IMPACT OF ŠABAC INDUSTRY ON THE ENVIRONMENTAL CONDITION OF THE SAVA RIVER [1]

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ABSTRACT

Microbiological, chemical and physico-chemical investigations along the course of the Sava River in the area of the town Šabac were carried out at the end of 1998 and during summer time in 1999. The investigations were performed over the period from 2nd December 1998 to 9th September 1999. The aim of these investigations was to get the picture of the ecology of the Sava River based on microbiological and chemical analyses in order to observe the effects of the Šabac industry on the ecology of the Sava River. The objective of our investigations was to establish the presence of certain bacteria, which in the indirect way would show the degree of saprobic quality of the Sava, the presence of pollutants and organic compounds and intensity of selfpurification in it. We assumed that the industry of Šabac had a negative effect on ecology of the Sava River and that the changes it had caused were influenced by its intensity, which was greater in winter than in summer period. Performing our analyses we established the presence of coliform and mesophylic bacteria, the number of which was much greater in winter than in summer. Streptococcus faecalis, Pseudomonas aerugynosa and sulfidoreducing clostridia were found only in winter time, whereas in the summer period they were absent in all localities. The bacteria Bacillus spp. was found both times although in very small quantities, which showed its soil origin. On the basis of the obtained results we concluded that the industry of Šabac had harmful effects on the ecology of the Sava River during winter period, which was caused by more intensive work of industry. Due to contamination by great quantities of pollutants and the process of selfpurification, which was impeded and slowed down, coliform and other bacteria multiplied massively. But, during summer that number decreased considerably because of extensive industry and reestablishing of intensive process of selfpurification.

Key words: environment, industrial facilities impact, river, contamination

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INTRODUCTION

During the last decades the industry developed quickly and many factories were built. Waste matter is produced in the processing of various materials in factories. Various fecal materials and effluents produced as by-products are dissolved in water representing industrial waste waters which flow through sewerage system or directly to the water system. That is why the factories and processing plants were built near rivers, seas or other ecosystems, where water always moves. After entering the river waste matter was contaminated and decomposed by various microorganisms. Flowing into rivers waste matter carries many organic and inorganic compounds. Under the influence of bacteria and other microorganisms organic and inorganic compounds are decomposed using up great quantity of oxygen and releasing harmful and poisonous gases (H2O,CO2, NH3, CH4). In that way anaerobic conditions were made affecting biological cycle of inhabited organisms, especially hindering the process of selfpurification. Increased concentrations of harmful and waste products cause breaking of biological regime of the river water and make selfpurification impossible. In that way saprobic quality of the water is increased and ecological balance is broken. These changes cause a great number of organisms, which participate in the process of selfpurification to disappear, because they cannot adapt to new life conditions. More tolerant and biologically more resistant groups of organisms, which can adapt to new life conditions, as well as new organisms, which came to this habitat, having much food, start to reproduce massively. These organisms, so-called allochthonous organisms, are indicators of certain degree of pollution of the given habitats.

However, it should be taken into account that the intensity of these changes is very variable, and mostly depends on the degree of industry development in the studied area, as waste waters made in factories should be, by rule, purified in the factories themselves to the level of quality which is in the water they flow to.

Many rivers on our planet are exposed to such problems, especially those running in developed and highly developed countries, where industrial facilities are widely distributed. In such areas rivers are more saprobic and all water organisms living in them are exposed to a danger of great pollution. They may disappear from their habitats or from the whole ecosystem.

The aim of these investigations was to get the picture of the ecology of the Sava River based on microbiological and chemical analyses in order to establish the effects of the Šabac industry on the ecology of the Sava River.

Our task was to establish the presence and number of specific and dominant bacterium species as indicators of the existing conditions and present compounds, which affect the biological regime of this river and its ability of selfpurification.

We assumed that the industry of Šabac had a harmful effect on ecology of the Sava River and that the changes it caused were influenced by its intensity, which was greater in winter than in summer period.

The main reason why the Sava River was chosen is the industrial zone along the Sava course in the Šabac area, which represents the ideal example for examination of the influence of industry of an area on the ecology of the river studied.

If our hypotheses prove to be true, the importance of this paper itself is far greater, because it will then represent a model for investigations of similar problems, especially in the countries with developed industry where saprobic quality of rivers and changes caused by it are much more pronounced. These changes primarily cause disappearing of plant and animal species, i.e. these changes happen at the level of the ecosystem.

LOCALITY DESCRIPTION

The Sava River is the right tributary of the Danube. It springs above Julian Alps under Triglav, at 2738 m above the sea level. The length of its course in the Šabac area is about 15 km. The terrain where the samples were taken is basically pebble-sandy.

Locality 1: 100 m in front of the influx of the Kočin channel (drainage channel where waste water from the factory of milk products "Mlekara-Šabac" flows to). The bottom is pebbly; banks are mostly studded with woody plants.

Locality 2: Kočin channel, 20 m before it enters the Sava. The bottom is covered with fairly large pebbles, under which are larger pebbles. The sides of the channel are mostly covered with green plants, while woody plants are rare.

Locality 3: The Sava River, 50 m after the influx of the Kočin channel. The bottom is sandy; the sides are studded with woody plants.

Locality 4: The Sava, 50 m in front of the railway bridge, or 200 m in front of the mill "Žitoratar". The bottom is pebble-sandy, without vegetation around it. In the vicinity of the locality there are weekend cottages, so that this place is active only in summer.

Locality 5: The Sava, 100 m up stream of the influx of waste water of the mill "Žitoratar". The bottom is sand-muddy; the banks are covered with woody and green plants.

Locality 6: Waste water from the mill "Žitoratar", which enters the Sava directly from the mill.

Locality 7: The Sava, 3-5 m downstream of the influx of the waste water. There is no vegetation around.

Locality 8: The Sava, 50 m behind "Žitoratar". The bottom is sandy; the banks are covered with scarce vegetation of bushes.

Locality 9: The Sava River in front of the castle, lack of vegetation, concrete banks (dike).

Locality 10: The Sava in the area of "Stari grad". The bottom is sand-pebbly, lack of vegetation on the wider part of the banks.

Locality 11: The Sava, 50 m behind the locality 10 and 50 m in front of the "Alaska koliba", lack of vegetation, pebbly banks.

Locality 12: The Sava, just under the restaurant "Alaska koliba", lack of vegetation.

Locality 13: The Sava, 10 m down the river, with scarce vegetation.

Locality 14: The Sava, 30 m down the river, vegetation present.

Locality 15: 30 m in front of "Yu-petrol", in the Sava, with a lot of vegetation.

Locality 16: The Sava, next to "Yu-petrol", or 150 m in front of the factory "Zorka-Šabac". The bottom is sandy, only vegetation is woody plants on the left bank.

Locality 17: The Sava next to the factory "Zorka-Šabac". The bottom is sandy, mostly woody plants and some green plants cover the banks.

MATERIAL AND METHODS

The investigations were performed from 2nd December 1998 to 25 April 2000. Sampling was performed along the course of the Sava in the area of the town Šabac. The samples were taken for the first time on 2nd December 1998, then on 2nd December 1999, for the third time on 22nd March 2000 and for the fourth time on 25th April 2000. We planned to take samples in May 1999 and during 2001, but we could not do that. For that period we

took the results from the Institute for Health Protection "Vera Blagojević" at Šabac, where experimental part of this project was done as well. During 1998 and 1999 we did not make all analyses, which we did in 2000 because of financial difficulties.
Together with bacteriological analyses, chemical and physico-chemical analyses were made.
Within chemical analyses biological usage of oxygen (BPK5), quantity of ammonia, nitrates and nitrites, chlorides, phosphates and oxygen in one litre of water were calculated.
As for physico-chemical analyses, while sampling we measured temperature of air and water, while pH values were calculated under laboratory conditions by use of pH meter MA 5740 ISKRA (error 0.001) using combined electrode and standard buffers (pH 7.02+, 00.1 (20 C) and Ph 8.00+00.l (20 C).

BACTERIOLOGICAL ANALYSES

1. Establishing the total number of aerobic mosophylic bacteria

The total number of mesophylic bacteria was established by growing culture on medium for the total number of bacteria from 0.1 ml of sample of 10 and 10 dilution. Inoculated media were incubated for 24 h at 37 C, after which the grown colonies were counted (author).
The calculation of the total number of aerobic mesophylic bacteria were done according to the formula:

$$X = \frac{S_V \cdot K}{10^{-n}} \quad ,$$

where x is the total number of living cells in 1 ml of sample, Sv is mean value of the number of colonies, K is coefficient and n is the order of dilution.

2. Establishing the most probable number (MPN) of coliform bacteria in the sample

The presence of coliform bacteria was established by fermentation test, whereas their most probable number was calculated by MPN (Most Probable Number) method, by use of Swaroop's tables (Regulations on waters of FR of Yugoslavia).

Preliminary experiment:

The quantities of 0.1 ml, 0.01 ml and 0.001 ml, for each sample were grown in sterile test tubes with lactose andrade peptic water and Durham's tubes. The test tubes were incubated in a thermostat for 48 h at 37 C, and then the results were recorded.

Control Experiment:

To confirm the presence of coliform bacteria, we carried out the control experiment, where 9 test tubes (one for each sample, with gas and change in indicator colour) were inoculated on Endo agar and incubated for 24 h at 37 C.

Final experiment:

For final identification of grown colonies the final experiment was performed by inoculation of growth colonies to the surface of slanting Triple Kliger's sugar and sticking loops in the depth of this medium. For this we used 11 test tubes because some colonies were lighter

(S) and the other were darker (T). After that IMV and C test was done by inoculation on peptide water and methyl, a seri red-Voges-Proskauer and Simon's citrate agar.
In addition to this, a series of tests were performed by growing culture on the media of manite, urea, agar-agar, saharose, maltose and phenyl-alanin in order to identify the present coliform bacteria. After incubation of 24 h at 37 C we recorded the obtained results.

3. Establishing the presence of bacteria belonging to the genus Bacillus

After heating of 0.5 ml of sample for 20 min. at 80 C, we made decimal dilutions 10 and 10, and then inoculated media for the total number of bacteria by 0.1 ml of the mentioned dilutions for each sample. After incubation of 24 h at 37 C we counted the grown colonies of the genus *Bacillus.*

4. Establishing the presence of anaerobic sulfidoreducing clostridia

On 1ml of each sample half cooled sulfide agar was poured. After 24 h of incubation at 37 C, inoculation of blood agar and Gramm staining were performed and slides checked on the presence of characteristic spores. The absence of colony growth on blood agar due to aerobic conditions confirmed the presence of sulfidoreducing clostridia.

5. Establishing the presence of Streptococcus faecalis

The presence of *Streptococcus faecalis* was established by growing culture from previously inoculated sample on LAP medium to the cooled and hardened Klauberg s tellurium medium in Petri dishes. After 24 h of incubation at 37 C, Gramm staining and catalase test were performed. The catalase test was performed by pouring a few drops of H2O2 on grown colonies. The lack of bubbles confirmed the presence of Streptococcus faecalis.

RESULTS AND DISCUSION

Table 1. Results of bacteriological analyse from december 1998

Locality	**U**	**MPN**	**Sc**	**Proteus**	**Bacillus**	**P.a.**	**S.f.**
1	$2.6x10^5$	38000	1	/	1000	-	-
2	$1.35x10^4$	>240000	0	/	0	-	+
3	$1.901x10^4$	240000	0	/	0	-	+
4	$2.39x10^4$	150000	0	/	2000	-	-
5	$1.15x10^4$	21000	0	/	0	-	+
8	$7305x10^4$	240000	1	/	0	1	+
10	$3.452x10^4$	240000	0	/	0	-	-
16	$4.601x10^4$	96000	0	/	45000	-	-
17	$1.902x10^4$	210000	0	7	0	-	+

Legend: MPN – the most probable number of coliform bacteria, U – total number of aerobic mosopfylic bacteria at 1ml sample, Sc – number of sulfidoreducing bacteria, P.a. – number of bacteria Pseudomonas aerugynosa, S.f. – Streptococcus faecalis, / - not founded

Table 2. Results of bacteriological analyse from december 1999

Locality	U	MPN	Sc	Proteus	Bacillus	P.a.	S.f.
1	$7x10^4$	16000	/	-	/	/	-
2	$4.8x10^5$	38000	/	-	/	/	-
3	$3x10^5$	0	/	-	/	/	-
4	$1x10^3$	15000	/	-	/	/	-
5	$2x10^3$	2200	/	-	/	/	-
8	$5x10^3$	15000	/	-	/	/	-
10	$1x10^3$	7600	/	-	/	/	-
16	$1x10^2$	15000	/	-	1000	/	-
17	$9x10^3$	8800	/	-	/	/	-

Legend: MPN – the most probable number of coliform bacteria, U – total number of aerobic mosopfylic bacteria at 1ml sample, Sc – number of sulfidoreducing bacteria, P.a. – number of bacteria Pseudomonas aerugynosa, S.f. – Streptococcus faecalis, / - not founded

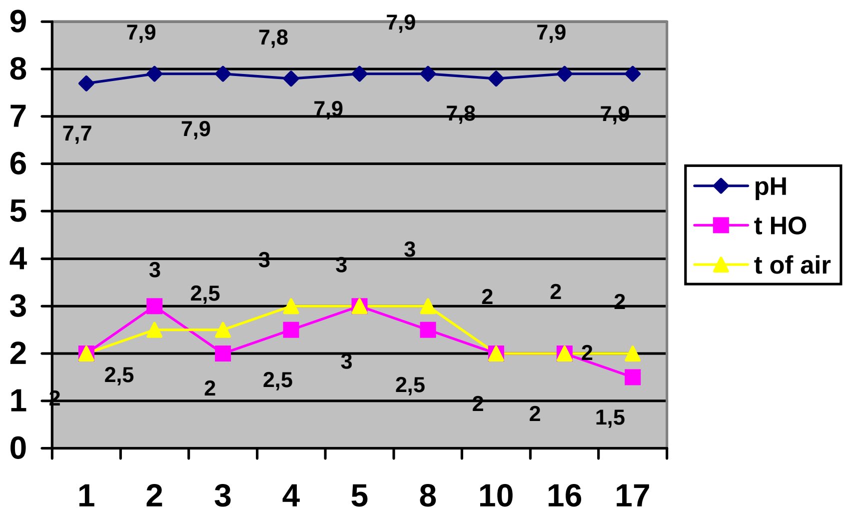


Fig.1. Results of the physico-chemical analysis from the first sample

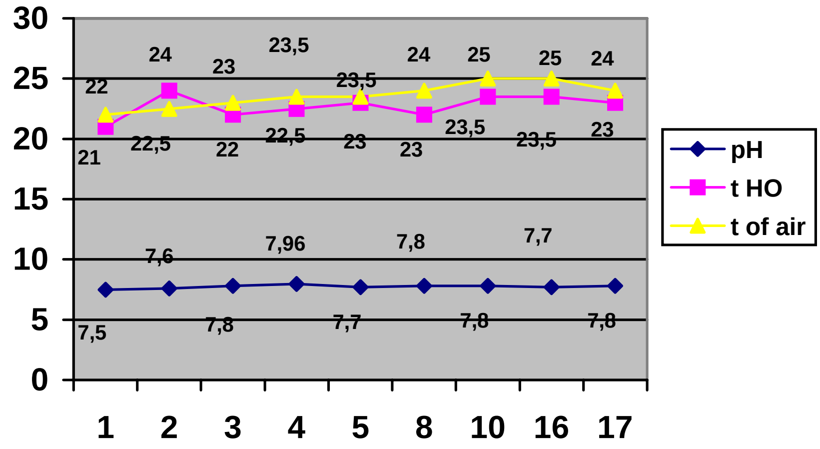


Fig. 2. Results of the second sample physici-chemical analysis

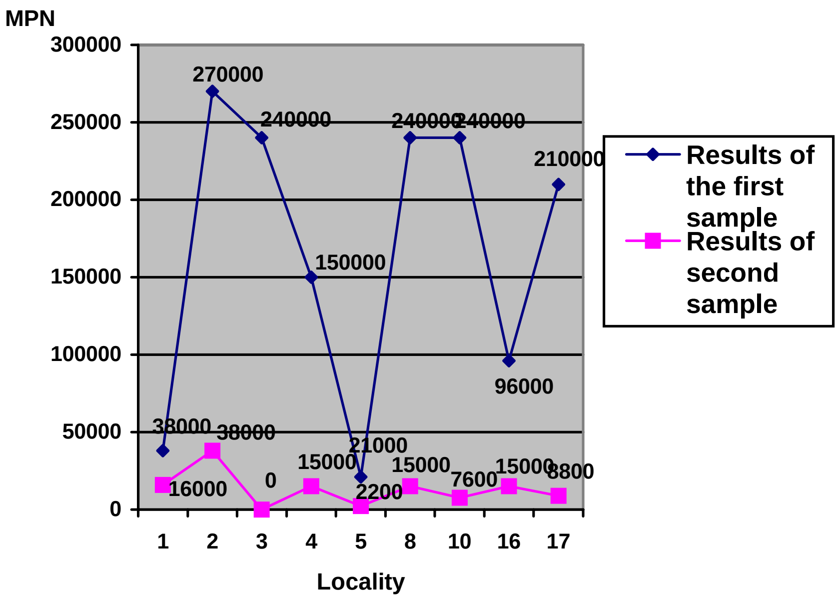


Table 3. Results of the bacteriological analyse from march 2000

Locality	U	MPN	Sc	Proteus	Bacillus	P.a.	S.f.	F.k.
1	$1.02x10^6$	> 240000	6	/	/	/	/	+
2	$1x10^3$	5000	masa	/	/	/	/	-
3	$4x10^4$	4400	0	/	/	/	/	+
4	$4.2x10^5$	38000	masa	/	+	/	/	+
5	0	> 240000	masa	+	/	/	/	-
6	$3.5x10^6$	240000	0	/	/	/	/	+
7	$2x10^3$	16000	0	/	/	/	/	+
8	$3.x10^4$	38000	0	/	/	/	/	-
9	$1x10^4$	5000	0	/	/	/	/	+
10	$5.3x10^4$	5000	0	+	/	/	/	+
11	$4.5x10^4$	7600	0	/	/	/	/	+
12	$1x10^6$	21000	0	/	+	/	/	+
13	$5x10^3$	5000	0	/	/	/	/	+
14	$1.6x10^5$	0 ☻	0	/	/	/	/	+
15	$3x10^4$	2200 ☻	0	/	/	/	/	+
16	0	5000 ☻	masa	/	/	/	/	+

Legend: MPN – the most probable number of coliform bacteria, U – total number of aerobic mosopfylic bacteria at 1ml sample, Sc – number of sulfidoreducing bacteria, P.a. – number of bacteria Pseudomonas aerugynosa, S.f. – Streptococcus faecalis, / - not founded, F.k. – presens fecal coliform, ☻- prisustvo difteroida

Table 4. Results of the physico-chemical analysis from march 2000

Locality	pH	t H_2O	t of air
1	*	2	1
2	*	2	2
3	*	2	2
4	*	3	3
5	*	0,5	4,5
6	*	11	4,5
7	*	0	0,5
8	*	0	0
9	*	0	0,5
10	*	0	3
11	*	0	0,5
12	*	1	2
13	*	1,5	2
14	*	1	2
15	*	2	2
16	*	1	1

Legend: * - not doing mearching pH valures

Table 5. Results of bacteriological analysis from april 2000

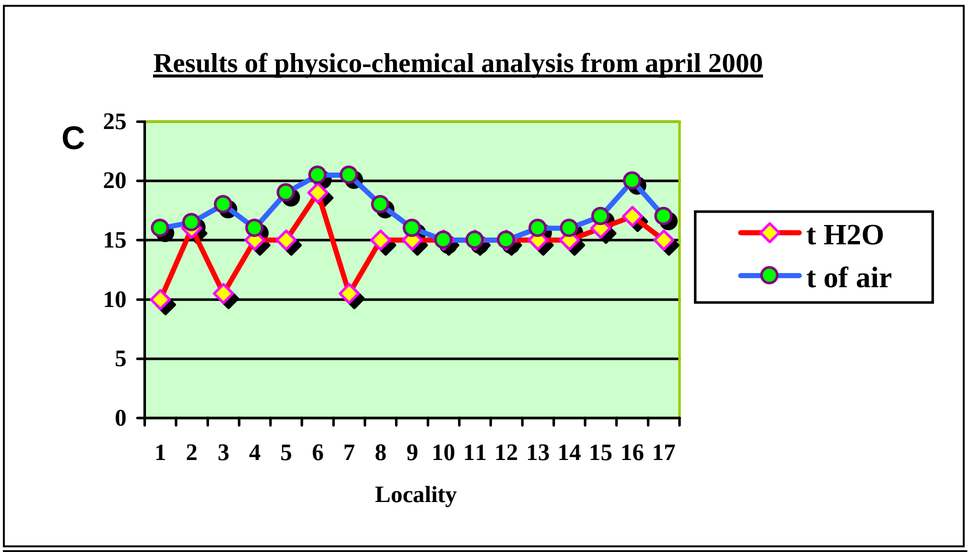
Locality	U	MPN	Sc	Proteus	Bacillus	P.a.	S.f.	F.k.
1	$1x10^2$	2000	/	/	/	/	/	+
2	0	240000	/	/	/	/	/	+
3	$1x10^3$	5000	/	/	/	/	/	+
4	0	12000	/	/	/	/	/	-
5	0	8800	/	+	/	/	/	-
6	$5.92x10^4$	67000	40	/	/	/	/	+
7	$1x10^3$	240000	5	/	/	/	/	+
8	$4x10^3$	8000	/	/	/	/	/	+
9	0	2200	/	/	/	/	/	+
10	0	2200	/	/	/	/	/	+
11	$1x10^2$	5000	1	/	/	/	/	+
12	$1x10^2$	5000	/	+	/	/	/	+
13	$3x10^2$	8000	1	/	/	/	/	+
14	0	0	/	/	/	/	/	-
15	$5x10^3$	2200	/	/	/	/	/	-
16	$1x10^2$	5000	/	/	/	/	/	-
17	$3x10^2$	96000	/	/	/	/	/	+

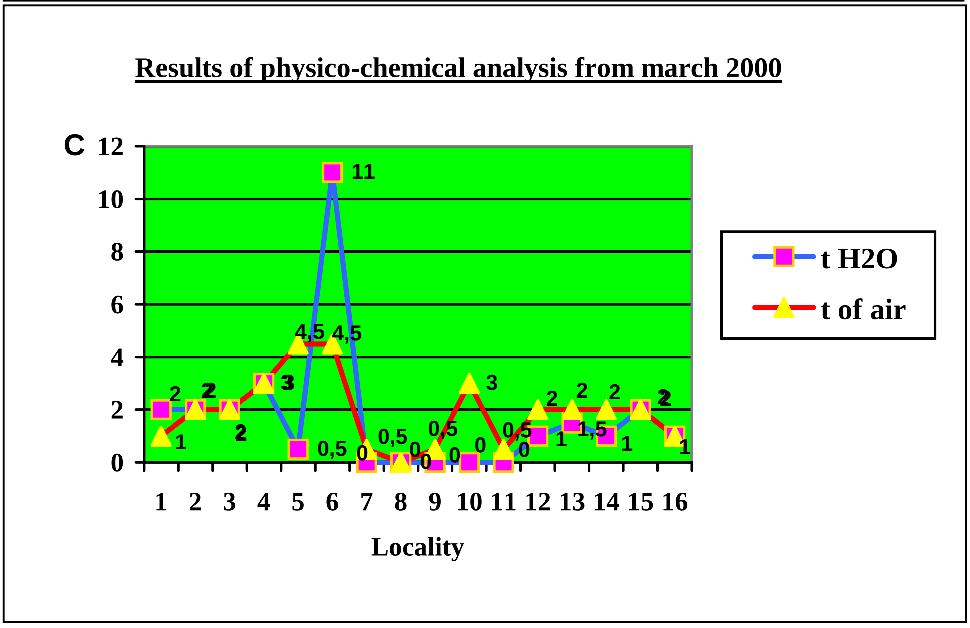
Legend: MPN – the most probable number of coliform bacteria, U – total number of aerobic mosopfylic bacteria at 1ml sample, Sc – number of sulfidoreducing bacteria, P.a. – number of bacteria Pseudomonas aerugynosa, S.f. – Streptococcus faecalis, / - not founded, F.k. – presens fecal coliform

Table 6. Results of physico-chemical analysis from april 2000.

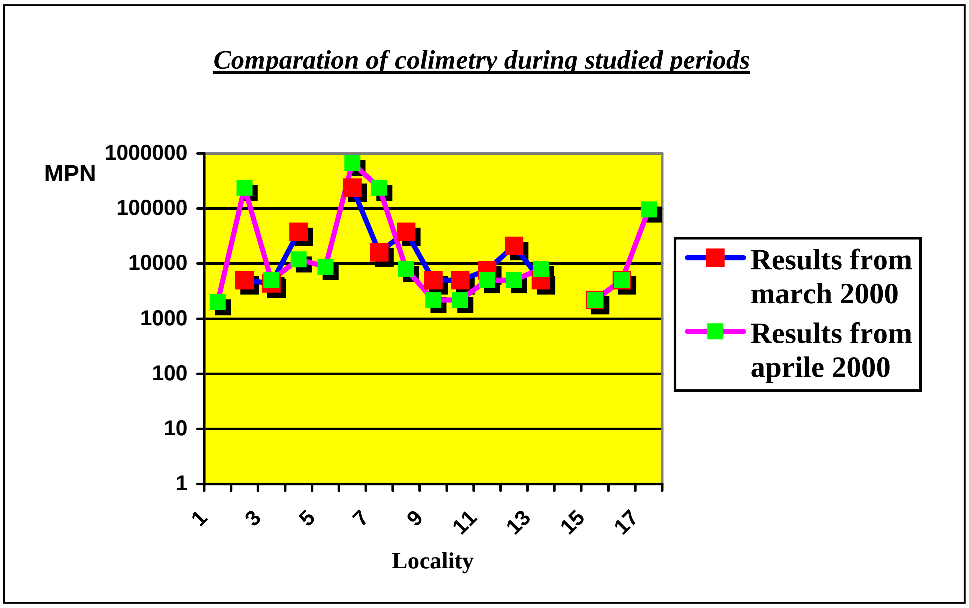
Locality	pH	t H_2O	t of air
1	7,5	10	16
2	7,4	16	16,5
3	7,4	10,5	18
4	7,5	15	16
5	*	15	19
6	*	19	20.5,
7	*	10,5	20,5
8	*	15	18
9	7,5	15	16
10	7,5	15	15
11	7,5	15	15
12	*	15	15
13	*	15	16
14	*	15	16
15	*	16	17
16	7,5	17	20
17	7,5	15	17

Legend: * - not doing mearching pH values





On the basis of physico-chemical analyses during first two periods of investigation, it can be seen that there is no great variation in water and air temperatures in relation to other localities. During investigations in winter periods the highest air temperature was 3 C, the lowest 2 C, while the water temperature varied between 1.5 and 3 C. During the second sampling air temperature varied from 22 C to 25 C, while water temperature ranged from 21 C to 23.5 C. On the graphs it can be seen that pH value varied depending on locality, pointing to the fact that pH value increased in the industrial zone, which was the effect of the influx of industrial waste waters into the Sava.



By microbiological investigations of samples taken on 2nd December 1998, the presence of coliform bacteria was found in all localities. The number of coliform bacteria varied depending on locality (Table l). The greatest number occurred in locality 2 (> 2.4x10), the smallest being in locality 5 (2.1x10). The presence of great number of coliform bacteria in the Kocin cannel (locality 2), may be explained by the fact that waste waters from the factory of milk products "Mlekara-Šabac" flow into this cannel close to its mouth into the Sava. Also, a great number of coliform bacteria existed in the locality 8 and 17 (2.4x10 and 2.1x10, respectively). In the locality 8 it was caused by the influx of waste products made in the processing of crops in the mill "Žitoratar". In the locality 17 various compounds and products from the chemical factory "Zorka-Šabac" flowed into the Sava, making, by disassembling them, ideal conditions for further multiplication of the present bacteria. By use of IMVandC test and biochemical series of tests the coliform bacteria were determined and it was found that in most localities the dominant bacterium was *Enterobacter anglomerans 1*. In addition to it, the presence of bacteria belonging to the genera *Esherichia coli, Citrobacter, Kluyvera* and *Klebsiela oxytoca* was observed, while Pseudomonas aerrugynosa was found only in the locality 8.

The total number of mosophylic bacteria was somewhat increased and varied from 1.5x10 to 2.6x10. The presence of *Streptococcus faecallis*, which is an indicator of fecal pollution of animal origin, was observed in the localities 2,3,5,8 and 17. Sulfidoreducing anaerobic clostridia were found only in localities 1 and 8. Their presence can be explained by increased disassembling of organic material (starch in locality 8) in water of the studied area. The bacteria of the genus *Bacillus* occurred in the localities 1,4 and 16, but in small quantities, what points to the fact that these bacteria came into water by washing off soil due to changes in the level of water.

Looking at the course of the river, it may be seen that the number of coliform bacteria increased (graph 3), which was the effect of the influx of waste waters from the mentioned industrial installations. Also, on the basis of the obtained results we can see that the greatest pollution was in localities 2 and 8, i.e. in Kocin cannel and in the Sava at the point 50 m downstream the influx of waste waters from "Žitoratar".

On the basis of bacteriological analyses of the second sampling, the presence of the coliform bacteria was also established but not in all localities. The greatest number was 3.8x10 (locality 2), the smallest being 2.2x10 (locality 5). The lack of coliform bacteria was observed in the locality 3. The number of aerobic mosophylic bacteria increased and varied from 1x10 to 4.8x10 (Table 2). Among identified bacteria during both periods of time the dominant bacteria were Enterobacter anglomerans 1 and Escherichia coli, Citrobacter freundii, Providencia alcalifaciens, while Serratia odorifera 2 was also present. A small number of bacteria from the genus Bacillus were found in locality 16, which showed their soil origin. Sulfidoreducing clostridia, Pseudomonas aerugynosa and Streptococcus faecalis, during that period were not found in any locality, what in continuity with a small number of coliform bacteria showed the low degree of pollution by organic matter and intensive process of selfpurification.

The great difference in abundance of coliform bacteria and lack of studied species between the first and the second sampling was caused by different periods of time and different intensity of processing in factories. Namely, during winter the industry worked more intensively and great quantity of harmful material and pollutants were produced, which flowed within waste waters into the Sava. These pollutants accumulated and various microorganisms disassembled them. Due to the lack of vegetation and reduced number of organisms in the Sava (many plant and animal species could not adapt to low temperature and died, while some others disappeared because they could not adapt to conditions caused by the presence of pollutants), the process of selfpurification was considerably slacked up, which caused the overpopulation of bacteria, because they fed on these compounds and made favourable conditons for massive development and multiplication.

During winter, environmental conditions greatly improved, owing to increased water and air temperatures and considerably lower intensity of industrial processing caused by a few months war crisis. They made greater diversity and abundance of organisms possible. In the process of selfpurification increased concentration of organic matter was reduced by microorganisms which used it as their food. In accordance with a small number of coliform bacteria and other bacterium species as indicators of fecal pollution, the saprobic quality of the Sava was far weaker than in the previous periods of investigations.

According to the results obtained in 2000 it may be seen that the number of coliform bacteria varied considerably depending on localities.

During March the lowest number of coliform bacteria was found in the locality 15 where it accounted to 2.2x10 , the greatest being in localities 1 and 5, where it accounted to 2.4x10. The great number of coliform bacteria was found in locality 6 as well, where it was 2.4x10, as well as in localities 4, 8 and 12, where it exceeded the limit allowed for bathing (Tab. 3). In locality 14 coliform bacteria were not found. The number of aerobic mesophylic bacteria considerably differed according to localities. The greatest number was found in locality 6 and accounted to 3.5x10, while the smallest were observed in localities 2 and 7, where they accounted to 1x10 and 2x10, respectively. The great number of aerobic mesophylic bacteria was found in localities 1 and 12, where it was 1x10, whereas in localities 5 and 16 these bacteria were absent. The presence of sulforeducing clostridia was observed in localities 1,2,4,5,and 16 while the bacteria of the genus *Proteus* were found only in locality 5. *Bacillus* spp. was found only in localities 4 and 13, while *Pseudomonas aerugynosa* was not observed in any locality (Table 3).

As for physico-chemical parameters, maximum air temperature was 4.5 C in localities 4 and 5, whereas minimum was 0.5 C in localities 7,9 and 11. The highest water temperature was registered in locality 6, i.e. in the sample of waste water from "Žitoratar" and accounted to 11 C, while the lowest was 0.5 C (Table 4).
On the basis of the data from April, shown in table 5, it may be seen that the number of coliform bacteria considerably differed from most localities in relation to data recorded in March. The highest number was found in localities 2 and 7 where it accounted to 2.4x10, while the lowest was in locality 1 (2x10). The great number of coliform bacteria was also found in localities 6 and 17 considerably exceeding the limit allowed for bathing. In other localities the number of bacteria was not high, varying from 2.2x10 to 1.2x10. Similar to the previous period of investigation, in locality 14 coliform bacteria were absent. When compared to that period the number of aerobic mesophylic bacteria was much lower, varying from 5x10 (locality 6) to 1x10 (localities 1, 11, 12, 16). Among identified bacteria the most common one was *Escherichia coli* in addition to it, *Enterobacter aglomerans* and *Citrobacter freundi* were identified. Anaerobic sulforeducing clostridia occurred in localities 6, 7, 11 and 13, while *Proteus spp.* occurred in localities 5 and 12 and *Pseudomonas aerugynosa, Streptococcus faecalis* and bacteria belonging to the genus *Bacillus* were not found in any locality. Using catalase test the presence of *Staphylococcus spp*. was found in all localities.

During that period the air and water temperatures were much higher than those in the previous period due to weather conditions. The highest air temperature was 20.5 C, the lowest 15 C. The lowest water temperature was in the locality 1 and accounted to 10 C, while the highest one was in the locality 6 and accounted to 19 C. As in the previous period, in locality 6, the water temperature differed greatly in comparison to the water temperature in locality 7. The pH values for most samples of water accounted to 7.5 (Table 6).
In the Fig. 1 we may see that the number of coliform bacteria during March 2000 was much greater in the industrial zone where the water samples were taken (localities 4,5,6 and 12) than in other localities downstream from the industrial zone where that number was much lower, being lower than the limit allowed for bathing. The results obtained by analysis of the waste water from the mill "Žitoratar", where the great number of coliform bacteria occurred due to the high temperature of waste water and its contents, are very significant. However, the number of these bacteria in the Sava just after the influx of waste water was far lower, which may be explained by the low water temperature of 0°C. Due to the same conditions the number of aerobic mosophylic bacteria in the sample of waste water was remarkably high. The increased number of coliform bacteria, as well as mesophylic ones, and along with it sulforeducing clostridia in locality 4 points to the fecal pollution and reduced ability for selfpurification, which may be explained by the settlement (weekend cottages) spreading along the Sava, downstream from this locality. The great number of coliform bacteria together with P.spp., sulforeducing clostridia in locality 5 was probably caused by the fact that around 30 m in front of this locality there is a restaurant, 10 m far from the Sava bank, so that there is a possibility that waste water from this object flows directly into the Sava. The finding of *Proteus spp*. in locality 10, as earlier mentioned, points to the fecal pollution and pollution by organic matter which decays. Besides mentioned localities, the presence of sulforeducing clostridia in other localities (Table 3) points to the fecal pollution and increased biodegradation. The presence of *Bacillus spp*. could be explained by the fact that it is soil bacterium, and came into water by washing off the soil due to changing of the water level of the Sava.

During April the temperatures were much higher than in the previous period, which favoured much better conditions for multiplication of bacteria. The great number of coliform bacteria and mesophylic ones in locality 6 as in the previous period was caused by the contents of the waste water and its high temperature. The effect of this was the abundance of these bacteria in the Sava immediately after the influx of waste water into it. Since in these localities the presence of anaerobic sulfidoreducing clostridium bacteria was observed, it showed that fecal pollution and anaerobic conditions prevailed in the Sava. Since during that period of investigation the bacteria belonging to the genera *Proteus*, *Pseudomonas aerugynosa* and *Streptococcus faecalis* were not found, we may conclude that the pollution by organic matter was smaller than that in March 2000.

CONCLUSION

On the basis of the obtained results and comparing them with the standard values for classification of waters, we may state that during 1998 the water of the Sava belonged to the third and fourth classes, during 1999 to the second class and during March and April 2000 also to the second class of water quality.

Comparing the results of bacteriological analyses from the studied periods, we came to the conclusion that the Sava was the least polluted in summer 1999, and the most polluted in winter 1998. In March 2000 the pollution of the Sava was greater than in April.

During winter 1998 the factories and industrial installations along the course of the Sava worked with full capacity. Those are primarily the factory of milk products “Mlekara-Šabac” and the mill “Žitoratar”, the products of which flowed into the Sava, causing together with restaurants along the river, the greater pollution and degree of saprobic quality in the river water.

The obtained data show that the process of selfpurification of the Sava water is intensive outside the industrial zone, pointing to the fact that the Sava water in that area belongs to the second class of water, and even to the first class at some points.

All mentioned above show that the industry zone along the Sava has a harmful effect on ecology of this river because of the pollutants produced in it and disturbs ecological balance and increases the degree of biodegradation of this river.