високої вартості робочої сили, накопичення людського й соціального капіталу, підтримки підприємницької активності населення, зміцнення середнього класу, підвищення соціальних стандартів і гарантій, а також надання необхідної соціальної підтримки вразливим групам населення.

Пріоритетом політики сталого розвитку є забезпечення гідних умов праці та життя у власній країні.

Стратегія спрямована на побудову справедливого та демократичного суспільства, де буде забезпечено підтримку прав людини, зокрема екологічних прав, розвиток національної культури, гендерну рівність і зростання соціального капіталу (здатності суспільства до спільної роботи, що базується на спільних цінностях).

Необхідним для реалізації Стратегії є дотримання принципів верховенства права, демократії, незалежного управління на всіх рівнях, створення ефективних, результативних, інклюзивних та підзвітних інституцій.

Керівними принципами Стратегії визначено верховенство права, захист прав людини, належне врядування, участь громадськості, представників бізнесу та соціальних партнерів, інтеграція політики та управління, солідарність всередині поколінь і між поколіннями, використання найкращих з наявних знань, принцип запобігання забрудненню і «забруднювач платить».

Стратегія спрямована на досягнення визначеної мети розвитку та має супроводжуватись Національним планом дій (дорожньою картою) переходу України до сталого розвитку.

Стратегія встановлює цілісну систему стратегічних та операційних цілей переходу до інтегрованого економічного, соціального та екологічного розвитку країни до 2030 року. Вона також визначає інституційні засади впровадження стратегії, напрями міжгалузевої та міжсекторальної взаємодії, основні рушійні сили та інструменти її реалізації. Цільові показники визначено для трьох етапів реалізації Стратегії: 2016-2020 рр., 2021-2025 рр. і 2026-2030 роки.

Стратегія є результатом врахування міжнародних документів (світових і європейських), аналізу чинного законодавства, врахування численних пропозицій від центральних органів виконавчої влади, органів місцевого самоврядування, експертного середовища та громадянського суспільства. Це також інтерактивна процедура узгодження кожного положення Стратегії на регіональних консультаціях, на робочих зустрічах експертів.

Проект Стратегії сталого розвитку України на період до 2030 року було обговорено з червня до грудня 2016 року на регіональних та національних консультаціях, у яких взяли участь представники органів державної влади та місцевого самоврядування всіх областей України, депутати різних рівнів, науковці та освітяни, представники інститутів громадянського суспільства, професійних об'єднань, бізнесу, ЗМІ, експерти міжнародних організацій.

Більшість учасників консультацій схвально оцінили проект оновленої Стратегії як документ, що повністю відповідає прийнятому в Україні формату управлінського документа.

Проект Стратегії сталого розвитку України на період до 2030 року розміщено на сайті Інституту географії НАН України igu.org.ua/

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IMPACT OF ROAD TRAFFIC ON SOIL PROPERTIES (POLISH CASE STUDY)

The aim of the paper is to show relations between road traffic and soil contaminations along 6 road corridors located in Poland. The corridors for the research are national roads, expressways and motorways characterized by different traffic intensity. We investigated samples along transects perpendicular to road axes, at locations situated from 1 to 100 meters away from the edge of the road, from the surface layer (horizon O/A) and at a depth of 30 cm (horizon B). In terms of soil quality, lower content of heavy metals in organic and mineral horizons was observed in the vicinity of the motorways and expressway comparing to areas surrounding local roads. Particularly high level of soil contamination was observed at border crossings, due to queues of trucks.

Keywords: *road traffic; pollution; soil contamination; Poland.*

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ВПЛИВ АВТОМОБІЛЬНОГО ТРАНСПОРТУ НА ВЛАСТИВОСТІ ҐРУНТУ (НА ПРИКЛАДІ ПОЛЬЩІ)

Мета статті – показати зв'язок між рухом транспорту і забрудненням ґрунту вздовж 6 транспортних коридорів у Польщі. Для дослідження обрано коридори національних доріг, швидкісних доріг і магістралей, що характеризуються різною інтенсивністю руху. Досліджено зразки вздовж поперечних перетинів, перпендикулярних до дорожної осі, у точках, розташованих від 1 до 100 метрів від краю дороги, з поверхневого шару (горизонт O/A) і на глибині 30 см (горизонт B). Стосовно якості ґрунтів, виявлено, що вміст важких металів в органічних і мінеральних горизонтах в безпосередній близькості від автомагістралей і швидкісних доріг нижчий порівняно з прилеглими дорогами місцевого значення. Особливо високий рівень забруднення ґрунту спостерігався у місцях перетину державного кордону у зв'язку з великими чергами транспортних засобів.

Ключові слова: *дорожній рух; забруднення; забруднення ґрунту; Польща.*

Introduction

Humans are affected by the environment they live in. The impact of traffic on some environmental components such as water or soil has a crucial influence on living conditions [1, 9, 10]. There are several types of traffic pollution, but one of the most dangerous ones is air and soil pollution. Some substances, such as carbon monoxide, nitrogen dioxide, sulphur dioxide and heavy metals, are particularly harmful [2, 3, 5-7]. The aim of the paper is to show some relations between road traffic and soil contamination based on a case study from Poland.

Along with traffic intensity and vehicle speed, the duration of anthropopressure on the soils is also a key determinant of heavy metal content. Habitat factors constitute another group of determinants of the intensity of heavy metal accumulation in the soil; particularly important here are soil-specific factors such as buffering properties, sorptive properties or biochemical activity [5, 6].

The presented study was carried out along transects perpendicular to road edge that represented different categories of roads highways, express roads and national roads. All soils under study have developed from similar lithological material (sands), support the same form of land use (meadows) and possess similar physicochemical characteristics, therefore the individual transects represented similar environmental conditions. The only differential factors were the intensity of traffic and the duration of traffic-related impact on the environment. Where the duration of impact is similar, the factors underlying differences in heavy metal content in soils are traffic intensity, parameters of the road and vehicle speed.

Material and Methods

The selection of road sections for the study was based on the average daily traffic volume of trucks in 2010, 2005 and 2000 and an increase in intensity between 2000 and 2010 (preference was given to sections that registered a perceptible increase in the period 2000-2010) and different categories of roads. The study involved 6 road corridors and embraced 8 sections of national roads and motorways (Fig.1).

Samples were obtained along transects perpendicular to road axes, at locations situated from 1 to 100 meters away from the edge of the road, from the surface layer (horizon O/A) and at a depth of 30 cm (horizon B). The distances between sampling locations and the edge of the road are shown in Fig. 2. As the infrastructure prevented access to two of the segments, soil samples at these sites were collected only at 10, 20, 50 and 100 m from the edge of the road.

Samples collected for geochemical analyses were dried at 105ºC, and subsequently sifted through a sieve with a mesh diameter of 2 mm. Analyses were carried out for <2mm fractions. Organic matter and carbonate content was determined by LOI method according to the procedure proposed by Heiri et al. [8]. Carbonate concentration was calculated according to the formula: Carb[%] = 1,36•LOI950, where LOI950 is the amount of CO2 released from the samples as a result of thermal decomposition of carbonates [8]. The mass of carbonate-bound carbon was assumed to represent total inorganic carbon (TIC) and its content was calculated as TIC[%] = 0.27·LOI950. The content of total carbon (TC), total nitrogen (TN) and total sulphur (TS) was determined with a VarioMax CNS (Elementar) analyser. Total organic carbon (TOC) was calculated as TOC = TC-TIC. Ni, Fe, Pb, Cu and Zn content was analysed in aqua regia (HCl :HNO3 = 3:1vol/vol) based solutions. Mn, K, Cu and Zn content was determined by AAS method using a Varian SpectrAA 220 spectrometer. The correctness of determinations of C, N, S and Ni, Pb, Cu and Zn content was tested with reference materials CP1, NIST1646a, SQ001C and sulphadiazine. A total of 168 soil samples were examined. Soil results was elaborated by statistical methods [4].

Results

The soil samples obtained along the road sections under study displayed wide differences in heavy metal content. Analysis of all samples showed a statistically significant correlation between the presence of iron and nickel (r=0.6636) and copper and zinc (r=0.7283).

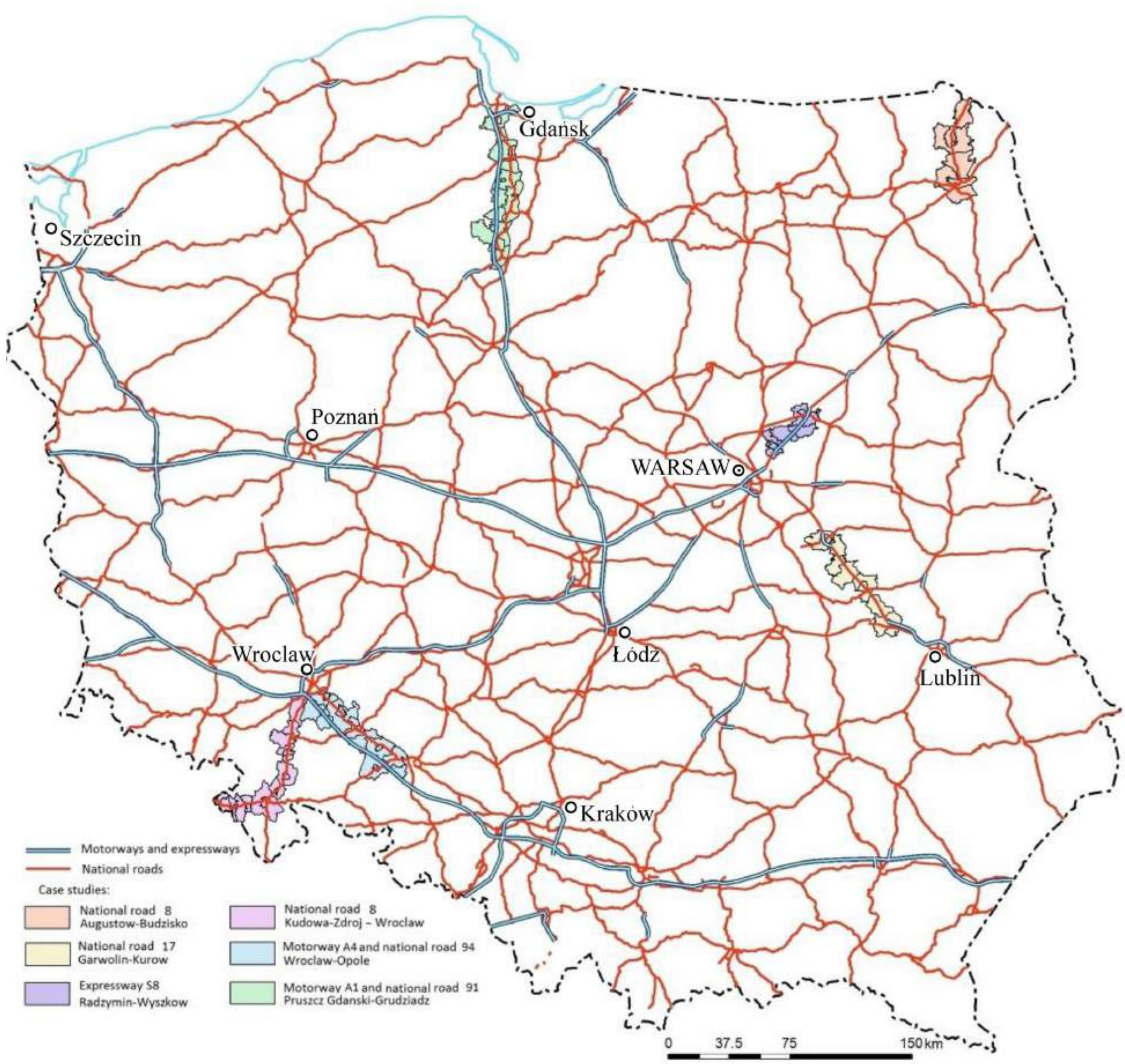

Fig. 1. Map of research points in Poland

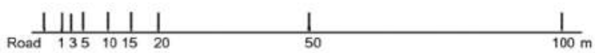

Fig. 2 Distribution of soil sampling points on the transect perpendicular to the road.

There was no correlation between heavy metal content and organic matter or calcium carbonate content. Very interesting results were, however, obtained with regard to correlations between the content of specific metals and distance from the road.

National road (DK8)

Four soil transects were studied along national road DK8, of which two were situated in north-eastern Poland (Budzisko and Suwałki transects) and two in southern Poland (Koźmice and Szczytna transects). The soils along the transport corridor to the Polish-Lithuanian border, which is characterised by the highest number of cargo lorries per day, had the highest content of individual heavy metals. For example, near Suwałki, Cu content was nearly 30 times higher, Zn content Suwas 10 times higher and Ni content was 4 times higher than the respective figures noted along the same road in southern Poland, e.g. in the Szczytna transect (Fig. 3). With regard to metal accumulation in soil profiles, most samples taken near the border crossing at Budzisko showed higher elemental content in the layer obtained at a depth of 30cm (B) than in the surface layer (A). Cu and Zn content in samples

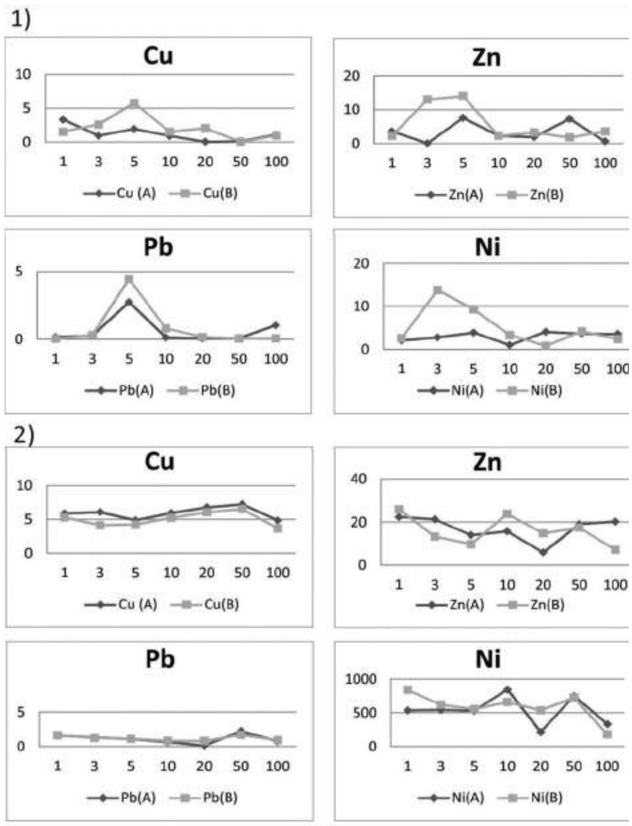

Fig 3. Content of heavy metals (Cu, Zn, Pb, Ni) in A and B horizons (mg*kg-1) of soils near roads located in Szczytna (1) and Koźmice (2) villages (Poland).

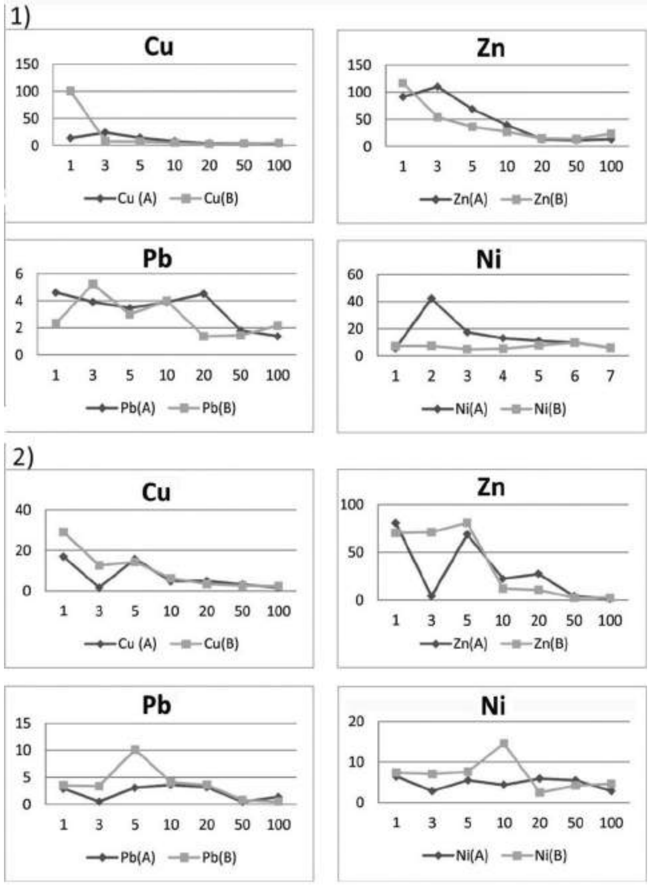

Fig.4. Content of heavy metals (Cu, Zn, Pb, Ni) in A and B horizons (mg*kg-1) of soils near Suwałki (1) and Budzisko (2) town (Poland).

decreased distinctly as distance from the road edge increased. Maximum concentrations of Pb and Ni were noted in horizon B at a distance of 5 m and 10 m from the road, respectively. The soil samples collected along the transect near the town of Suwałki demonstrated the highest Cu and Zn concentrations in samples taken at the road edge, with Cu concentrations falling dramatically already at 3 m away from the road and Zn content exhibiting a gradual decrease. High Cu content was only noted in soil surface samples, while high Zn content was found in both surface and depth samples. Pb content in samples from that transect did not vary according to the distance from the road. Maximum Ni content was noted at 3 m in the depth layer (Fig.4). There was also a correlation between Zn content in horizons A and B in the samples collected in this transect. With the exception of Ni, heavy metal content in the Koźmice and Szczytna transects did not correlate with distance from the road. Pb content increased slightly in both surface and depth samples collected at 5 m (Szczytna) and 50 m (Koźmice) from the road. The samples collected along the Szczytna transect revealed a correlation between Pb content in horizons A and B, while in the case of the Koźmice transect, a similar correlation was noted for Cu, Pb and Ni.

Expressway S8

The effect of expressways on heavy metal content was investigated along a transect near the town of Radzymin (Fig. 5). Heavy metal content in the soil of that transect was the lowest of all transects analysed. No trend was noted between metal content and distance from the road. The only notable finding was that Cu was present in horizons A and B. The road section near Radzymin has been in use for the shortest time of all road sections in the study, which will also have influenced the results (Fig.5).

National road No. 17

The sections of national road No. 17 selected for analysis were situated off the village of Trzcianka and the town of Ryki. Most soil samples collected near Trzcianka demonstrated higher content of heavy metals in the surface layer of soil (A) than in the depth samples collected at 30 cm (B). The concentrations of Pb and Zn decreased with increasing distance from the road, with maximum concentrations recorded in horizon A at 1 m from the road edge. Pb concentration in horizons A and B showed a correlation in that transect. Most soil samples collected near Ryki demonstrated higher heavy metal content in the surface samples

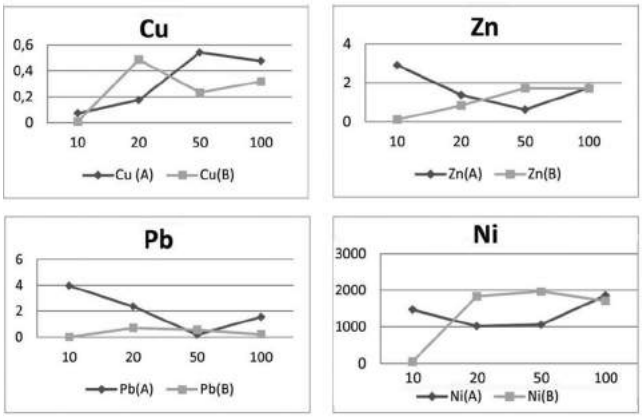

Fig. 5. Content of heavy metals (Cu, Zn, Pb, Ni) in A and B horizons (mg*kg-1) of soils near city of Radzymin (Poland).

(horizon A). Concentrations decreased with increasing distance from the road for Cu, Zn and Pb, with higher concentrations of lead in the depth samples (30 cm, horizon B). Maximum levels of these metals were recorded at 3 m from the road edge. Zn concentrations correlated between horizons A and B (Fig. 6).

National road No. 94

The sections of national road No. 94 selected for analysis were situated off the villages of Godzikowice and Buszyce. The transect near Godzikowice demonstrated a very distinct trend of decreasing heavy metal concentrations with increasing distance from the road. The surface samples had slightly higher heavy metal content (Fig.7). There were correlations between concentrations in horizon A and B for all metals investigated.

The samples obtained along the Buszyce transect revealed no trend in heavy metal content. Interestingly, Pb concentrations were higher in both the surface and depth (30 cm) samples at 5 m from the road edge. Correlations between metal concentrations in horizons A and B were noted along this transects for Pb and Ni.

Motorway A1 and national road DK 91

The effect on heavy metal content of a motorway vs. a national road representing an old transport route was compared by investigating soils situated near the town of Pelplin (old route) and a traveller service point (TSP) at the motorway. The analysis revealed several-fold higher heavy metal content in the soils surrounding the old transport route compared to the motorway. A pattern was also noted in the spatial distribution of heavy metals in soil. The transect perpendicular to the old transport route had the highest concentrations of Cu, Zn and Pb at the road edge, decreasing with increasing distance from the road. No distinct trend was observed for Ni (Fig. 8). The samples obtained along the transect perpendicular to the motorway revealed no statistically significant correlations between changes in the concentration of the various metals and the distance from the road.

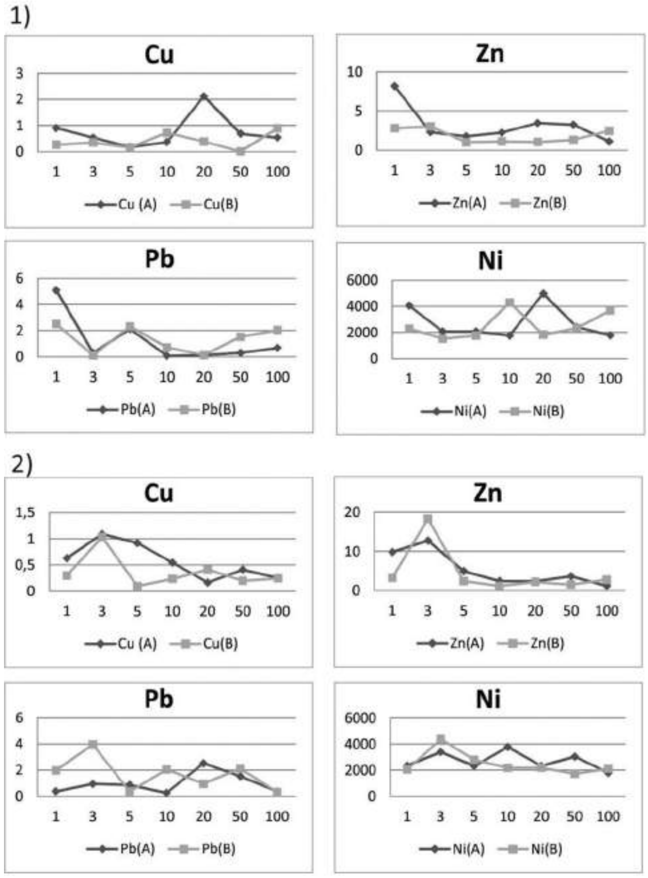

Fig. 6. Content of heavy metals (Cu, Zn, Pb, Ni) in A and B horizons (mg*kg-1) of soils near Trzcianka (1) and Ryki (2) villages (Poland).

In our study it was found that traffic has a local influence on some environmental components such as water or soil in Poland. Regardless of this local influence of traffic on environment, it has to be taken into consideration the impact on human well-being.

Conclusions

Presented study of heavy metal content in soils in the vicinity of transport routes leads to the following conclusions:

1. Differences in the concentration of specific heavy metals between the sections of transport routes investigated in our study were more than 100-fold. The highest concentrations were recorded near a Polish-Lithuanian border crossing (DK 8, Suwałki transect), and the lowest along the new expressway S8 (Radzymin transect).

2. Heavy metal content in soils decrease from the sampling points closest to the road towards the open area. This pattern was more regular in transects

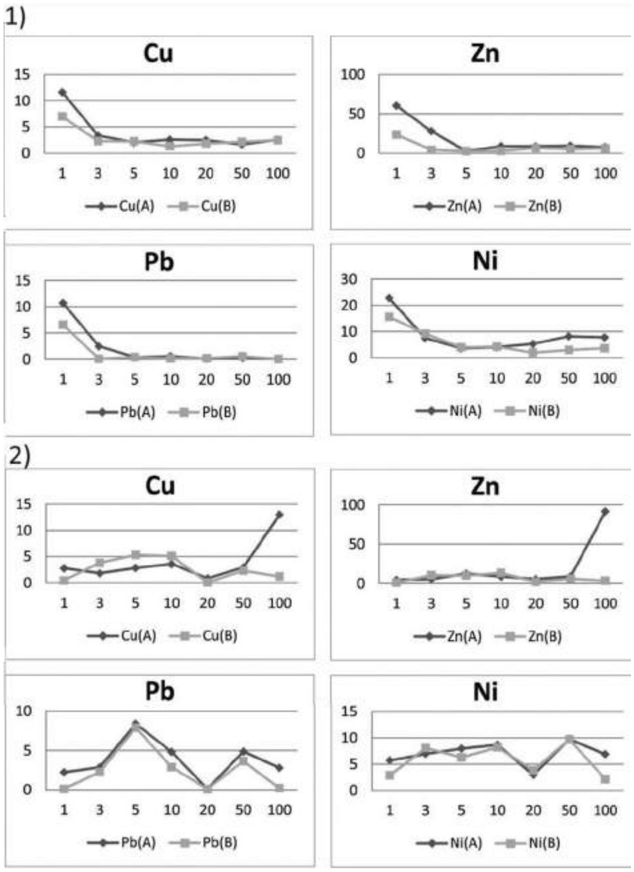

Fig. 7. Content of heavy metals (Cu, Zn, Pb, Ni) in A and B horizons (mg*kg-1)of soils near Godzikowice (1) and Buszyce(2) villages (Poland).

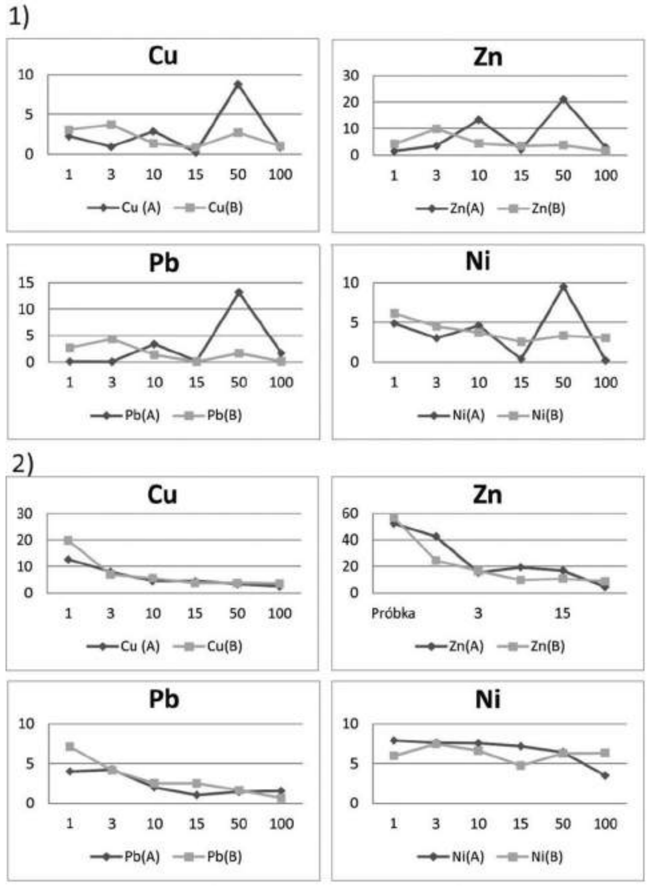

Fig. 8. Content of heavy metals (Cu, Zn, Pb, Ni) in A and B horizons (mg*kg-1) of soils near Grudziądz (1) and Pelplin (2) towns (Poland).

intersecting the long existing national roads and less regular in transects intersecting the relatively new motorways.

It may be concluded that, given similar traffic intensity, the environmental impact of motorways is much lower than that of national roads. High speed appears to be safer for the environment and human well-being than low speed.

References

1. Apeagyei E., Bank M.S., Spengler J.D. (2011). Distribution of heavy metals in road dust along an urban-rural gradient in Massachusetts. *Atmospheric Environment, 45,* (13), 2310-2323.
2. Bataillard P., Chamber P., Picot C. (2003). Short-termtransformations of lead and cadmium compounds in soil after contamination. *European Journal of Soil Sciences, 54*, 365-376.
3. Clemens S. (2006). Toxic metal accumulation, response to exposure and mechanisms of tolerance in plant. *Biochemie, 88,* 1707-1719.
4. Coles A., ed.(2004). *An Introduction to Statistical Modeling of Extreme Values*. Springer Verlag.
5. Degórski M. (2011). Influence of traffic into the environment properties and human. IGU Regional Geographic Conference. *United Integration with the World*. Conference Proceedings, CD, 20111743H5VYV4, Santiago, Chile, 1-9.
6. Degórski M., Zawiska I.(2015). The influence of car traffic on the sanitary state of the soils. *Europa XXI,* 28, 142-155.
7. Filipek-Mazur B., Gondek K., Mazur K.(2007). Heavy metal contents in soils and plants from areas localized along the No. 4 road within the boundaries of the ropczycko-sędziszowski county. *Ecological Chemistry and Engineering, 5–6,* 445–449.
8. Heiri O., Lotter A.F., Lemcke G.(2001). Loss on ignition as a method for estimating organic and carbonate content in sediments: reproducibility and comparability of results. *Journal of Paleolimnology, 25,* 101-110.
9. Jullien A., François D. (2006). Soil indicators used in road environmental impact assessments. *Resources, Conservation & Recycling, 48,* (2), 101-124.
10. Legret M., Pagotto C. (2006). Heavy metal deposition and soil pollution along two major rural highways. *Environmental Technology, 27,* 247–254.

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