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SOME ECOLOGICAL CHARACTERISTICS OF A BROOK WATER*

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The water of a mountain brook was analysed and selected water quality parameters were determined. The pristine mountain brook water contained the smallest numbers of microorganisms whereas in the polluted water body downstream, the values of chemical oxygen demand, biochemical oxygen demand after five days and the count of specific indicator organisms (faecal coliforms) were increased.

Key terms: biochemical oxygen demand values, chemical oxygen demand values, indicator microorganisms, water quality, water pollution

The homeostasis of aquatic ecosystems is maintained in a large part by members of the microbial community. The combined metabolitic activities of the various microbial populations function in the cycling and regeneration of materials within these systems. In flowing-water systems the smallest numbers of microorganisms are found in pristine mountain streams in which the nutrient concentration is very low. As the waters flow toward the low lying areas more nutrients enter the water and the number of organisms increases (1).

Routine monitoring of flowing-water systems is conducted for the purpose of detecting the presence of faecal wastes which may in turn contain certain pathogenic bacteria hazardous to public health (2–4). Watercourses are classified into four classes according to use: water supply, bathing, fish spawning and general use. So, the determinants which serve to produce index scores for the water uses are: dissolved oxygen, pH, suspended solids, turbidity, temperature, biochemical oxygen demand (BOD_5), ammonia and faecal coliforms (5). Some of these determinants were adopted in this work.

Increasing quantities of municipal, industrial and agricultural wastewaters enter streams, lakes and brooks, so that the chemical and biological characteristics of water are completely changed. The objective of this work was to analyse the water quality of the Veliki Potok brook, which flows from Mt. Medvednica through urban (individual homeowners) and industrial zones of the city of Zagreb before entering the Sava river.

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MATERIALS AND METHODS

Sample collection. Water samples were taken at seven sampling sites along the Veliki Potok brook on its way from Mt. Medvednica to the recreational Lake Jarun (Figure 1). The first two samples were taken in a wood, the third was collected in an urban zone (individual homeowners), the fourth, fifth and sixth in a mixed urban and industrial

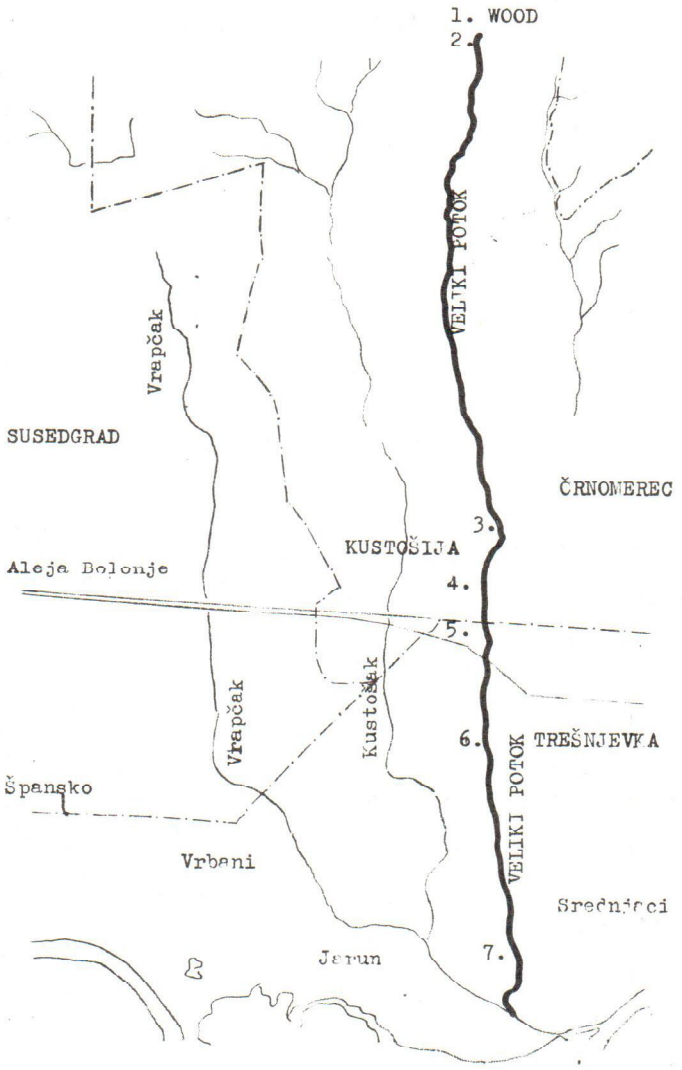

Figure 1 *Topographic chart of the Veliki Potok brook (Sampling sites marked 1 to 7)*

zone the seventh from nearby Lake Jarun. Sampling took place at the beginning of June, at the end of July and in the middle of December 1990; sample series were marked A, B and C. Water samples were collected in 500 ml sterile storage bottles, placed in coolers with ice packs and transfered immediately to the laboratory for processing.

Bacterial count. Standard plate count was made by the pour plate method (6) after 24 h incubation at 37 °C in nutrient agar inoculated with a 1 ml water sample and expressed as colony forming units (CFU) per millilitre. When the water was highly contaminated, dilutions (1/10, 1/100 or 1/1000) were made initially. For the detection of total coliforms a multiple-tube technique using Andrade lactose broth and confirmed test on Endo medium at 37 °C for 48 h were applied. Identification of faecal coliforms was carried out using brilliant green bile broth at 44.5 °C for 24 h (6). Anaerobic bacteria (sulphite reducers) were counted using sulphite agar in a deep column according to Baker (7) at 37 °C for 48 h and all water samples were previously inactivated at 80 °C for 5 min. The media for bacterial count were products of Difco, Detroit, Michigan, USA.

Physical and chemical water quality tests. Several physical and chemical determinants of water quality were measured: pH (Model PHM 28C, Copenhagen, Denmark), water temperature at sampling site and temperature of ambient air, dissolved oxygen, chemical oxygen demand (COD) and biochemical oxygen demand (BOD). The COD was measured using standard methods (6) and BOD was determined after five days of incubation (BOD_5) in a thermostat (MLS Electromechanics and Electrotechnics, Izola, Slovenia).

RESULTS

The physical characteristics and pH values of the water at seven sampling sites along the Veliki Potok brook are shown in Table 1.

Differences in water and ambient air temperatures at sampling sites were due to change of season (summer/winter); other parameters did not change to any great extent.

The dissolved oxygen concentrations of all water samples are shown in Figure 2. At sampling sites 4, 5 and 6 in some series there was no oxygen present. Measurements of COD and BOD_5 in the brook water (Figure 3a and b) showed the highest COD values to have been present at the third and fourth sites while BOD_5 values were constantly elevated after the third site.

The microbial water quality was compared in samples taken from different sampling sites (Figure 4a and b). The bacterial population differed significantly from one site to the other and averaged between 10^2 and 10^7 CFU/ml. The total coliform number in the upper brook section was low but grew higher downstream (most probable numbers 10^2 and 10^6 per 1000 ml, respectively). Although only a qualitative test was carried out, faecal coliforms were identified in all water samples after the second site. Analysis of water samples for anaerobic bacteria, such as sulphite reducers, failed to prove their presence at the first three sites but all the way from the fourth to the seventh site their number grew from 1.4×10^2 to 8.2×10^3 CFU per 1000 ml (Figure 5).

DISCUSSION

Selected water quality determinants were monitored in the Veliki Potok brook from June till December 1990. The water in the upper part of the brook was clear, clean, the pH 6.5. Water temperature was not stable because the brook was shallow (Table 1). The values for dissolved oxygen, COD and BOD_5 as well as bacteriological parameters were

Table 1 *Physical characteristics and pH values of water at sampling sites along the Veliki Potok brook*

Sampling sites	Series	Appearance	Temperature °C		pH	Depth/m
			air	water		
1 wood	A	clear	17.1	12.6	6.5	0.15
	B	clean	17.5	15.2	6.5	0.17
	C	pure	5.0	4.3	6.5	0.13
2 before urban zone	A	clear	15.0	12.6	6.5	0.17
	B	clean	17.6	16.2	6.5	0.19
	C	pure	5.0	4.3	6.5	0.16
3 Črnomerec	A	less	15.0	12.2	6.5	0.43
	B	clear	28.0	18.6	6.5	0.44
	C		5.0	4.1	6.5	0.42
4 urban zone	A	muddy	21.0	19.1	7.5	0.49
	B	dirty	29.0	21.2	7.0	0.52
	C		6.0	4.9	7.5	0.47
5 industrial zone	A	muddy	21.0	20.0	7.5	0.48
	B	dirty	28.0	21.4	6.9	0.50
	C		–	–	–	–
6 industrial zone	A	muddy	21.2	19.6	7.5	0.55
	B	dirty	28.0	19.8	6.7	0.57
	C		5.9	4.3	7.0	0.52
7 near Lake Jarun	A	muddy	21.0	20.0	7.0	0.54
	B	dirty	29.0	22.8	6.7	0.55
	C		6.0	4.2	7.0	0.53

quite satisfactory (Figures 2–4). According to Croatia's water quality legislation (8), the brook water in its upper part (the first two sampling sites) could be classified as belonging to the water categories I and II. The water may be used after extensive treatment as public water supply; occasional contact use is permitted such as swimming or stock watering, fishing etc, as reported by *Smith* (5).

Entering the urban and industrial zones (sampling sites 3–7) the water became muddy, dirty and dark and the pH value slightly increased (to 7.5). In summer, water temperature rose up to 22.8 °C because the brook was not entirely overshadowed by trees like in its upstream part where the water temperature was about five degrees lower. Dissolved oxygen in water samples drastically decreased, especially in summer so that at the sampling site 5 oxygen was not present (Figure 2), while COD and BOD_5 values increased. Microbiological surveys show that the bacterial number rose up to 10^7 CFU (Figure 4a) and anaerobic bacteria were present in abundance (Figure 5). Due to lack of oxygen in water and forming of anaerobic zones, the proportion of gram-positive microorganisms

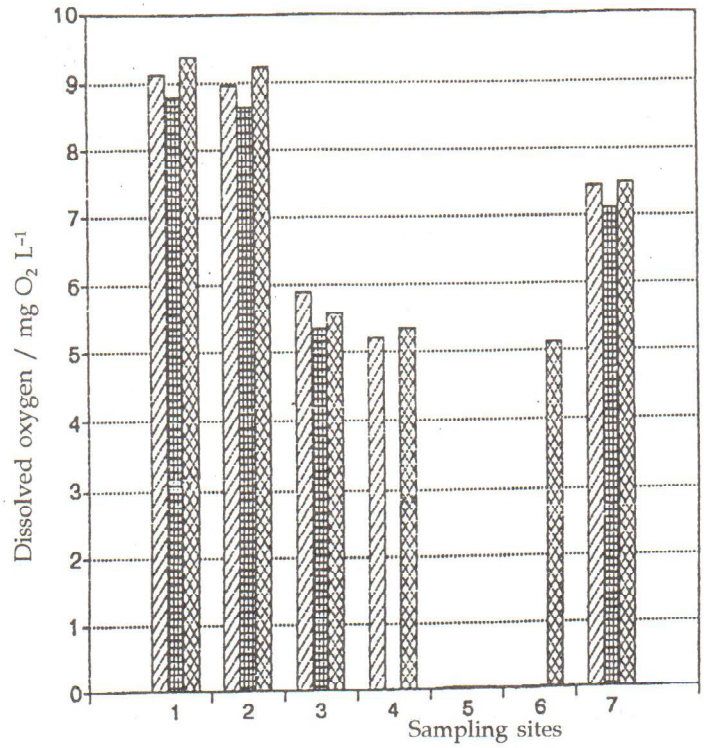

Figure 2 *Concentration of dissolved oxygen in the water (Series A ▨, B ▦, C ▩)*

increased. Thus the brook water in that part belonged to category IV meaning that the water was unsuitable for any use. *Bergstein-Ben Dan and Stone* (4) reported that each bacterial species had its own specific survival rate and unique characteristic determining its distribution over the length and depth of the water and time as well.

Fifteen years ago *Munjko* (9) reported that the Veliki Potok water in the city district of Črnomerec (sampling site 4) belonged to the categories II and III. The water quality has changed over the past decade because of increase in the population in that part of the city. Many new residences have been built without an appropriate communal sewage system. It is assumed that individual homeowners discharge wastewater, primarily gray-water into the brook. Graywater (2) is defined as all wastewater in the household, excluding toilet wastes. Our results show that the brook water contains a high bacterial count including the presence of coliforms. That implies a great risk to human health, because of possible presence of other intestinal pathogens. Nevertheless, at the last sampling site some parameters (dissolved oxygen, COD and most probable number) show ecological improvement of water quality, which might be due to ceasing of wastewater input and to the process of autopurification.

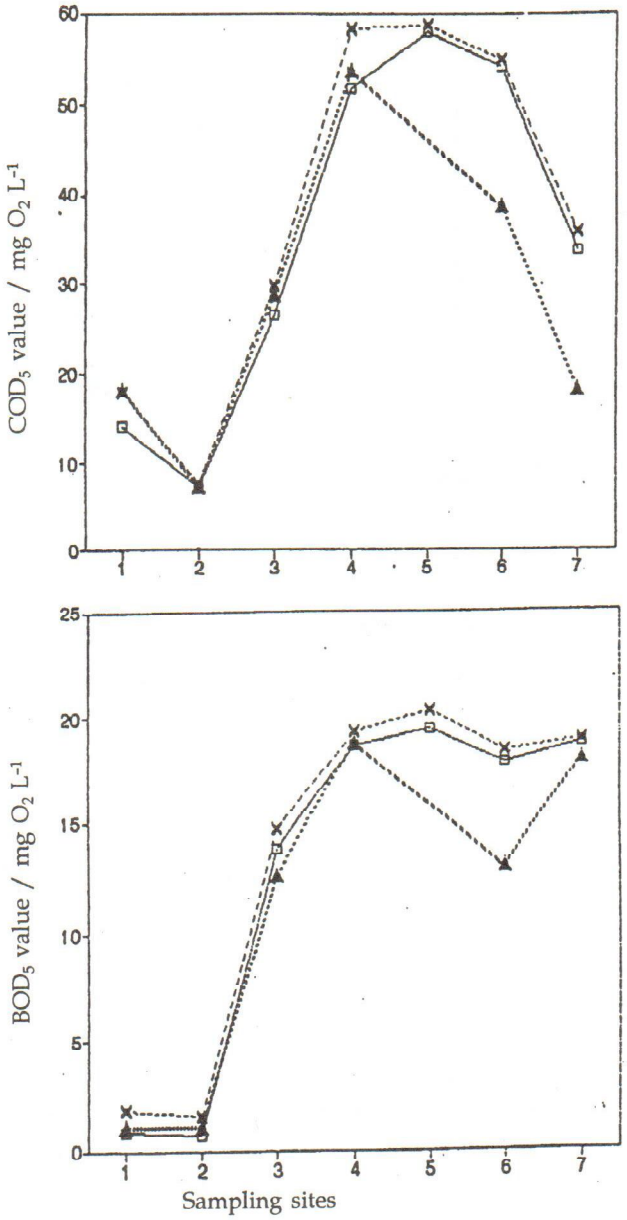

Figure 3 *COD values (top) and BOD_5 values (bottom) determined in the brook water (Series A□; B-×; C-▲-)*

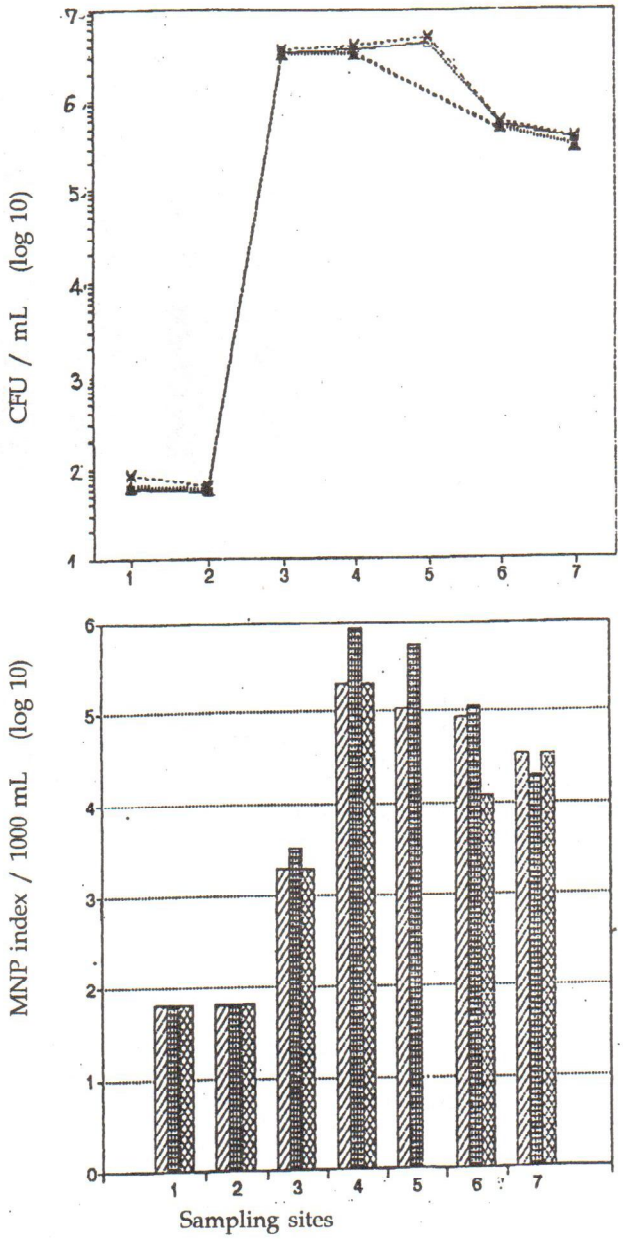

Figure 4 *Bacterial number (top, Series A-□, B-×, C-▲) and most probable number of total coliforms (bottom) in the brook water (Series A ▨, B ▦, C ▩)*

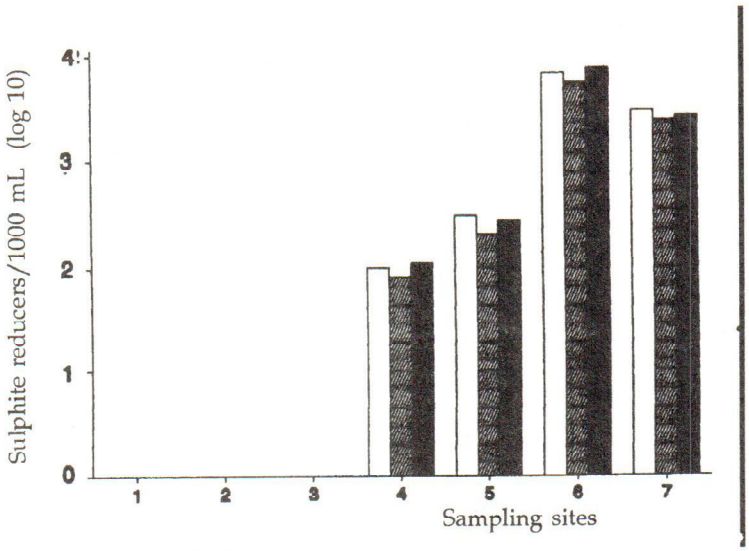

Figure 5 *Presence of anaerobic sulphite reducers in the brook water (Series A □, B ▨, C ■)*

CONCLUSION

This study was designated to evaluate the quality of the brook water. From the results obtained and in accordance with the Croatian water legislation criteria the water in the upper part of Veliki Potok can be classified into categories I and II, while in the lower part (urban and industrial zones) into category IV. The main problem is that over the past decade many private residences have been built in that part of the city unaccompanied by a proper communal sewage system. Thus, large volumes of wastewater have been entering the brook bringing along a high number of coliform bacteria and anaerobic microorganisms.

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Sažetak

NEKE EKOLOŠKE KARAKTERISTIKE POTOČNE VODE

Ispitana su osnovna obilježja vodotoka Veliki Potok koji izvire u Zagrebačkoj gori i teče kroz zagrebačke općine Črnomerec i Trešnjevka. Uzorci vode uzimani su na sedam mjesta duž vodotoka i određivani su fizikalni (temperatura, pH, dubina), kemijski (otopljeni kisik, kemijska potrošnja kisika) i biološki (ukupni broj mikroorganizama, najvjerojatniji broj koliformnih bakterija, sulfitoreducirajuće bakterije, biološka potrošnja kisika) pokazatelji onečišćenja vodotoka. Ustanovljeno je da je voda na izvorištu vrlo čista (prva kategorija), no zbog aktivnosti okolnog stanovništva ona se postepeno zagađuje tako da pri utoku u potok Kustošak poprima karakteristike vodotoka četvrte kategorije kojom su obuhvaćene sve one vode koje se ne smiju koristiti za piće, u prehrambenoj industriji, za uzgoj riba i rekreaciju.

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Ključne riječi: biokemijska potrošnja kisika, indikatorski mikroorganizmi, kemijska potrošnja kisika, kvaliteta vode, onečišćenje vode