, whereas those for basin 4 indicate even better water quality. It could be explained by distance the overflow pipe-Basin 4 and time of wastewater into Basin 4.

The results show that Alpis plant produced wastewater is heavily polluted and requires proper treatment before it is discharged into the basins, i.e., on land.

Table 5. Parameters for Alpis plant-produced wastewater sampled during the last week of Fall 2005.

Water Quality Parameters		**The overflow pipe**	**Basin 2**	**Basin 4**
Temperature	(^oC)	57	12	12
pH		7.41	7.24	7.04
Electroconductivity	(mS/cm)	27.1	45.1	23.1
Dry residue	(mg/l)	86932	69828	32463
Suspended matter	(mg/l)	939.0	766.0	357.3
COD	(mg O_2/l)	74490	61182	6280
BOD_5	(mg O_2/l)	21826	22860	5338
Amonia – NH_3	(mg/l)	36.6	61.0	131.4
Total - N	(mg/l)	41.83	61.2	225.4
Total - P	(mg/l)	349.3	349.3	255

Conclusions

In summary, the quality of Danube river water before the discharge of Alpis technology cooling water into it belonged to a Class I based on the analyzed parameters, with exception of BOD_5, which indicates a Class II. The results show that technology cooling water containes high concentrations of pollutants which are delivered into the Danube, thereby decreasing the river water quality from a "Class II" to "Class IV", in regard to BOD_5. The results presented have confirmed the poor water quality of Danube river in the vicinity of Alpis, Kovin, and the need for a local wastewater treatment facility. Moreover, it appears that a regular water quality monitoring scheme should be established for Danube river water near the town of Kovin in order to secure acceptable river water quality in the area.

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