Effects of Deicing Salt in Protected Areas: Water Quality Monitoring in the River Basin with the Occurrence of a Rare Pearl Mussel

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Abstract

The effects of deicing salt on water ecosystems have been studied in the Šumava National Park and Protected Landscape Area. A pilot study was conducted in the Upper Vltava River basin, a habitat of the strictly protected pearl mussel. Dataloggers were used to investigate conductivity, often recommended as an important indicator of water quality.

In this pilot project two pairs of dataloggers were installed in two streams crossed by the roads with different road maintenance regime. The first site was established in location, where deicing salt has not been allowed at all, but preliminary results of soil and vegetation monitoring indicated some impacts of deicing salts in this location. The records from dataloggers confirmed this, but conductivity was not so high at the second site. The second site was established on a priority road, permanently maintained by deicing salt. In this site, we often recorded conductivity higher than 75 μS/cm, water quality limit for suitable habitats of the strictly protected pearl mussel. High conductivity may negatively affect viability of the population.

From a methodological point of view, there are two main outputs of this pilot project. (1) We found that dataloggers can be frozen and out of records in shallow water during longer frost period. (2) We also confirmed hypotheses that not all ions are transported rapidly through the soil and groundwater. Conductivity was lower during winter and increased with snow melting. During vegetation season dataloggers recorded decrease of conductivity after heavy rains or longer rain period. Conductivity increased again in dry period.

We conclude that the dataloggers improve our knowledge of impact of deicing salt in water ecosystems and offer relevant arguments for EIA in the area of high conservation value. Of course more statistical analyses are necessary; more detail information about annual differences in weather conditions and amount of deicing salt applied in different locations (not only a total amount of salt for a whole road) could help to interpret our data.

Keywords: EIA, Natura 2000, road salting, ecosystem monitoring, datalogger

Introduction

The negative effects of applying deicing salts to ecosystems are well known and documented for many countries, both in urban and natural areas (Findlay & Kelly 2011). There is emerging evidence that simple salt (NaCl), the most often used deicing salt, contrary to what was previously thought is not transported rapidly through the soil and groundwater. This can affect the living conditions of water organisms, especially their most sensitive developmental stages (Karraker et al. 2008). High concentrations of salt affect competition and predation and also cause significant changes in plant composition (i.e. Angold 1997, Richburg et al. 2001, Wrobel et al. 2006) and soil invertebrate communities (Rusek & Rusek 1999).

The Šumava National Park (Šumava NP) and the Šumava Protected Landscape Area (Šumava PLA), are the largest protected areas in the Czech Republic with high conservation value (Křenová & Hruška 2012, Křenová & Kindlmann 2015) and the application of deicing salts to roads in large protected areas is prohibited by law. There are special exceptions for several main roads, where deicing salts are applied but only when particular conditions prevail. The monitoring was started in 2003 (Zýval et al. 2015).

The shallow water and oligotrophic oxbow pools of the Upper Vltava River in the Šumava NP are habitats for some relict plant communities, rare and relict invertebrates and one of the last viable Central European populations of pearl mussels (Margaritifera margaritifera), protected by Natura 2000. The species is well known for its extremely high sensitivity to water quality. Pearl mussels need water with conductivity lower than 75 μS/cm and can be threaten by increasing eu-

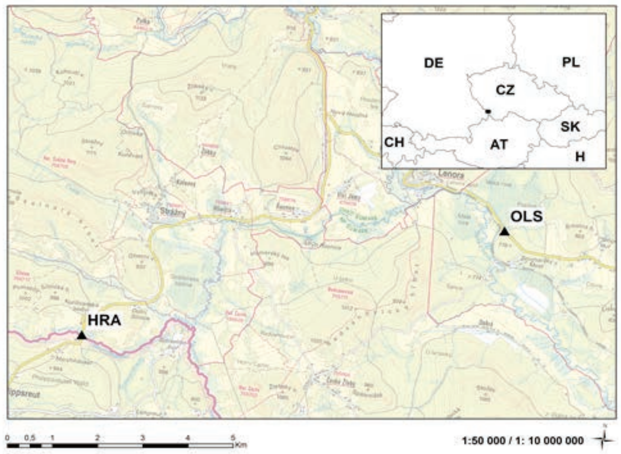

Fig. 1. A map of study area. Study sites the Hraniční potok stream (HRA) and OLS = the Olšinka stream are shown. (source: ZM 50 ČUZK online, http://geoportal.cuzk.cz/WMS_ZM50_PUB/WMService.aspx and EU STAT online, http://services.arcgis.com/2DbqGRRQS9wbBetw/arcgis/rest/services/state_type/FeatureServer)

Rys. 1. Mapa badanego terenu. Badane tereny: Hraniční potok (HRA) i OLS = Olšinka potok

trophication and salinity in the basin. Natura 2000 legislation requires the EIA for all projects and activities that could affect the habitats and species of European interest. Until now only few information are available about the effect of deicing salts on water ecosystems in our study area.

Materials and method

Study site

In the Šumava NP & PLA the effect of deicing are annually studied since 2003. Currently twelve permanent study sites are used (Zýval et al. 2015). Twenty new dataloggers were installed in summer 2015 to improve monitoring of impact of deicing salt on water environment. In this paper we present results from two study sites (distance 10 km) which were chosen to optimize the monitoring design and methods. Dataloggers were installed in the Hraniční potok stream (HRA; Fig. 1; GPS: N 48°52.86497', E 13°42.25907')) and the Olšinka stream (OLS; Fig. 1; GPS: N 48°54.89433', E 13°49.56480') in June 2015. The HRA site - a priority road, permanently maintained by deicing salt. The OLS site was established in location, where deicing salt has not been allowed at all.

Methods of monitoring

A pair of dataloggers (type LTC Levelogger Edge) was installed at each of our study sites. Always the first datalogger was installed at least 50 meters above the bridge, where the road crossed the stream. The second datalogger from the pair was installed 50 meters downstream from the bridge. This pilot monitoring was started on 1 August 2015 and continued throughout a year until 31 July 2016. Data were recorded hourly and daily averages of conductivity were calculated and used for analysis. Daily sums of precipitation from a local meteorological station were investigated to explain fluctuations of conductivity during the year.

The STATISTICA (data analysis software system), version 12 (www.statsoft.com) was used to analyze data (descriptive statistics, ANOVA), if necessary log transformations LOG (x+1) were used.

Research outputs

From the site HRA we could use data from 352 days. The dataloggers were out of record for 12 days during the winter due to a very low temperature. The stream Olšinka is smaller and shallower than the Hraniční stream and the dataloggers were frozen for many days. The records of 127 days starting on 1 December, 2015 were excluded from the analysis (Table 1).

Compering the records from the same period we found that the study sites HRA and OLS significantly differ (ANOVA, $p<0.001$). Higher conductivity was recorded at the site HRA. Conductivity at the site OLS above the bridge (OLS_1) was very low. This stream springs in a near peat bog forest and conductivity of this water is naturally very low. There were also significant differences in records of dataloggers above the bridge and downstream from the bridge at the both study sites HRA and OLS (ANOVA, $p<0.001$).

Nevertheless, fluctuations of conductivity of all four dataloggers were synchronized and partly correlated with precipitation. Daily averages of conductivity at the subsites HRA_01 (above the bridge) and HRA_02 (down the stream) were significantly different. Always conductivity recorded downstream from the bridge was higher. During vegetation season, middle of April – middle of October, HRA_02 conductivity was often higher than 75 μS/cm, water quality limit for the pearl mussel (Fig. 2).

Tab. 1. Basic descriptive statistics for records of conductivity from two study sites HRA (the Hraniční potok stream) and OLS (the Olšinka stream). At each location, two dataloggers were installed. The first one above the bridge (HRA_01, OLS_01) and the second one downstream from the bridge (HRA_02, OLS_02).

Tab. 1. Podstawowa statystyka dla przewodności dla dwóch lokalizacji HRA (the Hraniční potok) i OLS (Potok Olšinka). Zainstalowano dwa datalog-gery. Pierwszy ponad mostem (HRA_01, OLS_01) I drugi poniżej mostu (HRA_02, OLS_02).

Variable	Descriptive Statistics – Conductivity			
	Valid N	Mean	Maximum	Std.Dev.
HRA_01 – above the bridge	352	32,7	91,0	12,4
HRA_02 – downstream	352	40,8	66,2	12,5
OLS_01 – above the bridge	237	0,6	6,5	1,4
OLS_02 – downstream	237	6,3	62,0	10,8

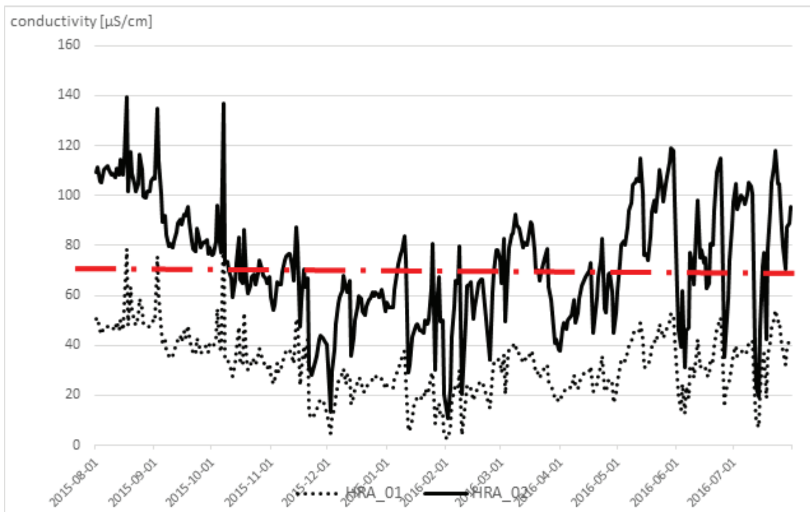

Fig. 2. Daily averages of conductivity at the sites HRA_01 (above the bridge) and HRA_02 (downstream from the bridge) were significantly different. Dotted line __.__.__ indicates the limit of water quality in suitable habitats of the strictly protected pearl mussel (Margaritifera margaritifera).

Rys. 2. Średnia dzienna prewodność w lokalizacji HRA_01 (powyżej mostu) I HRA_02 (poniżej mostu) były zdecydowanie różne. Linia __.__.__ oznacza graniczną wartość zanieczyszczeń wody dla omułka perłowego (Margaritifera margaritifera).

Conclusions

The effects of deicing salt on water ecosystems have been studied at two study sites in the Šumava NP and PLA. We used dataloggers to investigate conductivity, often recommended as an important indicator of water quality. In this pilot project, we found that conductivity recorded downstream from the bridge was always higher and during vegetation season, middle of April – middle of October, was often higher than 75 µS/cm. This is water quality limit for suitable habitats of the strictly protected pearl mussel. High conductivity may negatively affect viability of the population. This finding should be reflected in preparation of new regulation the road maintenance in this area.

We believe that the long-term monitoring using a proven methodology is a very important tool for better understanding of the ecological impacts of road salting on surrounding ecosystems. The dataloggers improve our knowledge and offer relevant arguments for EIA in the area of high conservation value.

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Skutki usuwaniu lodu za pomocą soli w obszarach chronionych: Monitorowanie jakości wody w dorze-czu wraz z analizą występowania rzadkiego perłowego omułka

Wpływ wykorzystania soli do usuwania lodu z dróg na ekosystemy wodne badano w Parku Narodowym Szumawa i Parku Krajobrazowym.Badania pilotażowe przeprowadzono w dorzeczu Górnej Wełtawy, siedlisku ściśle chronionego omułka perłowego. Zastosowano rejestratory danych (Dataloggers) do badania przewodnictwa, często zaleca-nego jako ważny sposób oceny jakości wody. W zrealizowanym projekcie pilotażowym zainstalowano dwie pary rejestratorów danych w dwóch strumieniach przecinanych przez drogi o różnym poziomie utrzymania zimowego. Pierwsza lokalizacja została wybrana w miejscu, gdzie sól do odladzania nie została w ogóle stosowana, aczkolwiek wstępne wyniki badania gleby i monitorowanie wegetacji roślin wskazało na występowanie oddziaływania soli w tym miejscu. Zapisy z rejestratorów danych potwierdziły to zjawisko. Przewodnictwo nie było tak wy-sokie jak w drugiej lokalizacji. Druga lokalizacja została wybrana na drodze pierwszej kolejności odśnie-zania o ciągłym stosowaniu soli do odladzania. W tym miejscu często rejestrowano konduktywność wyższą niż 75 µS / cm, (limit jakości wody dla siedlisk ściśle chronionego omułka perłowego). Wysoka przewodność może negatywnie wpływa na żywotność populacji. Z metodologicznego punktu widzenia uzyskano dwa główne wyniki projektu pilotażowego. (1)Stwierdzono, że rejestratory (dataloggery mogą) zamarznąć w płytkiej wodzie podczas dłuższego okresu mrozu. (2) Potwierdzono hipotezę, że nie wszystkie jony są transportowane szybko przez glebę i wody gruntowe. Przewodnictwo było niższe w okresie zimowym i zwiększało się wraz z topnieniem śniegu. Podczas sezonu wegetacyjnego rejestratory rejestrowały spadek przewodnictwa po ulewnych deszczach lub dłuższym okresie deszczowym. Przewodność ponownie wzrosła w okresie suchym. Przedstawiono wniosek, że rejestratory danych zwiększają wiedzę na temat wpływu soli do odladzania na ekosystemy wodne i oferują istotne argumenty za wykonywaniem ocen oddziaływania na środowi-sko w obszarze chronionych. Oczywiście konieczne są dalsze analizy statystyczne; więcej szczegółowych informacji o rocznych różnicach warunków pogodowych i ilości soli do odladzania stosowanej w różnych lokalizacjach (nie tylko całkowitej ilości soli dla całej drogi) może pomóc w interpretacji danych.

Słowa kluczowe: EIA, Natura 2000, posypywanie dróg solą, monitorowanie ekosystemów, datalogger