Serbian Society of Soil Science
University of Belgrade, Faculty of Agriculture

BOOK OF PROCEEDINGS

3rd International and 15th National Congress

SOILS FOR FUTURE UNDER GLOBAL CHALLENGES

21–24 September 2021
Sokobanja, Serbia

Serbian Society of Soil Science
University of Belgrade, Faculty of Agriculture

BOOK OF PROCEEDINGS

3rd International and 15th National Congress

SOILS FOR FUTURE UNDER GLOBAL CHALLENGES

21–24 September 2021
Sokobanja, Serbia

BOOK OF PROCEEDINGS

3rd International and 15th National Congress

Publisher

Serbian Society of Soil Science

Editors

Prof. Dr Boško Gajić
Assist. Prof. Dr Ljubomir Životić
MSc Aleksa Lipovac

Each contribution included in the Book of Proceedings was positively reviewed by international referees.

Organized by:

Serbian Society of Soil Science
University of Belgrade, Faculty of Agriculture

Supported by:

Ministry of Education, Science and Technological Development of the Republic of Serbia
Maize Research Institute "Zemun polje", Belgrade, Serbia
Semenarna d.o.o., Niš, Serbia
Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia – Directorate for Agricultural Land
Terra Optima d.o.o., Topola, Serbia
Best Seed Producer d.o.o., Feketić, Mali Iđoš, Serbia

Printed by:

Štamparija Nikitović, Užice, Serbia, 2021

Published in 130 copies

ISBN-978-86-912877-5-7

FOREWORD

The Serbian Society of Soil Science continues its tradition of hosting conferences, which is one of its primary activities. It organized the 3rd International and 15th National Congress – Soils for Future Under Global Challenges in the International Decade of Soils 2015–2024, collaborating with the University of Belgrade Faculty of Agriculture and under the auspices of the Ministry of Education, Science and Technological Development of the Republic of Serbia, along with sponsors and numerous contributors of papers. Namely, the International Union of Soil Sciences (IUSS) proclaimed the International Decade of Soils 2015-2024. In the Vienna Soil Declaration of 7 December 2015, IUSS recognized the key roles soils play in addressing major resource, environmental, health and social challenges currently facing humanity.

Due to the COVID-19 pandemic, the Congress was held as an online event, in combination with limited physical presence of international and domestic participants who observed the prescribed epidemiological measures and recommendations of the Serbian Government.

The topics of the Congress were grouped into the following four sessions: (i) Soil fundamentals, (ii) Soil-water-plant-atmosphere continuum, (iii) Soil degradation and soil and water conservation, and (iv) Soil and water future socio-economic pathways. The thematic areas were selected to support the distinct efforts of agriculture, and humankind in general, to deal with current resource, environmental, health and social issues.

Growing population pressures, industrialization and intensive use of soil exhaust natural resources and limit the performance of soil functions, such as biomass production, water purification, carbon sequestration, and the like. The additional impacts of climate change, land use changes and the above-mentioned global changes affect the ability of soils to regenerate and even lead to degradation. The future capacity of soils to support life on Earth is in question.

A number of conferences on soil and global changes have been held worldwide over the past several years. Continuing these efforts, we need to keep in mind that the study of soils has changed rapidly. Previously, soil science was seen as supporting agriculture and forestry, and justified by increased soil productivity. However, the focus has recently expanded considerably. Soil science is now a major component of each environmental science course, given that soil plays a key role in elementary natural cycles. Soil pollution is also extremely important, often more persistent than air or water pollution. The impacts of global changes on soils are viewed from a much broader perspective than only several decades ago. However, despite the interest in new fields, the agricultural imperative must not be forgotten. Agriculture remains the main economic purpose of the use of soils and hunger is certainly among the most serious potential disasters set off by global changes.

Ninety-eight contributions were accepted for presentation at the Congress. More than 320 authors and co-authors from 18 countries participated. Fourty contributions from the Congress and included in this Book of Proceedings. They reflect the outcomes of the most recent research of 154 authors and co-authors from 15 countries worldwide. This shows that most of the presentations were a result of teamwork, which not only guarantees a comprehensive approach, but also quality.

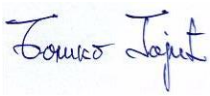
Seven distinguished domestic and international professors and scientists prepared the keynote speeches. The submitted papers are available on the website of the Serbian Society of Soil Science (https://congress.sdpz.rs). The contributions contained in this Book of Proceedings have been reviewed by international peers.

An excursion completed the program and content of the Congress. It included showing of four soil profiles of the dominant soil types in the Sokobanja area, including Calcomelanosol, Brownized Calcomelanosol, Calcocambisol and Vertisol, under different land uses (native meadow, devastated native pasture, native forest and intensive apple orchard).

It is our wish to see all the positive outcomes of the Congress implemented in due course, along with recommendations of scientists and professionals. This would fulfil the objective of the Congress in the best possible way. The permanent legacy of the Congress should be the inclusion of soil in the core of policies that support environmental protection and sustainable development.

In closing, I wish to express once again my sincerest gratitude to all who contributed to the publication of this Book of Proceedings.

September 2021 in Sokobanja



Prof. Dr. Boško Gajić

President of the Serbian Society of Soil Science
Editor-in-Chief of the Book of Proceedings

SCIENTIFIC COMMITTEE

1. Prof. Gajić Boško, PhD, University of Belgrade, Faculty of Agriculture, Serbia, President of the Serbian Society of Soil Science, President of the Scientific Committee of the Congress
2. Prof. Lavrishchev Anton, PhD, St. Petersburg State Agrarian University, St. Petersburg, Pushkin, Russian Federation
3. Litvinovich Andrey, PhD, Agrophysical Research Institute, St. Petersburg, Russian Federation
4. Prof. Mueller Lothar, PhD, Leibniz-Centre for Agricultural Landscape Research, Muencheberg, Germany
5. Dr. Eulenstein Frank, Leibniz-Centre for Agricultural Landscape Research, Muencheberg, Germany
6. Prof. Schindler Uwe, PhD, Mitscherlich Academy for Soil Fertility, Paulinenaue, Germany
7. Prof. Todorović Mladen, PhD, Mediterranean Agronomic Institute of Bari, Italy
8. Prof. Vingiani Simona, PhD, University of Naples Federico II, Italy
9. Pachikin Konstantin, PhD, Kazakh Research Institute of Soil Science and Agrochemistry named after U. Uspanov, Almaty, Republic of Kazakhstan
10. Prof. Tanaskovik Vjekoslav, PhD, the Dean, Faculty of Agricultural Sciences and Food, Skopje, Republic of North Macedonia
11. Rakhimgalieva Saule, PhD, West Kazakhstan Agrarian Technical University named after Zhangir Khan, Almaty, Republic of Kazakhstan
12. Abi Saab Marie Therese, PhD, Lebanese Agricultural Research Institute, Researcher, Head of the Fanar climate and water unit, Lebanon
13. Asst. Prof. Mahmoudi Nemat, PhD, Tarbiat Modares University, Noor, Mazandaran, Iran
14. Papazoglou Eleni G., PhD, Agricultural University of Athens, Greece
15. Prof. Bani Aida, PhD, Agricultural University of Tirana, Faculty of Agriculture and Environment, Albania
16. Prof. Ristić Ratko, PhD, the Dean, University of Belgrade, Faculty of Forestry, Serbia
17. Prof. Kresović Mirjana, PhD, University of Belgrade, Faculty of Agriculture, Serbia
18. Prof. Antić-Mladenović Svetlana, PhD, University of Belgrade, Faculty of Agriculture, Serbia
19. Prof. Onjia Antonije, PhD, University of Belgrade, Faculty of Technology and Metallurgy, Serbia
20. Prof. Belanović Simić Snežana, PhD, University of Belgrade, Faculty of Forestry, Serbia
21. Prof. Đorđević Aleksandar, PhD, University of Belgrade, Faculty of Agriculture, Serbia
22. Prof. Košanin Olivera, PhD, University of Belgrade, Faculty of Forestry, Belgrade, Serbia
23. Saljnikov Elmira, PhD, Institute of Soil Science, Belgrade, Serbia
24. Topalović Ana, PhD, Biotechnical faculty, University of Montenegro, Montenegro

25. Prof. Nešić Ljiljana, PhD, University of Novi Sad, Faculty of Agriculture, Serbia
26. Prof. Radmanović Svjetlana, PhD, University of Belgrade, Faculty of Agriculture, Serbia
27. Prof. Dugalić Goran, PhD, University of Kragujevac, Faculty of Agriculture, Čačak, Serbia
28. Prof. Vasin Jovica, PhD, Institute for Field and Vegetable Crops, Novi Sad, Serbia
29. Radanović Dragoja, PhD, Institute for Medicinal Plant Research „Dr Josif Pančić“, Beograd, Serbia
30. Prof. Ćirić Vladimir, PhD, University of Novi Sad, Faculty of Agriculture, Serbia
31. Dragović Snežana, PhD, Institute of Nuclear Sciences, Vinča, University of Belgrade, Serbia
32. Prof. Dragović Ranko, PhD, Faculty of Sciences and Mathematics, University of Niš, Serbia
33. Prof. Boćanski Jan, PhD, University of Novi Sad, Faculty of Agriculture, Serbia
34. Kresović Branka, PhD, Director of Maize Research Institute "Zemun Polje", Serbia
35. Tolimir Miodrag, PhD, Maize Research Institute "Zemun Polje", Serbia
36. Pivić Radmila, PhD, Institute of Soil Science, Belgrade, Serbia
37. Prof. Đurović Nevenka, PhD, University of Belgrade, Faculty of Agriculture, Serbia
38. Prof. Manojlović Maja, PhD, University of Novi Sad, Faculty of Agriculture, Serbia
39. Mrvić Vesna, PhD, Institute of Soil Science, Belgrade, Serbia
40. Pekeč Saša, PhD, Institute of Lowland Forestry and Environment, Novi Sad, Serbia
41. Prof. Pejić Borivoj, PhD, University of Novi Sad, Faculty of Agriculture, Serbia
42. Predić Tihomir, PhD, Agricultural institute, Banja Luka, Bosnia and Herzegovina
43. Prof. Kapović Solomun Marijana, PhD, University of Banja Luka, Faculty of Forestry, Bosnia and Herzegovina
44. Prof. Raičević Vera, PhD, University of Belgrade, Faculty of Agriculture, Serbia
45. Prof. Lalević Blažo, PhD, University of Belgrade, Faculty of Agriculture, Serbia
46. Sikirić Biljana, PhD, Institute of Soil Science, Belgrade, Serbia
47. Prof. Stričević Ružica, PhD, University of Belgrade, Faculty of Agriculture, Serbia
48. Prof. Tomić Zorica, PhD, University of Belgrade, Faculty of Agriculture, Serbia
49. Prof. Gregorić Enika, PhD, University of Belgrade, Faculty of Agriculture, Serbia
50. Prof. Ćosić Marija, PhD, University of Belgrade, Faculty of Agriculture, Serbia
51. Prof. Šeremešić Srđan, PhD, Faculty of Agriculture, University of Novi Sad, Serbia
52. Prof. Lukić Sara, PhD, University of Belgrade, Faculty of Forestry, Belgrade, Serbia
53. Stajković Srbinović Olivera, PhD, Institute of Soil Science, Belgrade, Serbia
54. Asst. Prof. Životić Ljubomir, PhD, University of Belgrade, Faculty of Agriculture, Serbia, Executive Secretary of Serbian Society of Soil Science

ORGANIZATION COMMITTEE

1. Asst. Prof. Životić Ljubomir, PhD, University of Belgrade, Faculty of Agriculture, Serbia, Executive secretary of Serbian Society of Soil Science, President of the Organization Committee of the Congress
2. Prof. Gajić Boško, PhD, University of Belgrade, Faculty of Agriculture, Serbia, President of the Serbian Society of Soil Science
3. Prof. Matović Gordana, PhD, University of Belgrade, Faculty of Agriculture, Serbia
4. Prof. Jovićić-Petrović Jelena, PhD, University of Belgrade, Faculty of Agriculture, Serbia
5. Prof. Kljujev Igor, PhD, University of Belgrade, Faculty of Agriculture, Serbia
6. Asst. Prof. Počuča Vesna, PhD, University of Belgrade, Faculty of Agriculture, Serbia
7. Asst. Prof. Kaludjerović Lazar, PhD, University of Belgrade, Faculty of Agriculture, Serbia
8. Tapanarova Angelina, PhD, University of Belgrade, Faculty of Agriculture, Serbia
9. Radovanović Vesna, PhD, BEA Agency, Belgrade, Serbia
10. Asst. Prof. Čabilovski Ranko, PhD, Faculty of Agriculture, University of Novi Sad, Serbia
11. Golubović Slađana, PhD, Collegue of Agruculture and Food Technology, Prokuplje, Serbia
12. Milić Stanko, PhD, Institute for Field and Vegetable Crops, Novi Sad, Serbia
13. Đalović Ivica, PhD, Institute for Field and Vegetable Crops, Novi Sad, Serbia
14. Jakšić Snežana, PhD, Institute for Field and Vegetable Crops, Novi Sad, Serbia
15. Ljubičić Janko, MSc, University of Belgrade, Faculty of Forestry, Serbia
16. Asst. Miljković Predrag, PhD, University of Belgrade, Faculty of Forestry, Serbia
17. Dugonjić Mladen, PhD, Agriculture Collegue of Applied Studies, Šabac, Serbia
18. Lipovac Aleksa, MSc, University of Belgrade, Faculty of Agriculture, Serbia
19. Bogosavljević Jelena, MSc, University of Belgrade, Faculty of Agriculture, Serbia
20. Krpović Matija, MSc, University of Belgrade, Faculty of Agriculture, Serbia
21. Živanov Milorad, MSc, Institute for Field and Vegetable Crops, Novi Sad, Serbia
22. Radovanović Dragan, MSc, Faculty of Agriculture, University of Novi Sad, Serbia
23. Koković Nikola, MSc, Institute of Soil Science, Belgrade, Serbia
24. Đorđević Slaviša, BSc, University of Belgrade, Faculty of Agriculture, Serbia
25. Vukelić Nebojša, BSc, University of Belgrade, Faculty of Agriculture, Serbia

PROGRAM COMMITTEE

1. Prof. Antić Mladenović Svetlana, PhD, University of Belgrade, Faculty of Agriculture, Serbia, President of the Program Committee of the Congress
2. Prof. Gajić Boško, PhD, University of Belgrade, Faculty of Agriculture, Serbia, President of Serbian Society of Soil Science
3. Prof. Pejić Borivoj, PhD, University of Novi Sad, Faculty of Agriculture, Serbia
4. Prof. Belanović-Simić Snežana, PhD, University of Belgrade, Faculty of Forestry, Serbia
5. Prof. Vasin Jovica, PhD, Institute for Field and Vegetable Crops, Novi Sad, Serbia
6. Prof. Ćirić Vladimir, PhD, University of Novi Sad, Faculty of Agriculture, Serbia
7. Saljnikov Elmira, PhD, Institute of Soil Science, Belgrade, Serbia
8. Asst. Prof. Životić Ljubomir, PhD, University of Belgrade, Faculty of Agriculture, Serbia, Executive secretary of Serbian Society of Soil Science
9. Prof. Vingiani Simona, PhD, University of Naples Federico II, Italy
10. Asst. Prof. Knežević Mirko, PhD, Biotechnical faculty, University of Montenegro, Montenegro
11. Rakhimgalieva Saule, PhD, West Kazakhstan Agrarian Technical University named after Zhangir Khan, Almaty, Republic of Kazakhstan
12. Abi Saab Marie Therese, PhD, Lebanese Agricultural Research Institute, Researcher, Head of the Fanar climate and water unit, Lebanon
13. Asst. Prof. Mahmoudi Nemat, PhD, Tarbiat Modares University, Noor, Mazandaran, Iran
14. Prof. Saud Hamidović, PhD, University of Sarajevo, Bosnia and Herzegovina
15. Prof. Kresović Mirjana, PhD, University of Belgrade, Faculty of Agriculture, Serbia
16. Ass. Prof. Markoski Mile, PhD, Faculty of Agricultural sciences, Skopje, Republic of North Macedonia
17. Prof. Radmanović Svjetlana, PhD, University of Belgrade, Faculty of Agriculture, Serbia
18. Prof. Žarković Branka, PhD, University of Belgrade, Faculty of Agriculture, Serbia
19. Predić Tihomir, PhD, Agricultural Institute, Banja Luka, Bosnia and Herzegovina
20. Vidojević Dragana, PhD, Environmental Protection Agency, Ministry of Agriculture and Environmental Protection, Serbia
21. Ninkov Jordana, PhD, Institute for Field and Vegetable Crops, Novi Sad, Serbia
22. Ranđelović Dragana, PhD, Institute for Technology of Nuclear and Other Mineral Raw Materials, Serbia
23. Delić Dušica, PhD, Institute of Soil Science, Belgrade, Serbia
24. Prof. Todosijević Mirjana, PhD, University of Belgrade, Faculty of Forestry, Serbia
25. Prof. Beloica Jelena, PhD, University of Belgrade, Faculty of Forestry, Serbia
26. Prof. Tunguz Vesna, PhD, University of East Sarajevo, Faculty of Agriculture, Sarajevo, Bosnia and Herzegovina

HONORARY COMMITTEE

1. Prof. Živković Dušan, PhD, Dean, Faculty of Agriculture, University of Belgrade, Serbia
2. Prof. Belić Milivoj, PhD, Serbia
3. Prof. Hadžić Vladimir, PhD, Serbia
4. Prof. Knežević Milan, PhD, Serbia
5. Prof. Milivojević Jordan, PhD, Serbia
6. Prof. Stevanović Dragi, PhD, Serbia
7. Prof. Rudić Dragan, PhD, Serbia
8. Prof. Petković Sava, PhD, Serbia
9. Prof. Ličina Vlado, PhD , Serbia
10. Fuštić Budo, PhD, Montenegro
11. Prof. Sekulić Petar, PhD, Serbia
12. Prof. Bogdanović Darinka, PhD, Serbia
13. Prof. Vasić Gradimir, PhD, Serbia
14. Prof. Kadović Ratko, PhD, Serbia

Table of Contents

ENHANCING MANAGEMENT OF CONTAMINATED SITES USING ENVIRONMENTAL MONITORING DATA AND PRELIMINARY RISK ASSESSMENT METHODOLOGY IN SERBIA

Dragana Vidojević*[a], Lana Kukobat[b], Darko Damnjanović[a], Nemanja Jevtić[c], Aleksandra Šiljić Tomić[d]

[a]Environmental Protection Agency, Ministry of Environmental Protection, Zabljacka 10a, 11000 Belgrade, Republic of Serbia
[b]University of Belgrade – Faculty of Biology, Studentski trg 16, 11000 Belgrade, Republic of Serbia
[c]Arup, DOO, Kneginje Zorke 77, 11000 Belgrade, Republic of Serbia
[d]UN Environment, Bulevar Zorana Djindjica 64, 11070 New Belgrade, Republic of Serbia
*Corresponding author: dragana.vidojevic@sepa.gov.rs

Abstract

According to the Law on Soil Protection, the Cadastre of Contaminated Sites is a set of relevant data on endangered, polluted, and degraded soil. Serbian Environmental Protection Agency (SEPA) has been constantly working to improve the national methodology for collection, analysis and assessment of data on contaminated sites. The last updated database of the Cadastre shows that 309 potentially contaminated and contaminated sites have been identified and recorded on the territory of the Republic of Serbia. The main purpose of the Cadastre is to provide systematic data on sources of pollution such as the type, quantities, methods and location of discharges of pollutants into the soil, in order to implement preventive or remediation measures. Data collection is defined in more detail in the Rulebook on the content and manner of keeping the Cadastre of contaminated sites, type, content, forms, manner, and deadlines for data submission. Investigation of industrial sites suspected to be contaminated was a part of the GEF-funded project "Enhanced Cross-sectoral Land Management through Land Use Pressure Reduction and Planning" which is implemented by United Nations Environment Programme (UNEP) in close cooperation with the Ministry of Environmental Protection and SEPA in the period 2015–2019. The main goals of the Project were to provide the lacking methodologies, knowledge, and coordination mechanisms for sustainable and integrated management of soil as a natural resource. The Project also supported further development of the Cadastre of contaminated sites and preliminary analysis of selected 32 potentially contaminated sites. Field missions to the identified sites were conducted in 2016 with the purpose to identify receptors of pollution and potential exposure routes, previous land use, surface area, type and quantity of hazardous substances found at the location and in the surrounding area, soil and groundwater quality, as well as geological, pedological and hydrological features and to prepare and elaborate sampling programs, whereas the soil sampling itself took place in 2017 when 264 soil samples were analysed. Site specific environmental monitoring data and soil sampling results allowed performing the comparative analysis and application of preliminary risk assessment methodology that served to compile the relative risk-based priority list of contaminated sites. For this purpose, the Preliminary Risk Assessment Model for the identification and assessment of problem areas for Soil contamination in Europe – PRA.MS has been applied.

Keywords: Contaminated sites, Preliminary Risk Assessment, Remediation

INTRODUCTION

Investigation of 32 industrial sites suspected to be contaminated was a part of the GEF-funded project "Enhanced Cross-sectoral Land Management through Land Use Pressure Reduction and Planning" which is implemented by United Nations Environment Programme (UNEP) in close cooperation with the Ministry of Environmental Protection and SEPA in the period 2015 – 2019 (Vidojevic et al., 2016, 2017). The Project also received a contribution from the Italian Ministry of Environment, Land and Sea that enabled the development of Site Characterization Plans for two priority sites, in addition to the procurement of the laboratory analytical equipment, personal protective equipment and data storage server for SEPA as well as numerous study visits and opportunities for experience sharing with Italian expert institutions ISPRA, ENEA, ISS and INAIL (Falconi et al., 2018). The Project supports the development of a policy framework for integrated land use management and its implementation at local level.

The data and information for the selected 32 potentially contaminated sites collected from previous studies and through numerous consultations included: previous land use, type of industry, surface area, type and quantity of hazardous substances found at the location and in the surrounding area, soil and groundwater quality, as well as geological, pedological and hydrological features (Kukobat et al., 2018). The collected data are sorted and transferred to digital format in order to complete a database of contaminated sites. Field missions to the identified sites were conducted in the period September - December 2016 with the purpose to identify receptors of pollution and potential exposure routes, and to prepare and elaborate sampling programs, whereas the soil sampling itself took place in 2017 when 264 soil samples were analysed.

MATERIALS AND METHODS

The locations for soil sampling within 32 industrial sites were selected based on project criteria and existing data on the presence of contaminated land within the industrial complexes. Particular attention was given to abandoned locations. The visits and situation analyses of the locations lead to the conclusion that in most cases there is historical pollution within the complexes of enterprises that were, or are still state-owned (under bankruptcy, in the restructuring or privatization phase). In addition to the above form of ownership, a smaller number of enterprises has been privatized, or the locations have been fully or partly leased.

Soil samples were taken at each location as per the envisaged sampling plan (at depths of up to 0.5 m), in accordance with the situation in the field and the need for the samples to be as representative as possible. A number of samples have been taken outside the industrial complexes, in the immediate vicinity of vulnerable facilities, next to waste landfills or at lagoons for wastewater treatment.

The following parameters has been analysed in the total of 264 soil samples:
• Mechanical composition and chemical properties: pH, organic matter, $CaCO_3$ and total N,
• Content of heavy metals and metalloids: Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Nickel (Ni), Lead (Pb), Zinc (Zn), as well as Mercury (Hg), but only in select samples,
• Organic pollutant content, hydrocarbons (C10-C40), polychlorinated biphenyls (PCB), polycyclic aromatic hydrocarbons (PAH), organochlorine pesticides, and
• Asbestos and cyanide (only in select samples, in accordance with the plan of analysis).

Study area

In order to set priorities for detailed investigations and remediation, all locations have been sorted into 4 groups (I-IV) according to the:

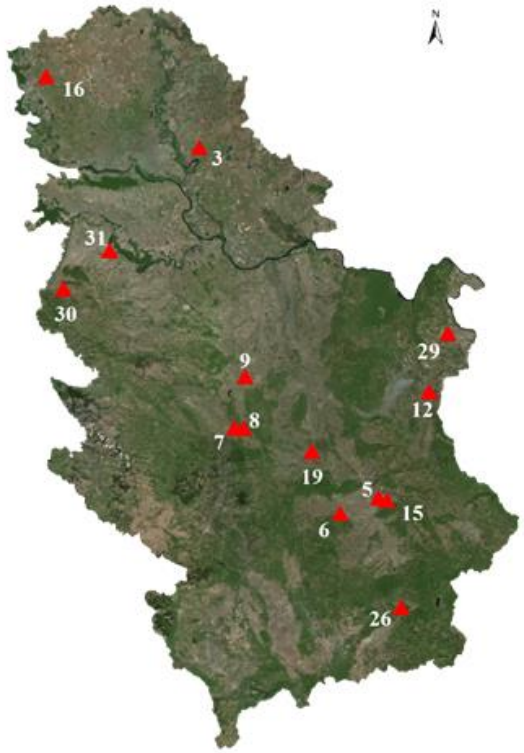
- amount of data on the soil condition,
- concentrations of pollutants,
- types of pollutants,
- proximity of vulnerable facilities,
- activities on the given locations,
- size of the complex, and
- estimated scope of works.

Group I contain locations where, based on the available data, no contamination has been found and no remediation is proposed. In accordance with regulations, industry complexes need to establish soil monitoring.
Group II contain locations where, based on the available data, no remediation is proposed at this time. At the same time, in the majority of the tested locations the values of certain pollutants exceed the limit values multiple times which, in addition to establishing soil monitoring, requires expansion of testing, including sampling of surface and ground waters and plant matter.
Group III contain locations where contaminated soil was found and requires remediation (Figure 1).
Group IV contain large industrial enterprises where certain parts of the complex require remediation.

The preliminary risk assessment methodology

Given that the sites within Group III were estimated as sites where urgent remediation activities are necessary, a model for preliminary assessment of risks to human health was used as a method for compiling the risk-based priority list. The selected model for prioritization is the PRA.MS methodology developed by the European Environmental Agency (EEA) in 2005. This model was developed to support the national, regional or local programs for the rehabilitation and remediation of contaminated sites (Altieri et al., 2004). The PRA.MS methodology is based on a scoring system of the relevant site parameters (Table 1) and factors grouped according to the *source-pathway-receptor* paradigm, adopted for the design of a conceptual model of locations and relative risk assessment.
According to this methodology, the "source" represents contaminated soil, while the human health exposure pathways are via groundwater (GW), surface water (SW), air

(AIR) and direct contact (DC) (Figure 2) (Falconi et al., 2005). Within the PRA.MS methodology it is also proposed a classification of locations according to the obtained relative risk and uncertainty factor values that was used to classify 14 selected locations in this study (Altieri et al., 2005).



No	Location name
3	Radijator AD, Zrenjanin
5	Electronics Industry, Niš
6	Non-ferrous metal factory, Prokuplje
7	Fabrika vagona AD, Kraljevo
8	Magnohrom, Kraljevo
9	Šumadija d.o.o., Kragujevac
12	Leather and Textile Processing Factory "Koža", Zaječar
15	Mechanical Engineering Industry, Niš
16	Battery Factory, Sombor
19	Chemical industry "Župa" AD, Kruševac
26	Paper and packaging factory - lagoons, Vladičin Han
29	"Elixir" Mineral Fertilizer Industry Prahovo, Negotin
30	Viskoza, Loznica
31	"Zorka" non-ferrous metallurgy, Šabac

Figure 1. Map of 14 locations from Group III locations

Table 1. The parameters required for the calculations in the "tier 2" rank of the relative risk assessment

The parameters required for the "tier 2" rank of the relative risk assessment	
• toxicity of contaminants (risk phrases) • site area • disposal type • engineered containments • known releases of contaminants to sw, air, gw • lithology of the unsaturated zone • aquifer depth • slope • thickness and presence of the impermeable layer	• mean annual temperature, wind velocity, and precipitation • distances to nearest well, residential area, and surface water • groundwater and surface water use • land use at and off site • site accessibility • waste mass and volume • source area and volume • flooding return

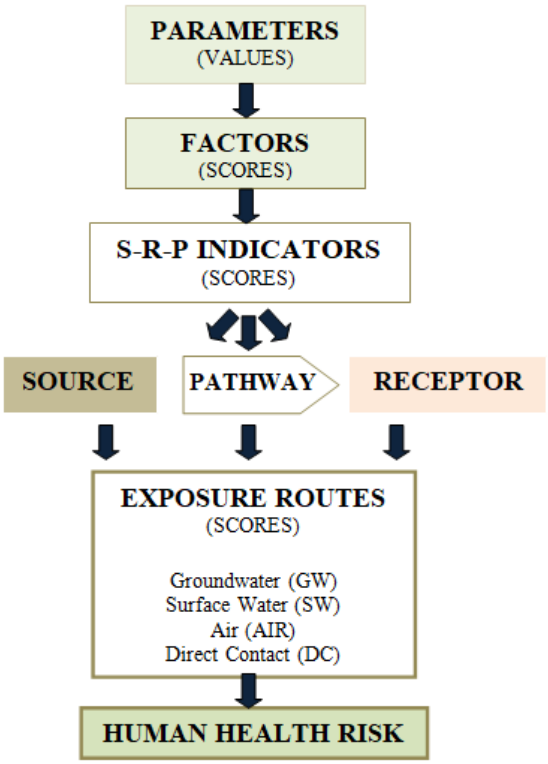


Figure 2. Scoring system and risk assessment algorithm of the PRA.MS methodology (modified after Quercia et al., 2006).

RESULTS AND DISCUSSION

Concentrations of contaminants identified at 14 locations within Group III were compared with the values from the Regulation on limit values for pollutants, harmful and hazardous substances in soil ("Official Gazette of the Republic of Serbia" No. 30/18 and 64/19) (Table 2).

After entering all parameters that are required for the calculations in the PRA.MS model (Table 2), the compiled priority list of 14 locations is shown in the Table 3 and listed according to the total risk values.

Table 2. Locations from Group III with identified contaminants that exceeded the remediation values

Location map number	Location name	SiteID	Exceed Limit values (LV)	Exceed Remediation values (RV)
3	Radijator AD, Zrenjanin	Rd-ZR	Cr, Cu, Zn, Ni, C10-C40	PCB
5	Electronics Industry, Niš	EI-NI	Cd, Cu, Ni, Pb, C10-C40	Pb
6	Non-ferrous metal factory, Prokuplje	Fom-PK	As, Cd, Cr, Cu, Ni, Pb, Zn, C10-C40, PAH	Cr, Cu, Ni, Zn, C10-C40
7	Fabrika vagona AD, Kraljevo	Fv-KV	As, Cd, Cr, Cu, Ni, Pb, Zn, PCB, PAH, C10-C40	As, Cu, Ni, Pb
8	Magnohrom, Kraljevo	Mgh-KV	As, Cr, Cu, Pb, Zn, Ni, C10-C40	As, Cu, Ni
9	Šumadija d.o.o., Kragujevac	Sum-KG	As, Cr, Cu, Zn, Ni, Cd, Pb, PAH, C10-C40	As, Cu, Zn, Ni
12	Leather and Textile Processing Factory "Koža", Zaječar	KTK-ZA	As, Cr, Cu, Ni, Pb, C10-C40	As, Cr, Pb
15	Mechanical Engineering Industry, Niš	Mi-NI	As, Cd, Cr, Cu, Ni, Pb, Zn, C10-C40, PAH, PCB	As, Cr, Cu, Ni, Pb, Zn
16	Battery Factory, Sombor	Fa-SO	As, Cd, Cu, Ni, Zn, Pb, C10-C40, PAH	Pb, C10-C40
19	Chemical industry "Župa" AD, Kruševac	HiZ-KS	As, Hg, Cd, Cr, Cu, Ni, Pb, Zn, C10-C40, PAH,	As, Hg, Cr, Cu, Ni, Pb, Zn
26	Paper and packaging factory - lagoons, Vladičin Han	Fp-VH	As, Cd, Cr, Cu, Ni, Pb, Zn, C10-C40	Cd
29	"Elixir" Mineral Fertilizer Industry Prahovo, Negotin	Ih-NG	As, Hg, Cd, Cu, Ni, Zn, C10-C40	As
30	Viskoza, Loznica	Vi-LO	As, Cd, Cu, Cr, Pb, Ni, Zn	As, Cd, Cu, Pb, Ni, Zn
31	"Zorka" non-ferrous metallurgy, Šabac	Z-SA	As, Cd, Cr, Cu, Ni, Pb, Zn, PCB, C10-C40	As, Cd, Cr, Cu, Ni, Pb, Zn, DDE/DDD/DDT, PAH

Table 3. The priority list of locations from Group III compiled in the PRA.MS model

No	SiteID	Relative risk and uncertainty factor values and risk classes				Ranked exposure pathways			
		Total risk value	Risk class (PRA.MS)	Total uncertainty value	Uncertainty factor class (PRA.MS	1st	2nd	3rd	4th
1	Fp-VH	41.7	High risk class	5.3	LOW UNCERTAINTY CLASS	SW	DC	GW	AIR
2	Vi-LO	41.0	High risk class	5.3		SW	DC	GW	AIR
3	HiZ-KS	40.0	High risk class	5.2		SW	DC	GW	AIR
4	Z-SA	32.6	Medium risk class	4.2		SW	DC	AIR	GW
5	Fom-PK	32.4	Medium risk class	6.9		SW	DC	GW	AIR
6	Fv-KV	31.8	Medium risk class	6.9		DC	SW	GW	AIR
7	EI-NI	31.4	Medium risk class	7.5		DC	SW	AIR	GW
8	Mgh-KV	30.7	Medium risk class	6.1		SW	DC	GW	AIR
9	Rd-ZR	29.6	Medium risk class	10.3		DC	SW	GW	AIR
10	Sum-KG	28.5	Medium risk class	7.1		SW	GW	DC	AIR
11	Ih-NG	27.6	Medium risk class	10.0		DC	SW	AIR	GW
12	Fa-SO	26.1	Medium risk class	10.6		DC	GW	SW	AIR
13	Mi-NI	24.8	Medium risk class	8.1		DC	GW	SW	AIR
14	KTK-ZA	24.4	Medium risk class	7.4		DC	GW	SW	AIR

GW – groundwater; SW - surface water; AIR – air; DC - direct contact

CONCLUSION

The results of the Project contributed to the development of the lacking methodologies, knowledge, and coordination mechanisms for sustainable and integrated management of soil as a natural resource. The priority list compiled based on the PRA.MS methodology can be further used for: planning the further site investigation strategies, enhancing the site monitoring, risk communication in the process of site management, decision-making purposes and allocation of resources for remediation projects.

ACKNOWLEDGMENT

This study was developed in the framework of UN Environment/GEF project "Enhanced cross-sectoral land management through land-use pressure reduction and planning". Thanks to the support of the Italian Ministry of Environment, Land and Sea supported by the UN Environment/GEF project through the initiative "Assistance to the Republic of Serbia in the Implementation of MEAs and EU Obligations through Improvement of Pollution Monitoring of Soil Quality at Industrial Sites" consultations and exchange of experiences are enabled with colleagues from the Italian National Institute for Environment and Research (ISPRA).

REFERENCES

Altieri, A., Falconi, M., Quercia, F., Vecchio, A., 2004. Towards an EEA Europe-wide assessment of areas under risk for soil contamination. Vol II. Review and analysis of existing methodologies for preliminary risk assessment. European Environment Agency

Altieri, A., Fons, J., Jarva, Quercia, F., Tarvainen, T., 2005. Application of the PRA.MS model to selected industrial and mining sites. Towards an EEA Europe-wide assessment of areas under risk for soil contamination. s.l.: European Environmental Agency.

Falconi, M., Quercia, F., Schamann, M., Tarvainen, T., Vecchio, A., Wepner M., 2005. PRA.MS: scoring model and algorithm. Vol III. Towards an EEA Europe-wide assessment of areas under risk for soil contamination. s.l.: European Environmental Agency.

Falconi, M., Fratini, M., Leoni, G., Vidojevic, D., Aleksic, N., Jevtic, N., Kukobat, L., Angelini, P., Egerer, H., Siljic Tomic, A., Montalbetti, F. 2018. UN Environment supports Serbian Environmental Protection Agency in the management of contaminated sites, FAO. 2018. Proceedings of the Global Symposium on Soil Pollution 2018. Rome, Italy, Food and Agriculture Organization of the United Nations. p. 524

Kukobat L., Vidojević, D., Šiljić Tomić, A., 2018. Towards soil decontamination in the Republic of Serbia. Ministry of Environmental Protection - Environmental Protection Agency. Belgrade. ISBN 978-86-87159-20-4.

Quercia, F., Gentile, A.R., Falconi, M., Vecchio, A., Tarvainen, T., Schamann, M., Fons Esteve, J., 2006. Soil Inventory and Assessment Project: the EEA experience towards a Europe-wide assessment of areas under risk for soil contamination. NATO CCMS Pilot Study. Prevention and Remediation in Selected Industrial Sectors: Small Sites in Urban Areas, Athens, 4–7 June 2006

Regulation on limit values for pollutants, harmful and hazardous substances in soil ("Official Gazette of the Republic of Serbia" No. 30/18 and 64/19)

Rulebook on the content and manner of keeping a Cadaster of Contaminated Sites, as well as type, content and forms, manner and deadlines for delivering the data ("Official Gazette of the Republic of Serbia" No 58/19)

Vidojevic, D, Bacanovic, N, Dimić, B., Jevtic, N, Gligoric, M. 2016: Assessment and management of contaminated sites in Serbia. Abstract book. 5th EUROSOIL International Congress 16-21 October 2016, Istanbul – Turkey: p. 366.

Vidojevic, D, Bacanovic, N, Dimic, B, Jevtic, N, Jovanovic, L, Siljic-Tomic, A. 2017: Management of contaminated sites in the Republic of Serbia, Congress Proceedings. "Solutions and projections for sustainable soil management", 2nd International and 14th National Congress of Soil Science Society of Serbia, Novi Sad, Serbia, 25-28 June. p. 102