DANUBE QUALITY WATER ASSESSMENT FROM THE MICROBIOLOGICAL POINT OF VIEW IN CERNAVODĂ NUCLEAR PLANT AREA

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Herein are analysed the following microbiological parameters: total viable count, total coliforms and faecal coliforms, which represent a standard indicator for water quality. The study has been done during 1998 – 2002 upon the water in the Danube River and in the channels for cooling water used by Cernavodă Nuclear Power Plant condensers. In this area, based on these values of evaluated parameters, the water feature is placed in the quality classes II and III (moderate and critical pollution), in conformity with European Community Directives.

Key words: microbiological water quality, total coliforms, faecal coliforms.

INTRODUCTION

Bacterial communities, component part of aquatic biocenosis, are very important for matter and energy flux. Their contribution to self-purification processes of rivers is of great interest regarding the scope of water quality assessment.

Microorganisms are ideal sensors, because they respond fast to the fluctuation of environmental conditions by specific changes, detectable physiologically and metabolically (6).

The temperature is a major factor, which directly affects the intensity of all microbial processes. Because the microorganisms are interconnected with the other living organisms, the qualitative or quantitative changes of their activity will affect the functions of the whole ecosystem (3), (5).

Bacterial indicators such as total viable count (colony count), total coliforms or faecal coliforms (thermo-tolerant coliforms) are widely applied to the assessment of water quality. Because of their mostly allochthonus origin, these are used as indicators of changes in the natural water conditions; they point out an organic matter or faecal water pollution (2), (4).

Although the water quality can be considered acceptable from the chemical or biological point of view, the bacteriological parameters might be detected in critical concentration.

The objectives of this microbiological assessment are:

– analysis of the variation of bacteriological indicators in some sampling points of Cernavodă aquatic ecosystems area, monitoring the manner of using the water by cooling systems in the nuclear power plant;

– assessment of bacteriological quality of water by analysing the response of bacteriological parameters to anthropogenic impacts, respectively to water changes caused by thermal conditions;

– evaluation of water capacity, from the microbiological point of view, to tolerate a higher temperature growth, in the situation of two functioning units at Nuclear Power Plant (NPP) Cernavodă;

– conclusions and recommendations for monitoring these parameters in the future.

MATERIAL AND METHODS

The water samples have been collected in sterile borosilicate glass bottles, from depths of 0.2–0.3 m, stored and transported in refrigerating bags. Within 24 h they were processed in lab conditions.

The analysed indicators are:

– total viable count (TVC) which grows at 22°C – an indicator for water pollution by easily degradable organic matter;

– coliforms bacteria (total coliforms-TC) – these organisms are doubtful for a faecal pollution in aquatic medium;

– thermo tolerant coliforms (faecal coliforms-FC) – a very good indicator for faecal water contamination.

The bacteriological analysis methods were those from STAS 3001 – 91 – "Water – the bacteriological analysis":

– aerobic colony plate count number at 22°C;

– the tubes methods for establishing the most probable number for total and faecal coliforms.

To facilitate the interpretation of microbiological results, the EU-Bathing Water Quality Directive 76/160 EEC (5) and new EU-expert proposal were taken into consideration (6), (Table 1).

There were six stations for sampling (Fig. 1):

– Station no. 1 (S_1): The Danube River 300.5 km, 500 m upstream from the Danube – Black Sea Channel (DBSC);

– Station no. 2 (S_2): influent (incoming) cooling water – Bridge NPP – "Bief I" of The Danube – Black Sea Channel (DBSC);

– Station no. 3 (S_3): effluent cooling water – Seimeni Gallery;

– Station no. 4 (S_4): effluent cooling water – Evacuation Channel;

– Station no. 5 (S_5): The Danube River, 100 m upstream from cooling water effluent confluence; 200 m downstream from Cernavodă city waste water;

– Station no. 6 (S_6): The Danube River, 500 m downstream from cooling water effluent confluence.

RESULTS AND DISCUSSIONS

During 1988 – 2002, 120 samples were taken from 6 stations (Fig. 1).

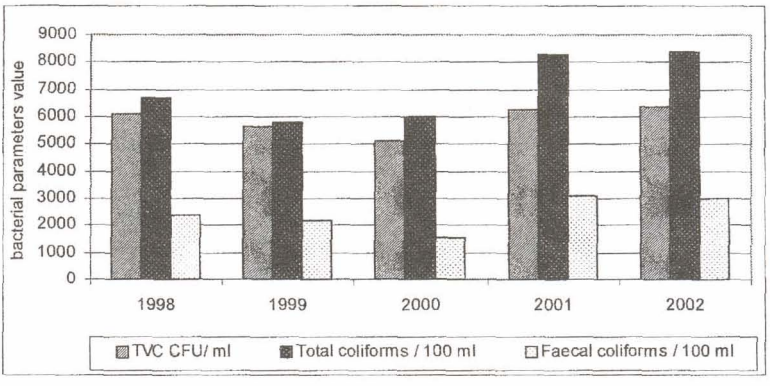

Fig. 1 – Station number 1 – Time variation of bacterial parameters.

Each station will be analysed because their locations are influenced by particular factors.

The Station no. 1 (Fig. 2) is a reference station, placed upstream from NPP (cooling water) and from waste water outpour of Cernavodă city too. TVC varied between 3,500 CFU / ml and 8,900 CFU / ml with 5,905 CFU / ml average value and the water join in the quality class with moderate degree of pollution by organic matter (class II). From faecal pollution point of view the water quality oscillated between moderate and critical pollution classes with 4,300 and 14,000 total coliforms / 100 ml limit values (7,025 TC /100 ml average value) and 270 and 4,600 FC / 100 ml limit values (2,434 average).

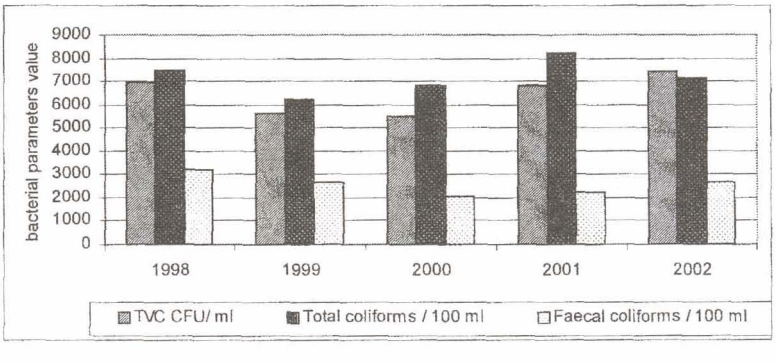

Fig. 2 – Station number 2 – Time variation of bacterial parameters.

The Station no. 2 (Fig. 3) is located upstream from Cernavodă sluice of the Danube – Black Sea Channel, Bief I. Here the water could be characterized having the same quality like the Danube River. But in the selected sampling point the water can have another temperature, because in the winter the water of NPP cooling system is recirculated in adduction pool for an optimal working. Comparatively to station number 1 it is noticed a light growth for TVC number with 6,470 CFU / ml average value (3,900 and 9,700 CFU / ml limit values); this growth could be influenced by the feature of working of NPP specified herein before and by the specific parameters of the derived channel (depth and water speed). From coliforms point of view the water quality varied between some faecal pollution classes (moderate and critical), the TC limit values were 3,300 and 14,000 / 100 ml (7,890 TC / 100 ml average value) and 700 and 4,900 FC / 100 ml limit values (2,565 FC / 100 ml average value).

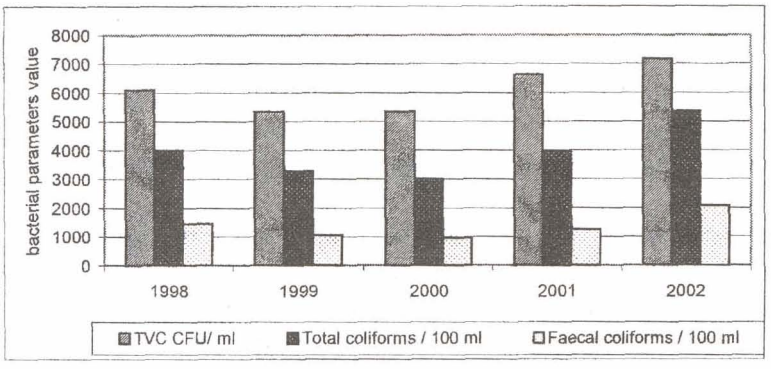

Fig. 3 – Station number 3 – Time variation of bacterial parameters.

The Station no. 3 (Fig. 4) is located nearby the cooling water output gallery. Though having the highest temperature values, the water does not have also the highest bacteria charge. This fact can be attributed both to the cooling system filters and the thermal shock. TVC is situated between 2,290 and 8,500 CFU/ ml with the average 6,110 CFU/ ml. These values state the same class of moderate pollution by organic matter for this water. The TC average value is 3,565/100 ml with the limits 1,700 and 9,400/100 ml – that means a moderate faecal pollution class. The FC average value in this station was 1,335/100 ml, with 600 and 3,400/100 ml limits and the water quality exceeds the moderate (faecal) pollution class and for this reason it is placed in a critical class of pollution.

The Station no. 4 (Fig. 5) is located on the channel in a place with low speed and the water has the greatest bacteriological charge with TVC average 8,230 CFU/ml (the limit values are 4,900 and 11,200 CFU/ml), the TC average 8,585/100

ml (limit values 4,900 and 17,000) and the FC average 2,960/100 ml (limit values are 1,700 and 7,000). Though these values are greater than the values from the other stations, the water quality maintains the same pollution classes.

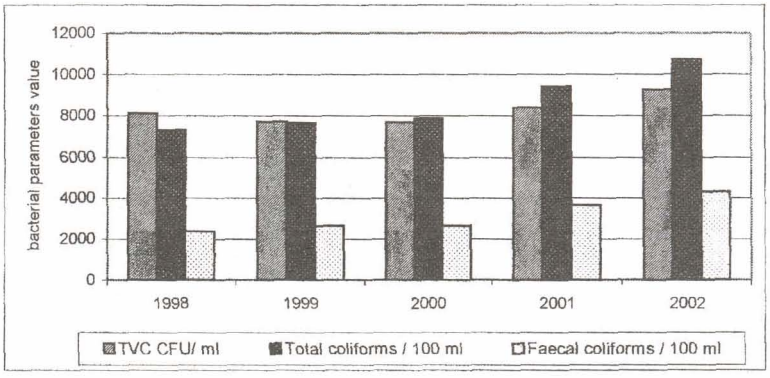

Fig. 4 – Station number 4 – Time variation of bacterial parameters.

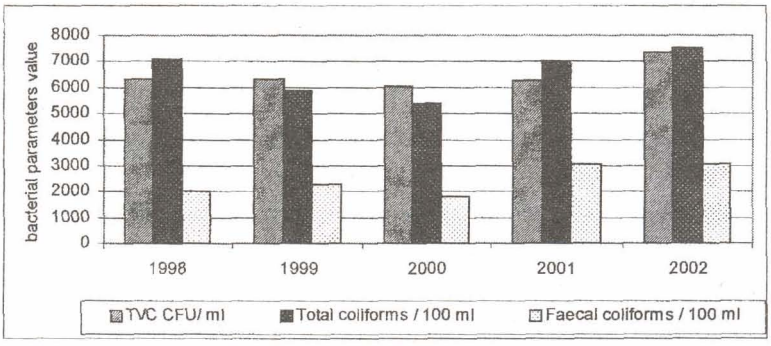

Fig. 5 – Station number 5 – Time variation of bacterial parameters.

The Station no. 5 (Fig. 6), located upstream from cooling water channel for NPP Cernavodă, was chosen for the influence of wastewater city, which could change the bacteriological values parameter of the Danube River. The average value of TVC was 6,453 CFU/ml (with 2,760 and 7,800 limit of values), TC was 6,320/100ml (with 4,300 and 11,000 limit of value) and 2,425 FC/100 ml (with 900 and 4,900 limit of value). These values put the water in the same quality classes.

In the Station no. 6 the water still keeps the thermo contribution of the heat affluent; the thermo charge of the Danube water oscillated, given Station no.1, function of season and river flow rate, between 3°C (May 1998 and May 2000) and

7.2°C (August 2001). The water keeps the same quality classes, both from organic matter pollution and faecal pollution point of view. The average value TVC was 7,091 CFU/ml (with 910 and 10,600 limit of value), TC was 7,945/100 ml (4,600 and 17,000 limit of values) and FC was 2,745/100 ml (1,400 and 4,600 limit of values).

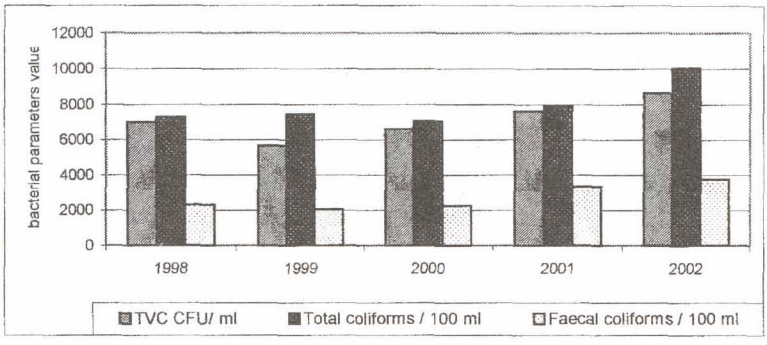

Fig. 6 – Station number 6 – Time variation of bacterial parameters.

Temperature is a basic factor, which influences the microbial growing rate. For the water sampled from Reference Station (no.1), it has not been found out any certain direct dependence of bacterial pollution with seasonal temperature variation of the river. In the Station no. 6 increasing values of the monitoring parameters correlated with the temperature of the water from NPP have been observed. These parameters values could be also correlated with the increase of the flow rate of the river. This proved the Danube capacity for self-purification and for tolerating a more bacterial quantity determined by heated effluent of NPP.

The water provided by the "Bief I" Danube Black-Sea Channel, passing through the cooling system of the NPP, suffers an increase of the temperature by an amount of up to 16 °C. Initially, in the effluent cooling water, in the zone of the Station no. 3, a decrease of the bacterial parameters value is observed. But further, when the flow decreases, nearby the junction of the Seimeni Channel with the Danube, the water pollution is growing. Finally, this value decreases due to the water of the river, which acts as a purifier.

In accordance with the classification limits for the quality of the water based on the evaluation of bacteriologic parameters (Table 1), the results of the microbiological analysis for each of the six Sampling Stations are presented herein (Table 2).

Table 1

Class limit values for bacteriological indicators

INDICATOR	CLASS				
Pollution by organic matter	I	II	III	IV	V
	low	moderate	critical	strong	excessive
Colony count at 22 °C / ml	< 500	500–10.000	10.000–100.000	100.000–1.000.000	>1.000.000
Faecal pollution	low	moderate	critical	strong	excessive
Total coliforms/ 100 ml	< 500	500–10.000	10.000–100.000	100.000–1.000.000	>1.000.000
Faecal coliforms /100 ml	<100	100–1.000	1.000–10.000	10.000–100.000	>100.000

Table 2

The Danube's Water Quality Pattern around Cernavodă area, expressed by microbiological parameters

Parameter	Year	TVC	Total coliforms	Faecal coliforms
Station		CFU/ ml	/ 100 ml	/ 100 ml
Station no. 1 – Danube – 300.5 km; 500 m upstream from Danube – Black Sea Channel	1998			2375
	1999			2175
	2000			1543
	2001			3100
	2002			2975
Station no. 2 – influent cooling water – Bridge NPP – Bief I DBSC	1998			3200
	1999			2675
	2000			2075
	2001			2225
	2002			2650
Station no. 3 – effluent cooling water – Seimeni Gallery	1998			1450
	1999			1050
	2000			
	2001			1250
	2002			2075

Table 2

(continued)

Station no. 4 – effluent cooling water – Evacuation Channel	1998		2375
	1999		2650
	2000		2675
	2001		3650
	2002	10700	4300
Station no. 5 – Danube – 100 m upstream from cooling water effluent confluence; 200 m downstream from Cernavodă city waste water	1998		2000
	1999		2275
	2000		1775
	2001		3025
	2002		3050
Station no. 6 – Danube – 500 m downstream from cooling water effluent confluence	1998		2300
	1999		2050
	2000		2250
	2001		3350
	2002	10050	3775

CONCLUSIONS

– From the microbial point of view, in all analysed probes, the monitored bacterial factors have moderate or almost critical values of pollution; TVC heterotrophic bacteria varied between 5125 and 9250 CFU / ml, total coliforms between 3 000 and 10 700 / 100 ml and faecal coliforms between 950 and 4 300 /100 ml;

– Despite the appreciable increase of the water temperature along the cooling system of the NPP, this fact does not generate a significant growing of the monitored bacteriologic factors.

– If the water temperature decreases, the value of the bacterial concentration decreases too, the Danube providing an important self-purification process;

– When the Second NPP Unit is in function it will be necessary a continuous monitoring process for the bacterial factors, for a quick reaction to a possible modification of the actual state of the aquatic ecosystems.

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