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*Research Article*

# ENZYMATIC ACTIVITY OF SOILS EXPOSED TO TRANSPORTATION POLLUTANTS, LOCATED ALONG ROAD NO. 957

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**ABSTRACT**
The research was conducted in order to determine the catalase, dehydrogenase, and arylsulfatase activities of soils exposed to transportation pollutants. The research material consisted of soil samples collected from points located along road no. 957 at a section passing through Zawoja (the Malopolska Region), from places at a distance of 5 and 200 m from the road edge. The samples were collected from a 0–10 cm layer, from areas covered with grasses. No considerable diversification in the enzymatic activity of the soils, depending on their distance from the road edge, was found. The mean activity of catalase and dehydrogenases in the soils located 5 m from the road edge was, respectively, 4 and 7% greater than the activity of the soils located 200 m from the road edge. The mean arylsulfatase activity in the soils located 5 m from the road edge was 3% lower than in the soils located at a distance of 200 m. A positive correlation was found between the catalase and arylsulfatase activities, and the dehydrogenase activity in the soils.

**Keywords:** soil, transportation, dehydrogenase, catalase, arylsulfatase.

## INTRODUCTION

Biological activity of soil is, next to their physical and chemical properties, an important element which decides its fertility. It is characterized by enzymatic activity, micro-organism biomass, the composition and number of microorganisms, and also by an activity specific for particular soil conditions [Brzezińska 2006]. A lot of researchers [Gostkowska et al. 1998, Koper et al. 2008] believe that enzymes can be a sensitive index of changes in soil. The number of micro-organisms in soil as well as the activity of enzymes depend on a lot of factors (e.g. soil pH values, water-air relationships, the content of organic compounds) which are formed by management and state of the natural environment [Barabasz, Vorisek 2002]. Environmental pollution from anthropogenic sources, including transportation, causes changes in chemical properties of soils, leading to changes in the enzymatic activity of these soils [Bielińska et al. 2010, Szymczak et al. 2011, Kuziemska 2012, Niemeyer et al. 2012]. Car transportation (combustion of fuels, abrasion of vehicle parts, wear of fluids and operating lubricants) is a source of environmental pollution with, among other things, heavy metals and organic compounds [Wang, Zhao 2008, Dao et al. 2010].

The research was conducted in order to determine the catalase, dehydrogenase, and arylsulfatase activities of soils exposed to transportation pollutants.

## MATERIAL AND METHODS

The research material consisted of soil samples collected from points located along road no. 957 at a section passing through Zawoja (the Malopolska Region), from places at a distance of 5 and 200 m from the road edge (Figure 1). The samples were collected from 13 points, from a 0–10 cm layer, from areas covered with grasses. The precise characteristics of the research area, the intensity of car traffic as well as basic physico-chemical properties of the studied soils were presented in a previous publication [Filipek-Mazur et al. 2013].

The determination of the dehydrogenase and arylsulfatase activities in the soils was conducted by colorimetric method on a Beckman UV/VIS DU 640 Spectrophotometer. The dehydrogenase activity was determined using 2,3,5-triphenyltetrazolium chloride as a substrate [Brzezińska and Włodarczyk 2006]. The soil was incubated with the substrate for 24 hours at a temperature of 37 $^{o}$C. The content of the created 1,3,5-triphenylformazan (TPF), extracted with alcohol, was determined at a wavelength of 485 nm. The catalase activity was determined by manganometric method consisting in shaking the soil with 0.3% H2O2 0.3% $H_2O_2$ (30 rot.·min$^{-1}$, 20 min) at room temperature. The arylsulfatase activity was determined after incubating the soil with p-nitrophenyl sulfate for 1 hour at a temperature of 37 $^{o}$C, determining the content of the formed p-nitrophenol (pNP) at a wavelength of 400 nm [Allef, Nannipieri 1995, Brzezińska, Włodarczyk 2006].

All the analyses were carried out in 4 replications. The obtained results were elaborated statistically – minimum and maximum values were stated, and arithmetic mean and standard deviation were computed. All statistical analyzes were performed using the STATISTICA data analysis software system, version 10 (StatSoft, Inc.).

## RESULTS AND DISCUSSION

The results of determining the enzymatic activity of the studied soils are presented in Table 1 and Figure 2. The dehydrogenase activity was slightly higher in the soils located closer to the road (5 m) and was, on average, 0.200 µmol TPF·g$^{-1}$ d.m.·24h$^{-1}$. For the distance of 200 m from the road, that value amounted to 0.187 µmol TPF·g$^{-1}$ d.m.·24h$^{-1}$ and was 7% lower than the mean value determined in the distance of 5 m from the road. Determination of dehydrogenase activity in soils is used as an indicator of the intensity of respiratory metabolism of all populations of soil micro-organisms, which is used to determine the total microbiological activity of soils. The dehydrogenase activity is commonly used to evaluate the factors which have a negative impact on soil micro-organisms [Brzezińska 2006].

Similar relationships were found in respect to the catalase activity which at the distance of 5 and 200 m from the edge of the road was, on average, 6.36 and 6.11 µmol $H_2O_2$ · g$^{-1}$ d.m.· min$^{-1}$, respectively. Closer to the road the value was 4% higher. The earlier tests on pollution of the analyzed soils with heavy metals, including cadmium, showed that the content of this element in the soils located 200 m from the road was slightly higher than at the distance of 5 m [Filipek-Mazur et al. 2013]. This higher cadmium content might have been the cause of the decrease in the catalase activity.

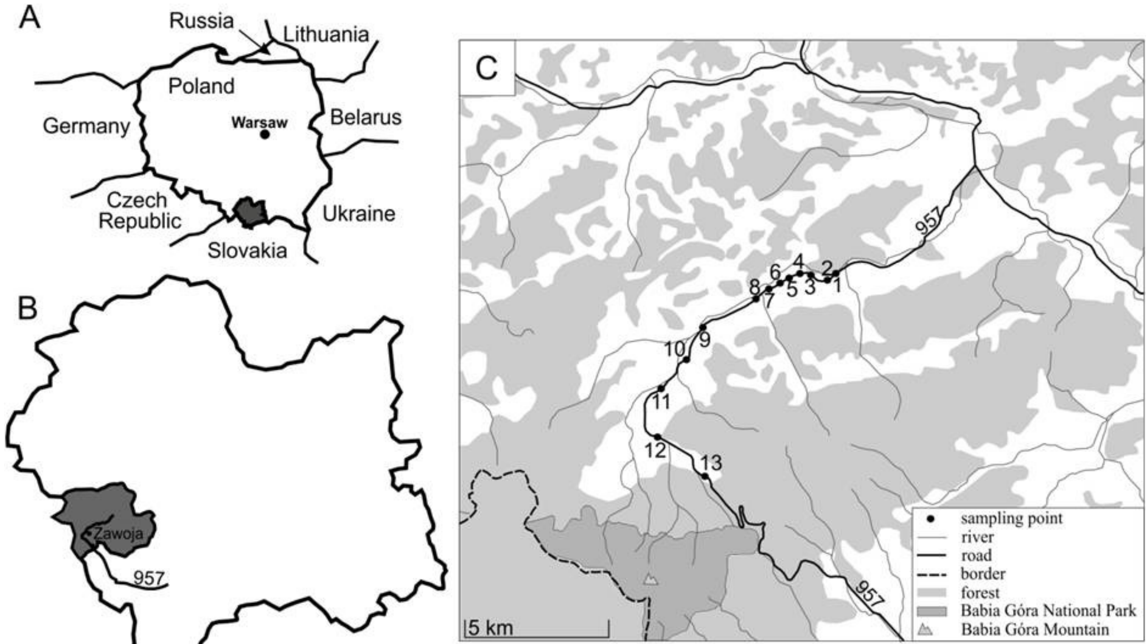


**Figure 1.** Location of sampling points: A – Poland with marked Małopolska province, B – Małopolska province with marked Suski district, road No. 957 and Zawoja, C – sampling points along road No. 957

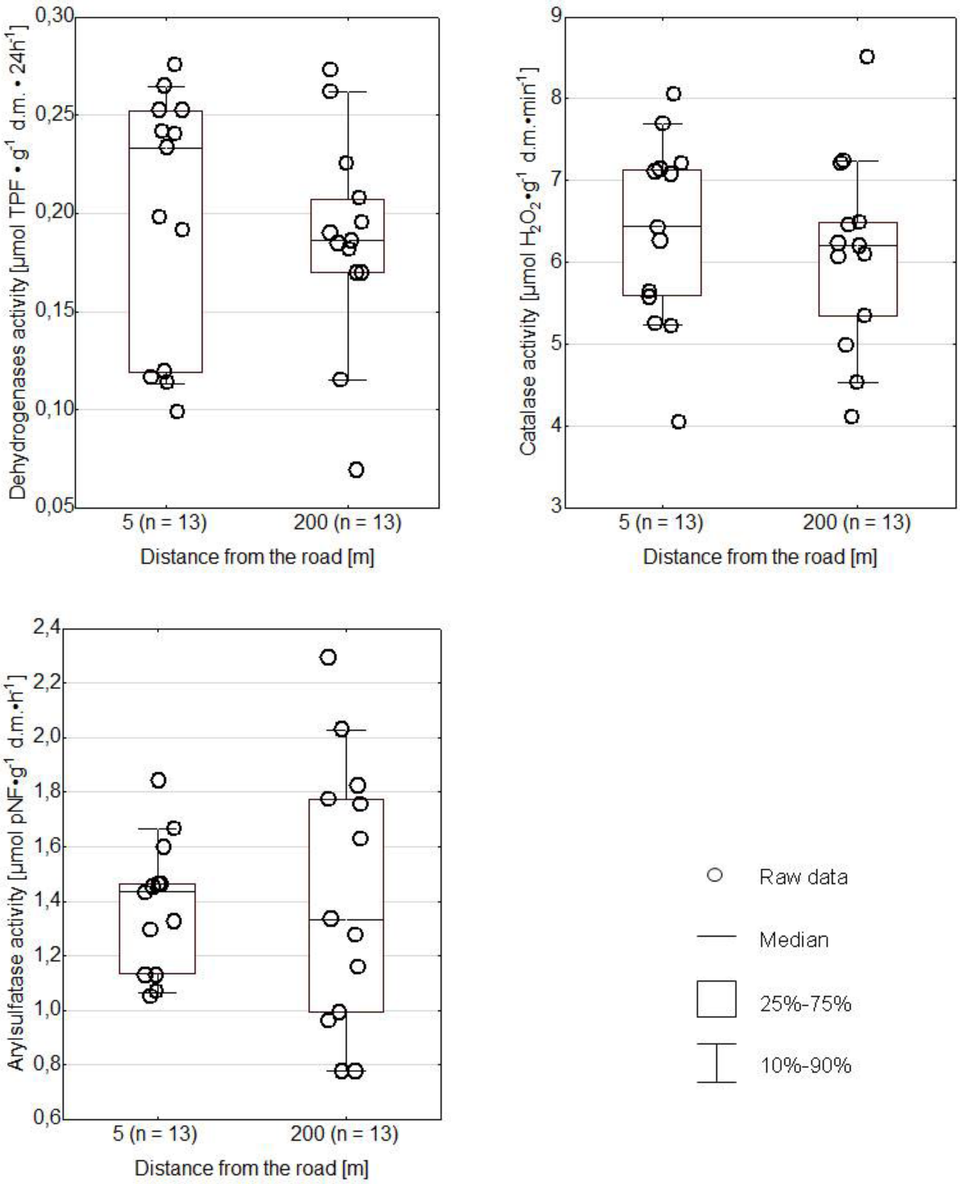


**Figure 2.** Dehydrogenase, catalase, and arylsulfatase activities in soils from Zawoja region

Szymczak et al. [2011] obtained such an effect in their research, whereas Wyszkowska et al. [2009] showed a slight decrease in the activity of soil catalase under the influence of increased copper content in the soil.

Relationships between the values of arylsulfatase activity were different, depending on the distance of soils from the road. The mean arylsulfatase activity in the soils located 5 m from the road edge was 3% lower than in the soils located at a distance of 200 m (1.38 and 1.43 µmol pNF·$g^{-1}$ d.m.·$h^{-1}$, respectively). The determined values were lower than the ones obtained in the research of Siwik-Ziomek [2005], but the author analyzed soils from the fertilization experiment. Table 2 shows the values of correlation coefficients between selected soil properties and the values of their enzymatic activity. A positive correlation was found between the catalase and arylsulfatase activities, and the dehydrogenase activity in the soils (the correlation coefficient values were 0.405 and 0.429, respectively). The arylsulfatase activity depended on concentration of hydrogen ions in the soil as well as on the contents of organic carbon and total nitrogen in the soil (the values of correlation coefficients between 0.398 and 0.565). Organic compounds which constitute a source of energy for soil micro-organisms influence an increase in enzymatic activity of soils. Siwik-Ziomek and Koper [2013] noticed a beneficial effect of fertilization with manure on arylsulfatase activity.

**Table 1.** Dehydrogenase, catalase, and arylsulfatase activities in soils from Zawoja region – statistical parameters

| Distance from the road [m] | Parameter | Dehydrogenase activity [μmol TPF·g$^{-1}$ d.m.·24 h$^{-1}$] | Catalase activity [μmol $H_2O_2$·g$^{-1}$ d.m.·min$^{-1}$] | Arylsulfatase activity [μmol pNF·g$^{-1}$ d.m.·h$^{-1}$] |
|---|---|---|---|---|
| 5 (n = 13) | Mean | 0.200 | 6.36 | 1.38 |
| | Minimum | 0.099 | 4.03 | 1.05 |
| | Maximum | 0.275 | 8.05 | 1.84 |
| | Standard deviation | 0.065 | 1.16 | 0.24 |
| 200 (n = 13) | Mean | 0.187 | 6.11 | 1.43 |
| | Minimum | 0.070 | 4.11 | 0.77 |
| | Maximum | 0.273 | 8.50 | 2.29 |
| | Standard deviation | 0.054 | 1.18 | 0.49 |

**Table 2.** Values of correlation coefficients between selected soil properties and their enzymatic activity

| | Dehydrogenase activity | Catalase activity | Arylsulfatase activity |
|---|---|---|---|
| Fraction content $\phi$ < 0.02 mm | -0.234 | 0.188 | 0.220 |
| $H^+$ | -0.191 | -0.048 | 0.454 * |
| Organic C | -0.002 | 0.135 | 0.398 * |
| Total N | -0.060 | 0.174 | 0.565 ** |
| Total S | 0.001 | 0.050 | 0.375 |
| Organic S | 0.006 | 0.047 | 0.386 |
| Sulfatic S | -0.132 | 0.090 | -0.170 |
| Arylsulfatase activity | 0.429 * | 0.353 | – |
| Catalase activity | 0.405 * | – | – |

* significant at $p < 0.05$; ** significant at $p < 0.01$

Such a dependence was not observed with respect to catalase and dehydrogenases. Scientific literature shows a positive correlation between the activity of dehydrogenases and catalase, and the content of organic carbon in soils [Brzezińska 2006], which was not confirmed by the authors' own research.

## CONCLUSIONS

No considerable diversification in the enzymatic activity of the soils, depending on their distance from the road edge, was found. The mean activity of catalase and dehydrogenases in the soils located 5 m from the road edge was, respectively, 4 and 7% greater than the activity of the soils located 200 m from the road edge. The mean arylsulfatase activity in the soils located 5 m from the road edge was 3% lower than in the soils located at a distance of 200 m.

A significantly positive correlation was found between the catalase and arylsulfatase activities, and the dehydrogenase activity in the soils. The arylsulfatase activity was positively correlated with the concentration of hydrogen ions in the soil and with the contents of organic carbon and total nitrogen in the soil.

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