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Fish community in the chronically polluted middle Elbe River

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Abstract. The evaluation of resident fish communities is an important component of the ecological status assessment in aquatic habitats. Despite significant water quality improvement in the Czech Republic in the last decade, several important pollution sources in the Elbe River basin remain. The aim of the study was to evaluate fish community in a chronically polluted part of the channelized lowland Elbe River and its potential indicative capability.
The effluent from both industrial and municipal sewage treatment plant exhibited low pH, high conductivity and wide set of organic compounds (PAH, PCB, DDT etc.). Ecological characteristics of fish communities were obtained by boat electro fishing at selected sites in four inter-weir sections in July 2005 and 2006. Relatively high fish species richness (24 species) was observed in both seasons. Generalists (bleak, roach, chub) form the majority of the fish community in all four sections. There was no significant difference in fish species richness or density among study sections (river segments between weirs) even with a high level of measured organic compounds at the pollution inlet. Significant differences in fish species richness and density were registered among individual sites within study sections. Sites downstream the weirs had significantly higher species richness and density than the other two sites in the middle and upstream weirs. Fish community does not display any indicative remarks concerning water pollution, or in the case of mid-size river, sampling strategy was not efficient to recognize it. Channelization and regulation of the study stretch of the Elbe River seems to be the most important determinant of fish community structure.

Key words: fish, bioindicators, pollution, channelization

Introduction

Higher level responses at population and community levels to either single or multiple stressors have been well-defined for invertebrates but less well for fishes (Elliott 1994, Walker et al. 1996, Elliott & Hemingway 2002). Stress is defined in this context as the cumulative, quantifiable response to adverse environmental conditions or factors as the result of anthropogenic activities which results in a reduction of fitness to survive at any biological level of organization (cellular, individual, population or community). In addition, certain extreme stressors, such as a loss of habitat (McLusky et al. 1992) or overfishing (Svelle et al. 1997) could have an overarching effect over the lesser stressors, such as pollution and are difficult to detect and quantify.

In communities exposed to chronic pollutant stress, the density of tolerant species may increase, together with the development of resistance as organisms induce the ability to detoxify or sequester pollutants (physiological acclimation and/or genetic adaptation). If the stress remains, then a new equilibrium will develop. Ecosystems where the stress is then removed or reduced will recover through recruitment, recolonisation and/or immigration, although the recovery stages may be transient until a stable system is regained. The ability of any system to withstand and tolerate such changes may be regarded as „environmental homeostasis“ (Whitfield & Elliott 2002).

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An important component of assessing site-specific toxic hazards in aquatic habitats is to study the resident fish communities as fish represent different levels of the food chain, allow evaluation of long-term accumulation of xenobiotics since they are long-lived, and they offer a broad spectrum of relatively well studied toxicological endpoints. The toxic hazards to fish can be assessed at different levels of biological complexity. Community responses are less evaluated especially in river system (Lawrence & Hemingway 2003).

The fish is one of the Biological Quality Elements (BQE) from the Water Framework Directive (WFD) and its function is the notion/assumption that responses to environmental stressors are reflected in fish health and their community composition and distribution (Karr 1981, EU 2000, Breine et al. 2007). The objective of this study was the ecological characterisation of fish communities in the mid-size river in chronically polluted stretch of the Elbe River. Although the Elbe River is one of the largest rivers in Europe, very limited information is available about the structure of fish communities in the main channel (IKSE-MKOL Project 1996, Fuksa 2002).

Material and Methods

Study area

Fish communities were studied in middle Elbe River sites with different suspected levels of chronic chemical pollution near Pardubice town. The sites were selected based on information and data collected within the project MODELKEY and long-term monitoring projects IKSE-MKOL Project (1996) and Project Elbe (Fuksa 2002).

The Elbe River has a total length of 1154 km with 370 km in the Czech Republic (CR). Total basin is 144055 km^2, of which 51391 km^2 is in CR. Average annual discharge in study area is 56 m^3.s^{-1} (Vlček 1984). Most of the Elbe River is channelized and regulated with two reservoirs, 24 locks and 67 weirs. The stretches from German border upstream to Pardubice (river km 241) are modified and used for navigation.

Despite significant water quality improvement in the last decade, two important pollution sources for the investigated stretches of the Elbe River still persist: Spolana Neratovice and Pardubice industrial zone (e.g. Synthesia Pardubice) (Fuksa 2002). This study comprised a stretch of the Elbe River up- and downstream of the industrial zone of Pardubice. This part of the River Elbe was reported by several authors to be heavily contaminated, e.g. by chloroorganics, aromatic compounds as well as other compounds (Heinisch et al. 2007, Randák et al. 2008).

The study stretch was divided into four sections (downstream ordered) representing inter-weir sections (Table 1, Fig. 1).

Section 1 (Vysoká – Pardubice): partly regulated and unpolluted section (with respect to the Pardubice industrial zone), long riffle stretch, no backwater, 2 tributaries,

Section 2 (Pardubice – Srnojedy): regulated, unpolluted section (with respect to the Pardubice industrial zone), no riffle stretch, 2 backwaters, no tributary,

Section 3 (Srnojedy – Přelouč): regulated and directly polluted hotspot section (with respect to the Pardubice industrial zone), discharge of effluent about 1 m^3.s^{-1}, no riffle stretch, no backwaters, no tributary,

Section 4 (Přelouč – Týnec): partly regulated and polluted section (with respect to the Pardubice industrial zone), long riffle stretch, no backwaters, no tributary.

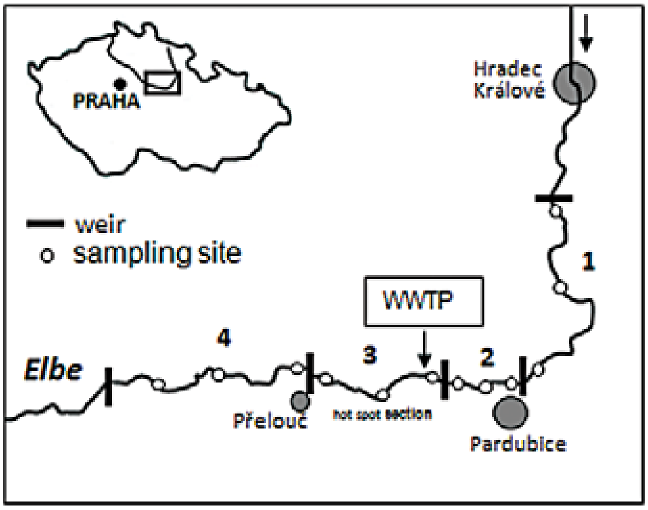

***Fig. 1**. Schematic map of study sites. Four sections and 12 sampling sites (open rings) indicated in the Elbe River near Pardubice surveyed in years 2005 and 2006.*

Because the different habitat character, three sites were sampled within each section: under weir – with relatively low depth (< 1 m) and stronger current; middle zone – with higher depth (average 2 m) and low current; and above weir – with relatively high depth (up to 6 m) and minimum current (Table 1). It was hypothesized, that the industrial area of Pardubice, with its main effluent in section 3, impaired the fish community. Therefore, the pollution by chemicals mentioned in literature was measured in section 1, serving as reference site, downstream of the effluent and directly in the effluent. Further analysis of the effluent water was carried out to enhance the knowledge about substances released by the outlet.

Chemical characterisation – Elbe River

Semipermeable Membrane Devices (SPMD) were used to collect non-polar compounds (polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), chloropesticides (p,p'-DDT, p,p'-DDE, p,p'-DDD), chlorobenzenes (CB) in the river. These lipophilic compounds were reported to be present in elevated concentrations downstream of Pardubice and originate probably from contamination of factory grounds in the industrial zone (Heinisch et al. 2007). SPMD were first introduced by Huckins et al. (1990) as passive samplers for non-polar compounds. SPMD consist of a neutral lipid (triolein) encapsulated in a layflat low-density polyethylene tubing. Compounds in the river water diffuse through the polyethylene membrane and are absorbed by the triolein. Time averaged water concentrations can then be calculated by using uptake rates given in the literature (e.g. Huckins et al. 1990). Further details about the passive sampler itself, principles of sampling procedures and uptake rates can be found elsewhere (Huckins et al. 1990, Luellen & Shea 2002). Three SPMDs were deployed each year (2005 and 2006) for four weeks prior to the fish sampling in section 1, directly into the plume of the effluent from the chemical plant (section 3), and further downstream in section 3. After retrieving the membranes from the river they were cleaned and extracted (Streck et al. 2008). Extracts were purified with gel permeation chromatography (US EPA 1994). Analyses were carried out in the Single Ion Monitoring (SIM) mode with an HP6890 gas chromatograph coupled to an HP5973N mass spectrometer (both Agilent, Sunnyvale, USA).

Chemical characterisation – effluent

Water released via the effluent form the industrial area of Pardubice (section 3) showed a deep red colour and an aromatic smell. It appeared likely, that at this site other compounds than the reported classical contaminants which were sampled with SPMDs are entering the Elbe River. Therefore, water samples were taken directly from the effluent using brown glass bottles. In order to get information on compounds that are actually released into the Elbe River, a simple screening method was employed. This method consisted of a liquid-liquid extraction of water from the effluent with dichloromethane and a subsequent analysis of the concentrated extract by GC-MS in Scan mode. Substances were identified

Table 1. *List of selected sites on the Elbe River surveyed for fish communities in years 2005 and 2006.*

Section	Sites	Name of locality	r. km	Coordinates
1	1.I	Vysoká – below weir	152.5	50°9'29.36"N, 15°48'28.78"E
	1.II	Dříteč village	145.0	50°6'90.45"N, 15°48'20.28"E
	1.III	Pardubice – above weir	133.0	50°2'48.23"N, 15°46'58.37"E
2	2.I	Pardubice – below weir	131.0	50°2'33.11"N, 15°46'14.08"E
	2.II	Pardubice – railway bridge	128.0	50°2'25.78"N, 15°44'57.34"E
	2.III	Srnojedy – above weir	125.0	50°2'34.67"N, 15°42'19.81"E
3	3.I	Srnojedy – below weir	124.5	50°2'30.83"N, 15°41'18.52"E
	3.II	Valy village	118.0	50°1'58.88"N, 15°37'10.24"E
	3.III	Přelouč – above weir	115.0	50°2'23.71"N, 15°34'45.27"E
4	4.I	Přelouč – below weir	113.5	50°2'40.83"N, 15°33'34.48"E
	4.II	inlet of Opatovice canal	111.0	50°2'36.77"N, 15°30'58.27"E
	4.III	Řečany – above bridge	107.0	50°2'45.15"N, 15°28'51.35"E

tentatively using a library of mass spectra (NIST 2005). If standards were available, the identity of the compounds was checked using retention time and mass spectra, and the compounds were quantified.

A simplified scheme for the calculation of the ratio of Predicted No-Effect Concentrations (PNEC) to Predicted Environmental Concentrations (PEC) was used in order to estimate whether the identified and quantified compounds may pose a risk for the fish community. For the River Elbe, PECs were simply calculated by taking dilution of the effluent entering the river into account. Calculations were done using the discharge of the effluent estimated in the field (0.5 m^3 s^{-1}) and the low-flow discharge of the River Elbe. The latter value was derived from the average discharge, which is 56.3 m^3 s^{-1} in the middle of section 3, by dividing it by three (EC 2003). Binding to particles and subsequent sedimentation was neglected in order to achieve a conservative estimation of PEC-values. PNECs were calculated using the lowest LC50-values retrieved from the ECOTOX database (US EPA 2008) for the fish species *Pimephales promelas* or other species, as available, by dividing them by an assessment factor of 1000 (EC 2003).

Fish sampling

Ecological characteristics of fish communities were obtained by classical ichthyologic methods, in accordance with the Water Framework Directive (Fame Consortium 2004). The adult fish (1 year and older) were sampled by boat electro-fishing (type EL63GI, DC 4.5 kW, 12A, 350V) upstream directed along both banks. The caught fish were determined into species and then released back into water. The length of each sampled river stretch (in average 1900 m) was noted and numbers of caught individuals recalculated into density presented as a catch per unit effort (CPUE – individuals per 100 m sampled). The width and depth of the Elbe River channel (in average 40 m and 2 m respectively) in the study sites do not allow the quantitative survey at all. Sampling was undertaken during low flow condition (mean 20 $m^3.s^{-1}$) in 26-29 July 2005 and 17-21 July 2006 in the same sites.

Data analysis

Basic ecological parameters, like species richness, relative community structure (dominance in %), density (CPUE) in adult fish community (1+ and older) were analyzed for particular sampling site and cumulated for each section. Diversity indices (Shannon H´, Simpson) and similarity indices (Jaccard, Renkonen´s Percentage similarity) were calculated (Begon et al. 1990). Ecological and reproductive guilds were analysed (Balon 1975, Schiemer & Waidbacher 1992).

A three-way analysis of variance (ANOVA) was used to determine whether sampled section, site, and year influenced number of fish (log-transformed in order to comply with requirements of ANOVA), number of species and H´.

Results

Species richness and density

A total of 2951 caught adult fish (1+ and older), belonging to 22 fish species, were recorded at twelve river sites (four sections sampled at three river sites each) in the Elbe River in 2005 (Table 2). In the year 2006, a total of 949 adult fish were caught, belonging to 23 species (Table 2). No significant differences in species richness were found between the years nor among sampled sections (ANOVA, both $p > 0.05$; Fig. 2), though it differed significantly between the sites (ANOVA, $p < 0.05$), with more species occurring in site 1 (downstream the weirs) than in other two sites (Sheffé post hoc test, p both < 0.05) (Fig. 3). Dominant species were the generalists bleak (*Alburnus alburnus*) and roach (*Rutilus rutilus*). These species were the most abundant in all sections studied. Chub (*Leuciscus cephalus*) was dominant in all sections except section 2. White bream (*Abramis bjoerkna*) was dominant in section 2 (Table 2).

No significant difference in fish density was found

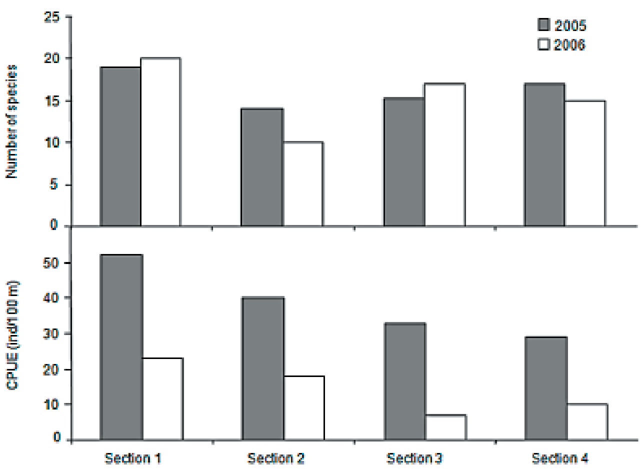

Fig. 2. *Species richness (above) and relative density (below) of fish communities in the particular sections on the Elbe River in years 2005 and 2006.*

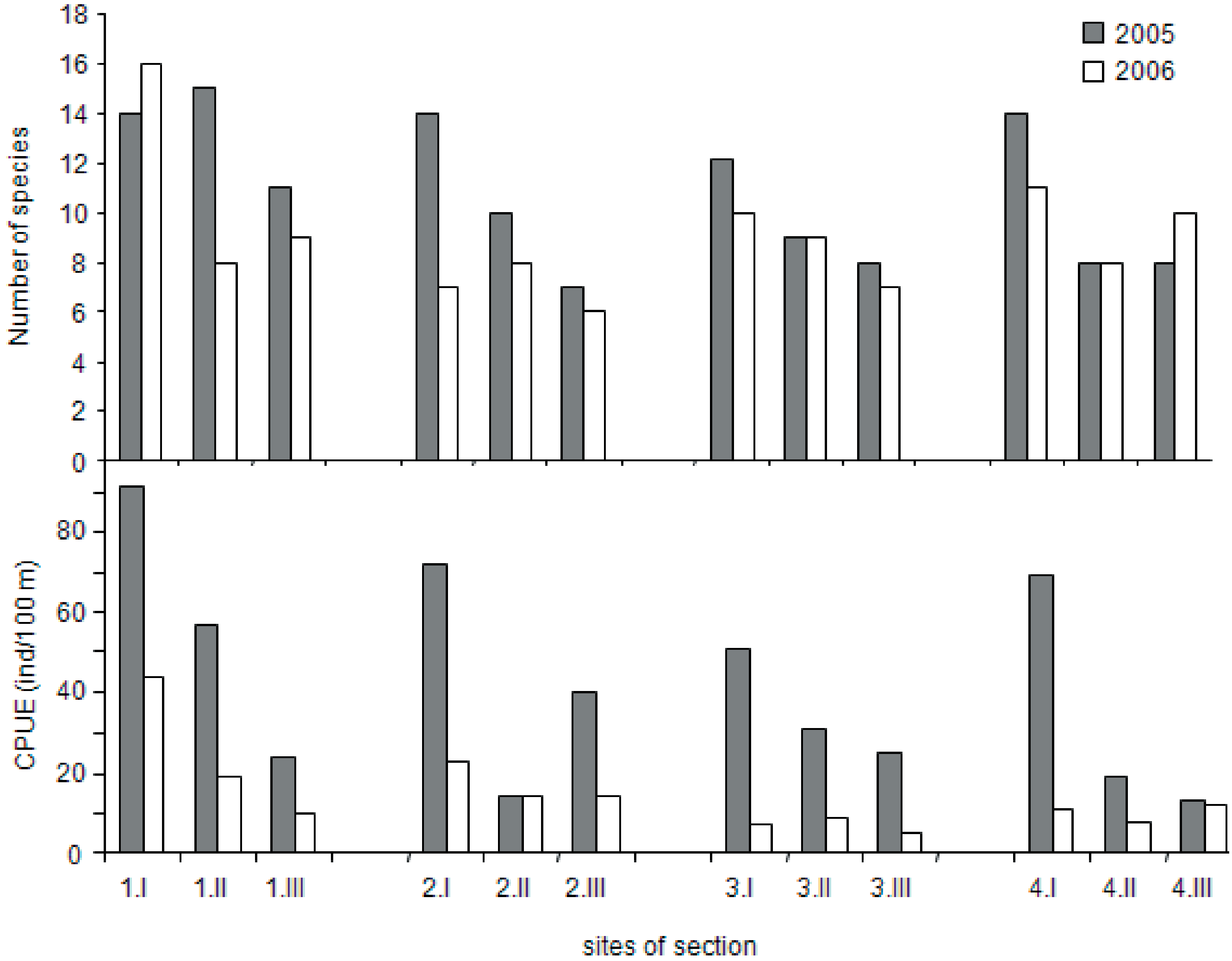

Fig. 3. *Species richness (above) and relative density (below) of fish communities in the particular sites of each section on the Elbe River in years 2005 and 2006.*

among the studied sections (ANOVA, $p < 0.05$; Fig. 2). ANOVA found significant differences in fish density (log-transformed) between the years, and among the sites (both $p < 0.05$), with densities in site 1 (downstream the weirs) being significantly higher than in other two sites (Sheffé post hoc test, p both < 0.05) (Fig. 2 and 3).

Diversity indices and ecological guilds

Diversity indices were rather similar in the two years studied. No decrease of diversity was observed in hot spot section 3 (Table 2). Shannon´s index of diversity did not differ among the sections, nor between the years, (ANOVA, both $p > 0.05$), though it differed among the sites (ANOVA, $p < 0.05$), with site 1 providing higher values of H´ than site 2 (Scheffé post hoc test, $p < 0.05$; Table 2).

In both years, the dominant fish species (bleak, roach, white bream) represent the eurytopic guild; they show no preference for running or still waters. Chub belongs to the rheophilic guild, requiring running water at least in some life stages. Higher density of other rheophilic specialists like barbel (*Barbus barbus*), vimba (*Vimba vimba*), dace (*Leuciscus leuciscus*) or gudgeon (*Gobio gobio*) is limited by the inconvenient habitat of the channelized river. Their occurrence was higher only in section 1 (Table 2). The occurrence of limnophilic species, preferring still water habitat with aquatic vegetation for reproduction is supported by the existence of two large backwaters in section 2. Generalist *sensu* ecological guild could be considered also as generalist *sensu* reproductive guild. Except lithophilic chub, all other dominant species belong to the phyto-lithophilic guilds, with low requirements for spawning substrate.

Table 2. Dominance of adult fish (1 year and older) in four sections (1–4) of the Elbe River in year 2005 and 2006 (in %). (– species under the stocking program of Czech Anglers union).*

	2005				2006			
Scientific name/section	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
*Esox lucius**	0.8	1.3	1.0	0.2	1.5	0.7	7.4	1.5
*Rutilus rutilus**	33.9	38.5	22.8	19.9	20.5	51.6	12.7	32.1
Leuciscus leuciscus			0.1	0.2				
*Leuciscus cephalus**	10.1	6.3	45.3	31.2	11.2	2.6	53.4	25.8
*Leuciscus idus**	0.7	0.3	0.9	0.8	0.3		3.0	1.5
Scardinius erythrophthalmus	2.0	3.6	3.1	0.6	1.8	4.8		1.0
*Aspius aspius**	0.7			1.1	0.6		0.7	
*Tinca tinca**	0.5	0.8	0.1		0.9	0.7		0.5
*Chondrostoma nasus**	0.5	1.0	0.1		1.2		1.5	0.5
Gobio gobio	4.4		1.8	3.9	0.3		1.5	5.4
Barbus barbus	1.1		0.4	0.6	1.5		0.7	
Alburnus alburnus	39.2	21.7	21.3	30.1	46.5	22.2	10.5	11.1
Abramis bjoerkna	2.8	23.8	0.4	9.0	2.1	13.7	0.7	13.6
*Abramis brama**	1.5	0.6	0.3	0.4	6.5	1.5	0.7	0.5
Vimba vimba					0.6			
Rhodeus sericeus			0.9	0.4			1.5	
Carassius auratus	0.6							2.5
*Cyprinus carpio**	0.2			0.2	2.4		0.7	2.0
*Silurus glanis**	0.1	1.0	1.2	0.4	0.9	0.7		1.0
Ictalurus nebulosus		0.1		0.6			0.7	
*Anguilla anguilla**	0.1	0.3			0.3		0.7	
Lota lota	0.3				0.3			
Perca fluviatilis	0.5	0.7		0.4	0.3	1.5	2.2	1.0
Lepomis gibbosus					0.3		0.7	
A. alburnus x R. rutilus			0.3				0.7	
TOTAL (ind)	**1 098**	**715**	**671**	**467**	**339**	**270**	**135**	**205**
Shannon H´	1.66	1.63	1.49	1.71	1.77	1.42	1.70	1.89
Simpson 1-D	0.72	0.74	0.70	0.77	0.72	0.67	0.69	0.80
Equitability	0.56	0.62	0.55	0.60	0.59	0.62	0.60	0.70

Similarity indices

Fish community structure based on species richness was very similar in 2005 and 2006 (total similarity, Jaccard index = 88%) (Table 3). Higher similarity was found in relative composition of fish assemblages between particular sections (Renkonen´s PS index = 93%), due to high density of dominant species and low density of rare species. In 2005, all the sections were relatively highly similar. The highest similarity was found between the section 3 and 4 (Ja 68%, PS 78%). In 2006, the differences between sections were more obvious, with the highest difference found between sections 2 and 3. Higher interannual differences were found in sections 3 and 4 than in sections 1 and 2 (Table 3).

Chemical characterisation – basic parameters

Conductivity, pH, oxygen and temperature data on the Elbe River and the effluent of the chemical plant

Table 3. Similarity indices of fish communities in particular sections of the Elbe River in 2005 and 2006.

Jaccard					**Renkonens´ PS**				
2005	**1**	**2**	**3**		**2005**	**1**	**2**	**3**	
2	0.65				**2**	0.70			
3	0.62	0.61			**3**	0.61	0.57		
4	0.64	0.63	0.68		**4**	0.70	0.60	0.78	
2006	**1**	**2**	**3**		**2006**	**1**	**2**	**3**	
2	0.50				**2**	0.53			
3	0.68	0.35			**3**	0.42	0.29		
4	0.67	0.67	0.52		**4**	0.53	0.64	0.57	
2005 vs. 2006					**2005 vs. 2006**				
1	**2**	**3**	**4**	**total**	**1**	**2**	**3**	**4**	**total**
0.86	0.71	0.52	0.60	0.88	0.80	0.84	0.74	0.73	0.93

Table 4. Basic characterization of the River Elbe in section 3 up- and downstream of the effluent from the chemical plant and of the effluent itself.

Site / parameter	pH [-]	Conductivity [µS/cm]	O_2 [mg/L]	Temperature [°C]
River Elbe, upstream	7.66	303	12.4	12.8
River Elbe, downstream	7.19	345	12.3	13.1
Effluent	2.66	3600	6.7	19.3

are given in Table 4. The red coloured effluent, which released an aromatic smell, exhibited a remarkably low pH-value and a high conductivity.

Chemical characterisation – SPMDs

For PAHs, only small differences in water concentrations between the sections could be observed (Table 5). Concentrations were below the threshold values defined as environmental quality standards (EQS) in the context of the Water Framework directive. This is also true for chlorobenzenes as well as for DDT and metabolites. No EQS-value exists for PCBs. However, the effluent from the industrial area proved to be a source of chlorobenzenes and PCBs of lower weight, and increased the concentrations of the Elbe River notably (Table 5). While p,p'-DDD and p,p'-DDE were in the same magnitude at both sections (1 and 3), the parent compound p,p'-DDT showed a remarkable increase from below detection limit to 1.2 ng/L in 2005 and even 3.3 ng/L 2006 at the last site (section 3 downstream), indicating a source of fresh DDT in the vicinity of this site.

Chemical characterisation – screening

The screening analysis of the effluent from the industrial area revealed the presence of a vast number of compounds (Table 6). Especially, the waste water contained large amounts of compounds used in the production of explosives, which are produced in Pardubice by Synthesia Semtin a.s.. Toxicity data for fish – LC50-values for *Pimephales promelas* if available – and $PEC_{Effluent}$/PNEC-values have been included in the table in order to allow a rough evaluation of the findings. LC50-values are only available for a subset of the identified compounds. $PEC_{Effluent}$/PNEC-values were calculated from the concentrations quantified in the effluent, divided by an assessment factor of 1000 and the lowest LC50-values available. Two of the compounds (trinitrotoluene and 1-Chloro-2,4-dinitro-benzene) showed values above one. Furthermore, several other compounds display values close but below one. These results demonstrate that the effluent itself has to be considered as toxic. In order to evaluate the relevance of the concentrations for the fish community in the Elbe River, the dilution of the effluent by the river water has to be taken into account. All PEC_{Elbe}/PNEC-ratios for the river itself were below one. Values calculated for trinitrotoluene and 1-Chloro-2,4-dinitro-benzene were 0.28 and 0.06, respectively. All in all, it has to be stated that the effluent clearly increases toxicity of the River Elbe, but due to dilution the chemicals do not pose a risk to the fish community. However, these conclusions are based on a very simple risk assessment. Our reflections do not consider mixture toxicity neither that only a subset of compounds released by the effluent could be quantified. Furthermore, they are solely based on data on acute toxicity (Table 6).

Discussion

During the two-year study, a total of 24 fish species were registered in the four studied river sections of the Elbe River near Pardubice. Even the Elbe River is one of the most important rivers in the Czech Republic; limited information about the fish community is available only from the large scale

Table 5. *Concentrations of chlorobenzenes, PCBs, chloropesticides and PAHs in the River Elbe (in pg/L).*

section	section 1	section 3 effluent	section 3 downstream	section 1	section 3 effluent	section 3 downstream
year		2005			2006	
1,2,4,5-Tetrachlorobenzene	4.8	1183.9	121.5	n.d.	172.0	103.0
1,2,3,4-Tetrachlorobenzene	1.2	584.6	59.7	n.d.	79.9	45.6
Pentachlorobenzene	7.5	230.7	21.0	4.0	34.2	20.6
Hexachlorobenzene	54.0	151.8	18.7	21.9	77.8	51.1
PCB-28	31.7	752.4	52.4	12.2	306.4	149.8
PCB-52	35.9	795.9	60.3	16.6	376.0	177.5
PCB-101	27.8	87.8	14.0	10.8	36.1	21.0
PCB-153	81.8	118.6	39.6	33.6	72.4	42.0
PCB-138	54.3	70.8	24.8	23.3	47.2	30.6
PCB-180	27.6	39.4	19.1	14.5	26.4	21.3
p,p'-DDE	265.8	214.2	121.4	137.3	316.8	191.9
p,p'-DDD	214.1	125.5	89.0	78.4	199.2	107.6
p,p'-DDT	n.d.	n.d.	1196.2	n.d.	n.d.	3277.5
Acenaphthylene	0.27	0.62	0.08	0.27	0.38	0.26
Acenaphthene	1.41	n.d.	n.d.	0.63	2.79	2.01
Fluorene	2.26	n.d.	0.03	1.15	2.36	1.75
Phenanthrene	14.40	8.34	1.83	7.18	9.08	7.60
Anthracene	0.66	4.64	0.39	0.53	0.77	0.92
Fluoranthene	31.90	13.70	3.94	10.20	17.30	15.50
Pyrene	30.50	65.60	8.42	13.10	25.80	24.00
Benz[a]anthracene	4.12	5.80	1.10	1.87	4.29	2.92
Chrysene	20.80	27.60	4.82	8.22	21.60	14.10
Benzo[b+k]fluoranthene	12.10	3.08	1.57	1.98	4.25	2.70
Benzo[a]pyrenee	1.14	0.54	0.31	0.35	0.48	0.42
Indeno[1,2,3-cd]pyrene	0.62	0.25	0.09	0.11	0.24	0.11
Dibenz[a,h]anthracene	n.d.	0.12	n.d.	0.12	0.20	0.15

n.d. = not detected

Table 6. *Identified compounds in industrial waste water entering the Elbe River in section 3. The LC50-values have been included for fish species as available. PEC_{Elbe}/PNEC was calculated from effluent concentration data, dilution by river water and from lowest LC50-values taking an assessment factor of 1000 into account. $PEC_{Effluent}$/PNEC was calculated in the same way without considering a dilution factor.*

Name	CAS-no.	Conc. [µg/L]	LC50 [mg/L]	$PEC_{Effluent}$/PNEC [-]	PEC_{Elbe}/PNEC [-]	Species	Reference
Trinitrotoluene	118-96-7	13.15	1.2-4.2	11.0	0.28	*Pimephales promelas*	US EPA 2008
N,N'-diethyl-N,N'-diphenylurea	85-98-3	5.7	10	0.57	0.01	*O. tshawytscha* *O. kisutch*	US EPA 2008
1,3-dinitro-benzene,	99-65-0	3.74	7.0-16.8	0.53	0.01	*Pimephales promelas*	US EPA 2008
1-Naphthol	90-15-3	3.07	3.6-4.6	0.85	0.02	*Pimephales promelas*	US EPA 2008
Dinitrotoluene	121-14-2	2.69	24.3-33	0.11	0.003	*Pimephales promelas*	US EPA 2008
Benalaxyl	71626-11-4	2.65	3.8	0.70	0.02	Not specified	EC 2004
1-Chloro-2,4-dinitro-benzene	97-00-7	0.48	0.2	2.40	0.06	*Poecilia reticulata*	US EPA 2008
1,4-Naphthalene-dione	130-15-4	0.37	-	n.q.	n.q.	*Oncorhynchus kisutch*	US EPA 2008
Diphenylmethane	101-81-5	0.03	7.5	0.004	0.0001	*L. idus melanotus*	US EPA 2008
1H-Isoindole-1,3(2H)-dione	85-41-6	n.q.	16.5-30	n.q.	n.q.	*Oryzias latipes*	US EPA 2008
2-Nitrotoluene	88-72-2	n.q.	19-50	n.q.	n.q.	*Pimephales promelas*	US EPA 2008
Methyl-phenyl-sulfone	3112-85-4	n.q.	-	-	-		
Dimethylbiphenyl (diff. isomers)	-	n.q.	-	-	-		
2-Methoxy-4-nitro-phenol	3251-56-7	n.q.	-	-	-		
Diphenylsulfone	127-63-9	n.q.	-	-	-		
4-Methyl-2-nitro-phenol	119-33-5	n.q.	-	-	-		
1,2,3-Benzothiadiazole	273-77-8	n.q.	-	-	-		
Dichloroguaiacol (diff. isomers)	-	n.q.	-	-	-		
1,2-Dichloro-4,5-dimethoxy-benzene	2772-46-5	n.q.	-	-	-		

- = no LC50-values available
n.q. = not quantified

monitoring projects IKSE-MKOL Project (1996) and some years of Project Elbe (Fuksa 2002). Fifteen fish species in the two sites (our number 1.II and 3.II) were documented in 1999, with similar dominance of roach, chub and gudgeon (Fuksa 2002). Comparing with our study, bleak was less abundant in survey in 1999. Within the large scale survey of longitudinal profile of the whole Elbe River in years 1991-93 (IKSE-MKOL Project 1996), 24 species were registered in 7 sites, corresponding to our study stretch of the Elbe River. However, only presence-absence data were available in that study (IKSE-MKOL Project 1996). Eleven of the 24 species registered within the study are stocked by the Anglers union. Additionally, five species that were stocked by the Anglers union (Danubian salmon *Hucho hucho*, grass carp *Ctenopharyngodon idella*, rainbow trout *Oncorhynchus mykiss*, brook trout *Salvelinus fontinalis*, zander *Sander lucioperca*) were not documented in the field. Nevertheless, including all stocking information increased the total fish diversity to 28 species.

When comparing species richness and community composition, it is necessary to take into account the lower efficiency of potential sampling methods for channelized medium-size rivers, like the investigated part of the Elbe River. The differences can be influenced by the sampling method as well as by spatiotemporal distribution of fishes within the river channel. Nevertheless, one can gain a rough picture of fish assemblage condition of the studied river stretch from obtained results and the same sampling effort allows the comparison between the sections under study.

Present fish community is not well-balanced. Dominant species are classified as generalists, with wide ecological valence. Roach, bleak and white bream (more common in 2006) are typical eurytopic species (Schiemer & Waidbacher 1992) living both in running and standing water. Chub and gudgeon are rheophilic species requiring running water for particular life stages; nevertheless especially chub is common even in sections without riffle zone or tributaries (section 2 and 3) (Baruš & Oliva 1995). Perch, that is indicated as a fish species typical for channelized rivers and canals (Wolter & Vilcinskas 1997) was not as abundant as expected, according to the river character. Many other species with more specific habitat requirement were registered in low density only (Table 2).

The trend of decreasing CPUE in longitudinal profile of studied sections was apparent, though not significant, in both years, but there were significantly lower CPUE values in all sections in the year 2006 than in the year 2005 (Fig. 2). Decreasing density in longitudinal profile in both years could be affected by the decreasing habitat complexity from section 1 downstream to section 4 (see Study area). The reduction of the CPUE to a half from 2005 to 2006 is difficult to explain. A strong spring flood in 2006 could be a reason. Nevertheless, the composition of the studied river stretch remained relatively unchanged (Ja 88%, PS 93%). Significantly higher fish diversity and density among the sites were documented in sites below the weirs, with diversified habitats and more oxygenated water (IKSE-MKOL Project 1996, Slavík & Bartoš 2001).

There was no straight relationship with the presence of pollutants and ecological descriptors of adult fish community. No significant differences were found between four river sections neither in species richness, CPUE nor in diversity indices. Also species composition in all sections was similar. The elevated water concentrations of PCBs, CBs and DDT in section 3 compared to the upstream sections did not impair the fish community, since concentrations are still below threshold values, e.g. EQS-values. These findings agree well with a recently published survey of body burden and biomarkers in chub in the same stretch of the Elbe River (Randák et al. 2008), which demonstrated an increase of PCBs, HCBs and DDT in chub downstream of the effluent, but couldn't find differences in biomarker response (e.g. ethoxyresorufin-O-deethylase (EROD)) between sites upstream and downstream of section 3.

A lack of adverse effects on fish community was also observed when sampling nearby the outlet from the industrial area. The chemical analysis revealed that waste water released by the effluent contained considerable concentrations of toxic substances, even if PEC_{Elbe}/PNEC-values calculated from these concentrations and taking dilution by the Elbe River into account indicated no risk to the fish community (Table 6). However, this conclusion might be misleading, since only a small subset of compounds could be identified and quantified, and only acute toxicity was taken into account. Therefore, other explanations of the findings cannot be omitted. E.g., another reason could be a limited efficiency of sampling methods in mid-size channelized rivers to detect fish community differences (Casselman et al. 1990). Furthermore, the size of the effluent's discharge compared to that of the Elbe River should be taken into account as well as that the plume does not mix instantaneously with the river water, leaving space for fish to avoid chemicals released from the effluent. During minimal discharge, water from the effluent will be diluted at least by a factor of 20. Taken altogether, an influence of waste water on the fish community seems to be unlikely.

We therefore conclude that in this study fish community was not a good biological indicator of chemical pollution possible due to insignificant adverse effect of chemicals in concordance with the size of a river (discharge). The main influential factor on the fish community in this study site was most likely geomorphologic and hydrological river character. Fish community presented weak adverse changes in CPUE eight months later in the case of catastrophic poisoning by cyanide in January 2006 in the stretch near the town of Kolín (about 30 km downstream of study stretch) (Křížek et al. 2007).

Fish community is a widely used BQE (WFD), but its indicative value was rarely evaluated, especially in case of chemical pollution (Lawrence & Hemingway 2003). Based on our results in chronically polluted river, fish community is a biological indicator of general ecological river status, including geomorphology of channel, hydrology and water quality. In the case of water quality it seems to be a good indicator only of significantly strong adverse effect accordingly with the river size (Libosvárský et al. 1967). In the mid sized and large rivers, indicative value of fishes in community level is lower owing to insufficient representative sampling efficiency and dilution effect of river.

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