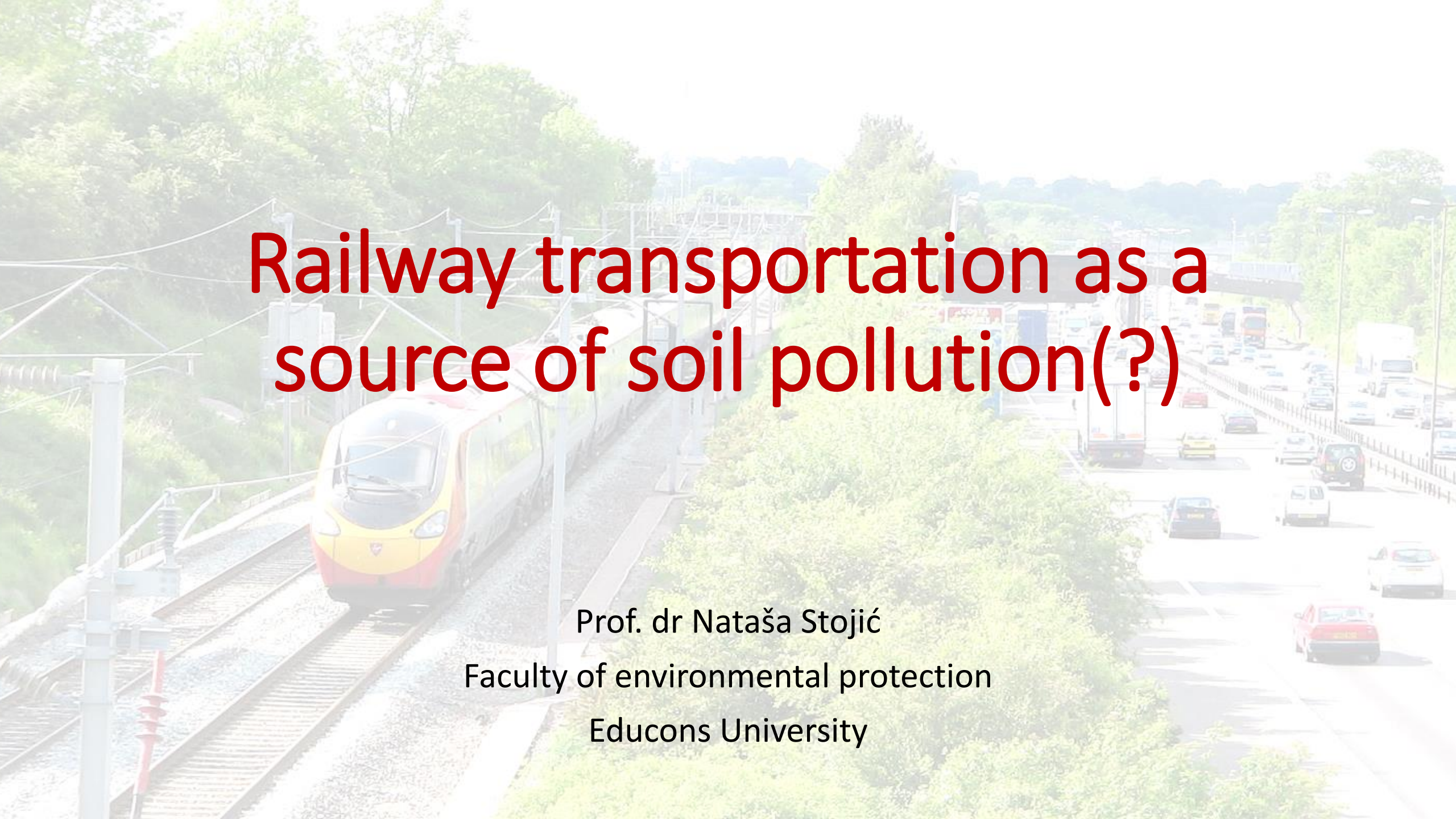

Railway transportation as a source of soil pollution(?)

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Facts about Serbian railway

- 139 years since the First Serbian Railway
- 21 locomotives, 127 passenger and 702 freight wagons, and all of them were used on 532 km of railway, of which 243.5 km were on the Belgrade-Niš railway.
- The journey of passenger trains from Belgrade to Niš lasted 8 hours and 15 minutes
- The first electrified railway on the network JŽ - Belgrade - Šid - state border (Zagreb) was put into traffic on May 31, 1970.

1884 ~ 30 km/h

2022 ~ 200 km/h*

* Beograd – Novi Sad

Serbian railway today

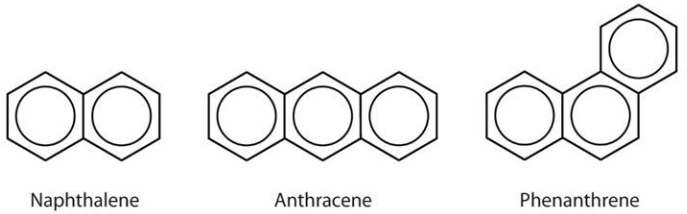
- On the territory of Serbia, a total of 1,301.9 km of open railway tracks were electrified, of which 245 km are on the territory of Vojvodina.

Railway network on the territory of AP Vojvodina ~ 1.386 km

Railway and environment

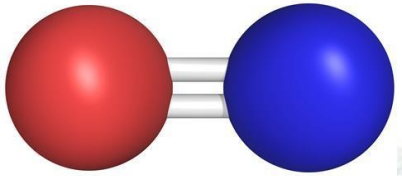
- **Heavy Metal Contamination**:
- Diesel locomotives produce exhaust emissions that contain heavy metals such as lead, cadmium, and arsenic.
- These metals can deposit onto the soil near railway tracks through air deposition or from fuel spills and leaks.
- Once in the soil, heavy metals can persist for a long time and accumulate over time, posing a threat to plants, animals, and humans.
- Heavy metal pollution can also lead to the contamination of nearby water bodies and groundwater resources.

Railway and environment



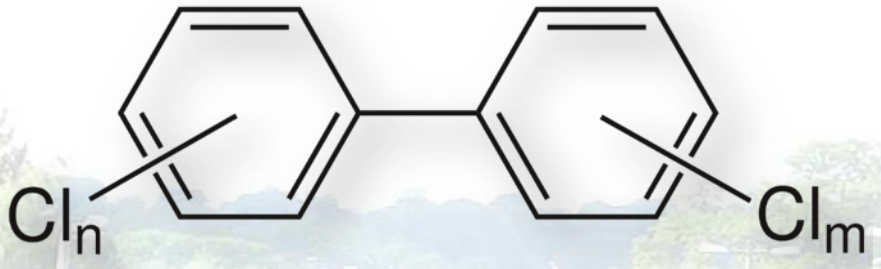
- **Polycyclic Aromatic Hydrocarbons (PAHs):**
- PAHs are another group of pollutants emitted by diesel locomotives.
- They are formed during the incomplete combustion of diesel fuel and engine lubricants.
- PAHs can adhere to soil particles and can be transported to nearby areas through wind erosion or water runoff.
- These compounds have been found to be carcinogenic and can have toxic effects on both humans and terrestrial ecosystems.

Railway and environment



- **Air Pollution and Deposition:**
- Diesel locomotives emit various air pollutants, such as nitrogen oxides and particulate matter.
- These pollutants can be carried by wind and deposited onto the soil, contributing to soil pollution.
- The deposition of particles onto the soil surface can impact soil structure, nutrient cycling, and microbial activity, ultimately affecting plant growth and ecosystem productivity.

Railway and environment



- **Polychlorinated biphenyls (PCBs):**
- PCBs are a group of synthetic chemicals that were commonly used as dielectric fluids in electrical equipment, including railway transformers and capacitors.
- They are highly toxic and persistent in the environment and have been linked to various adverse health effects in humans and wildlife.
- While diesel and electric locomotives themselves do not directly release PCBs, railway transport can be a source of PCB contamination through several indirect pathways.

Railway and PCBs

1. Historical Use: In the past, PCB-containing materials such as electrical transformers and capacitors were used in railway infrastructure, including power substations and signaling systems. Over time, these materials can deteriorate, leak, or be damaged, leading to the release of PCBs into the environment. Trains passing through such areas can disturb the contaminated soil, potentially spreading PCBs.

2. Maintenance and Repair: Railway maintenance activities, including repair and replacement of electrical equipment, may involve handling PCB-containing materials. Construction materials, such as paints, sealants, and adhesives, used during railway construction or maintenance may have contained PCBs in the past. Improper handling, storage, or disposal of these materials can result in PCB leakage or spills, leading to environmental contamination.

Railway and PCBs

3. Accidents and Spills: Accidental incidents such as train derailments, collisions, or fires can damage electrical equipment and release PCBs into the environment. In these scenarios, the risk of PCB contamination is heightened, especially if the locomotives or train cars contain PCB-containing materials.

4. Atmospheric Deposition: Diesel locomotives emit various pollutants into the air, including particulate matter. PCBs can adsorb onto these particles, forming a complex mixture that can be transported through the atmosphere. Deposition of these particles onto soil, water bodies, or vegetation can contribute to PCB contamination in the surrounding environment.

Academic study in Serbia

Transportation Research Part D 57 (2017) 124–129

Contents lists available at ScienceDirect

Transportation Research Part D

journal homepage: www.elsevier.com/locate/trd

Railway transportation as a source of soil pollution

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ARTICLE INFO

Keywords:
Environment
Heavy metals
PCB
Pollution
Railway

ABSTRACT

Surface soil (0–10 cm) samples from 60 sampling sites along the length of railway tracks on the territory of Srem (the western part of the Autonomous Province of Vojvodina, itself part of Serbia) were collected and analyzed for seven polychlorinated biphenyls (PCBs) and ten heavy metals in order to see how the distance from the railroad affects the concentration of some organic and inorganic pollutants in the soil. Samples were taken at a distance of 0.03–4.19 km from the railway. For the soil extraction was used USEPA 3540S method. The extracts were purified on a silica-gel column (USEPA 3630C). The analysis of the extracts was performed by gas chromatography with tandem mass spectrometry. PCBs were not detected only at two locations. Mean total concentration of PCBs for all other sampling locations was 0.0043 ppm dry weight (dw) with a range of 0.0005–0.0227 ppm dw. According to values of Nemerow pollution index Cu, Co, Zn and Ni were the most ubiquitous heavy metals in the area near railroad. Based on these results, it can be said that railway transport is a potential source of PCBs and some heavy metals.

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ISSN 0543-5846
METABK 53(4) 689-692 (2014)
UDC – UDK 669.70.74.5.26.24.4.25:661.42:628.516=111

TRANSFORMERS AS A POTENTIAL FOR SOIL CONTAMINATION

Received – Primljeno: 2014-02-23
Accepted – Prihvaćeno: 2014-05-20
Preliminary Note – Prethodno priopćenje

The aim of this paper is to investigate the presence of PCBs and heavy metals in the surrounding soil and also in the soil of the receiving pit located below the PCB contaminated transformer. Concentrations of PCBs in our samples are ranged from 0,308 to 0,872 mg/kg of absolutely dry soil.

Key words: heavy metals, Polychlorinated biphenyls (PCBs), contamination, oil pit, transformer

Transportation Research Part D

Are cars heavier than trains?

--Manuscript Draft--

Manuscript Number:	TRD-D-23-01292
Article Type:	VSI:Road Ecology
Keywords:	soil environment; heavy metals; pollution index; traffic; railway; highway
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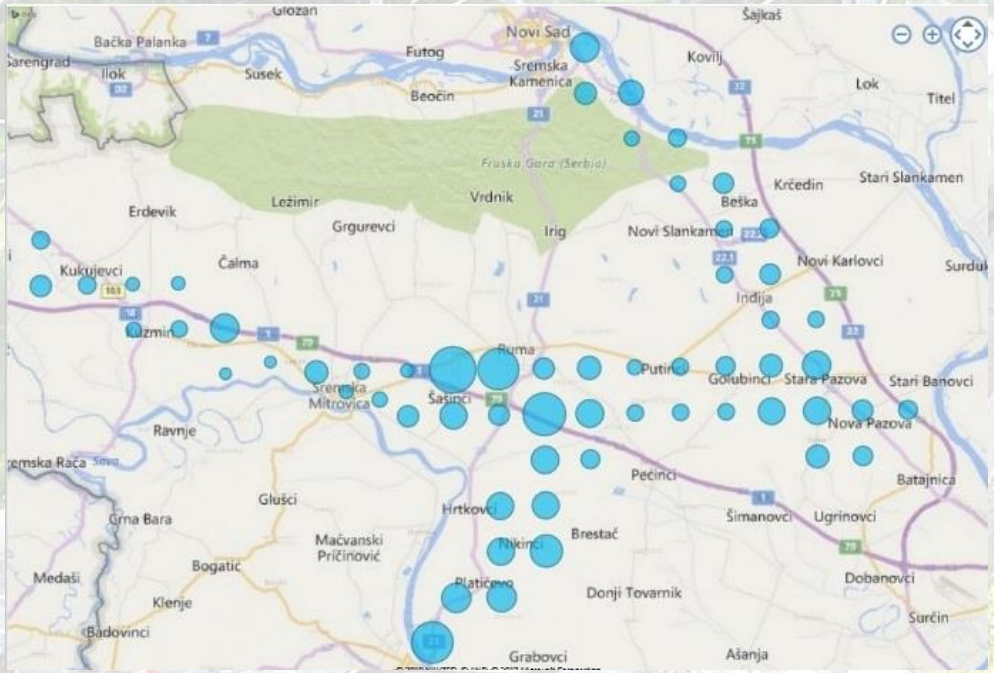
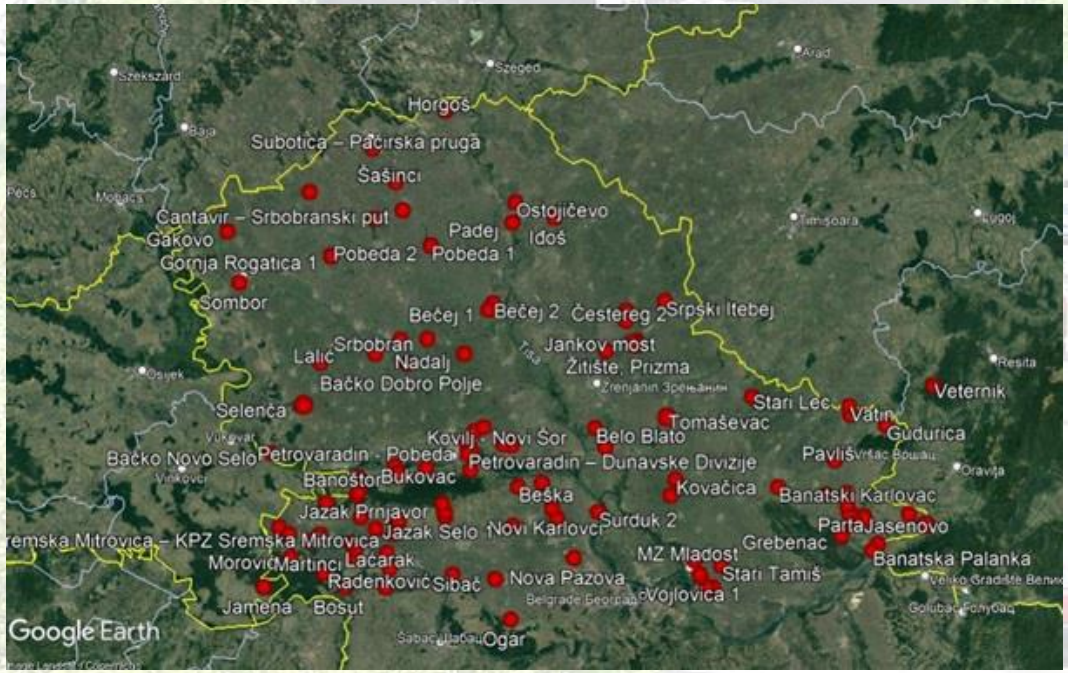
	Jasna Stepanov
	Gordan Stojić
Abstract:	The subject of research in this paper was the impact of road and rail traffic on the soil environment. The main objectives of the research were achieved through the analysis of the presence and impact of heavy metal pollution on the soil environment caused by the transport sector in the northern part of Serbia. The selected locations were next to a busy highway, local roads, and next to an active railway line in the entire territory of the Autonomous Province of Vojvodina (APV). A geochemical approach was used for evaluating the pollution degree. The values of the calculated indices like geo-accumulation index, potential toxicity response index, ecological risk factor, contamination factor, pollution load index, Nemerow's pollution index, and degree of contamination confirm that the soil samples sampled near the highway are the most polluted and highway have the greatest negative impact on the soil environment.

Study area



2017 - Srem



2018/2022 – Vojvodina

Study area*

- The study area is in the northwest of Serbia
- The study sections, located between Stara Pazova–Novi Sad and Stara Pazova-Ruma-Sremska Mitrovica, were constructed about 130 years ago.
- Sections were used for passenger and cargo traffic.
- The area around the sampling section was used mainly for the cultivation of corn but there were also present farmlands with cabbage, soybean, sunflower, wheat, sugar beet, vegetables and alfalfa.
- There were no industrial objects near sampling area.

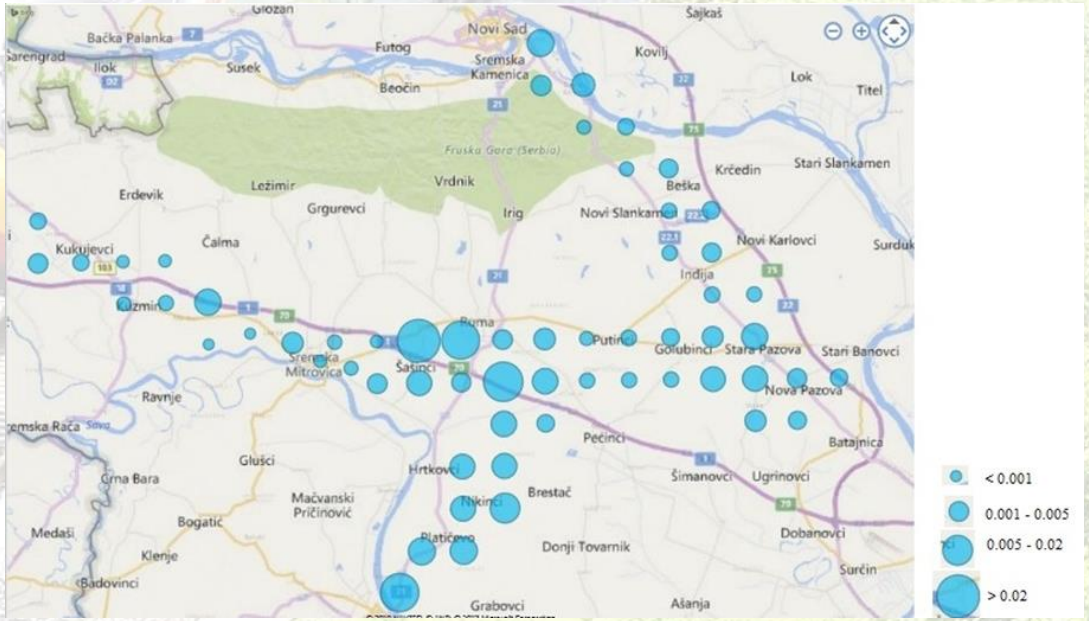
*First research

Soil analysis

- The sampled soils were tested for the presence of the following PCB congeners: PCB 28, PCB 52, PCB 101, PCB 118, PCB 138, PCB 153 and PCB 180, and
- heavy metals: Cu, Zn, Mn, Pb, Co, Cr, Ni, Cd, As and Hg

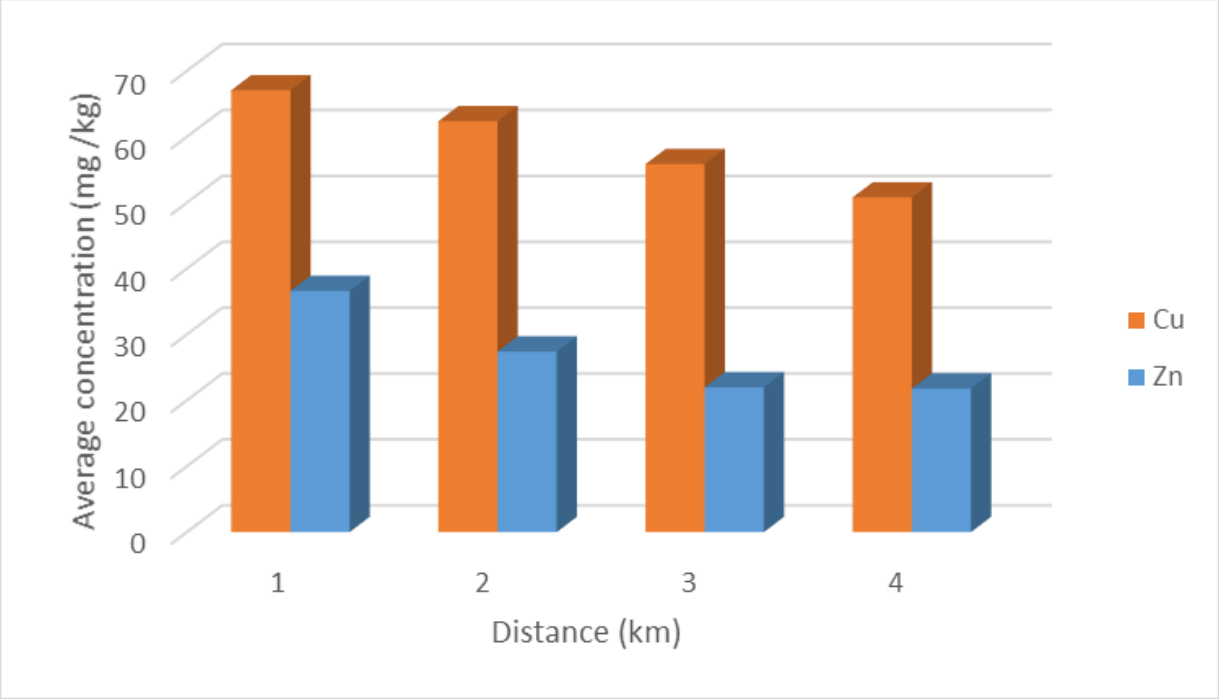
Soil analysis - PCBs

- Higher concentrations of PCBs were measured in the soil samples taken at the distance up to 1 km from the railway track.
- Samples with concentration higher than 0.02 ppm were taken near rail station in municipality of Ruma and Šabac.
- PCBs at the other samples did not exceed admissible pollution levels.
- It is assumed that this is the result of the activities of cargo handling, maintenance and washing of trains that take place in railway stations.



Soil analysis – heavy metals

The concentrations of Co and Ni at almost all sampling sites were increased compared to the maximum allowable concentration - MAC (according to national regulations - Official Gazette of RS 88/2010).
Increased concentrations of Cu and Zn occurred only in samples up to 1 km indicating the obvious impact of railroad traffic on the accumulation of those metals in the soil near railroad

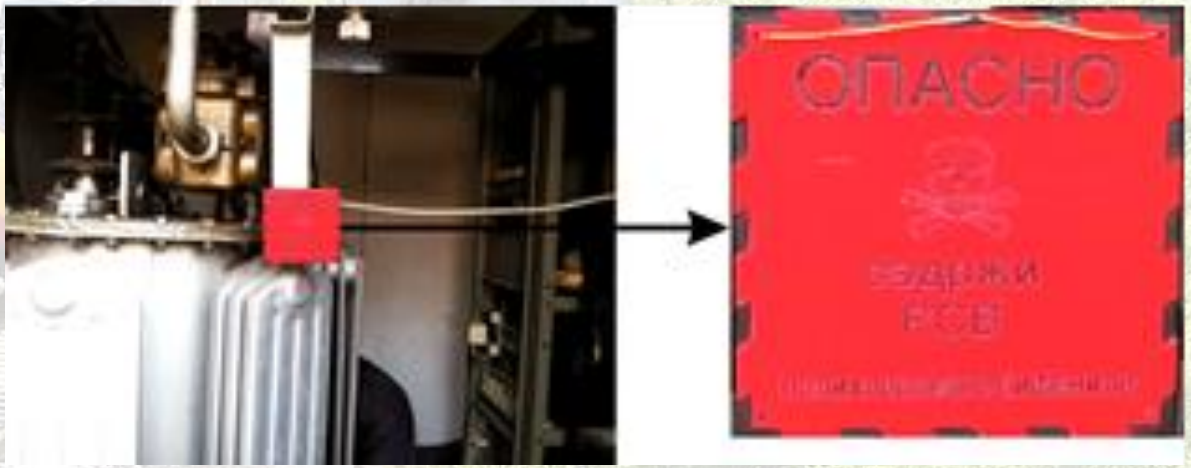


Soil analysis – heavy metals

- The % CVs of Cu, Ni, Cd and Zn in the samples that were closer to the railroad was higher than in those who were sampled at a distance greater than 1 km.
- To remove the possibility of occurrence of this result because of different sample numbers the average coefficient of variations (ACV) of these elements was calculated
- The results showed that Cu, Zn, Ni and Pb, in that order, varied greatly along the railroad. This result leads us to the conclusion that the concentration of this metals is probably most associated with human activities along the railroad.

TRANSFORMERS and SOIL POLLUTION**

- PCBs commonly enter the environment as a result of transformer oil leaks caused by transformer failures, mishandling of damaged electrical equipment, spills during oil changes, and improper waste disposal.
- Each power transformer or device that individually contains more than 1000 kg of oil must have an oil collecting pit for quick oil removal or collection.



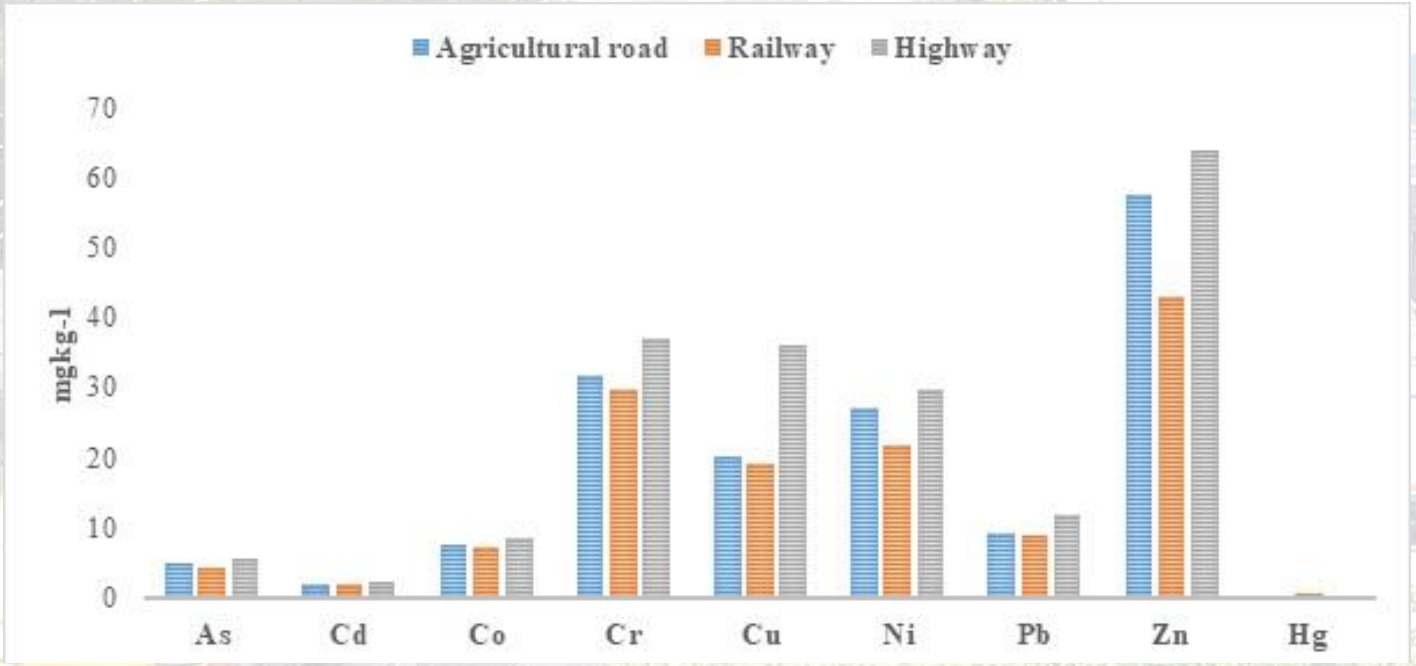
** Second research

TRANSFORMERS and SOIL POLLUTION

- Analysis of PCBs and heavy metals in the oil pit soil directly below the PCB-contaminated transformer and in the soil near the oil pit.
- The PCB values range from 0.308 to 0.872 mg/kg d.w.
- In all samples (from the pit and next to the pit), the value of total PCB congeners was about 10 times higher than the limit value stated in the regulation (0.02 mg/kg). It can be said that the concentrations are almost equal to the value of 1 mg/kg which indicates a significant PCB contamination.

	ΣPCB (mg/kg)	Cd (mg/kg)	Cr (mg/kg)	Co (mg/kg)	Cu (mg/kg)	Ni (mg/kg)	Pb (mg/kg)	Mn (mg/kg)	Zn (mg/kg)
1	0,70	0,09	41,76	5,52	13,43	24,02	15,46	319,95	86,51
2	0,45	0,09	38,43	5,22	25,77	22,72	15,33	333,10	89,10
3	0,31	0,08	40,82	4,97	14,55	21,65	13,40	324,10	75,94
4	0,52	0,07	48,74	5,70	22,78	30,64	14,82	419,75	126,40
5	0,87	0,10	41,03	5,49	16,51	27,33	20,86	313,95	245,65
6	0,56	0,09	38,64	5,12	19,47	23,47	14,06	340,45	217,25
7	0,54	0,09	34,45	4,81	16,35	19,54	15,01	317,15	152,85
8	0,44	0,09	36,11	5,09	22,83	19,83	14,24	317,85	75,67
9	0,53	0,11	43,05	5,56	159,20	26,30	22,29	365,40	94,06
10	0,79	0,15	39,77	5,62	70,16	24,47	10,04	297,70	81,88

Rail vs. road traffic***



The analysis presented in the study suggests that road traffic has a higher propensity to contribute to soil pollution with heavy metals compared to rail traffic. This is primarily due to the higher emissions of pollutants from road vehicles, including exhaust emissions and wear and tear from tire particles. These pollutants are released into the atmosphere, eventually settling down onto the soil, leading to contamination.

***Third research

Conclusions

Overall, while diesel and electric locomotives themselves do not directly release PCBs, railway transport can be a potential source of PCB contamination due to historical use, maintenance activities, accidents, and atmospheric deposition. Implementing proper management practices, infrastructure upgrades, and pollution control measures can help reduce the environmental impact of PCBs associated with railway transport.

1. PCB Management: Rail operators should have proper management plans in place to identify, handle, and dispose of PCB-containing materials safely. This includes regular inspections, maintenance, and appropriate storage and disposal methods to prevent leaks and spills.

2. Infrastructure upgrades: Older railway infrastructure containing PCB-containing materials should be identified and replaced with non-PCB alternatives. This includes transformers, capacitors, and other electrical equipment used in power substations and signaling systems.

Conclusions

3. Spill Response and Emergency Preparedness: Rail operators should have well-defined spill response plans and emergency protocols in place to minimize the impact of accidents involving PCBs. This includes having appropriate containment measures, training for personnel, and coordination with local environmental agencies.

4. Air Pollution Control: Diesel locomotives should be equipped with effective emission control technologies to reduce the release of particulate matter into the atmosphere. This can help minimize the transport of PCBs through atmospheric deposition.

Conclusions

5. Rail traffic demonstrates a relatively lower impact on soil pollution. Rail systems generally employ electric or diesel-electric locomotives, which emit fewer pollutants compared to internal combustion engines used in road vehicles. Additionally, rail tracks are designed to minimize soil contact, reducing the chances of contamination.

6. It is important to note that the findings of this research are based on scientific research conducted up until September 2022. Future studies and advancements in transportation technology may provide further insights into the relative environmental impacts of rail and road traffic on soil pollution.

Conclusions

7. Considering the adverse effects of soil pollution on ecosystems, human health, and agricultural productivity, it is crucial to prioritize sustainable transportation solutions. The research underscores the importance of promoting and investing in environmentally friendly transportation modes, such as rail, to mitigate soil pollution caused by heavy metals.

8. By evaluating the environmental impacts of rail and road traffic, we can make informed decisions and develop strategies that support sustainable and greener transportation options for a healthier and cleaner future.

Thanks for your attention!