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Presence of pharmaceuticals in benthic fauna living in a small stream affected by effluent from a municipal sewage treatment plant

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ABSTRACT

Aquatic organisms can be affected not only via polluted water but also via their food. In the present study, we examined bioaccumulation of seventy pharmaceuticals in two benthic organisms, *Hydropsyche* sp. and *Erpobdella octoculata* in a small stream affected by the effluent from a sewage treatment plant (STP) in Prachatice (South Bohemia region, Czech Republic).

Furthermore, water samples from similar locations were analyzed for all seventy pharmaceuticals. In water samples from a control locality situated upstream of the STP, ten of the seventy pharmaceuticals were found with average total concentrations of 200 ng L^{-1}. In water samples collected at STP-affected sites (downstream the STP's effluent), twenty-nine, twenty-seven and twenty-nine pharmaceuticals were determined at average total concentrations of 2000, 2100 and 1700 ng L^{-1}, respectively.

Six of the seventy pharmaceuticals (azithromycin, citalopram, clarithromycin, clotrimazole, sertraline, and verapamil) were found in *Hydropsyche*. Four pharmaceuticals (clotrimazole, diclofenac, sertraline, and valsartan) were detected in *Erpobdella*. Using evaluation criterion bioconcentration factor (BCF) is higher than 2000 we can assign azithromycin and sertraline as bioaccumulative pharmaceuticals. Even pharmaceuticals present at low levels in water were found in benthic organisms at relatively high concentrations (up to 85 ng g^{-1} w.w. for azithromycin). Consequently, the uptake of pharmaceuticals via the food web could be an important exposure pathway for the wild fish population.

1. Introduction

Effluent of municipal sewage treatment plants (STPs) contains numerous organic and inorganic pollutants due to insufficient removal efficiency during the treatment processes (Golovko et al., 2014a; Halling-Sorensen et al., 1998; Heberer, 2002; Petrovic et al., 2003). This incomplete removal broadly reflects the pharmaceuticals mixture to which fish and other aquatic organisms are typically exposed (Verlicchi et al., 2012).

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Most of the research examining the possible bioconcentration of environmental contaminants in fish has focused on either controlled laboratory conditions associated with known individual pharmaceuticals or mixture exposure (e.g. Brozinski et al., 2013; Cuklev et al., 2012; Lahti et al., 2011; Nallani et al., 2011; Steinbach et al., 2013) or on fish placed into cages and exposed directly to the effluent (e.g. Lajeunesse et al., 2011; Togunde et al., 2012). It means that bioconcentration is the prevailing or only exposure mechanism. However, intake of pollutants via contaminated natural food is completely ignored in these experimental setups. Depending on the exposure period, fish are either not fed or artificial feed is used. In the case of real conditions, fish in cages can be stressed and outcomes of these experiments do not truly mimic the natural conditions.

Aquatic organisms are exposed not only via the discharge of sewage waters but also via their food web. Benthic fauna is a very important part of the food web in aquatic environments (e.g. Hellmann et al., 2013; Hildrew, 1992). Benthic organisms are often used as bioindicators for assessing environmental pollution due to their limited movability and relatively easy sampling (Clews et al., 2014; Cortes et al., 2013; Pan et al., 2012; Smith et al., 1999). Larvae of caddisflies (*Hydropsyche* sp.) and leeches (*Erpobdella* sp.) are often used as indicators of water quality or pollution in streams (Azrina et al., 2006; Koperski, 2005, 2010; Sola and Prat, 2006; Stuijfzand et al., 1999; Tessier et al., 2000). These species have been used for monitoring of riverine pollution in the Czech Republic during the last decade (Kolarikova et al., 2012; Macova et al., 2009). These organisms significantly contribute to a fish diet as well (Elliott, 1967; Greenberg and Dahl, 1998; Laine, 2001; Reiriz et al., 1998).

The aim of this study was to investigate pharmaceutical levels in benthic organisms and consequently to reveal their importance in the exposure pathways of the fish.

2. Material and methods

2.1. Sampling location

Benthic organisms and water samples were collected in the Zivny stream (a tributary of Blanice River) situated in the south part of the Czech Republic, during May 2013. The stream is 13 km long with an average depth of 30 cm and an average width of 3 m. Flow varied from 0.150 to 0.600 $m^3\ s^{-1}$. The stream is highly impacted by effluent from the Prachatice STP. Prachatice (12,000 inhabitants) is a district town. There is only light industry (food, machinery and electronics) and a hospital. The STP's effluent can make up approximately 25% of the water flow in the Zivny stream. The details of treatment processes and permissible limits for final effluent from the STP are given in Supplementary material (S1). Except for stretches in Prachatice, the stream habitat is natural or semi-natural. The fish community is dominated by brown trout (*Salmo trutta* m. *fario* L.) with occurrences of other riverine species, including stone loach (*Barbatula barbatula* L.) and bullhead (*Cottus gobio*). Benthic invertebrate organisms, specifically *Hydropsyche* sp. and *Erpobdella octoculata*, were chosen for this study. Both of organisms are present in all (or in a majority) of sampled sites situated along the stream and make up an important part of the fish diet. Larvae of *Hydropsyche* are net-spinning omnivores (Benke and Wallace, 1997; Hellmann

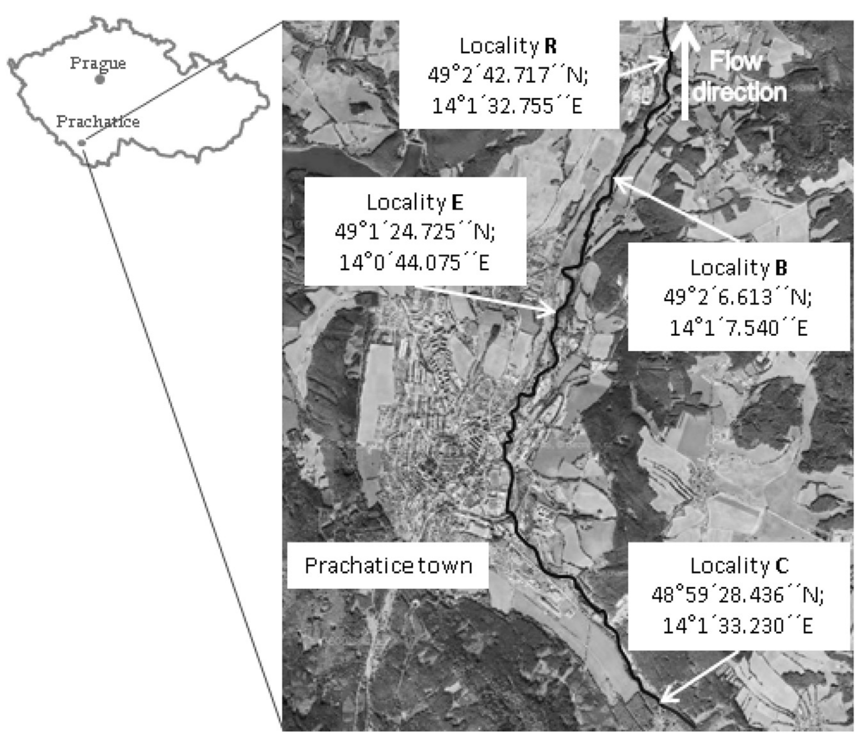

Fig. 1 – Sampling localities of the Zivny stream. Site E – area where the STP's effluent enters the Zivny stream; Site B – approx. 1.5 km downstream of the STP; Site R – approx. 3 km downstream of the STP; Site C – non-polluted area (approx. 4.5 km upstream of the STP).