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WATER QUALITY AND BIOTIC COMMUNITY COMPOSITION OF A HIGHLAND STREAM INFLUENCED BY DIFFERENT HUMAN ACTIVITIES

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Abstract

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The aim of the present study was to evaluate the influence of different human activities on water quality and benthos composition in the Ošetnice Stream that is located in the Western Carpathian Mountains. During the whole period of our monitoring, the high concentrations of dissolved oxygen and low content of organic matters were determined. Upstream part of the Ošetnice Stream is affected by long term building activities concerning railway tunnels and by the motorway along the stream that is in winter chemically treated to assure negotiability. Ski area situated close to the stream was used 110 days during the monitored period. Average daily visit was 590 persons. In winter, when road salting was used, concentrations of chlorides, sodium and calcium were noticeably increased in the stream tributaries which had an impact on monitored water parameters. Water quality assessment using macrozoobenthos and phytobenthos indices revealed the environmental state in a range from moderate to good. Decrease of salmonid community in the stream corresponds to start of road use in the year 2002. Salt applied in winter period to ensure road negotiability affected significantly water chemistry of the monitored stream. Deterioration of environmental conditions is mainly due to human activities; nevertheless self-cleaning ability of the stream is high and ensure a fast degradation of pollutants. Thus the biotic communities (except fish) of the Ošetnice Stream have to adapt to changes of the environment within the year.

phytobenthos, macrozoobenthos, hydrochemistry, pollution

Streams and rivers are the first and often the principal recipients of many anthropogenic influences (Petts and Calow, 1996). The characterization of stream conditions requires the assessment of physical and chemical characteristics, as well as the composition and structure of biotic communities. Various methods for evaluating pollution exist, mostly based on a list of indicator organisms. These methods use plankton, periphyton, macrophytes, fish and benthic macroinvertebrates (Rosenberg and Resh, 1993).

High density winter recreation is provided at many areas in the mountains. The streams closed to these ski areas are determined to be a catchment of winter precipitation and the subsequent spring runoff and provide the water for municipal, recreational and agricultural use in downstream parts. The chemical parameters of water and stream benthos community have been impacted below the ski area resulting in altered species composition, decrease of numbers, and biomass. These changes in water quality and in the biotic communities are attributable to salting of the road and construction activities (Molles and Gosz, 1980).

The aim of this study was to evaluate the influence of different human impacts on water quality, benthos and fish in a selected stream in the Western Carpathian Mountains.

MATERIALS AND METHODS

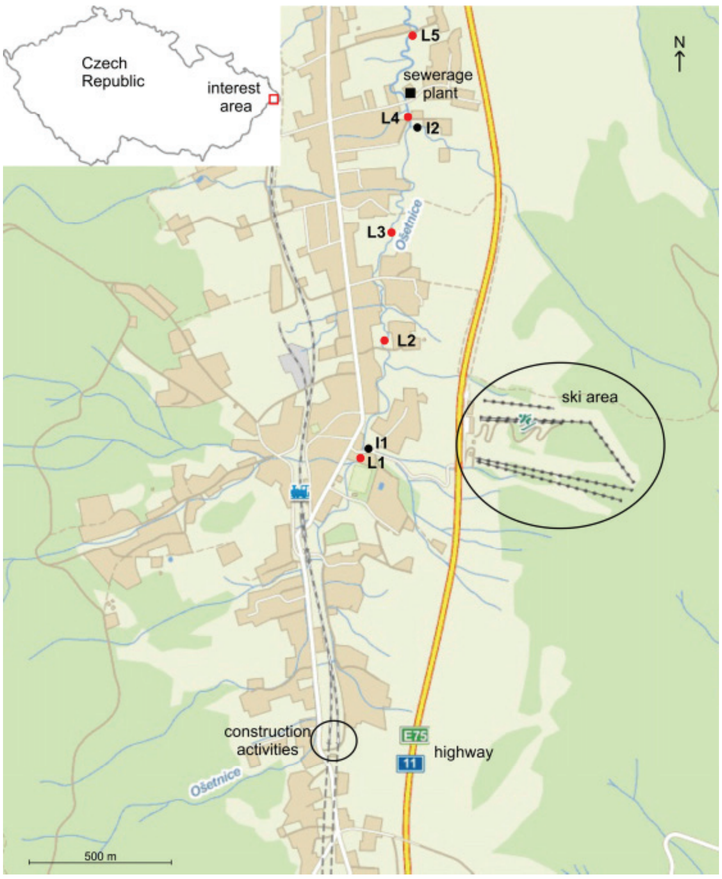
Characteristics of the area of interest

The Ošetnice Stream is the right tributary of the Lomna River into which it empties at the town Jablunkov. In the official intercalibration exercise for the Water Framework Directive, this stream type was named as a small stream in the lower mountainous areas of Central Europe (Hering *et al.*, 2004). The main stream and its tributaries have characteristics of speed/fast running water. The spring of the stream is near the hill of Beskyd at 600 m above sea level; its mouth into the Lomna River lies at 400 m; the main stream is 7.8 km long, average width of the stream is 2 m. Average discharge of Ošetnice Stream not exceeding 0.1 $m^3.s^{-1}$, average discharge of the tributaries from ski area not exceeding 0.01 $m^3.s^{-1}$. The water flow is significantly higher during the snowmelt. Monitored area is located in the upper part of the stream, near village Mosty at Jablunkov (four thousand inhabitants). We monitored five sites on the main stream (L1–L5) and two tributaries (I1, I2) that bringing water from the ski area (Fig. 1).

The Ošetnice Stream is used as a rearing stream to produce stock fish of brown trout (*Salmo trutta* L.). Results of stream management based on annual autumn electro fishing and provided by local organization of Czech Angling Union in Jablunkov are listed in Table I. Upstream part of the Ošetnice Stream is affected by long term building activities concerning railway tunnels and by the motorway along the stream that is in winter chemically treated to assure negotiability. Ski area situated close to the stream was used 110 days during the monitored period. Average daily visit was 590 persons. On the stream, there is a waste water treatment plant

I: *Data concerning fish management of the Ošetnice Stream* (St – *Salmo trutta*, Om – *Oncorhynchus mykiss*)

Year	Fish release (N)	Fish catch (N)
1999	3 000 $St_{1/4}$, 2 000 $Om_{1/4}$	2 248
2000	4 000 $St_{1/4}$, 2 500 $Om_{1/4}$	2 299 St, 541 Om
2001	4 000 $St_{1/4}$	2 530 St
2002	5 200 $St_{1/4}$	2 351 St
2003	4 200 $St_{1/4}$	1 010 St
2004	7 500 $St_{1/4}$	124 St
2005	9 200 $St_{1/4}$	Not catch
2006	7 000 $St_{1/4}$	487 St
2007	4 000 $St_{1/4}$	1 000 St
2008	6 500 $St_{1/4}$	103 St
2009	2 500 $St_{1/4}$, 40 000 St_0	705 St



1: *Map indicating sampling localities (L1–L5) – Ošetnice Stream, (I1, I2) – water inflow* designed for 2100 equivalent inhabitants with the capacity of 360 $m^3.day^{-1}$.

Chemical and hydrobiological methods

Water samples for chemical analyses were collected into plastic bottles from the depth of 10–20 cm. Water oxygen saturation (oxy), temperature (tem), pH, conductivity (cond) were measured at each locality prior taking the samples. Basic physico-chemical parameters (oxy, tem, pH) were measured using a HACH Hq 40d (Hach-Lange, Colorado, USA). Conductivity meter Conmet 1 (Hanna Instruments, USA) was used to assess conductivity. After the transport of water samples into the laboratory, ammonium ions ($N\text{-}NH_4$) were determined using the indophenols method, nitrite nitrogen ($N\text{-}NO_2$) by a method using N-(1-naphthyl)-ethylenediamine and nitrate nitrogen ($N\text{-}NO_3$) by a method using sodium salicylate. Total nitrogen (N_T) was measured with dimethylphenol after the transformation of all nitrogen compounds into nitrate by Koroleff´s method. Total phosphorus (P_T) and orthophosphate ($P\text{-}PO_4$) were measured using ascorbic acid and ammonium molybdenate. The acid neutralization capacity (ANC) was measured by a method using hydrochloric acid, iron ions (Fe) were reduced by ascorbic acid and determined with triazine, sulphate ions (SO_4) were measured using a turbidimetric method with barium, potassium (K) levels were measured by the photometric turbidity method as potassium tetraphenylborate, calcium (Ca) levels were determined by EDTA titration, magnesium (Mg) was measured with phthalein purple to form a violet dye, sodium and chlorine ions (Na, Cl) were measured by the reaction with mercury thiocyanate to mercury chloride. Total organic carbon (TOC) was determined by digestion with sulphuric acid and peroxodisulphate and transformation into carbon dioxide. Chemical oxygen demand (COD) was measured by a method using potassium dichromate (COD_{Cr}) and a method using potash (COD_{Mn}), and the biological oxygen demand (BOD) was determined by the standard diluting method. All the chemical parameters were measured by the standards methods (APHA, 1998). The physico-chemical parameters of the selected localities are given in Table II.

Qualitative samples of zoobenthos were collected with a hand net (25 × 25 cm aperture, mesh size 0.5 mm, sack length 75 cm). Quantitative samples of zoobenthos were collected using a Surber sampler (sampling area 1225 cm^2). The samples for qualitative and quantitative analyses were collected from each sampling locality. Zoobenthos samples were preserved in 4% formaldehyde. The biomass of the zoobenthos was determined by weighing the preserved samples after a standard period of three months.

Epilithic samples of phytobenthos were taken following the European protocol by brushing the surface of 3–5 submerged stones (Kelly *et al.*, 1998) and suspending these samples in 100 ml of water. Fresh samples were stored in an insulated cool box and transported to the laboratory. The most common species of cyanobacteria and algae (except the diatoms) were determined within 24 hours. The Lugol's iodine solution was added for short-term storage. Diatom frustules were cleaned by boiling with hydrogen peroxide to eliminate the organic matter, then they were washed and mounted in Pleurax (Fott, 1954); at least 300 undamaged valves per sample were counted using 1000× magnification to estimate the relative abundance of each taxon in the samples (CEN, 2004, 2010). Quantitative determination of algal biomass was performed using heated ethanol extraction of chlorophyll-*a* (Lorenzen, 1967).

Statistical analysis

Field data were statistically processed using principle correspondence analysis (PCA), Statistica 8.0 software (StatSoft, Tulsa, OK, USA).The data concerning water sampling were inserted into the model as locality data. Logarithmically transformed values of the parameters in Table II and III were input as environmental variables; a correlation matrix was used. The outputs are presented as two plots (date of water sampling and environmental variables) to explain the variability of the first two ordination axes.

RESULTS

Water quality

Table II shows the measurements of the physical and chemical characteristics of the sites in the Ošetnice Stream (L1–L5) and its tributaries (I1, I2). During the whole period of our monitoring, high concentrations of dissolved oxygen and low content of organic matters were determined. In winter, when road salting was used, concentrations of chlorides, sodium and calcium were noticeably increased in the stream tributaries which had an impact on monitored water parameters. Higher concentrations of ammonium nitrogen decreased in downstream direction. During April, extreme pH levels were measured in upstream sites and total nitrogen concentrations were increased within the whole stream. Water pollution was probably due to discharge of waste waters from building site situated several hundred meters above the locality L1. Negative impact of waste water treatment plant on water chemistry was not detected.

Phytobenthos

In total, we found 78 species of algae and cyanobacteria; the most common were Bacillariophyceae (69 species). The species richness of the phytobenthos per site was very similar and we only observed small differences among sampling localities. The dominant genera in all of the sites were *Achnanthes*, *Cocconeis*, *Navicula* and *Nitzschia*. Noticeable differences were observed in

II: *Physical and chemical characteristics of the sampling localities of the Ošetnice Stream (L1–L5) and its water inflow(I1, I2)*

Date	Locality	T	O_2	pH	Con.	TOC	N_T	P_T	N-NH_4	N-NO_2	P-PO_4	N-NO_3	SO_4	Fe	COD_{Cr}	COD_{Mn}	BOD_5	ANC	Cl^-	Ca^{2+}	Mg^{2+}	K^+	Na^+
		°C	%		$mS.m^{-1}$	$mg.l^{-1}$	$mg.l^{-1}$	$mg.l^{-1}$	$mg.l^{-1}$	$mg.l^{-1}$	$mg.l^{-1}$	$mg.l^{-1}$	$mg.l^{-1}$	$mg.l^{-1}$	$mg.l^{-1}$	$mg.l^{-1}$	$mg.l^{-1}$	$mmol.l^{-1}$	$mg.l^{-1}$	$mg.l^{-1}$	$mg.l^{-1}$	$mg.l^{-1}$	$mg.l^{-1}$
24. 11. 2009	**L1**	6.6	91.2	7.51	21.9	7.2	1.4	0.13	0.088	0.006	0.020	1.4	37	0.69	8.3	4.56	1.08	1.18	13.7	20.1	15.3	6.2	29
24. 11. 2009	**I1**	6.9	92.9	7.82	33.3	13.5	1.0	0.03	0.024	0	0	0.8	54	0.22	8.4	4.64	1.32	2.82	24.1	34.2	16.4	5.1	27
24. 11. 2009	**L2**	6.7	95.6	7.83	24.1	8.8	1.4	0.11	0.057	0.002	0	1.4	31	0.50	9.2	4.16	1.12	1.23	15.9	23.2	22.0	6.0	33
24. 11. 2009	**L3**	6.9	96.3	7.72	22.3	8.8	1.7	0.04	0.042	0.001	0.020	1.4	29	0.44	8.8	4.00	1.04	1.18	13.2	22.2	16.1	4.6	23
24. 11. 2009	**L4**	7.1	98.4	7.88	23.3	9.6	1.2	0.06	0.039	0	0.013	1.2	29	0.43	9.7	4.72	1.31	1.23	15.1	23.2	16.5	4.4	27
24. 11. 2009	**L5**	7.4	98.0	7.98	24.3	9.5	1.5	0.07	0.085	0.001	0	1.4	32	0.49	8.8	4.64	1.10	1.28	15.0	23.2	25.6	5.4	26
24. 1. 2010	**L1**	0.1	95.8	6.93	29.0	6.6	1.7	0.03	0.233	0.018	0	1.4	25	0.25	5.3	2.99	0.70	1.18	25.4	21.2	8.6	2.8	23
24. 1. 2010	**I1**	0.1	74.2	7.29	56.7	10.6	1.3	0.01	0.063	0	0	1.3	42	0.08	6.5	2.02	0.74	2.61	54.1	45.3	16.5	2.3	46
24. 1. 2010	**L2**	0	91.3	7.62	38.8	9.2	1.3	0.06	0.136	0.009	0	1.0	29	0.13	5.6	2.34	0.79	1.59	50.4	30.2	11.3	3.7	34
24. 1. 2010	**L3**	0	98.6	7.61	33.0	6.0	1.3	0.04	0.141	0.003	0	1.0	26	0.17	8.3	2.42	0.69	1.38	31.7	27.2	8.4	2.8	26
24. 1. 2010	**L4**	0	96.5	7.50	35.6	8.8	1.6	0.02	0.075	0.005	0	1.5	28	0.12	5.5	2.50	0.75	1.69	33.7	29.2	9.7	2.7	30
24. 1. 2010	**I2**	0	82.8	7.51	60.7	6.3	0.9	0.02	0.116	0.001	0	0.8	43	0.12	9.0	3.15	1.34	2.56	71.0	50.4	16.2	2.1	55
24. 1. 2010	**L5**	0	80.7	7.32	47.5	9.0	3.8	0.07	0.686	0.035	0	2.7	31	0.10	13.3	4.04	1.76	1.74	44.0	32.2	10.6	7.3	35
21. 2. 2010	**L1**	2.3	92.5	7.32	48.7	9.8	3.0	0.07	0.447	0.016	0.041	2.3	29	0.31	10.6	5.09	1.65	1.30	75.5	32.2	18.7	3.0	66
21. 2. 2010	**I1**	1.8	91.8	7.26	82.3	6.8	2.1	0.02	0.170	0.005	0.023	1.5	48	0.16	10.2	6.30	1.23	1.80	143.9	54.4	24.2	1.9	126
21. 2. 2010	**L2**	2.7	91.6	7.46	59.2	5.0	2.9	0.07	0.380	0.028	0.039	2.1	29	0.22	10.8	5.49	1.62	1.50	100.3	34.2	17.7	4.7	84
21. 2. 2010	**L3**	2.8	92.0	7.55	57.6	10.0	3.0	0.06	0.280	0.020	0.032	2.7	29	0.19	11.8	5.82	1.66	1.50	95.0	36.3	20.1	3.2	81
21. 2. 2010	**L4**	2.6	93.8	7.62	56.2	9.5	2.7	0.06	0.296	0.015	0.040	2.3	31	0.21	11.1	5.58	1.57	1.50	93.8	38.3	16.6	2.2	75
21. 2. 2010	**I2**	2.1	91.9	7.58	48.9	7.9	1.5	0.03	0.116	0.009	0.027	1.2	28	0.17	11.0	5.25	1.14	1.30	80.9	34.2	20.5	1.1	69
21. 2. 2010	**L5**	2.8	94.0	7.65	57.9	10.7	2.6	0.07	0.270	0.017	0.050	2.2	27	0.14	12.3	5.90	2.00	1.60	95.3	30.2	19.4	2.2	80
13. 4. 2010	**L1**	5.8	95.2	10.67	31.5	11.4	18.5	0.06	0.527	0.083	0.036	0	26	0.27	10.0	6.08	-	1.65	28.5	28.2	15.8	6.5	36
13. 4. 2010	**I1**	5.5	95.1	8.26	45.1	11.4	1.2	0.04	0.131	0.040	0.096	0	34	0.17	9.8	5.28	-	1.86	64.4	37.3	15.0	3.3	50
13. 4. 2010	**L2**	6.0	98.7	9.80	31.0	13.2	20.3	0.06	0.365	0.074	0.039	0	29	0.29	6.7	5.36	-	1.60	38.3	24.2	15.2	6.0	53
13. 4. 2010	**L3**	6.3	100.0	8.47	22.9	10.3	17.4	0.05	0.079	0.027	0.014	0	45	0.24	6.1	4.88	-	1.28	24.0	22.2	17.8	4.2	39
13. 4. 2010	**L4**	6.6	100.8	8.97	24.5	12.4	19.5	0.06	0.088	0.043	0.033	0	25	0.22	6.4	5.12	-	1.18	25.1	21.2	19.9	5.1	32
13. 4. 2010	**I2**	6.4	97.1	8.12	29.5	9.1	1.0	0.03	0.058	0.001	0	0	26	0.13	7.7	4.48	-	1.38	31.8	29.2	13.1	3.5	38
13. 4. 2010	**L5**	6.8	106.4	8.74	25.1	10.3	17.4	0.06	0.086	0.033	0.029	0	24	0.19	6.0	4.80	-	1.18	25.5	23.2	13.3	3.4	29
30. 8. 2010	**L1**	11.3	96.3	7.84	23.2	5.3	1.6	0.13	0.120	0.064	0.120	0.9	41	0.24	9.4	4.88	2.13	1.48	24.7	28.1	11.6	7.8	18
30. 8. 2010	**I1**	11.7	98.1	8.11	66.5	9.9	0.6	0.04	0	0	0.040	0.3	52	0.08	8.7	4.32	0.38	3.81	95.0	50.1	22.8	4.1	52
30. 8. 2010	**L2**	11.2	95.3	7.73	23.2	5.8	1.5	0.09	0.060	0.038	0.075	0.8	34	0.27	8.6	4.64	0.77	1.48	28.9	30.1	12.0	5.7	27
30. 8. 2010	**L3**	11.5	93.9	7.57	24.9	3.0	1.9	0.08	0.080	0.022	0.074	1.3	34	0.28	9.0	4.40	0.95	1.38	23.8	28.1	11.9	6.1	18
30. 8. 2010	**L4**	11.7	96.1	7.50	25.5	5.3	1.4	0.06	0.030	0.025	0.061	0.8	32	0.26	8.8	4.00	0.74	1.27	25.3	32.1	12.0	5.6	26
30. 8. 2010	**I2**	11.9	97.1	7.63	37.2	4.2	0.7	0.03	0	0.002	0.028	0.3	42	0.14	7.6	4.24	0.44	2.54	38.2	28.1	13.0	4.4	22
30. 8. 2010	**L5**	11.9	93.0	7.58	28.7	5.5	1.3	0.09	0.070	0.012	0.088	0.8	34	0.22	8.8	4.64	0.69	1.48	26.1	32.1	15.4	5.8	24

III: *Indices at the sampling localities (L1–L5) of the Ošetnice Stream. (Mean ± standard deviation)*

Index	L1	L2	L3	L4	L5
Phytobenthos					
Saprobic index CZ (Zelinka and Marvan, 1961)	1.81 ± 0.05	1.66 ± 0.49	1,64 ± 0.45	1.55 ± 0.33	1.62 ± 0.38
Saprobic index AT (Rott *et al.*, 1997)	2.33 ± 0.08	2.15 ± 0.17	2.16 ± 0.21	2.12 ± 0.11	2.12 ± 0.14
Trophic index AT (Rott *et al.*, 1999)	2.66 ± 0.23	2.67 ± 0.14	2.87 ± 0.17	2.49 ± 0.18	2.55 ± 0.43
Trophic diatom index TDI (Kelly, 1998)	73.4 ± 3.1	69.5 ± 11.5	72.6 ± 14.3	72.4 ± 12.8	72.2 ± 13.2
% tolerant taxa to organic pollution (Kelly and Whitton, 1995)	26.0 ± 14.7	18.9 ± 15.5	24.8 ± 10.7	17.3 ± 14.0	32.8 ± 27.8
Chlorophyll a (ČSN ISO 10260)	5.12± 2.82	6.27± 4.93	5.42± 2.64	10.43± 5.61	10.15± 8.76
Macrozoobenthos					
Saprobic index CZ (Zelinka and Marvan, 1961)	1.91 ± 0.09	1.68 ± 0.07	1.88 ± 0.12	1.99 ± 0.27	2.08 ± 0.05
Average score per taxon ASPT (Armitage *et al.*, 1983)	6.05 ± 0.33	6.32 ± 0.24	5.92 ± 0.45	5.67 ± 0.90	5.28 ± 0.01
EPT number of taxa (Plafkin *et al.*, 1989)	9.0 ± 4.4	8.3 ± 2.5	8.3 ± 3.5	7.7 ± 5.0	6.3 ± 3.1
RETI' (Schweder, 1990)	0.62 ± 0.07	0,58 ± 0.05	0.52 ± 0.06	0.59 ± 0.08	0.60 ± 0.06
Biomass (g . m^{-2})	1.45 ± 0.28	1.59 ± 0.27	1.71 ± 0.89	1.63 ± 0.61	1.57 ± 0.34
Abundance (ind. . m^{-2})	702 ± 94	624 ± 177	1029 ± 890	945 ± 414	980 ± 744

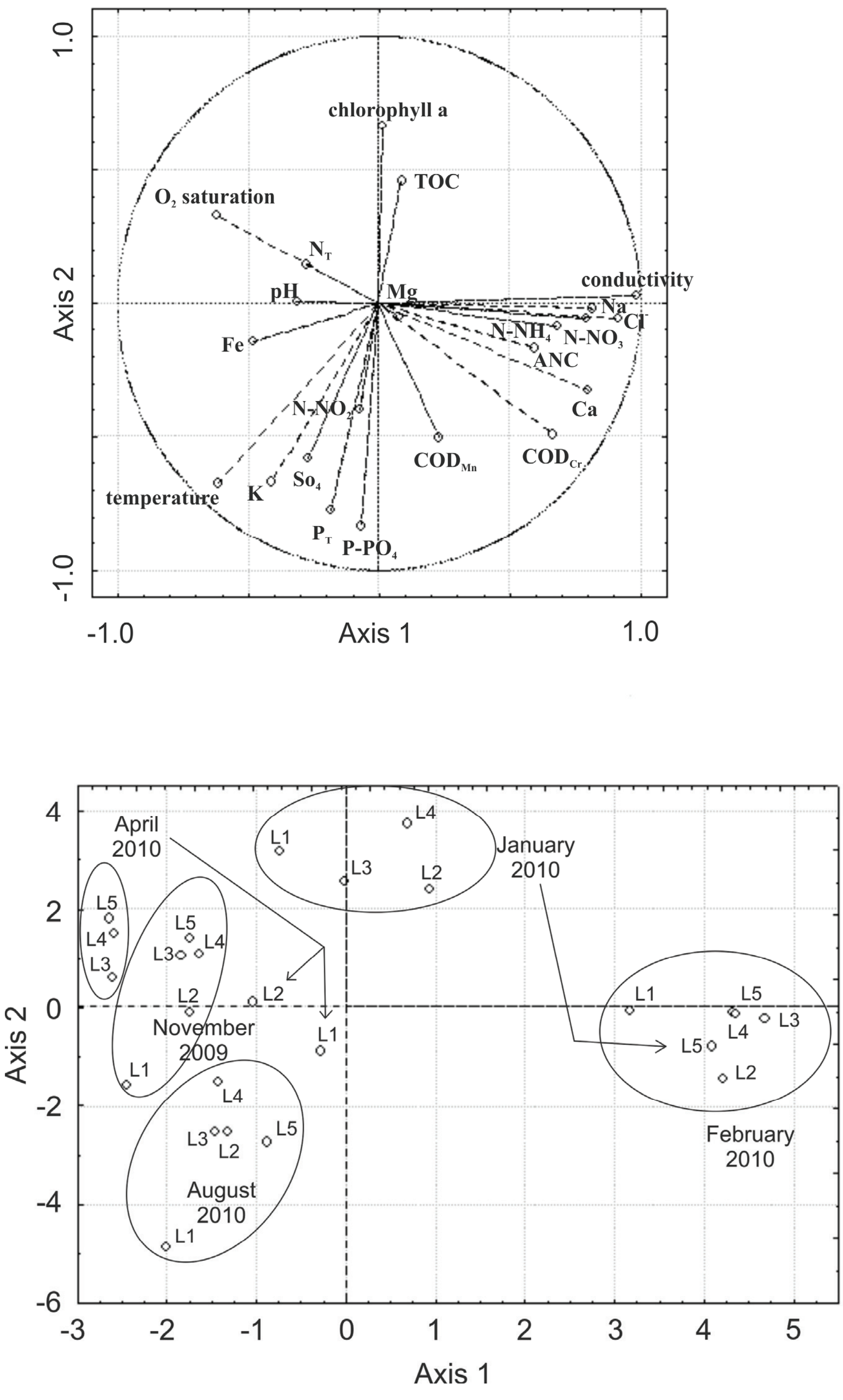
phytobenthos composition during the monitored periods. *Navicula avenacea* dominated within the whole streamcourse in autumn, followed by *Navicula gregaria, N. cryptotenella* and *Achnanthes lanceolata*. The most abundant species in spring time were those of *Navicula* genus (*N. gregaria, N. avenacea, N. cryptotenella*), *Nitzschia* genus (*N. dissipata, N. perminuta* agg.) and *Cymbella minuta* agg. *Cocconeis placentula* occurred during the year rather sporadically however it became a dominant species of phytobenthos in summer. Apart from *Cocconeis placentula*, also *Navicula avenacea, Nitzschia perminuta* agg., *Achnanthes lanceolata, Cymbella minuta* agg. and *C. sinuate* reached higher abundance in summer time. Saprobic and trophic indices (Table III) show good water quality of the Ošetnice Steam. Whereas saprobic and trophic indices have not changed a lot during the year, higher abundance of the species tolerant to organic pollution was recorded in spring.

Macrozoobenthos

Altogether, 72 taxa of benthic macroinvertebrates were recorded in the Ošetnice Stream. The main species of the bottom macroinvertebrates were water insects represented by three important groups; larvae of dipterans (Diptera), caddisfly larvae (Trichoptera) and mayfly nymphs (Ephemeroptera). High number of *Gammarus fossarum* occurred especially in autumn and mayflies of genus *Baetis* dominated in spring and summer time. Water quality assessment using macrozoobenthos indices (Table III) revealed the environmental state in a range from good to very good. Moderate deterioration of water quality was determined at the sites situated downstream.

DISCUSSION

To a certain extent, the chemical composition of the stream water depends on bedrock composition (Lukavský *et al.,* 2006). The Ošetnice Stream is located on siliceous substrate resulting in low concentrations of both organic and inorganic chemical compounds. In general, the water of the Ošetnice Stream can be rather classified as a clean water, even though high concentrations of organic carbon, total nitrogen and increased conductivity were recorded. In fact the values of the monitored physical and chemical parameters compared to the water quality standards (LAWA, 1998; ČSN 757221) were classified as classes I or I–II, except for the values of conductivity and TOC (class III). On the other hand, in accordance with the classification of stream trophic status by P_T and N_T variables, the water of the Ošetnice Stream is eutrophic (Dodds *et al.,* 1998). The values of pH and total nitrogen were notably increased in April. The value of toxic ammonia exceeded the LC_{50} concentration determined by Svobodová *et al.* (1987) for salmonids (0.5–0.8 NH_3) and reached the highest concentration of 0.55 mg.l^{-1} NH_3 at the L1 locality (Table II). The water pollution most likely caused by discharge of waste waters from the construction closed to the monitored locality had negative impact mainly on fish community. Extreme increase of pH in the flow was probably caused by the presence of cement from



2: *The principle correspondence analysis (PCA) ordination of two plots containing water samples and measured physico–chemical parameters performed at the day of water sampling. For chemical abbreviations see the chapter "Material and methods".*

railway tunnel construction above the monitored section (Fig. 1).

Total species richness of phytobenthos in the Ošetnice Stream is comparable with analogous studies from highland streams (Kawecka, 1980; Lukavsky *et al.,* 2004, 2006). Similar diatom structures have been observed in other streams and rivers (Lukavský *et al.,* 2004; Atazadeh *et al.,* 2007). Generally, species belonging to the genera such as *Navicula* and *Nitzschia* are predominant in the lower streams and thrive in nutrient-rich water. This is an indicator of medium-to-low water quality (Kelly and Whitton, 1995).

Species belonging to the genera such as *Achnanthes* and *Cymbella* were more abundant in the cleaner headwater sites. This structure of Bacillariophyceae from the Ošetnice stream is in agreement with the results of other authors (Atazadeh *et al.,* 2007; Centis *et al.,* 2010; Hollingsworth and Vis, 2010). The concentration of benthic chlorophyll-*a* ranged between 0.2 and 26.3 mg. m^{-2}, which corresponds to oligotrophic-mesotrophic conditions according to the classification scheme proposed by Dodds *et al.,* (1998). We observed an increase of Chl–*a* in the downstream samples, reflecting increased nutrient concentrations. On the other hand, the saprobic and trophic indices (Table III), indicate no deterioration in water quality of the downstream sites. The changes in nutrient contents and organic matter in the stream were probably too slight to induce significant changes in species diversity of the phytoplankton. All monitored sites were ranked as eutrophic by the trophic index (Rott *et al.,* 1999) as well as by the trophic diatom index (Kelly, 1998) i.e. as a stream with middle nutrient concentrations and some evidence of organic pollution.

Total species richness of the macrozoobenthos is comparable with analogous studies from highland streams (Dratnal and Kasprzak, 1980; Jurajda *et al.,* 2007). Good and poor water qualities were perfectly indicated by numerous occurrences of *Gammarus* sp. (Amphipoda) and *Assellus aquaticus* (Isopoda), respectively (Jurajda *et al.,* 2007). The genus *Gammarus* occurred abundantly in the Ošetnice Stream especially by the autumn. The indicator of pollution, *Assellus aquaticus*, occurred at a low abundance, during the whole monitoring period and confirmed the good water quality of the Ošetnice Stream. On the second hand, Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa have been widely used as indicators of environmental disturbances, organic enrichment and exposure to toxic chemicals because of their general sensitivity to anthropogenic stressors. The EPT group richness decreases with increasing environmental stress (Griffith *et al.,* 2005). Low numbers of EPT taxa from all localities of the Ošetnice Stream indicated low water quality and a high influence of environmental stressors. These indicated that the habitats of the basin were no diverse and that anthropogenic disturbance was serious problem in these areas (Jiang *et al.,* 2010).

The species diversity of macrozoobenthos in highland streams was shown to decline with decrease in water quality and physical stream habitat (Adámek and Jurajda, 2001). The decline in the number of the taxa below the influx of organic matter as a result of the elimination of less resistant species is a widely known phenomenon (Brabec *et al.,* 2004; Jurajda *et al.,* 2010). Our results showed only small differences in the diversity of macrozoobenthos between the individual sites in the Ošetnice Stream. RETI index ranged from 0.52 to 0.60, corresponding to the saprobic index (CZ) of betamesosaprobity (1.68–2.08), which is a class of moderate ecological status for the all monitored localities (Table III).

The decrease of brown trout stock in the stream (Table I) corresponds to the start of road use in the year 2002. Salt applied in winter period to ensure road negotiability affected significantly water chemistry of the monitored stream (Fig. 2). Based on statistical analysis, the dependency of data regarding water chemistry obtained in winter was shown. The beginning of the reconstruction of railway tunnels at the end of the year 2007 and especially the release of waste waters from building site caused deterioration in water parameters and increase of negative influence on biotic community. Deterioration of environmental conditions is mainly due to human activities; nevertheless self-cleaning ability of the stream is high and ensure a fast degradation of pollutants. Whereas the decrease of fish number is important (Table I), no evident impact on the communities of phytobenthos and zoobenthos was monitored.

SUMMARY

The aim of this study was to evaluate the influence of different human impacts on water quality, benthos and fish in a selected stream in the Western Carpathian Mountains. The monitoring of the physical and chemical characteristics at sites in the Ošetnice Stream indicated high concentrations of dissolved oxygen and low content of organic matters during the whole period of our monitoring. Upstream part of the Ošetnice Stream is affected by long term building activities concerning railway tunnels and by the motorway along the stream that is in winter chemically treated to assure negotiability. Ski area situated close to the stream was used 110 days during the monitored period. Average daily visit was 590 persons. In winter, when road salting was used, concentrations of chlorides, sodium and calcium were noticeably increased in the stream tributaries which had an impact on monitored water parameters. Saprobic and trophic indices of phytobenthos show moderate water quality of the Ošetnice Stream. Whereas saprobic and trophic indices have not changed a lot during the year, higher abundance of the species tolerant to organic pollution was recorded in spring. Water quality assessment using macrozoobenthos indices revealed the environmental state in a range from moderate to good. Moderate deterioration of water quality was determined at the localities situated downstream. Decrease of salmonid community in the stream (Table I) corresponds to the start of road

use in the year 2002. Salt applied in winter period to ensure road negotiability affected significantly water chemistry of the monitored stream. The beginning of the reconstruction of railway tunnels at the end of the year 2007 and especially the release of waste waters from building site caused deterioration in water parameters and increase of negative influence on biotic community. Whereas the decrease of fish number is important (Table I), no evident impact on the communities of phytobenthos and zoobenthos was monitored.

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