# The current state of the quality of urban soils in Bucharest

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*Abstract*

*The soil cover is subject to anthropogenic changes as well as other geoecosystems subjected to pressures due to sources. The results are recorded for the soil cover depending on the type of anthropogenic manifestations, intensity, nature, and number of their manifestations. Moreover, the interferences with the natural landscapes intervene, and from here appear the evaluation process difficulties.*
*In most cases, it is considered that the urban landscape is distinguished by a series of peculiarities regarding the quality of the urban hydrosphere, an atmosphere, and the biosphere, as well as a series of changes in the pedosphere, as a result of land use. Notable for the soil cover, being particularly important is the soil cover the surface of the pedosphere. The complex of ecological parameters can provide important information on the flows and balance within the ecological system. The ecological importance of urban soils has long been underestimated. Urban soils were protected only as a support for construction. It was not until the early 1970s that the first approaches to the study and classification of urban soils were initiated.*
*We can say that in 2020 the situation is completely different, in the sense that urban soils are studied and evaluated periodically in terms of quality.*

***Keywords:*** *soil quality, urban areas, assessment, pollution*

## INTRODUCTION

In this paper is presented an analysis of the quality of urban soils in Bucharest by analyzing 21 soil samples distributed in different areas, under the influence of different anthropogenic pressures that manifest in the urban environment. Moreover, two data sets are available for 2015 and 2020 years, which facilitated an analysis of the evolution over time of soil quality. The manifestation of anthropogenic factors in the urban environment in relation to the edaphic cover, respectively a cover located in the transition zone between the atmosphere and groundwater highlights the complexity of the phenomena and the result of their manifestation as an impact on urban soils.
The importance of the study of soils in the urban environment remains as a study priority in Romania to ensure that this natural resource is protected by adequate and responsible management like the other natural resources.
The urban soils have characteristics that differentiate them from the natural ones from which they come, respectively those that are not subject to anthropogenic pressures. For example, the change of the morphology and their chemical and physical characteristics. The development of the urban activities induced powerful structural changes to compaction; a significant presence on the soil surface crusts; reducing aeration and drainage, changes in temperature regime (higher temperatures in urban areas) disturbance in the circuit of the nutrients, changes of activity of soil microorganisms, present in the soil of the anthropogenic materials. Also, pollution is a very important aspect in the sense that in the urban environment the vulnerability of soils to pollution is much higher compared to the neighboring areas.
There is an in-depth ecosystem approach to the soil concerning influencing factors and interdependence with other compartments, such as the atmosphere that can introduce transport and influences at long-distances or short distances, the last one having a direct influence on the soil [1].
The soil is only a sub-geosystem, in turn, it is a source that by percolation makes the transition to groundwater, respectively the saturated area.
Soil pollution is a potential source of pollution

for groundwater, but the proper functioning of the soil has an attenuating or purifying effect in relation to groundwater. Relevant aspects are shown schematically in Figure 1.

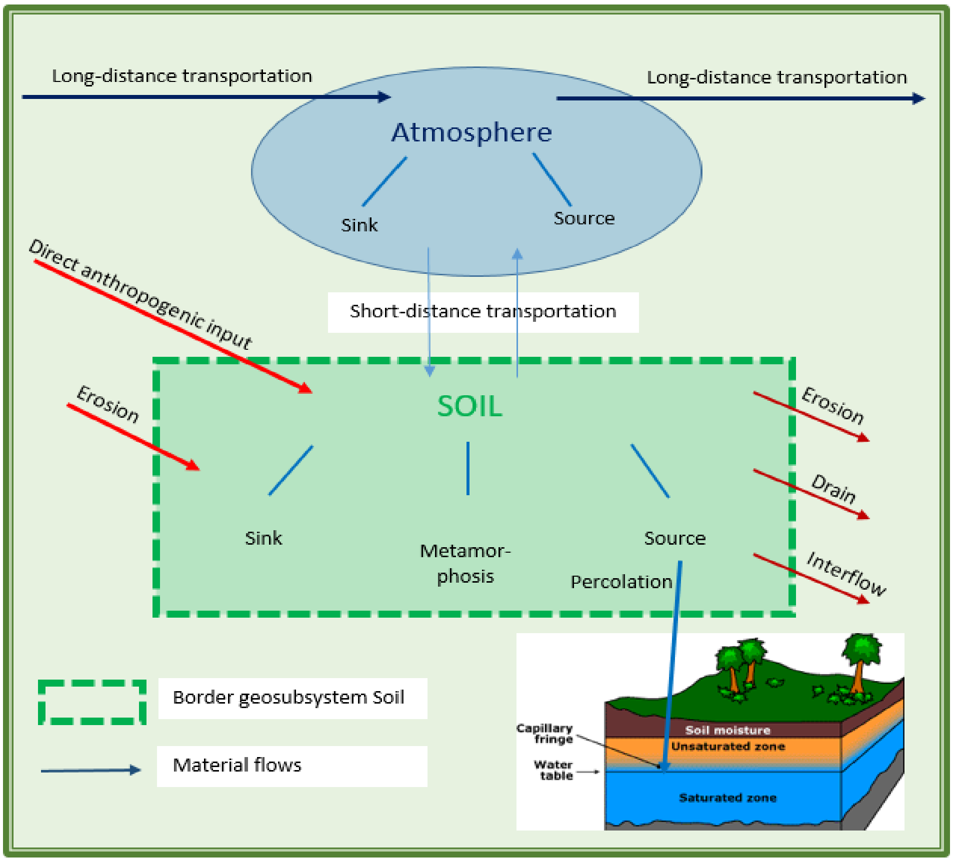


**Fig. 1.** Soil as an ecosystem compartment with relation and interdependences with the other compartments (modified after Sauerwien [2])

The soil is in a broad sense a living system, a complex ecosystem that has energy sources based on photosynthesis processes and microbial activity [2]. The ecosystem is defined by a physical structure, the presence of organic matter, the circuit of nutrients and water, as well as several abiotic and biotic factors. Soil provides ecosystem services that are different functions of soil ownership and its interactions, depending on the land use category [3].

Soil is a natural resource of undeniable importance; it provides society with valuable elements, which amplifies the importance of the soil that must be attributed to it.

Urban areas are characterized by the presence of an infrastructure or the "grey areas" that is grafted on the support provided by the natural soil cover. The urban environment wants to incorporate the green area or the so-called "green infrastructure", as harmoniously as possible integrated with the grey one. The urban infrastructure strongly modifies the soil, anthropizing it, the main effects being those of compaction, sealing and strong modification of the water hydrological regime. After the boundary of the cities, things change, because the landscape is usually made up of forested areas and agricultural lands, and the soil is much more suitable in appearance or natural pedogenetic [4].

## EXPERIMENTAL PART

The purpose of this paper was to perform investigations regarding soil quality in Bucharest, the main important city of Romania. The experimental network consists of 21 sampling points located in public places to cover a series of potential pollution sources. In Figure 2 is presented the localization of the sampling points on the map of Bucharest City and in Table 1 details about soil samples and GPS coordinates.

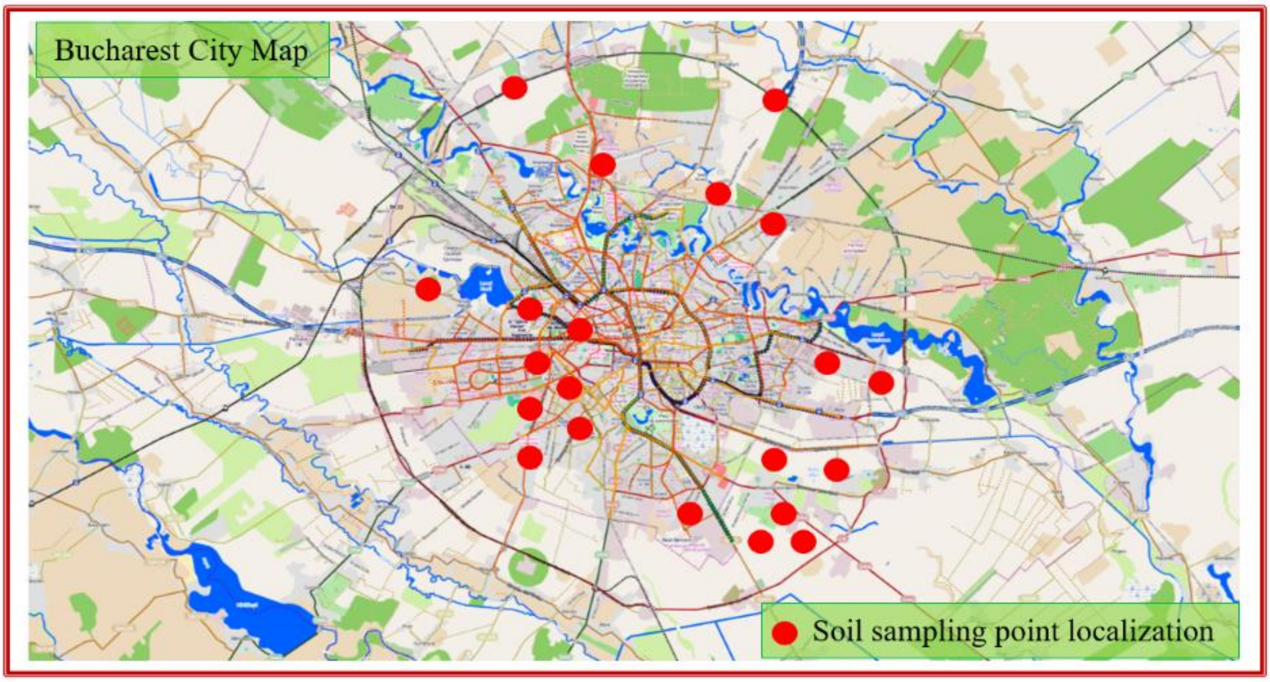


**Fig. 2.** Soil sampling point on Bucharest City Map

**Table 1.** Details about soil samples and GPS coordinates

| Sample ID | Description of the area of the soil sample | GPS coordinates WGS 84 |
|---|---|---|
| S1 | „Splaiul Independentei" street in the vicinity of ELCEN CET Grozavesti | 44°26'31.87"N 26° 3'46.75"E |
| S2 | „Soseaua Panduri" street in the vicinity of the Faculty of Chemistry | 44°25'52.12"N 26° 3'39.71"E |
| S3 | Area named „13 septembrie" ex-industrial are „Ventilatorul" | 44°25'26.61"N 26° 3'46.61"E |
| S4 | Sebastian Park, district 5 | 44°24'56.04"N 26° 4'12.08"E |
| S5 | Proximity fuel distribution station „Petrom Salaj" | 44°24'26.56"N 26° 4'42.40"E |
| S6 | Ferentari Park | 44°23'56.90"N 26° 5'3.37"E |
| S7 | Industrial area in Ferentari neighborhood | 44°23'26.58"N 26° 5'12.18"E |
| S8 | Area vicinity of ELCEN CET Progresu - a small area with uncontrolled storage of wastes | 44°21'50.08"N 26° 6'7.91"E |
| S9 | Industrial area „IMGB" in the vicinity of SC NEGRO 2000 SA | 44°21'56.38"N 26° 7'43.12"E |
| S10 | Public transportation terminal STB in the vicinity of „IMGB" | 44°21'36.45"N 26° 8'16.78"E |
| S11 | Industrial area IMGB (on-site) –metalurgical activities - SC RomEnergo Mecanic SA | 44°21'43.69"N 26° 8'30.54"E |
| S12 | Industrial area in the vicinity of „Fox" factory -the food industry | 44°23'39.77"N 26° 8'52.04"E |
| S13 | Bucharest City limits in the vicinity of SC LEOSER SA | 44°23'53.02"N 26° 9'43.99"E |
| S14 | Catelu neighborhood in the vicinity of Dyo paint factory | 44°24'57.29"N 26°13'6.12"E |
| S15 | A green space in the vicinity of Republica Metro station | 44°26'2.90"N 26°11'7.21"E |
| S16 | A neighbor of Fundeni hospital (Colentina neighborhood) – an area with uncontrolled storage of wastes | 44°27'53.24"N 26° 9'47.21"E |
| S17 | Andronache street area in the vicinity of railway station CF – an area with uncontrolled storage of wastes | 44°29'2.81"N 26° 8'23.41"E |
| S18 | In the vicinity of the railway in Pipera neighborhood | 44°29'8.28"N 26° 7'34.81"E |
| S19 | CB (ring road) – A3 penetration Bucuresti - Ploiesti | 44°31'36.37"N 26° 9'51.92"E |
| S20 | CB (ring road) – SC Vectra Eurolift SRL area | 44°31'26.99"N 26° 2'3.36"E |
| S21 | Reference sample in Rosu Forest, Chiajna locality | 44°27'10.85"N 25°59'45.48"E |

The investigations were carried out similarly to studies relevant to the issue of urban soils identified in practice at the international level [5-10]. The specialized scientific literature highlights for the Bucharest area as dominant Entiantrosoils, with a spatial extension of

48.5% of the entire surface of the city. These soils are defined by the Romanian Soil Taxonomy System are soils formed on anthropogenic parental materials having a thickness of at least 50 cm or at least 30 cm, if the anthropogenic parental material is skeletal on this thickness, without diagnostic horizons, outside an A0 horizon, except for those covered which may have a molic or umbric A horizon. The Entiantrosoils from the textural point of view fall into the category of soils with varied sandy-clayey texture. The soils have a weakly alkaline reaction (pH 7.5 ÷ 7.9), and the degree of saturation in bases has values in the range 94 to 100%, falling into the category of soils saturated in bases. The humus content is small-medium (2.9 ÷ 3.7%). The supply with total nitrogen is medium (0.164 ÷ 0.264%), the one with mobile phosphorus is very high (87 ÷ 874 mg/kg), and the one with mobile potassium is low - very high (112÷1210 mg/kg). In most of Bucharest, the Entiantrosoils are covered with asphalt and constructions. The soil cover of Bucharest is complex, consisting of eight soil types (Alluviosoils, Regosoils, Entiantrosoils, Cernozioms, Preluvosoils, Luvosoils, Gleisoils, and Stagnosoils) and nineteen subtypes that are included in four classes [11].

The activities were carried out as follows: in September 2015, the first soil sampling campaign with 21 sampling points. In May 2020, the investigation campaign was resumed, taking soil samples from the same points established in 2015. For the sampling, specific sampling equipment (hand-operated drilling type) was used (Eijkelkamp soil sampling kit). The samples were stored in sealed bags, properly labeled with unique ID code, and transferred to a specialized laboratory from National Research and Development Institute for Industrial Ecology - ECOIND. In the laboratory, the following quality indicators were analyzed by applying standardized test methods: pH, dry matter, humus, Kjeldahl nitrogen, sulphates, chlorides, iron, copper, lead, zinc, total chromium, and cadmium.

## RESULTS AND DISCUSSION

The results obtained during two investigation campaigns allowed highlighting a comparative analysis of the quality of soils in urban areas, respectively the city of Bucharest at two different time milestones 2015 and 2020, between these landmarks being identified a tendency of evolution specific to each area (Fig. 3-12).

For the interpretation of the results regarding heavy metals quality indicators was used the reference values from Romanian Order 756/1997 for the approval of the *Regulation on environmental pollution assessment* with subsequent amendments and completions, and threshold values were corroborated with the land use category-specific to each soil sampling point in part (sensitive or less sensitive use).

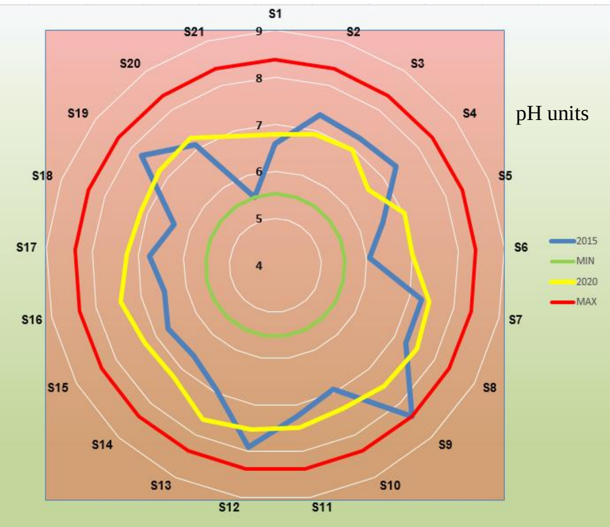


**Fig. 3.** pH of soil samples, 2015 *vs.* 2020

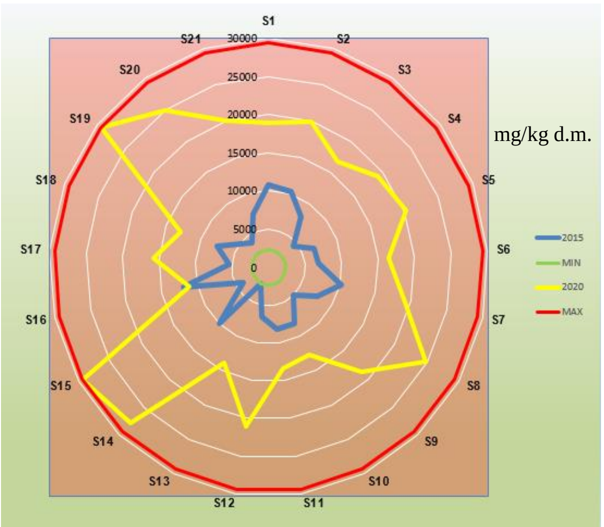


**Fig. 4.** Fe content in soil samples, 2015 *vs.* 2020

The pH variation for soil samples in Bucharest reveals a lower spatial variability in 2020 compared to 2015, which falls in the neutral pH range, and variations with higher amplitudes are found in 2015, respectively weak acid up to neutral weak (Fig. 3).

The Fe content in the soil has recorded the important variations in 2-time milestones, much lower iron values in 2015 compared with 2020. The maximum-recorded value was 29.37 g/kg dry matter (d.m.), in the zone that functions as a green area, located near to Republica large industrial platform (Fig. 4).

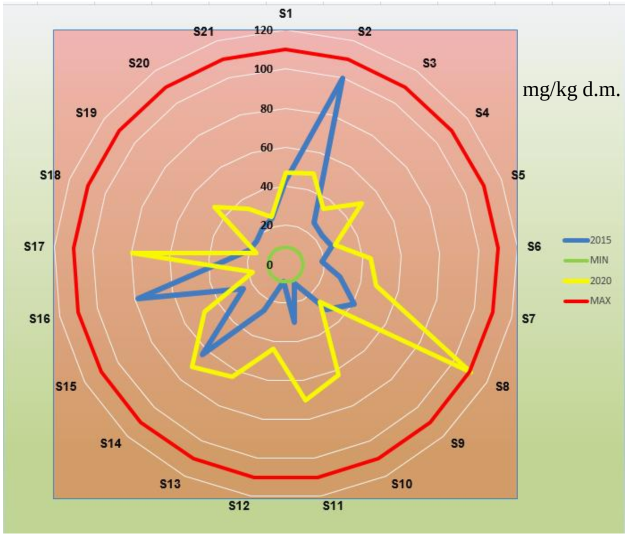


**Fig. 5.** Cu content in soil samples, 2015 *vs. 2020*

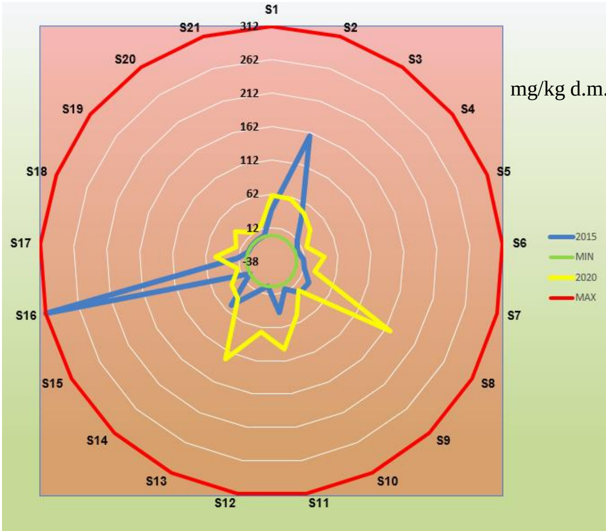


**Fig. 6.** Pb content in soil samples, 2015 *vs.* 2020

The values obtained for Cu content in the soil highlight the exceeding of the normal values, established at the threshold value of 20 mg/kg d.m. Higher values were registered in the campaign carried out in 2020, and the maximum value exceeds the alert threshold established for the sensitive use category, respectively 100 mg/kg d.m. (Fig. 5). The soil sample was collected from an identified area affected by uncontrolled waste disposal.

Regarding the quality indicator Pb, the maximum value was registered in 2015, the intervention threshold for the sensitive land use category was exceeded in an area from Colentina neighborhood, the pollution source being also uncontrolled waste disposal (Fig. 6). In 2020, the soil analysis revealed the return to normal values in this area, as a notable environmental positive aspect. The maximum value for the quality indicator Pb identified in 2020 is 169 mg/kg d.m., also in an area polluted by the uncontrolled waste disposal directly on the ground. It is also noted the frequent exceeding of the normal values, established at the threshold value of 20 mg/kg d.m.

Regarding the zinc content from the analyzed soil samples, higher values were founded in 2020 vs. 2015. The maximum value was recorded in an area where the wastes were discharged uncontrolled, directly on the ground. The maximum value was 482.41 mg/kg d.m. (S8, 2020 sampling campaign), represents an exceeding of the alert threshold for the sensitive use category. Approximately 50% of the total number of the analyzed samples exceeds the normal value (Fig. 7).

The total chromium content in the soil also reveals higher values in 2020 compared to 2015. The maximum value recorded (139.6 mg/kg d.m) corresponds to a location in the Ferentari neighborhood, near to an industrial site. The normal values in 2020 are frequently exceeded, respectively the threshold value of 30 mg/kg d.m. (Fig. 8).

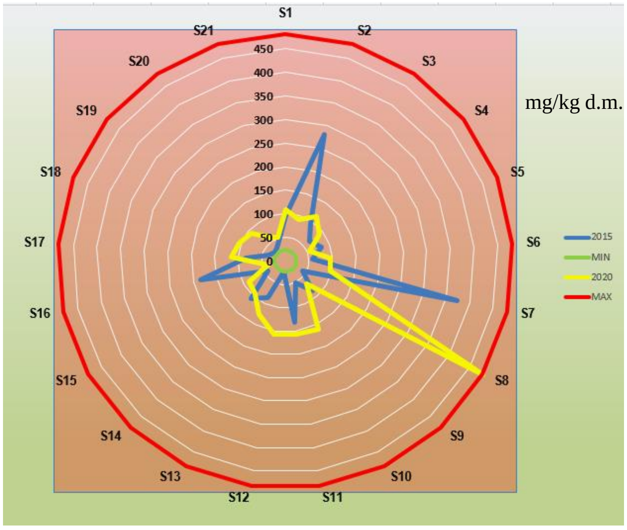

**Fig. 7.** Zn content in soil samples 2015 *vs.* 2020

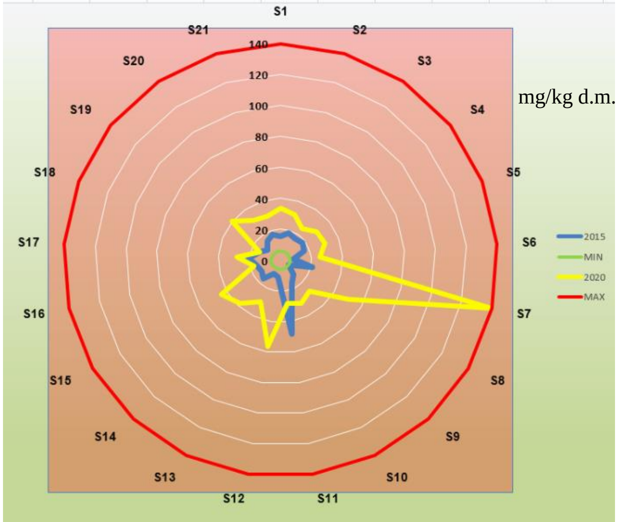

**Fig. 8.** Cr content in soil samples 2015 *vs.* 2020

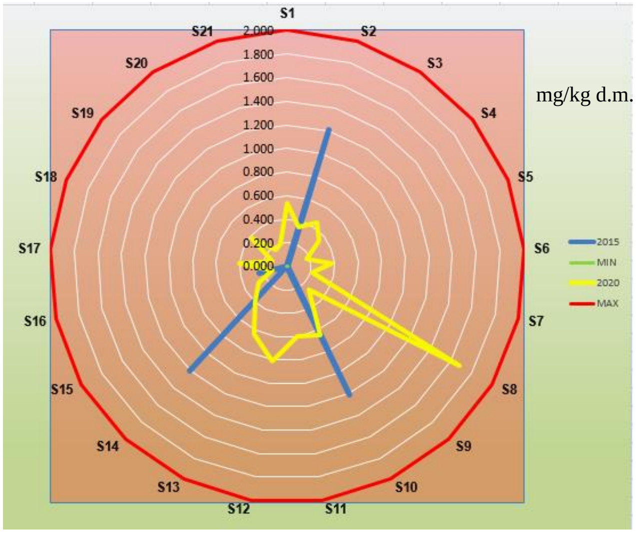

**Fig. 9.** Cd content in soil samples, 2015 *vs.* 2020

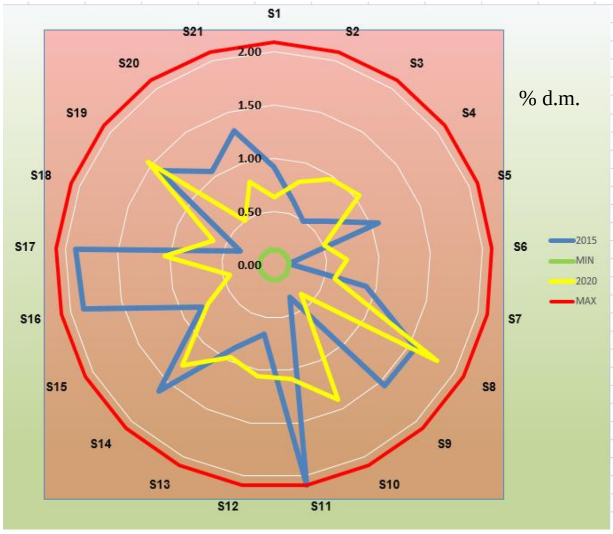

**Fig. 10.** Humus content in soil samples, 2015 *vs.* 2020

Regarding Cd content in the soil, the values were situated in most cases within the limits of the normal value, respectively lower than 1 mg/kg d.m. In the situation of exceeding the normal values, it is found that the value of the alert threshold for the sensitive use category is not exceeded, the higher values being reported in 2020 (Fig. 9).

The Humus content has values between 0.14 and 2.09%, this content easily correlates with the values in the literature regarding the quality of the urban soils.

Chlorides content in the soil was situated between 80.1 mg/kg d.m. and 97.1 mg/kg d.m. in 2020, the maximum value was recorded in 2015, respectively 233.47 mg/kg d.m (Fig. 11). Most likely, the source of pollution is also uncontrolled waste disposal in that urban area.

The variability of Kjeldahl nitrogen value was in the range 0.07 to 0.31% N, the best representation is the values that ensure a medium supply of the main macronutrient content in soils.

The analytical results obtained together with the relevant information collected following the field observations in the period 2015-2020 allowed the highlighting of some important conclusions that are presented graphically in Figure 13.

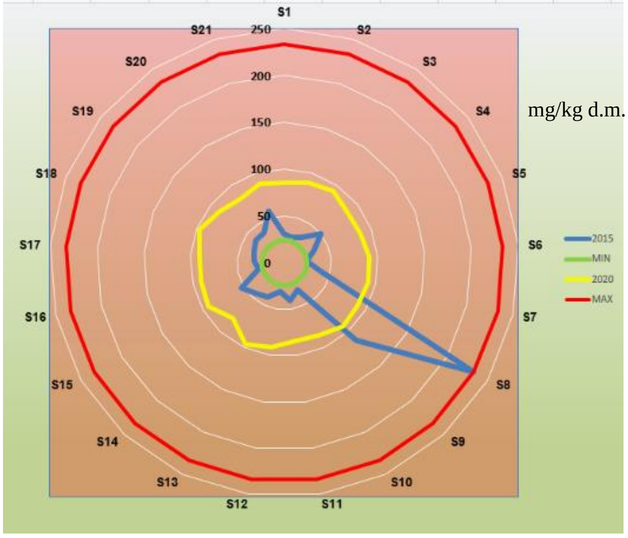


**Fig. 11.** Chlorides content in soil samples, 2015 *vs.* 2020

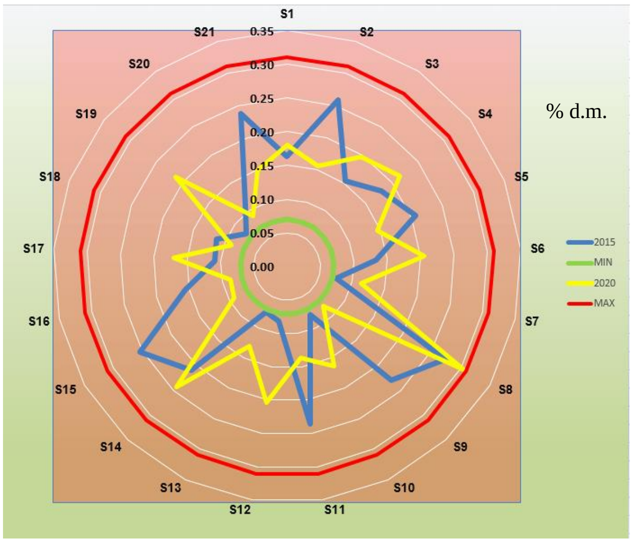


**Fig. 12.** Kjeldahl Nitrogen content in soil samples, 2015 *vs.* 2020

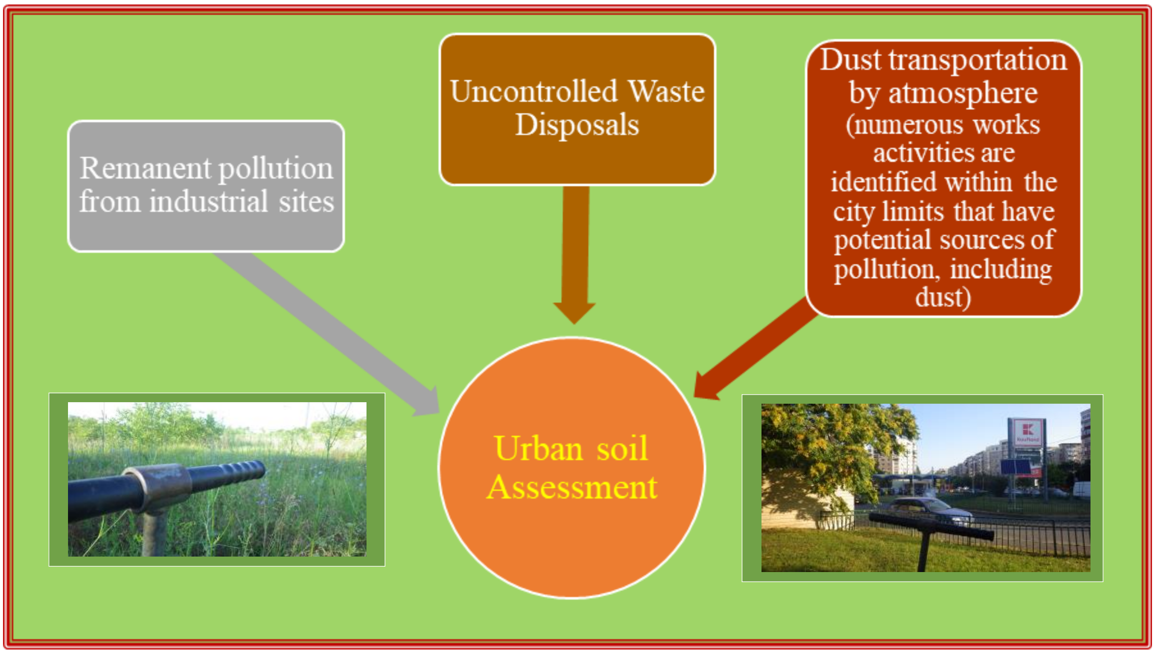


**Fig. 13.** The main conclusions of urban soil assessment in Bucharest 2015 *vs.* 2020

## CONCLUSIONS

The quality analysis of urban soils in Bucharest in two reference periods 2015 and 2020 allowed the highlighting of some important conclusions, which can be continued and thorough in new studies and, especially within permanent monitoring of the soil cover in the city.

Spatial variability is remarkable, but it is found that soil pollution remains closely correlated with the potential sources of pollution. Among these sources, there is a negative potential, the uncontrolled storage of waste directly on the ground in Bucharest, areas valued from a few square meters to hundreds of square meters. It is found that this problem remains far from being solved, in a reference period of 5 years. It is an alarm signal that must lead to urgent measures to eliminate these wastes and restore the soil to the accepted quality conditions. The second place among the potential sources of pollution for urban soils is attributed to the remanent sources of pollution in the vicinity of industrial sites. The industrial footprint in certain neighborhoods in Bucharest is strongly felt in the terms of quality of the soils. Among these potential sources, atmospheric factors and the manifestation of the transport of dust, particulate matters, and air pollution substances make the manifestation of soil pollution to have

a wide variability both, spatially and temporally.
Finally, it is important to mention that in the future to take into account some recommendations regarding the quality of soils in the urban environment:
- implementation of a functional soil quality monitoring program in Bucharest and major cities in Romania,
- introduction of elements of knowledge and learning regarding the aspects related to soil protection in the study programs in the educational units to the environmental protection lessons,
- elimination of uncontrolled waste disposal from the urban environment.

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**REFERENCES**

[1] NORRA, S., STUBEN, D., J. Soil. Sediment., **3**, no.4, 2003, p. 230.
[2] SAUERWEIN, M., Urban ecology: Patterns, Processes and Applications, Oxford Scholarship Online, 2013, p.45-58, https://doi.org/10.1093/acprof:oso/9780199563562.003.0006.
[3] ADHIKARI, K., HARTEMINK, A.E., Geoderma, **262**, 2016, p. 101.
[4] EPA Publication No.905R1103, Evaluation of Urban Soils: Suitability for Green Infrastructure or Urban Agriculture, 2011, https://nacto.org/docs/usdg/evaluation_of_urban_soils_epa.pdf [31.08. 2020].
[5] MADRID, F., BIASIOLI, M., AJMONE-MARSAN, F., Arch. Environ. Contam. Toxicol., **55**, 2008, p. 21.
[6] MORILLO, E., ROMERO, A. S., MAQUEDA, C., MADRID, L., AJMONE-MARSAN, F., H., DAVIDSON, C. M., HURSTHOUSE, A. S., VILLAVERDE, J. Environ. Monit., **9**, 2007, p. 1001.
[7] SCALENGHE, R., AJMONE-MARSAN, F., Landsc. Urban Plan, **90**, no. 1-2, 2009, p. 1.
[8] VANDERMEULEN, V., VERSPECHT, A., VERMEIRE, B., VAN HUYLENBROECK, G. AND GELLYNCK, X., Landsc. Urban Plan, **103**, no. 2, 2011, p. 198.
[9] VAN WEZEL, A., FRANKEN, R., DRISSEN, E., VERSLUIJS, K., VAN DEN BERG, R., Integr. Environ. Assess. Manag., **4**, no. 1, 2008, p. 61.
[10] TRESCH, S., MORETTI, M., LE BAYON R.-C., MADER, P., ZANETTA, A., FREY, D., STEHLE, B., KUHN, A., MUNYAGABE, A., FLIESBACH, A., Environ. Sci., 2018, https://doi.org/10.3389/fenvs.2018.00136.
[11] VLAD, V., FLOREA, N., TOTI, M., MOCANU, V., Correlation of soil classification systems SRCS and SRTS. System SRTS+, Ed. Sitech, Bucharest, 2014, p.12-191.