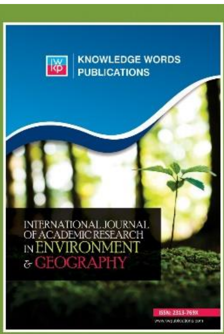

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Evaluation of the Anthropic Impact on the Environmental – Soil Factor Case Study: Alba Iulia Forest District, Romania

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Abstract
The evaluation of the impact on the soil in the Alba Forest District had as study the environmental-soil component, in terms of quantifying the anthropic impact pressure in the Alba Iulia Forest District. The purpose of the research was based on the premise that, although mining and industrial activities in the cities of Zlatna and Alba Iulia were stopped 15 years ago, and the permitted limit values of pollution indicators decreased, on average there are still remains from the sources of pollution from waste dumps and industrial waste deposits. Gradual soil pollution has affected the quality of forest vegetation (visible both in the forest litter and in its depth). The case study conducted in 2019 by the joint team of ecologists and geographers, focused on quantifying the anthropic impact on the soil by calculating the Average Index (I_{med}) of the impact of anthropic pressure RI-, followed by recommendations on soil quality restoration.
Keywords: Soil, Environmental Impact, Stress Index, Assessment, Forest Bypass, Tailings Dumps

Introduction

The soil is one of the environmental factors, along with water and air, which determines the quality of an ecosystem and therefore the development of plant and animal organisms. The soil has two components: *the mineral component* formed by the physico-chemical alteration of the rocks from the earth's surface and *the biological component*, the edaphic fauna, which is responsible for the formation of humic acid. Soil pH varies within very limited limits, in the sense of a very weak acid range, due to the presence of humic acid, to neutral. Therefore, by the presence of external substances, the pH can quickly move to acidic or basic conditions, conditions that are not good to the development of edaphic fauna and therefore we expect soil fertility to be affected. Moreover, the humus (formed by humic acid) together with the clay minerals from the soil, from a geochemical point of view, are characterized by *Cation Exchange Capacity / Cation Exchange Ability* CEC, so that there was the possibility of accumulation and residence of heavy metals, noxus etc. and this disadvantaged the development of microorganisms and therefore, led to impaired soil fertility (Benciu, 2007).

Viewed as a component of the environment, the *soil* (along with the other abiotic components important to sustain life - air and water), has undergone some qualitative changes due to increasingly aggressive anthropic pressure. Starting from the premise that *fertility* is the fundamental property of the soil in order to permanently provide optimal living conditions, through sustained studies pertinent observations have been reached, stating that, by introducing the soil into the economic circuit, its qualities have been and are permanently affected. The intensification of agro-industrial practices has led to the modification of natural ecosystems, the first environmental factor that has suffered from the loss of its natural quality, namely, fertility, being the soil (Radu, 2003).

In the ecological context, soil is seen as an important environmental factor that has undergone some qualitative changes as a result of exerting anthropic pressure. As an environmental factor, the soil seen as a complex system in continuous dynamics, is *receptive* to environmental conditions and *reactivity* (behavior) to their changes, but is sensitive to actions that disrupt its quality (Vasile, 2017). Environmentalists define "*Soil receptivity as its ability to suffer or assimilate and specifically integrate the action of any external factor or agent, and soil reactivity refers to its ability to respond, to behave specifically compared to reflectivity properties*" (Godeanu, 2013).

Approaching the soil as an environmental factor highlights the fact that it is active, dynamic and interacts directly with environmental factors: air and water, the result of this interaction influencing the quality of the soil (Benciu, 2018). Under conditions of significant anthropic pressure, the soil system can be disturbed and its operation modified, thus affecting the quality of the soil. Depending on their properties, the affected soils behave differently, known in the literature as *soil resistance* and *resilience* (Radu, 2003).

The pace of socio-economic development has made *soil quality assessment* one of the most important environmental issues, forcing decision-makers and environmentalists to implement and develop sustainable management programs for efficient terrain use. The complex procedure of soil quality assessment refers to both natural and man-made ecosystems, the latter being affected by local, non-compliant industrial development (Benciu, 2008). Therefore, in the study aspects of the difference between the natural contents of minor chemicals were observed, which give environmental problems (Clarke) of the soil, and a footprint of the local industry, which brought a consistent and residual quantitative addition to the soil, of pollutants from local industry according to models already applied in other polluted areas in Romania.[1] In this sense, two aspects stand out: the difference between the native quality of the soil developed under the influence of the natural processes of the environmental factors, by this we understand - the lack

[1]https://www.researchgate.net/publication/11901679_Baia_Mare_Accident-Brief_Ecotoxicological_ Report_of_Czech_Experts

of human pressure; and an artificial quality of the soil (anthropically modified) as a result of the application of land improvement works (Dumitru et al., 2011).

The evaluation of the quality status of the soil implies the establishment of a frame of reference with which its functional capacity can be compared. For a correct appreciation*, the assessment of soil quality* requires establishing the purpose for which estimation is made, which in turn is directly related to local land use conditions. This situation demonstrates how the interpretation of the data is dependent on the anthropocentric character and, at the same time, the subjective character of the evaluation of the soil properties is found (Scrădeanu, 2014).

Internationally, similar soil quality research has been conducted for the soils of Brazil and India, respectively for the Amazon plain (Brazil), the Indo-Gangetic plains (India) through a multitude of projects on the *assessment of organic soil stocks and changes in national scale* (GEFSOC); actions extending to countries in the Middle East or Africa (examples: Jordan and Kenya), all these are preparing unitary information for the creation of the Soil and Terrain Digital Database (SOTER) (Batjes et al., 2007).

For the European Union, the evolution of the Common Agricultural Policies on one hand and the awareness of environmental issues on the other hand, have led to the need to conduct soil research through a generalized information system. Thus, the CORINE Program and the MARS project (Modernization of Agriculture by Remote *Sensing*), as part of DG IV (Directorate-General for *the Environment*) supported this desideratum by involving a support group of the European Union , entitled Soil & IG (King et al, 1995).[2] The project, carried out over a period of four years, aimed to improve soil quality in the European area and create a digital information system. Thus, the Soil Map at European level was developed by DG IV and digitized by the CORINE program as part of the DG Research program, with each Member State of the European Union being tasked with updating its required data. Since 2011, agri-environment monitoring in the EU is carried out through land information systems provided by a database. It must comply with certain soil information requirements: identify national agri-environmental requirements and harmonize them with international initiatives; promote soil information systems (including terrain use); to develop the research side through new methodologies to obtain a better presentation of soil variability (King et al., 1995)[3].

In the United States, the assessment of soil quality is done through environmental modelers, who have developed a basic prototype with its own characteristics of land cover. The pattern/prototype was developed by teams of specialists from the EROS Data Center (Geological Survey) and the *Center for Advanced Land Management Technologies* at the University of Nebraska. This database focused on very high resolution advanced multiradiometric information known in the literature as the AVHRR *Advanced Very High Resolution Radiometer*; and sets of auxiliary data information on: terrain measurements, ecological regions and specific climatic characteristics, of a predetermined area. Case studies have demonstrated the importance of multi-annual AVHRR data in order to create, develop and maintain a flexible and accessible real-time database of land cover characteristics (Steyaert et al., 1994).[4] The US Department of Agriculture (USON) uses sets of crop analysis (by interpreting satellite imagery integrated into a

[2]https://esdac.jrc.ec.europa.eu/ESDB_Archive/eusoils_docs/esb_rr/n01_EUR16232.pdf
[3]https://esdac.jrc.ec.europa.eu/content/european-land-information-systems-agro-environmental-monitoring
[4] https://pubs.er.usgs.gov/publication/70113710

geographic information system - GIS) to help correctly assess adverse environmental conditions, such as floods and/or droughts, but also anthropic pollution. Subsequently, the specialists from the Laboratory of the Department of Agriculture will combine results, will make monthly and/or annual forecasts; and will monitor every parameter that can lead to the loss of soil quality for crops (Wade et al., 1994).[5]

Methodology

For the most accurate assessment of the anthropic impact on the soil, after the gradual cessation of economic activity in the Ampoi River valley, in the summer of 2019, the team of environmental specialists and geographers established that by calculating *the Environmental Impact Index* $\mathbf{I_{med}}$ and calculating the *Intensity impact* noted with $\boldsymbol{IR^-}$ it will be possible to obtain the quantification of the anthropic pressure in the area.

The applied methodology followed working models already existing in the specialized literature, exemplified in detail for the surface of Romania by Scrădeanu et al (2014, 2015). In order to obtain $\mathbf{I_{med}}$, several work steps were completed: the field observations stage was performed where the stress factors on the ground were identified; measurements were performed; data was collected and centralized. Their processing was done by using *the Soil Map of Romania* where the classes and types of soil related to the study area were identified, and through the CORINE Land Cover Copernicus program were recognized a number of 13 terrain uses. In order to obtain the value of the environmental impact index $\mathbf{I_{med}}$ of the Alba Iulia Forest District, a calculation was made (expressed in ha and percentage) for each area occupied by a soil class; establishing in advance the ranking of the intensity of the impact $\boldsymbol{IR^-}$. For the evaluation of the Stress Index according to the severity of the impact on the soil factor, the rating from 1 to 10 was established; each impact being assigned the value corresponding to the field observations.

The method of mathematical calculation was given by multiplying each area by the value of the given index, and then their sum was made, all in relation to the total area of the forest district. The value of the average index obtained was framed/compared with that of the $\mathbf{I_{med}}$ values per country (index used to reconsider the boundaries of Natura 2000 sites according to the land use of a site), namely: $\mathbf{I_{med} = 1}$ expresses a natural environment, $\mathbf{I_{med} = 2}$ does not require redefining the present/current land uses, and for $\mathbf{I_{med} > 2}$ revisions are recommended that will provide for the change of land use.

Case Study: Alba Iulia Forest District

The case study will present in detail how the actions to assess the impact on the soil in the Alba Iulia Forest District, Alba County took place by the mixed team of ecologists and geographers from the Faculty of Ecology and Environmental Protection of the Ecological University of Bucharest and the Faculty of Geography from University of Bucharest, in August 2019. The analysis focused on quantifying the anthropic impact on the soil by calculating *the Average Index (I_{med}) of the impact of anthropogenic pressure RI^-*, followed by brief *Conclusions* and recommendations on soil quality restoration.

[5] https://www.asprs.org/wp-content/uploads/pers/1994journal/sep/1994_sep_1145-1150.pdf

The evaluation of the impact on the soil in the Alba Forest District had as study the environment-soil component, in terms of quantifying the anthropic impact pressure in the Alba Iulia Forest District. This area was chosen for two reasons: on one hand, the surface of the forest district partially overlaps the two Natura 2000 sites - ROSPA0087 Trascăului Mountains and ROSCI0253 Trascău; on the other hand, due to the fact that the socio-economic development from the Ampoiului valley to the confluence with the Mureș river valley has left its mark on the soil and water environmental factors. The long activity of the two industrial centers from Zlatna and Alba Iulia generated, by accumulation, the degradation of the environment, especially of the soil. The aim of the research starts from the fact that, although the industrial activity of the Zlatna plant and the mining in the adjacent areas have been stopped for more than 15 years, and the permissible limit values of pollution indicators have decreased, on average remains of significant pollution *dumps* and *industrial warehouses sources are present.* The degree of soil damage directly affects the quality of forest vegetation (visible both in the forest litter and in its depth).

According to the public information of the Alba County Office of Pedological and Agrochemical Studies - OJSPA, most lands in the Alba Iulia Forest District are affected by natural processes (slope and erosion), to which the anthropogenic processes that affect soil quality are added such as: *primary and/or secondary compaction* generated by extraction activities, especially mining.[6]

The extension of rural settlements from the Piedmont area to the mountain area, from depressions, along valleys and to interfluves, the ramification of municipalities imposed the development of county, communal and forest road networks that, over time, led to the fragmentation of natural ecosystems. This anthropogenic action has led to a change in land use. The industrial centers strongly developed in the socialist-communist period Zlatna and Alba Iulia , being known as polarizing areas with intense activity until 2004, left their mark on the quality of the environment, in the whole region existing a marked degree of degradation of local vegetation. The environmental factor, the soil, was the one that underwent permanent changes, through residual pollution and the accumulation of pollutants, following the anthropic pressures generated by the local industry, the effects being felt in the Alba Iulia Forest District area.

The basic resource of this area is the soil, which, especially as a result of excessive use or non-use, deviations from the rules of the main agricultural works, as well as the type of soil or pollution, has experienced a process of continuous degradation; the frequency of slope processes, respectively landslides, degrading and surface erosion require a selective transindividual approach to land use (Bogan, 2008).

The eco-geographical location of the Alba Iulia Forest District

The study area is located in the eastern part of the Apuseni Mountains (Figure 1), extending mostly over the Zlatna and Meteș depressions. Framed north of the Trascău Mountains and south of the Metaliferi Mountains, the surface of the forest district is drained by the Ampoi River.

[6] Report on the state of environmental factors for 2019 in Alba county, Alba Iulia 2019

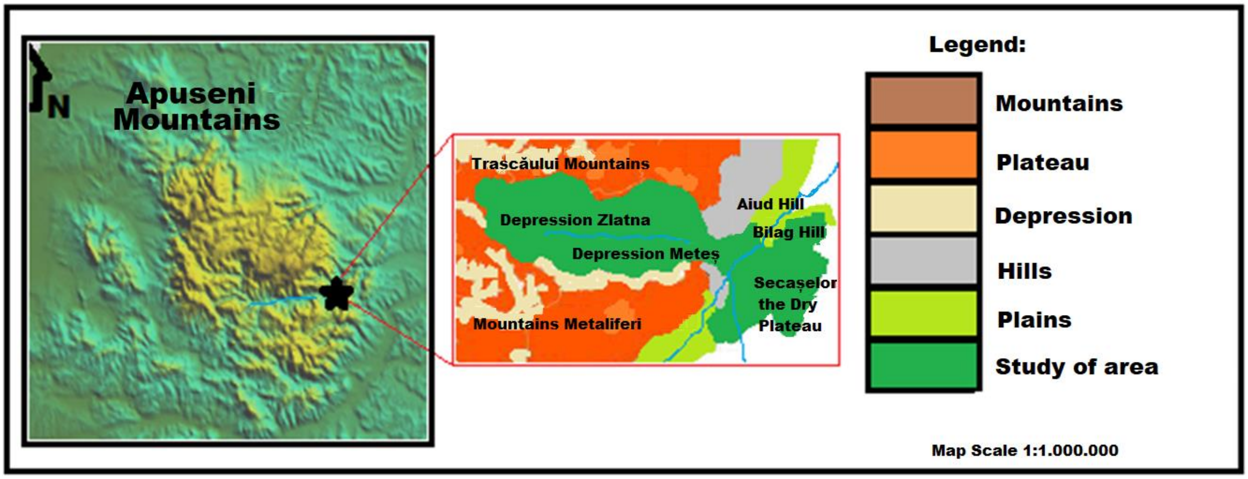

Figure 1. Morphometry of the Alba Iulia Forest District, (processed)
Source: https://www.uoradea.ro/display2394

The hilly landscape is represented by the Aiud and Bilag hills that make the transition from the mountain area of the Trascăului Mountains to the Mureș valley. The Mureș corridor has the appearance of a smooth and wide plain, as a result of the triple confluence of the Alba Iulia area, where it receives as affluent the following rivers: Ampoi, Târnava and Sebeș. East of the Mureș Valley, the surface of the Alba Iulia Forest District overlaps the western end of the Secaşelor Plateau, which is part of the Transylvanian Depression, so it can be emphasized that the morphology of the landscape introduces the stratification of all elements of the environment.[7]

As a result of the morphometry of the landscape, the Alba Iulia Forest District presents a stratification of the soil classes, as follows: in the mountain areas with forested slopes the class of brown forest soils was identified (district soils associated with lithosols on slopes); in the depression areas are present soils from the class of alluvial soils (rendzine, lithosols and eutricambosols). On the valley corridors and on the terraces of the majority rivers there are soils of the aluvisols class (luvosols, preluvosols) which have mainly gleic properties (Onea, 2013).

The study area completely overlaps Alba County (Figure 2) being one of the seven forestry schools subordinated to the Alba Forestry Directorate.

[7] http://alba.rosilva.ro/articole/prezentare_generala__p_1018.htm

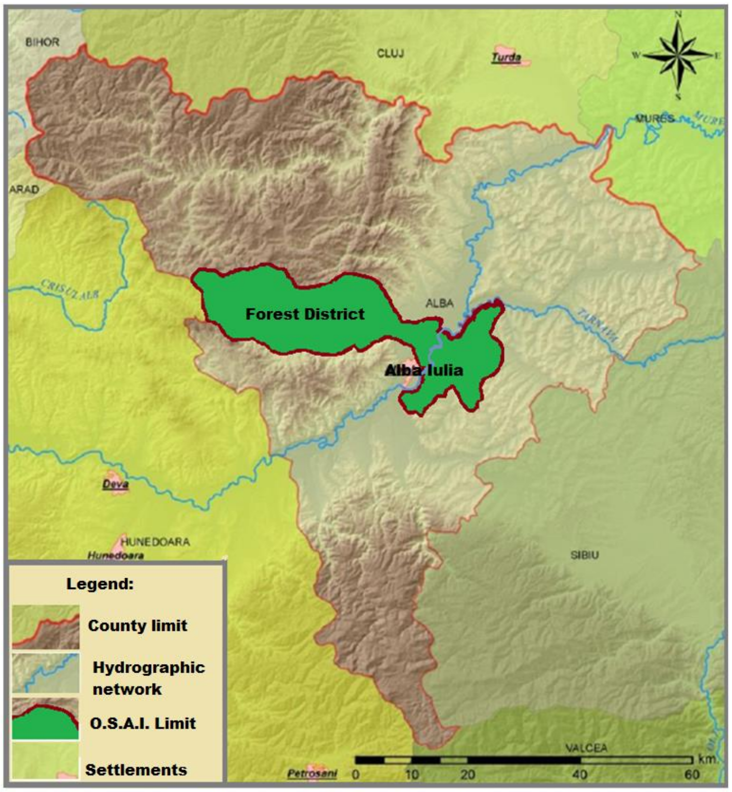

Figure 2. Geographical location and location in the county of Alba Iulia Forest District (processed)
Source: https://www.uoradea.ro/display2394

In a brief historical presentation, the area covered by the Alba Iulia Forest District in 2001 was 20,352.4 ha. As a result of the restitution of land according to the legislation in force: Law no.18/1991 of the land fund, Law no.1/2000 for the reconstitution of the property right over the agricultural and forest lands, requested according to the provisions of the Law of the land fund no.18/1992 and Law no.247/2005 on the reform in the fields of property and justice, as well as some adjacent measures, the area owned by the Alba Iulia Forest District in 2001 was gradually reduced to almost half, so that in 2011 it was only 10685, 86 ha. According to public information[8], currently the surface of the Alba Iulia Forest District has an area of 12713 ha, but after 2012 the area of the forest district (of 10665.86 ha) remained relatively ascertained until 2019.

The Alba Iulia Forest District is part of the alpine and continental bioregions[9] characterized by geological, climatic, pedological and vegetation features. The protected natural sites that overlap the forest district, ROSPA0087 - Trascăului Mountains and ROSCI0253 - Trascău express a combination of these elements that represent the habitat of various (and even endemic) species of flora and fauna.

The geographical position and the natural environment sum up the favorable elements for the development of the forests, while the anthropic pressure is a restrictive element for the

[8] http://www.rosilva.ro/unitati_silvice/alba__l_1.htm
[9] Natura 2000 standard form, Site - ROSPA0087 Trascăului Mountains

maintenance and expansion of the forest fund. With direct implications on the environmental factor - soil, the analysis of this anthropic impact is the purpose of this study.

Identification of Soil Types

Soil class map for Alba Iulia Forest District (Figure 3) was made according to the Soil Map of Romania at a scale of 1:500,000 from the Geographical Atlas of Romania (1978) and the FAO/UNESCO classification (adaptation according to SRTS 2003) and processed GIS (Onea, 2013). The data used was correlated with those from the Natura 2000 Network in Romania - Assessment of threats and pressures through the land cover data CORINE LAND COVER, presented in Image no.3 Types of land use in the Alba Iulia Forest District (Ursu et al., 2020).

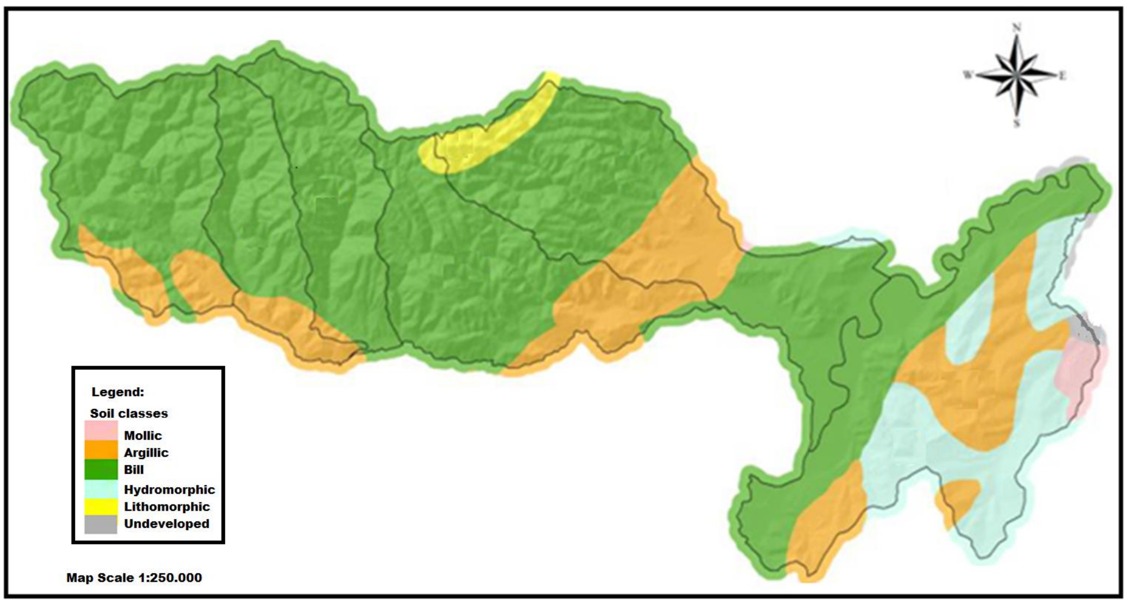

Figure 3. Distribution of soil classes for the Alba Iulia Forest District
Source: taken over after Onea, 2013

The soils of the Alba Iulia Forest District fall into 6 soil classes with 22 subtypes (Table 1) as follows:

- *mollic* type soil class (clay chernozioms and apical clay chernozioms and vertisols in humid climates),
- *fluvial clay* type soil (predominantly soft *fluvial clay* soils, brown clay soils, podzolite brown soils),
- *cambic* soil class (eu-mesobasic brown soils, acid brown soils, eu-mesobasic brown soils and podzolite browns, soils, acid browns, podzolite soils, fluvial clay podzolic soils, acid brown soils and andosoils),
- *hydromorphic* soil class (swamps, humic-gleic soils, black wet grass soils, wetland cambic chernozioms, vertisols and soft brown soils),
- *lithomorphic* soil class (rendzine and brown soils) and
- class of *undeveloped* type soil (regosols and eroded soils).

Table 1 presents the partial and total percentages of the classes and types of soils they own from the surface of the Alba Iulia Forest District (Onea, 2013).

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Table 1. Percentage of soil classes and soil types in the study area

No. crt.	Soil class	Soil type	Percentage %	
			Partial	Total
1.	Mollic	alluvial clay chernozioms vertic clay chernozioms vertisols in humid climates	0.04 1.04	**2.08**
2.	Fluvial clay	brown clay mollic soils brown clay soils brown podsolic soils	6.01 5.11 8.01	**19.13**
3.	Cambic	eu-mesobasic brown soils, podzolic brown soils eu-mesobasic brown soils, acid brown soils, podzolic brown soils, fluvial clay podzolic soils acid brown soils and andosols	14.72 31.01 3.05 14.47	**63.25**
4.	Lithomorphic	rendzine and brown soils	1.60	**1.60**
5.	Hydromorphic	swamps, humic-gleic soils black soils of wet grass cambic chernozioms in the wetland vertisols and soft brown mollic soils	1.50 1.68 0.36 9.82	**13.46**
6.	Undeveloped	regosols and eroded soils	0.58	**0.58**
Total			**100**	**100**

Source: processed after Onea (2013) - https://www.uoradea.ro/display2394

Identification of Soil Stress Factors

Until the end of 2003, the mining industry developed during the communist period, or mining operations and ore processing plants and Zlatna and Alba Iulia industrial platforms for obtaining the finished product - copper (Cu), located in the Ampoiului valley, operated permanently. Thus, the Forest District area was visibly affected, registering an accentuated degree of pollution, often exceeding the limit values allowed for the main indicators (especially heavy metals).

With the cessation of the activity of the Zlatna plant and the mining operations in the nearby perimeters, in 2004, the general degree of pollution decreased, the values of the pollution indicators decreasing until almost reaching the normal limits, but in the environment a historical pollution of the soil remained, by the accumulation and residence of heavy metals. In addition, the existence of non-compliant, non-green deposits: tailings dumps and industrial waste dumps that increased this historical soil pollution and implicitly the natural vegetation associated with it.

Determining the types of land use (Corine Land Cover). The data extracted and processed from the CORINE LAND Cover Program (CLC) were used, on the one hand, to identify threats and pressures in Natura 2000 sites and, on the other hand, to assess land from the perspective of evaluating the state of environmental conservation. Recent studies have shown that important changes in land covering took place in Romania after 1990, but the greatest dynamics were observed during 2012-2018. The major changes were mainly generated by forestry activities (deforestation), overgrazing, habitat expansion and agriculture (Ursu et al., 2020).

According to the classification of land use in the European program CORINE Land Cover Copernicus 2018 (CLC 2018) presented in Figure 4 and Table 2, on the surface of the Alba Iulia Forest District there are 13 types of soil from the 44 soil classes representative of Romania, namely: discontinuous urban areas and rural areas, industrial and commercial units, agricultural land mixed with natural vegetation, non-irrigated arable land, orchards, vineyards, pastures, areas with complex crops, transition areas with shrubs that have been generally cleared, deciduous forests, mixed forests, coniferous forests and watercourses.

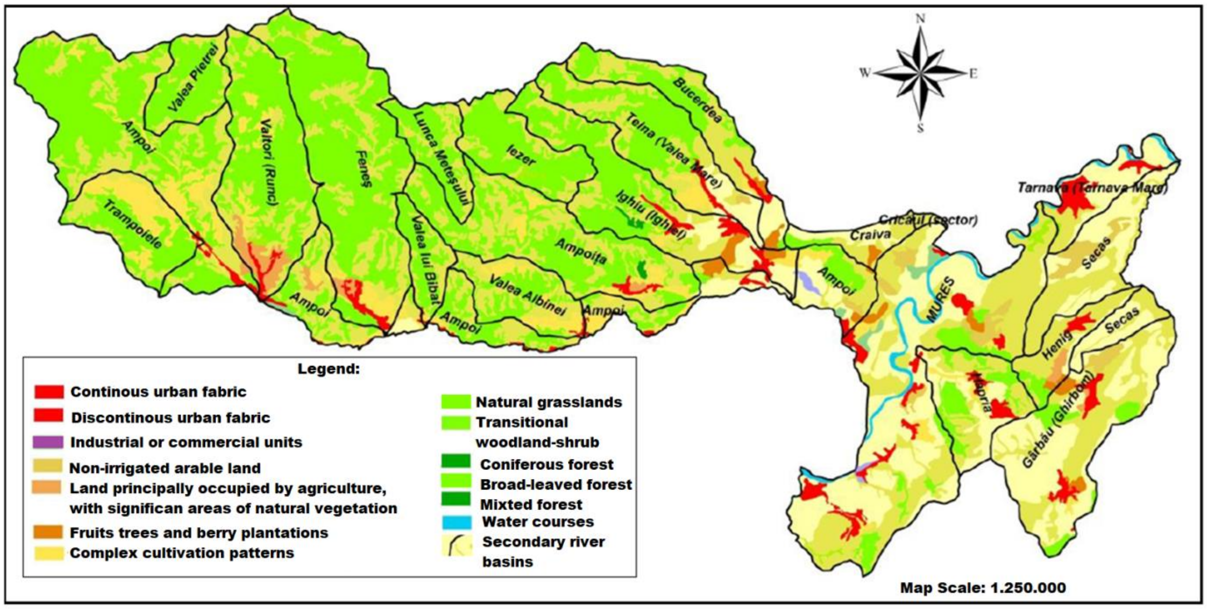

Figure 4. Types of land use in the Alba Iulia Forest District
Source: takeover/processed after Onea (https://land.copernicus.eu/pan-european/corine-land-cover/clc2018)

Table 2. The impact of the intensity of anthropic activities in the way of land use in Alba Iulia Forest District

No. crt.	CLC 2018 Corine Land Cover 2018 raster	CLC 2018 Corine Land Cover 2018 vector _ Cod	Areas			RI^- impact intensity ranking
			Name index	ha	%	
1.	Continuous urban fabric	111	q1	297.3	4.5	10
2.	Industrial or commercial units	121	q2	289.4	4.5	9
3.	Discontinuous urban fabric	112	q3	257.8	3.5	8
4.	Water courses	511	q4	189.1	3	1
5.	Non-irrigated arable terrain	211	q5	748.9	7	6
6.	Natural grasslands	321	q6	845.9	7.5	2
7.	Transitional woodland-shrub	324	q7	449.5	5.5	3
8.	Coniferous forest	312	q8	1457.6	11.5	1
9.	Broad-leaved forest	311	q9	1749.1	12	2
10.	Mixed forest	313	q10	2095.2	19	2
11.	Complex cultivation patterns	242	q11	1225.7	10.5	7
12.	Land principally occupied by agriculture, with significant areas of natural vegetation	243	q12	728.5	6.5	5
13.	Fruit trees and berry plantations	222	q13	351.8	5	4
	Total			**10685.8**	**100%**	

Source: processed after Scrădeanu, 2014

Evaluation of the Environmental Stress Index on the soil for the Studied Area

Table 2 shows the area of the forest district at the level of 2018 (10685.86 ha) and the land use, represented according to CLC 2018 raster and CLC 2018[10] vector, where, the 13 types of land uses are assigned a numerical code, depending on their destination. In the table, the partial areas are shown by the letter *q* and the indicative from 1 to 13, and the expression of the partial and total area was done both in hectares and in percentages (Figure 5).

[10] https://land.copernicus.eu/pan-european/corine-land-cover/clc2018

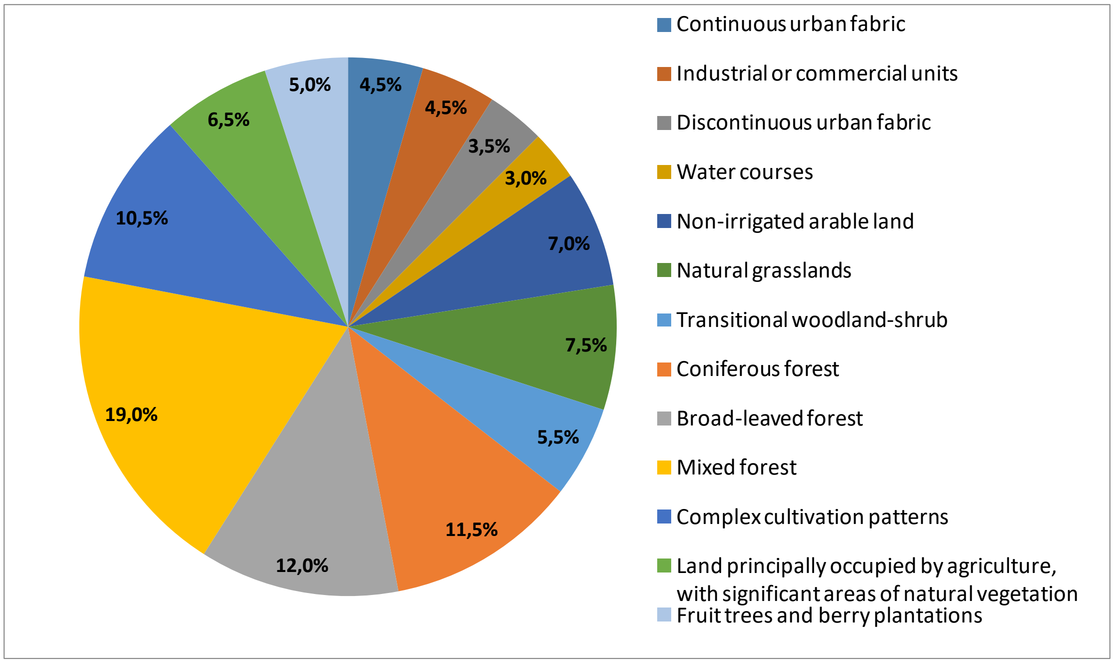

Figure 5. Types of land use at the Alba Iulia Forest District (2014)

It is observed that the largest areas are mixed forests, followed by broadleaf and coniferous forests, complex cultivated areas, natural meadows, predominantly agricultural and non-irrigated lands, wet forest vegetation, vineyards and orchards; urban and rural settlements, industrial and commercial spaces, and watercourses with the smallest areas.

The calculation method chosen to achieve *the RI Impact Intensity Ranking* showed in the last column of Table 2, presents the following attributions: an *index* was given from 1 to 10 on the intensity of soil stress, depending on the types of use and stress factors (physical, chemical or anthropic) borne by it and identified in the field. The impact generated by anthropic activity on the environment (of the soil environmental factor) will be assessed with a *grade of 1* for the least aggressive pressure and a *grade of 10* for the most aggressive pressure exerted on land use.

The evaluation of the surfaces corresponding to each stress class (1-10) according to the index ***IR***$^-$ (impact intensity) is given in Table 3, where the following are observed:

- **Low intensity:**
  - ***RI***$^-$ *1* - for the categories: 312 Coniferous forests and 511 Water streams;
  - ***RI***$^-$ *2* - for the categories: 311 Broadleaf forests, 313 Mixed forest and 321 Natural pastures;
  - ***RI***$^-$ *3* - for category 324 Wet forest vegetation.
- **Average intensity:**
  - ***RI***$^-$ *4* - for category 222 Vineyards and orchards;
  - ***RI***$^-$ *5* - for category 243 Predominantly agricultural lands;
  - ***RI***$^-$ *6* - for category 211 Non-irrigated lands;
  - ***RI***$^-$ *7* - for category 242 Areas with complex crops.
- **High intensity:**
  - ***RI***$^-$ *8* - for category 112 Urban and rural space;
  - ***RI***$^-$ *9* - for category 121 Industrial and commercial units;

- ***RI*** $^{-}$ *10* - for category 111 Urban industrial activities.

Table 3. Impact intensity ranking *RI* $^{-}$

CLC category	Name of index surfaces	*RI* $^{-}$
312, 511	**q8, q4**	I_1
311, 313, 321	**q9, q10, q6**	I_2
324	**q7**	I_3
222	**q13**	I_4
243	**q12**	I_5
211	**q5**	I_6
242	**q11**	I_7
112	**q3**	I_8
121	**q2**	I_9
111	**q1**	I_{10}

The calculation *of the average stress* ***index*** I_{med} is made by the *ratio* of the stress level of the affected area (q1 ÷ q13) multiplied by $I_{1 \div 10}$ correspondingly, *to* the total area Q (q1÷q13 summed) by the formula:

$$I_{med} = q1 \times I_n + q2 \times I_n + q3 \times I_n. \ldots + q_n \times I_n / Q \text{ (or } q1 + q2 + q3 \ldots + qn)$$

Where:
Q = total area
q = area of land use according to usage
$I_1 \ldots I_n$ = Environmental index/impact expressed from 1...10

By applying the formula, we will obtain:

I_{med} = 297,3x10 + 289,4x9 + 257,8x8 + 189,1x1 + 748,9x6 + 449,5x3 + 845,9x2 + 1457,6x1 + 1749,1x2 + 2095,2x2 + 1225,7x7 + 728,5x5 + 351,8x4 / 10685,8
I_{med} = 2973 + 2604,6 + 2062,4 + 189,1 + 4493,4 + 1348,5 + 1691,9 + 1457,6 + 3498,2 + 4190,4 + 8579,9 + 3642,5 + 1407,2 / 10685,8
I_{med} = 38140,7/10685,8 = 3,569288

$$I_{med} = 3{,}569288$$

The result of the impact index produced by the anthropic pressure regarding the land use for the Alba Iulia Forest District led to the value of 3.569288.

In Romania, the quantification of the stress induced by land use, for all the categories provided by the CORINE Land Cover program is done by classifying *RI* $^{-}/I_{med}$ in three groups, namely:

- ***RI*** $^{-}/I_{med}$ **= 1** is without environmental impact (natural environment) and does not require intervention on land use,

- ***RI*** $^{-}$**/I_{med} = 2** where the values of the impact index are less than or equal to 2 and do not require a redefinition of current land uses,
- ***RI*** $^{-}$**/I_{med} > 2** important land areas are affected, so it is necessary to review land use and take measures (Scrădeanu et al, 2015).

For the Alba Iulia Forest District, the calculation *of the environmental impact index* on land use resulted in the value of 3.569288, which places the land use in the third category (**I_{med} > 2)**, where the index exceeds the value 2. The result obtained involves recommendations on performing analyzes of anthropic (especially industrial) pressure on the soil and taking measures to reduce stress (for the soil).

Remedy actions recommend first of all the depollution, followed by the restoration of the productive capacity of the soil and the introduction of the affected areas in the forest or agricultural circuit. In parallel, it becomes necessary to perform a detailed analysis to identify pollution factors in the area; land use reviews for soil quality restoration and long-term monitoring.

Negative Impact on *Soil* Environmental Factor. Preventive Measures

The storage of sterile rock waste in dumps can have a *negative impact on the soil* being generated by the removal from the productive circuit of land areas occupied by the landfill and causing local landslides generated by the landfill activity.

A number of measures are put in place *to reduce the impact on the soil* (Mining Law no. 61 of March 5, 1998), such as:

- respecting the limits of the perimeter approved for the exploitation of the deposit, without affecting other surfaces;
- forbidden deforestation in the area adjacent to the dumps in order not to trigger surface erosion;
- taking over the rainwater and torrents through the guard and drainage channels, but also directing them outside the perimeter of the dump;
- revegetation with native species, after greening the land affected by the technological plants and in the post-closure period. This greening involves a series of measures to reduce the concentration of heavy metals in the soil, using semi-permeable layers with cationic exchange capacity, natural - zeolites or synthetics - synthetic resins, obtained industrially by reproducing the mineral network of zeolites. After making the aforementioned layer, you can put soil and then revegetation with native species, thus achieving a reduction of environmental impact in the affected areas (Benciu, 2007).

For the *protection of the soil*, the safety of the stability of the dumps and the avoidance of the slipping of the material from the dumps, measures have been established to follow the observance of: the geometric elements of the dumps' design; of the technological process of continuous and uniform piling; the geotechnical parameters established by the specialized studies (compaction of the dump, of the slope angles and of the behavior of the dumps in the neighboring areas); observance of safety zones; but also planting species that are suitable for slopes and platforms. Subsequently, it is necessary to monitor the soil quality through careful observations on the development and growth of vegetation / crops on the planted areas.

Recommendations on Soil Quality Restoration

In order to reduce the negative impact on the soil, the extraction and exploitation activity must be carried out using *the best available technologies* (BAT Technologies), regarding the mining activities and the processing of their products while respecting the legislative norms in force (national and European - in especially those on environmental protection).

Therefore, the works of closing the tailings dumps by arranging them for return to the productive circuit are correlated with the technological flow of the quarry, which are directly related to the period when the lands remain free of technological burdens. The soil restoration works are necessary to be executed both during the exploitation period and after the cessation of the quarry activity.

The post-closure and closure stages are carried out in compliance with two objectives: the landfill lands must be left for a period of at least one year from the date of release of the technological load (for the natural settlement of tailings deposits); and the ecological recovery periods will be declared following the efforts made for the biological recultivation works that take place in a minimum interval of 3-4 years.

In order to green the waste dump related to the mining perimeter that overlaps the Alba Iulia Forest District, it was recommended to *change the use of agricultural and forestry* land by *using the land as hay or pasture and less as arable land*.

Closure and greening of the mining perimeter (Mining Law no. 85 of March 18, 2003) from the Zlatna area was carried out through staged operations in which actions provided in the pedo-agrochemical and topographic substantiation studies took place, such as:

- *Stage I Works for the arrangement of the morphological framework*, which include: functional arrangements of the natural environment and ensuring the pedological conditions for the development of biodiversity.
- *Stage II Biological recultivation*, which aims to: improve the new soil environment created by pedo-improvement works and annual fertilization according to the fertilization plan; testing the crops practiced in the area; recultivation with dendrological or vegetal species that are suitable for the newly created edaphic environment, for a period of 3-4 years, regarding:
    - The planting/forestation works are scheduled to take place during the activity period, but also after the cessation of the activity in the quarry, specific for the first year.
    - Maintenance works are specific throughout the existence of plantations, and the increase of forested areas has a role in restoring air quality in the area, but also contributes to restoring the soil and biodiversity.
    - Weeding works or the establishment of grasslands and/or pastures cultivated to improve the structure of degraded soils in order to obtain animal food. These crops develop over a minimum period of 3 years.
    - Cultivation works for arable use: it is carried out in a crop rotation of 3 years, for crops with an ameliorating role: meslin, grains and corn.
    - Works for the arrangement and greening of the remaining unproductive pit where rainwater will accumulate. For the protection zone, it was proposed to plant hydrophilic dendrological species such as: willow *Salix sp.,* Poplar *Populus sp*. and ash *Fraxinus sp.*

It is useful for the agricultural area to know the agrochemical properties of the soils, in order to establish precisely the degree of pollution of the area and the possible measures that can be taken in order to reduce the effects of pollution or rehabilitation of affected areas (Bogan, 2008).

Conclusions

The observations on the soil in the study area - Alba Iulia Forest District - led to obvious results of quality deterioration on some surfaces at the contact of the forest edge with the agricultural lands or even inside the tree area.

The result of the calculation I_{med} = 3,569288 obtained for the Alba Iulia Forest District involves from environmental specialists, decision-makers at local and regional level: review of management programs on remediation and greening of local areas affected by historical heavy metal pollution; detailed studies on the impact of anthropic (especially industrial) pressure on the soil and the implementation of measures to reduce land use stress. Following the research carried out, as a proposal to fix the soil quality, it is recommended to depollute and restore the affected areas, recover the productive capacity and introduce them into the forest or agricultural circuit.

The tailing depots resulting from the processing of the extractive material lead in time to the creation of a stable micro landscape; however, the behavior of tailing dumps can change over time, so it becomes necessary to monitor them in the long term. The geotechnical monitoring studies must show the condition of the dump geometry, the changes occurred by the horizontal displacement or vertical deformation of the dump and the detection of possible cracks that may cause landslides. In parallel, the measurement and verification of geotechnical parameters, the water pressure in the pores becomes essential for maintaining the stability of the dump. In accordance with the unique rules of protection and technique of labor safety for mining operations and the rules on the design, construction and conservation of tailings dumps it is necessary to establish a rigorous control of them.

The processing of mining deposits results in significant amounts of industrial waste that is often toxic, so their storage requires a well-established management plan. Industrial waste from the ore extraction process is: *processing tailings, rock, and quarry sewage sludge, soil* (which can be fertile or bare). Waste management in the extractive industry is achieved by ensuring the technological flows of landfills, compliance with storage procedures and the environmental impact that these activities generate.

In order for the impact on the environment - and especially on the soil - to be minimal, the management plan must offer the best possible choice of the location of industrial waste and tailing dumps.

Mining waste management is a set of activities aimed at reducing environmental pollution generated by mining activities in impact areas. Adopting *good mining practices* (BAT techniques) means the adoption of environmental management by the authorized economic agent in the exploitation of underground or surface ores, the adoption of the latest technologies, collaboration with research and development institutions, in order to increase performance standards but also environmental protection, given that investments have the least possible impact on the environment, especially the soil (as the first environmental factor affected).

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