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Evaluating environmental impact of STPs situated on streams in the Czech Republic: An integrated approach to biomonitoring the aquatic environment

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ABSTRACT

Sewage water treatment plants (STPs) are frequently associated with the release of xenobiotics and, consequently, with biological responses of fish to these substances. The impact of three STPs situated on small streams was assessed in 2009. Brown trout (*Salmo trutta fario* L.), captured upstream and downstream of these STPs, were used as biomonitors. The concentrations of 39 organic pollutants (PCBs, OCPs, PBDEs, HBCDs, and MCs), and the biological responses related to oxidative stress (lipid peroxidation and carbonyl protein), and antioxidant responses (superoxide dismutase, glutathione peroxidase and glutathione reductase) were measured. Through chemometrics of these parameters, three groups with 97.62% of the total accumulated variance were distinguished. Integration of the assessed biomarkers using the IBR index, ranked environment impact on sites as: DS Pacov > DS Prachatice > DS Brloh > US Pacov > US Prachatice > US Brloh (most to least affected). STPs are a major source of xenobiotic pollution in streams of the Czech Republic. The combined use of chemical analysis and biological responses is necessary to validate the efficacy of a battery of biomarkers chosen to detect environmental stress due to pollution.

1. Introduction

The expansion in anthropogenic activity since the early 20th century has had a negative impact on all areas of the environment. Sewage water treatment plants (STPs) are frequently associated with the release of xenobiotics to the aquatic environment (Alonso et al., 2005). Xenobiotics, some of which have been demonstrated to result in ecological impacts at trace concentrations, have been reported to be widespread in aquatic environments (Kolpin et al., 2002; Loffler et al., 2005). Many, commonly known as endocrine-disrupting compounds (EDCs), have been linked to a variety of adverse effects in both

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humans and wildlife (Tyler et al., 1998). Since it is difficult or impossible to differentiate the impact of point sources of pollution sources on exposed organisms, their evaluation in small streams can be more suitable for monitoring water pollution than investigating larger aquatic ecosystems, which may have multiple pollution sources.

To assess the ecological status of water bodies, several approaches have been proposed, ranging from bioassays to community analysis. An effective system using biochemical markers has been established to evaluate xenobiotics in the environment, although some questions about their suitability remain (Zurita et al., 2007; Ricciardi et al., 2010). The toxic effects of xenobiotics or their metabolites on an organism often depend on its capacity to increase cellular levels of reactive oxygen species (ROS), which may damage crucial cellular components (Coutinho and Gokhale, 2000; Li et al., 2009,2010a). Uncontrolled production of free radicals leads to oxidative stress. Since the discovery of the importance of oxidative stress, there has been an increased application of related biomarkers in aquatic organisms, including measurement of specific antioxidant enzymes, biomarkers of protein and lipid peroxidation (Berglund et al., 2007; Li et al., 2010i).

As STPs cannot remove all xenobiotics, it is necessary to assess the impacts of STPs on the water quality of small streams, some of which are major sources of drinking water. Therefore, the aim of this present study was to examine the effects of three common sources of municipal waste pollution on the aquatic environment, situated on the upper reaches of streams in the Czech Republic. A battery of biomarkers measured in fish tissues, including oxidative stress levels [lipid peroxidation (LPO) and carbonyl protein (CP)] and antioxidant enzyme activities [superoxide dismutase (SOD), glutathione peroxidase (GPx) and glutathione reductase (GR)], coupled with chemical analysis, were used. The indicator species selected was the brown trout (*Salmo trutta fario* L.), which has been used as a bioindicator in previous studies (Behrens and Segner, 2005; Tarrant et al., 2008).

2. Materials and methods

2.1. Target sites

The upstream (US) and downstream (DS) locations were separated by weirs. The DS locations were situated as near as possible to discharges from suspected sources of pollution—STPs. The US locations were situated upstream of these STPs. The target STPs were the furthest upstream sources of anthropogenic pollution situated on the relevant streams. The locations of the sampling sites are illustrated in Fig. 1.

Prachatice (population 13 000) is a town situated on the Zivny stream (a tributary of the Blanice River) in South Bohemia. Commercial activity consists of light industry (food, manufacturing of machinery and electronics) along with agriculture in the surrounding area. The Prachatice STP is the main source of pollution for the Zivny stream. Sewage water treatment involves primary mechanical filtration and sedimentation followed by activated sludge treatment. The STP effluent contributes approximately 30% of the water in the Zivny stream. The US location was situated 1.5 km above the

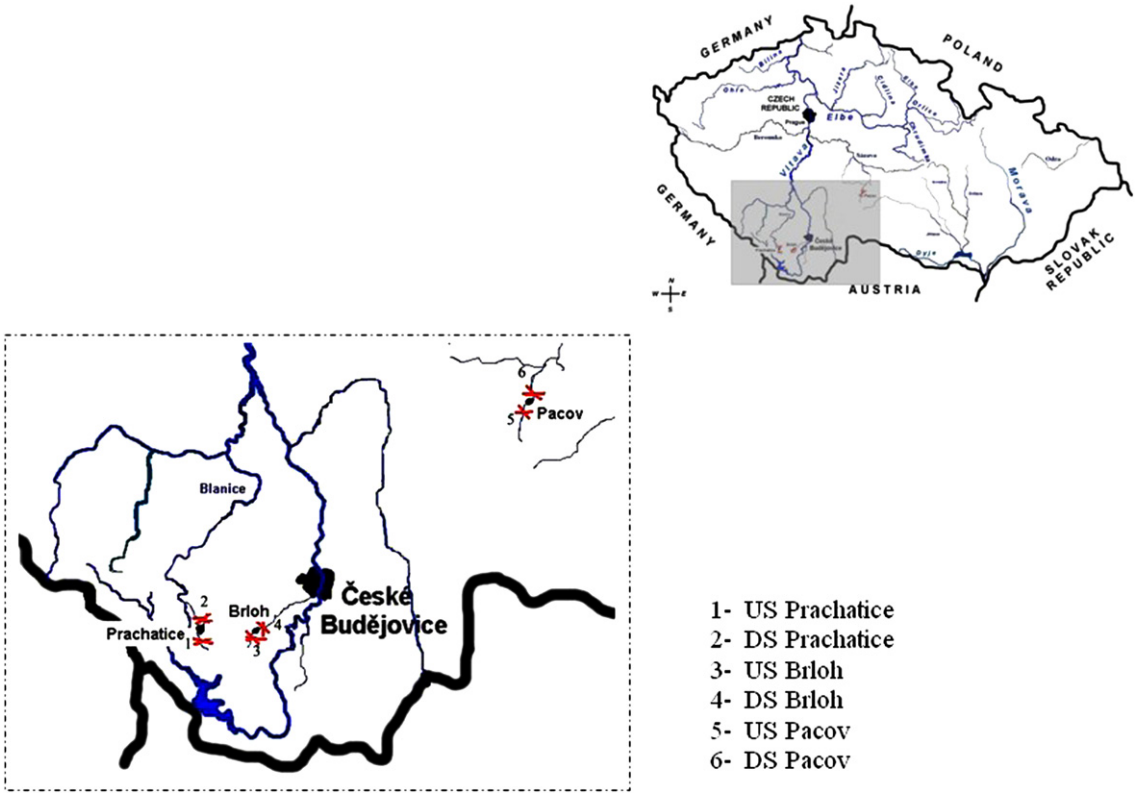

Fig. 1 – Map of sampling sites in Czech Republic.