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ANTHROPIC IMPACT UPON THE ENVIRONMENTAL QUALITY IN CLUJ-NAPOCA CITY

PhD Thesis
- *Summary* -

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Key words: territorial system, territorial dynamics, anthropogenic impact, assessment, environmental quality, antropization, bioindicators, Cluj-Napoca city.

Introduction

The present study aims to explore and argue, from a multidisciplinary perspective, the complexity and contradictory nature of the recent urban development specific to one of the big, reference cities of Romania: Cluj Napoca. Initially, the approach consisted of a thematic analysis of the environmental factors (investigated in a traditional geographical "key") and then focused on the qualitative aspects that define the city-urban environment connections: environmental impact, environmental impact assessment, environmental quality, its management etc. The scientific argument was based both on previous relevant studies and, equally, on original results obtained through field observations and experiments, laboratory analysis, and, last but not least, through selective filtering and personal interpretation of available or collected data.

In the current scientific world, great significance is given to studies concerning the environmental impact of human society.

The environmental study of Cluj-Napoca urban system knows many different approaches and levels ranging from rigorous research in the field of nature and social sciences, to economic, architectural and engineering research that imply not only a heterogeneous language, but also multiple meanings.

The present study was designed to cover a wide range of research, with continuity and interdependence, going from a preliminary approach to obtaining actual data, with a practical value. Field and laboratory studies were carried out, with emphasis on urban environmental geography and urban system ecology in order to characterize the anthropogenic impact on the quality of the environment.

1. CONCEPTUAL ASPECTS

1.1. Territorial systems - definition and content

The territorial system is defined as the structural and functional assembly that consists of several subsystems related by a variety of connections, among which, the most significant are retroactive ones. The territorial systems' ranking starts at the lower level represented by the smallest complete units that can be delineate in the geographical space and ends at the superior level, which is planet Earth as a whole (Vespremeanu, 1976).

In order to learn more about the territorial reality and to manage it as such, it is necessary to cut it in functional complexes, respectively territorial systems, consisting of elements and connections, which are aimed at achieving common goals.
The territorial system is essential in defining a certain type of territorial development, which wishes to achieve socio-economic and cultural facilities (Ianoş, 2000).

The analysis of the territorial system is made on different levels. First is the maximum level of reference, the most complex, that sums the other two and that is characterized by a high level of heterogeneity. The second level studies the middle spaces, of a medium complexity compared with the superior level and that blend organically in these. At a micro scale level are the national and local territorial systems that, much more simple, blend into and compose the superior ones.

The territorial system results from the interconnections that form between the natural environment and the other environments, respectively the economic, constructed, social and psychological environments, having a shape and a functionality closely dependent to the intensity and the forms that their connections comply.

1.2. Urban territorial systems

The definition given by the American scientist Pred, 1979 (aut. cit. in Ianoş, 2004) seems to be one of the most complete definitions of the '70s, definitions that shows that an urban system is a national or regional assembly of cities which are interdependent, so that any significant change in economic activity, occupational structure, income, or population of one of the cities will directly or indirectly lead to changes in economic activity, occupational structure, income or population of one or more elements of the assembly.

In the early '90s, the urban system was defined as a complex system, with multiple interrelations, that is constantly evolving.

According to Filip, 2009, the urban territorial system consists of the following subsystems: the subsystem of the natural elements, the social subsystem (human community), the subsystem of the built components and the economic subsystem.

All the basic components of an urban system exist, develop and evolve in a different, but it the same global context, of geographical, historical, social, cultural and political-organizational connections characteristic to the territory were that system forms. In that sense, the urban system can become operational and can be easily integrated into pragmatic approach related to the planning and the management of the territory.

1.3. Research methodology and basic concepts

This work was conceived to satisfy, under the methodological aspect, the requirements of applying the "scientific method". Thus, the study considered, first of all, the normative methodological guidelines (principles of research), then it defined the operational methodological categories (methods, procedures, techniques and research facilities) and finally, it clarified the defining concepts used in this paper.

Of methodological **principles** used some are: the principle of spatiality, the principle of causality, the ecological principle (Stugren, 1994, Mac 2000, Muntean, 2003), integration principle, the anthropic principle, the chronological principle etc.

The following **methods and procedures** were important for this study: the analysis method, the synthesis method, the inductive method, the mapping method, the modeling method, the comparative method etc.

The most relevant **concepts** for this study are: the concept of environment, environmental quality, impact, environmental assessment.

2. TERRITORIAL SUPORTS OF CLUJ-NAPOCA URBAN SYSTEM

2.1. Geographical location

Cluj-Napoca is located within Somesul Mic corridor, located at the intersection of tree major geographical units: the Transylvanian Plain, the Somes Plateau and the Apuseni Mountains, at an average altitude of 360 m and intersected by the parallel of 46º46' north latitude and the meridian of 23º36' east longitude.

2.2. Components of the physical environment

2.2.1. Geological characteristics of the substrate

The geological structure of Cluj-Napoca and its suburban area is characterized, as a result of the complex geologic evolution, by a wide variety of lithostratigraphical formations, distributed according to evolution of the active geological factors in different periods of time.

The formations found in Cluj-Napoca date: Paleocene (Upper Eocene, Oligocene), Neocene (Early-Middle Miocene), Pleistocene and Holocene.

2.2.2. The landscape – component and defining factor for the genesis and evolution of the urban system

The study area is focused on Somesul Mic corridor. The southern extremity of the hills of Cluj can bee seen in the northern part of the corridor. These hills are represented by several peaks: Vineyards, Lomb, St. George and Tarsa Mica, having more than 500 m altitude, fragmented by the left tributary of the Somesul Mic river (Popesti, Chinteni, Warm Valley), in the south, the northern slopes of Feleac Hill and between Somes Mic and Nadas corridors, the Căpuş-Someş-Nadăş, that enters as a peninsula in Cluj-Napoca (Pop, 2001, aut. cit in Buzilă şi colab., 2002).

The morphometric description of the landscape was realized by derivation of some terrain parameters of the numerical altitude model (slope, slope exposition, depth and density of fragmentation) and by cartographic analysis of their distribution.

The study analyzed the most representative genetic types of Cluj-Napoca landscape: structural landscape, sculptural landscape, denudational landscape and fluvial landscape.

2.2.3. Climatic particularities of urban environment

Cluj-Napoca has a moderate continental climate, with a wet character (Belozerov, 1972) specific to the hilly regions from the northwest of the country, with local differences resulting from the positioning of the city that lays in the shelter of the Apuseni Mountains, and from particularities of the landscape, which determine substantial changes in the processes that characterize the general circulation of the atmosphere.

Since most of the city is situated in the floodplain area and on the terraces, it is estimated that the city area has a total radiation of 115 kcal/cm^2/year.

Air circulation is under the predominant western influence through which air masses of oceanic origin maintain a closed wheatear in the cold season, with generally mild winters characterized by frequent precipitations that fall as rain, sleet and snow. During summer, the weather is unstable, precipitations fall as rain accompanied by lightning, followed by good weather determined by the warming of the air masses descending on the eastern slope of the Apuseni Mountains.

The mean annual wind speed is 4.3 m/s from north-west and 3.8 m/s from west. Absolute maximum speeds are recorded in June (18 m/s), with higher frequencies at noon and increased with the altitude of the slopes.

In the city area the annual average temperature value is 8.4°C, ranging between 6.9°C and 9.9°C, with a multi-annual amplitude of 3°C (Moldovan and Fodorean, 2002).

Average multi-annual precipitation is around 663 mm. The lowest average values are recorded in February (26.2 mm) and the rainiest month is June (99 mm); the maximum monthly amount recorded was o 223 mm (June 1901).

Annual average cloudiness is 6.2 tenths, with a maximum in December and a minimum in September. Relative humidity is also maximum in December (88%) and minimum in August (65%).

2.2.4. Hidrography of Cluj-Napoca urban area

Surface waters are represented by the Someşul Mic River, which crosses the city from west to east, and its tributaries: Nadăş and Chinteni to the left (originating from the Somes Plateau), Gârbăul, Becaşul, Murătorii and Zăpodie to the right.

Table 2.1 presents the tributaries of Someşul Mic River from Cluj-Napoca area and their characteristics.

Table 2. 1 - The codified tributaries of Someşul Mic River from Cluj-Napoca area[1]

Nr. Crt.	River name	Cadastral code	Length (km)	Medium slope (%)	Sinuosity coefficient	Mean altitude of the river basin	River basin surface (km)
1.	Gârbău	II-1.31.13	7	28	1,04	589	28
2.	Nadăş	II-1.31.14	44	6	1,27	505	372
3.	Popeşti	II-1.31.14.6	12	11	1,02	508	36
4.	Chinteni	II-1.31.15	15	12	1,15	505	45
5.	Becaş	II-1-31.16	9	22	1,10	462	44
6.	Murători	II-1-31.16	8	31	1,09	438	15
7.	Zăpodie	II-1-31.17	11	19	1,25	471	44

In natural conditions, Somesul Mic River carries an annual average flow of 14.3 m^3/s to Cluj-Napoca.

The mentioned tributaries, except for Nadas (multi-annual average flow of 1.95 m^3/s) have low flows (0.100 to 0.250 m^3/s), temporary drainage (they dry up in dry summers and freeze in cold winters) and a torrential character caused by showers, especially in summer, generating rarely over 8000 $l/s/km^2$, frequently 2500-3000 $l/s/km^2$.

[1] After Surd, V. (coord.), Belozerov, V., Puiu, V., Zotic, V., Cepoiu, Loreta, Bărăian, Stanca, Păcurar, B, 2010. *Planul Urbanistic General al Municipiului Cluj-Napoca. Matricea Geografică,* Presa Universitară Clujeană, Cluj-Napoca, 285 p.

There is a small number of urban lakes. In Cluj-Napoca city, such lakes are found in the central park and in Gheorgheni ditrict.

In the surroundings of Cluj, in the sedimentary succession of the subsidence basin, 8 major aquifer complexes, ranged in horizons, sub-horizons and aquifers can be found (Meszaros and Marosi, 1967).

Groundwater has generally high sulphatic mineralization, being inappropriate for drinking. Deep waters, less represented, are mostly found confined in Eocene formations having a high mineralization that makes them undrinkable (Baciu, 2002).

2.2.5. Soils

The soil cover of the studied area has a great diversity conditioned by the variety of rocks that compose the base rock, by the landscape, by the climate or vegetation factor (Piciu et al., 2002, aut. cit. in Poszet, 2011). These soils belong to different classes: “cernisoluri”, “cambisoluri”, “luvisoluri”, “vertisoluri”, “hidrosoluri”, “salsodisoluri”, “protisoluri”, “antrusoluri”.

2.2.6. Vegetation and land use mode

The forests, except for Faget, are fragments confined in the upper third of the slopes being derived from goruneto-as a result of exploitation, and can be assigned as *Quercetum robori-petraeae* and *Carpino-Quercetum petraeae.*

In a series of pastures (at Hoia, Mănăştur and Melcilor Hill) there is a rising of the shrubs species, due to the lack of maintenance of grasslands, which may be considered a first step towards the returning of forests. The dominant shrubs are blackthorn and hawthorn, stationed especially at the edge of crops and roads and sometimes at the edge of forests, where they act as a protective "skirt" (Cristea, 2002).

Coppices occupy narrow and highly fragmented strips along Somesul Mic River and its tributaries, but the composition of the phytocoenoses is extremely heterogeneous.

Several black alders, preserved in the central park and "I. Hațieganu" park are proof of the old water meadows, a century and half ago, when the Somes meadow has undergone urbanization.

The plantations near Cabana Izvor (Sf. Ion), Melcilor Hill and Sub Coastă are dominated, on the southern slope, by black pine and red pine. On the northern slope, at Sf. Ion, the goruneto-cărpinetul resulting from the deforestations conducted about two decades ago was completed with spruce and hackmatack.

Grasslands are used more as pasture, except some areas from meadows and small slopes, where they are still used as meadows.

Northeast of Cluj-Napoca, at Valea Caldă, is one of the most interesting botanical reserves ("Fânațele Cluj") characterized by the diversity and originality of the floristic composition. The reserve covers an area of 7.25

Among the species most commonly found on the main arteries of the city are: the lime, elm, maple, locust, horse chestnut, etc.

The green spaces within the city are very important components due to the complex functions they perform, being an essential frame of the urban system.

In Cluj-Napoca city public green spaces occupy an area of approximately 1480 ha (personal calculations).

2.2.7. Fauna

Due to its geographical conditions, Cluj-Napoca city and its surroundings have a rich and varied fauna.

The aquatic fauna includes species of fish such as: The common nase, the european chub, the barbell, the spirlin, the common minnow, more rarely the trout and frogs – the common pond frog, red mountain frog, etc.

Some of the most common reptiles are: the european green lizard, the slow worm the grass snake, the dice snake, etc.

Of sedentary birds some few are: the chaffinch, blackbird, the owl, the woodpecker, the eurasian collared dove, etc.

Winter migratory are: the the bohemian waxwing, the the mistle thrush the bullfinch, the eurasian siskin, the brambling, etc. Some of the summer migratory birds are: the skylark, the song thrush, the wren, the martin, the common cuckoo, etc.

Mammals are represented by insectivores: mole, hedgehog, greater white-toothed shrew and common shrew, bats; by rodents: fat dormouse, squirrel, european hare, etc.; by carnivores: the wolf, wild cat, badger, and least weasel; in the surrounding forests live the deer and the wild boar, both subjects of hunting.

2.3. Socio-economic component

2.3.1. Population

The city's population numbered, at the last census, in 2002, 317953 inhabitants compared with 328602 inhabitants in 1992, down 3.2%. This population decline is due to the emigration of a significant number of citizens to western countries and also a low birth rate.

In the year 2002, Cluj-Napoca had a population density, in the urban area, of 3407 inhabitants per km^2. Densities of more than 10,000 inhabitants/km^2 are registered in Gheorgheni, Marasti, Center and Mănăştur districts.

The lowest densities, under 3000 inhabitants/km2, characterize the outlying areas (the industrial area, Oaşului-Valea Chinteniului, Someşeni, Cordoş Colonies, Becaş and Borhanci).

2.3.2. Economy

Economic sectors like industry, agriculture, trade followed each other in parallel. In time, Cluj-Napoca has accumulated a significant number of economic units in the field of mechanical engineering, electronics and electrical engineering, textiles, knitwear, leather and footwear, construction materials and food industry. Simultaneously, transport and agriculture developed. Services also took a remarkable extent. Resources of raw materials from neighboring geographic units (coal, wood, salt, gas and rocky materials), represented the support for the development of industry, meanwhile land of various types, was the support for agriculture. In the years between the two world wars (1917-1925) a rapid pace of development was recorded. Most businesses belonged to metallurgical, wood processing and chemical industries. After the World War II, extensive economy prevails. After 1990 economic restructuring takes place, trough the transition from state to private economy.

2.3.3. Communication and transport routes

Cluj-Napoca is accessible from different directions through numerous road, rail and air communication channels. Railways, roads and air routes that cross the city assure the connection with major cities in the country and Europe, both for passengers and cargo.

3. TERRITORIAL DINAMICS OF THE URBAN SYSTEM

This chapter of the thesis addresses the retrospective analysis of the evolution of Cluj-Napoca urban system, analysis that followed the main historical periods: ancient times, Roman Napoca, Napoca from the Aurelian withdrawal to the end of the first millennium, medieval Cluj, Cluj in the modern era, 1918-1945 period, 1946-1976 period.

ArcGIS 9.3.1 program, the cartographic supports together with the map overlay technique were used in order to create a map of the evolution of Cluj urban system for the period 271-1974 (Fig. 3. 1).

Table 3.1. reveals the surface and population dynamics of the city located on the Somesul Mic River.

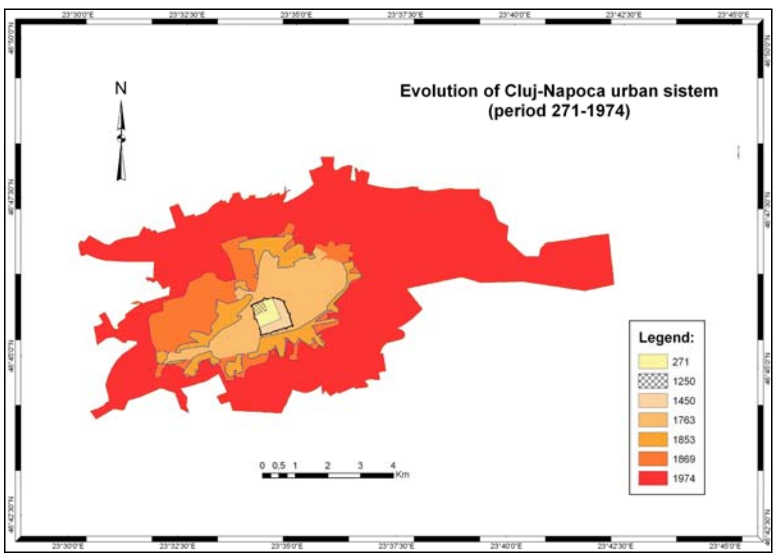

Fig. 3. 1 – Evolution of Cluj-Napoca urban system during 271-1974

Table 3. 1 - Surface and population dynamics of Cluj-Napoca during 271-1974

	Year	Surface (km^2)	Nr. of inhabitants
Cluj-Napoca	271	0,26	-
	1250	0,06	-
	1450	0,53	6000
	1763	4,05	7500
	1853	6,31	19612
	1869	10,01	32831
	1974	35,67	262858

The analysis of the evolution of urban territory in Cluj-Napoca from 1976 to present, was based primarily on studies that used GIS techniques and methods, the following variables being considered: urban area evolution, spatial dynamics of the built area; land use and street network in different periods.

The period from 1976 to present is characterized by very little control on the development of the built area, very interesting being the fact that the urban area extended approximately 5371ha after 1998, compared to the period 1976-1998 when the urban area had 3961 ha (after personal calculations).

In line with the upward trend of real estate development is also the evolution of the built area of Cluj, its territory tending to increase steadily from 2872 ha in 1980 to 3528 ha in 2003 and 3728 ha in 2010.

Digitizing three series of cartographic supports representing three distinct moments in time (1980, 2003, 2010), with the help of ArcGIS 9.3.1 software, lead to the realization of a map representing the spatial dynamic of the built area (Fig. 3. 2).

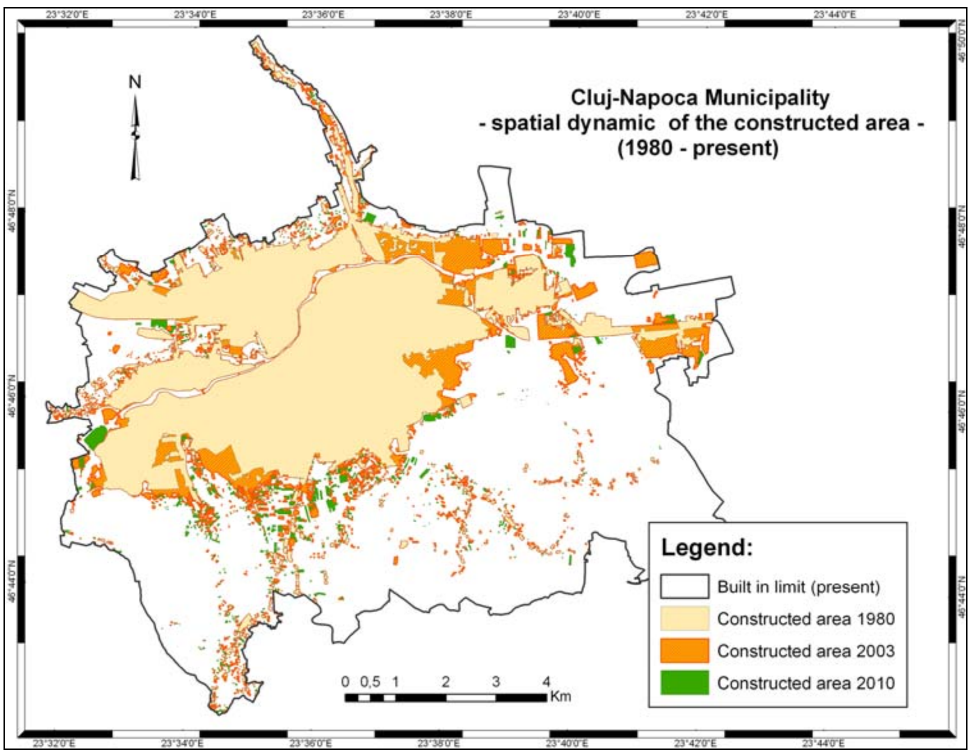

Fig. 3. 2 - Map representing the spatial dynamic of the built area (1980-prezent)

Analysis the maps representing the land use (years 2000 and 2006) showed that the urban structure increased in 2006 compared to 2000 with 274.8 ha, and area from: agricultural, orchard, pasture, forest and reed categories were transformed and included in the category - urban structure.

In terms of the street network, in order to highlight the spatial territorial evolution of the city, the "street nomenclature" was analyzed observing that the street network of Cluj-Napoca "enriched" with 348 blocks within 10 years. Most of them are found in the new neighborhoods in the southern part of the city (Bună Ziua, Zorilor Sud, Becaş, Borhanci, Mănăştur Sud area).

4. ANTHROPIC IMPACT ON THE QUALITY OF THE (URBAN) ENVIRONMENT

4.1. Environmental impact - definition and content

The concept of impact refers to all human actions (existing, potential) acting on the environment, health and human welfare in a territory (Mac 2003, Muntean, 2004).

The concept of impact is closely related to concepts of quality and state of the environment, being in a dialectical connection with them (Vespremeanu, 1980).

Depending on the geographical scale of manifestation strategic and local impacts can be distinguished. Considering the intensity, impacts can be classified as high intensity impacts, impacts of medium intensity and low intensity impacts. Depending on the effects of impacts, negative and positive impacts can be mentioned.

Another classification takes into account four categories of impacts: direct, indirect, visual and cumulative (Barrow, 1997; Muntean, 2005).

The literature outlines several types of environmental impacts.

Glasson, Therivel, Chadwick (1994) identify the following types of impacts: physical and socio-economic impacts; direct and indirect impacts; short and long term impacts, local and strategic impacts (including the regional, national levels); adverse and benefic impacts, reversible and irreversible impacts, quantitative and qualitative impacts; group and/or area distributed impacts, actual and perceived impacts, impacts associated with other types of development projects.

4.2. Assessment of anthropogenic impact on the environment

This is a theoretical chapter that addresses conceptual aspects regarding anthropogenic impact assessment, the process of environmental impact assessment, the procedure and methodology of environmental impact assessment.

4.3. Assessment of the anthropogenic impact on the environment in Cluj-Napoca city

Recent anthropogenic pressure as the generator of environmental impact

In order to assess the antropization of the territory in Cluj-Napoca, a synthetic indicator of antropization (Ia) was established. This indicator was calculated at district level and consists of the weighted average of five territorial variables (population density - V_1, built area - V_2, length of street network - V_3, green area surface/capita - V_4 and industrial area surface - V_5) and has the following formula:

$$\mathbf{Ia=(3V_1+3V_2+3V_3+2V_4+1V_5)/12}$$

Each variable is assigned a fixed value (score) based on evaluation criteria. The evaluation criteria were as follows:

• **population density** was noted as follows: density under 3500 inhab/km^2 – 1; density between 3500 and 7000 inhab/km^2 – 2; density between 7001 and 10,500 inhab/km^2 – 3; density between 10,501 and 14,000 inhab/km^2 - 4 and density over density 14 000 inhab/km^2 - 5.

• **built area** was noted as follows: built area under 0.1000 km^2 – 1; from 0.1001 to 0.1500 km^2 – 2; from 0.1501 to 0.2000 km^2 - 3, from 0.2001 to 0.2500 km^2 – 4 and built area over 0.2500 km^2 - 5.

• **length of street network** was assessed by providing notes as follows: under 12.50 km – 1; from 12.51 to 15.00 km – 2; from 15.01 to 17.50 km – 3; from 17,51 to 20.00 km - 4 and length of street network over 20.00 km - 5.

• **green area surface** was noted as follows: over 80 m^2/capita – 1; between 60.1 and 80 m^2/capita – 2; between 40.1 and 60 m^2/capita – 3; between 20.1 and 40 m^2/capita - 4 and under 20 m^2/capita - 5.

• **industrial area surface** was noted as follows: below 0.0500 km^2 – 1; between 0.0501 and 0.1000 km^2 - 2; between 0.1001 and 0.1500 km^2 - 3; between 0.1501 and 0.2000 km^2 - 4 and above 0.2000 km^2 – 5.

Local variable weights were set according to the importance of the variable in the formula of the antropization indicator, as follows: variable 1 - weight 3; variable 2 - weight 3; variable 3 - weight 3; variable 4 - weight 2; variable 5 – weight 1.

After the calculation of the antropization indicators, using GIS techniques and methods, the antropization map for Cluj-Napoca was realized (Figure 4. 1.)

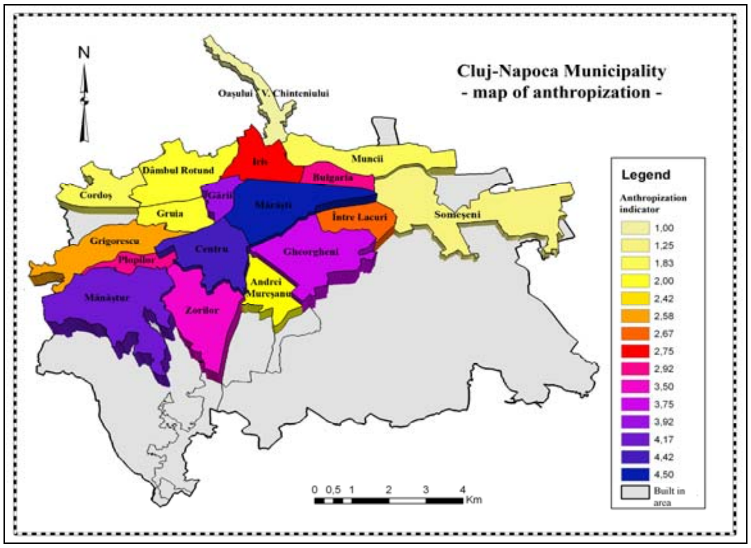

Fig. 4. 1 – Distribution of the antropization indicator's value

In accordance with the evaluation and representation of the antropizării, the most anthropogenic neighborhoods are Marasti, Center and Mănăştur, while the least anthropogenic neighborhoods are: Oasului-Valea Chinteniului, Someşeni, Cordoş, Dâmbul Rotund, Gruia şi Andrei Mureşanu.

Impact assessment using control lists

In order to illustrate the use of this method, Adkins-Burke checklist was applied for the following projects, which may have environmental importance in Cluj-Napoca:

a) "3500m take off-landing runway" project of Cluj-Napoca International Airport (potential project);

b) the "Modernization of the tramway line in the city of Cluj-Napoca project (existing project, in progress).

The methodology for assessing the impact generated by the two projects is based on the evaluation scale ranged from the value -5 (major negative environmental impact) to the value +5 (major positive environmental impact).

Three development alternatives were chosen for the two projects, taking into account the fact that one of them (3500m take off-landing runway) is a potential project and the other (Modernization of the tramway line) is a project in progress now.

The following development alternatives (phases) of the project were considered: Phase A –alternative 0 situation (no project), Phase B - construction phase and Phase C - operational stage (management stage).

Summing of the awarded points leads to a total impact score.

As a result of the assessment, a number of issues can be highlighted:

In the case of “3500m take off-landing runway” project, the alternative 0 (no project) seems to be the most viable compared to the construction phase (having impacts noted with -13) and the operational stage (having impacts noted with -9). For the construction and operational phases, several situations may arise that could improve in a positive way, the assessment scores.

For "Modernization of the tramway line" project there is a different situation. In this case, the operational phase is the most viable in a territorial and environmental context, compared to the alternative 0 and the construction alternative.

Matrix assessment of the anthropogenic impact on the environment

The assessment of the anthropogenic impact on the environment was conducted using a rapid assessment matrix developed by Pastakia and Jensen in 1998.

The study regarding the matrix assessment of the anthropogenic impact on the environment was based on the rapid assessment matrix applied by Muntean et al., 2006, ulterior modified.

As a result of the matrix assessment of the anthropogenic impact on the environment, the total evaluation score placed Cluj-Napoca in the category “changes/negative impacts”.

4.4. Assessment of the environmental quality in the city of Cluj-Napoca

The concept of environmental quality

Porteous (1971) defines the environmental quality as a "complex issue" that involves subjective perceptions, perspectives and meanings that vary within groups or at individual level.

Rapoport (1990) believes that the closest meaning to the concept of environmental quality is related to material aspects of the physical environment such as: air pollution, water pollution, industrial pollution, the consequences of overcrowding, etc. having certain effects on people.

Environmental quality is a set of properties and characteristics of the environment, either generalized or local, having effects on humans and other organisms.

Is a measure of the environmental conditions correlated to the requirements of one or more species or to human needs and intentions (Johnson et al., 1997).

Assessment of the air quality in Cluj-Napoca, using native lichens as bioindicators of heavy metal content

Location of the sampling points

The sampling points were chosen to be located both downtown, in high traffic areas like Union Square, in different districts such as Parcul Feroviarilor, Piața 14 Iulie and at the outskirts of the city, as for example as Hoia Forest (Table 4. 1).

It was also taken into account that these points should be placed on both the circulation axes of car traffic (Union Square, Square July 14, Calea Turzii) and in areas with many green surfaces (Central Park, Parcul Feroviarilor, Botanical Garden).

The aim was for the sampling points to differ in terms of the intensity of anthropogenic presence and proximate traffic.

Table 4. 1 – Traffic intensity in the area of the sampling points[2]

No.	Sampling point	Traffic intesity
1	P-ța. Unirii	Intens traffic
2	Calea Turzii	Intens traffic
3	Str. Clinicilor	Intens traffic
4	Str. Gr. Alexandrescu	Average traffic
5	P-ța. 14 Iulie	Intens traffic
6	Parcul Mărăşti	Intens traffic
7	Parcul Feroviarilor	Average traffic
8	Pădurea Hoia	Low traffic
9	Parcul Central	Average traffic
10	Grădina Botanică	Low traffic

Sampling of the native lichens was made in the period 17 to 24 May 2009. These lichens belong to two genders commonly found in urban areas, Xanthoria (*Xanthoria parietina*) and Physcia.

Sample analysis

Heavy metal content of the samples collected was found using a hybrid analytical technique: ICP-MS (Inductively-Coupled Plasma - Mass spectrometry).

Results of the analysis of the native lichens samples

The highest concentrations of copper and zinc were found at sampling points: Marasti Expo Transilvania, Calea Turzii, Parcul Feroviarilor, P-ța Unirii. Generally, in these areas, heavy car traffic (trucks, buses) is recorded. Another source of zinc might be the white zinc oxide from paints.

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[2] After Mag V.I., 2003, *Analiza poluării cu metale grele a municipiului Cluj-Napoca, folosind ca biomonitori lichenii*, Lucrare de licența, Facultatea de Biologie şi Geologie, UBB, Cluj-Napoca, 76 p.

Lower values were found in the samples from: Botanical Garden, P. Hoia, Parcul Central. Str. Gr. Alexandrescu, located away from pollutant factors. Although located in the middle of the city, these areas are well protected by tall trees and by the long distance to high traffic areas.

For most sampling points, the lead value was 0, the only higher value being found in the sampling point from Mărăşti-Expo Transylvania. The low values of lead could be due to the introduction of unleaded fuel.

It was shown that there is a difference between the concentrations of the metal studied for the two genders (Xanthoria and Physcia). We can thus conclude that the two genders have physiological mechanisms that favor the predominant absorption and fixing of only certain metals.

4.4.4. Assessment of the air quality in Cluj-Napoca, using transplanted lichens as bioindicators of heavy metal content

Location of the sampling points and the study period for the analysis of heavy metal accumulation in transplanted lichens

For the transplantation, *Pseudevernia furfuracea* lichens were harvested in mid-November, 2010, from Muntele Băişorii area.

Also in mid-November the samples were placed in the transplant sampling points in Cluj-Napoca, given in Table 4. 2.

Table 4. 2 – Lichen transplant stationeries (in Cluj-Napoca)

No.	sampling point	**Traffic intesity**
1	Pădurea Hoia	Low traffic
2	Piața Gării	Intens traffic
3	Str. Clinicilor	Intens traffic
4	Observator sens giratoriu	Intens traffic
5	Parcul Feroviarilor	Average traffic
6	Strada Plevnei	Intens traffic
7	Podul Calvaria	Average traffic
8	Environmental Science Faculty	Average traffic
9	Expo Transilvania	Intens traffic
10	Parcul Central	Average traffic
11	Iulius Mall	Intens traffic
12	Piața 14 Iulie	Intens traffic
13	B-dul Muncii	Intens traffic
14	Grădina Botanica	Low traffic
15	Piața Unirii	Intens traffic
16	Strada Republicii	Average traffic
17	Str. Grigore Alexandrescu	Low traffic
18	Cordos	Average traffic

For each sampling point, the *Pseudevernia furfuracea* specimens were tied in bundles of about 10 cm in diameter, bundles that were then fixed on the branches of trees.

The control sample was taken at the end of transplant period from the unpolluted area (Muntele Baisorii).

These transplanted samples were held in Cluj-Napoca for about five and a half months (15/11/2010 - 04/05/2011), and then collected for analysis.

Sample analysis

Analysis of the heavy metal content (Pb, Cd, Zn) in the transplanted lichen samples was done by flame atomic absorption spectrometry technique (FAAS).

Results of the analysis of the transplanted lichen samples

For the transplanted lichens, all the studied elements were found in higher concentrations after 5 months of exposure than for the control sample.

Lead concentrations in the exposed lichens ranged between 14 and 35 mg/kg in different sampling points, as opposed to a concentration of about 12 mg/kg measured in the control sample. Therefore, lead concentration increased approximately 2.9 times in the most polluted area. The highest concentrations of lead, according to the analysis of the transplanted samples, can be found at Expo Translivania (Marasti) and Plevna Street, and, relatively high values are found in Hoia Forest (Tăietura Turcului), Observatorului Street, Gării Square. The lowest values were those of samples from Cordoş area and Central Park.

Cu concentrations in the transplanted lichens ranged from 3.63 to 28.75 mg/kg, while the control sample had a concentration of 3.62 mg Cu/kg. Thus, the copper concentration increased approximately 8 times in the most polluted area.

Zn concentration values were between 84 and 247 mg/kg, while the control sample measured a concentration of 69 mg/kg. However this value was higher than the other heavy metals, Cu and Pb, found in the control samples. One explanation could be that, according to some authors (Hale aut cit in Bartok et al., 1992), lichens naturally have a Zn content of 30-80 ppm in unpolluted areas. Zinc concentration increased approximately 3.6 times in the most polluted area.

Distribution maps for heavy metal pollution in transplanted lichens for Cluj-Napoca were created by Inverse Distance Weighted interpolation (IDW), using the ArcGIS 9.3.1 software.

Based on the metal content in transplanted lichens, a ranking of the studies sampling points from Cluj-Napoca, based on degree of pollution was made. For each metal, weak and heavily polluted areas can be distinguished. Thus, considering the contamination with heavy metals, in Cluj-Napoca, five areas with different levels of pollution have defined:

- **Excessive pollution** – over 202 mg/kg of element, in the areas with higher traffic (Plevna Street, Expo Transilvania, Gării Square, Iulius Mall sampling points)
- **Highly polluted** - 180-202 mg/kg (Observator Street, Hoia Forest, Clinicilor street, Muncii Avenue sampling points)
- **Medium pollution** - 163-180 mg/kg (Feroviarilor Park, July 14 Square, Calvaria Bridge, Botanical Garden sampling points)
- **Less polluted** - 145-163 mg/kg (Environmental Science Faculty, Union Square, Central Park sampling points)

• **Very weakly polluted** - below 145 mg/kg (Republicii Street, Cordoş, Grigore Alexandrescu Street sampling points).

The obtained data showed that the city of Cluj-Napoca is a medium polluted urban center.

Comparative Study

Already before it started, this study was designed so that the obtained results could be compared with the results of a previous study realized by Bartók et al., 2003.

When comparing those results with the current ones, it can be clearly seen that the concentration values of heavy metals in the studied lichens have significantly decreased from 2001 to present.

Lead concentration in 2011 has decreased almost to half of the value measured in 2001. The reason for the strong decrease of the atmospheric concentration of this element in the last decade might be related to the ban of leaded fuels since 2001.

Zn concentrations in the atmosphere show a less significant decrease, being close to the values recorded in 2001.

The strongest decrease is seen in copper concentrations which are almost an order of magnitude lower.

Prohibition of leaded fuels and measures for air pollution reduction could be the causes for the decrease of the concentrations of these elements in the atmosphere.

4.4.5. Assessment of the aquatic environment quality in Cluj-Napoca and the suburban areas using invertebrate organisms as bioindicators of water quality

The study regarding the assessment of the quality of the aquatic environment, on Somesul Mic River, involved using invertebrates as bioindicators of water quality (Stoian et al., 2009).

Location of the sampling points and the study period for the aquatic ecosystem analyzed

Within this stage of the research the particularities of the Somes River have been considered, adapting the sampling techniques and equipment to the morphology of the watercourse and to the composition of the habitats. The samples were drawn from 5 sampling points.

I - Someşul Rece (for crenon);
II - Gilau - Luna de Sus (for ritron);
III - Grigorescu - Sala Sporturilor (for ritron);
IV - Marasti - Industrial Area (for potamon);
V - Someşeni - Sânnicoară (for potamon).

Within sampling point II (Lake Gilau), the sampling was made in three points:

- IIa – at the entrance to the lake
- IIb – at the middle of the lake
- IIC – at the dam

The sampling was made during March and June 2009, twice a month.

Sample analysis

After the sampling of the water and biological material the samples were transported to the laboratory and analyzed.

The study of the following parameters was considered necessary: pH, salinity, temperature, total dissolved solids (TDS), oxidation-reductive potential (ORP), electrical conductivity (EC).

These analyses were performed using the equipment called WTW Inolab.

Analysis of physico-chemical parameters (pH, salinity, electrical conductivity (EC), total dissolved solids (TDS), oxidation-reductive potential (ORP), temperature) of the samples collected from Somesul Mic River and lake Gilau showed no significant exceeding of the water quality indices.

There was however, a slight exceeding of these values, for samples from the last sampling point. It was also found that this increase in values of the studied parameters, especially for electrical conductivity and TDS, goes along the river, from upstream of Cluj-Napoca toward downstream of the city.

The value of electrical conductivity varied little during the sampling period but was always higher in the last sampling point, downstream of Cluj-Napoca. This suggests that there may be a link between the increased pollution and increased electrical conductivity.

The processing of the biological material revealed the presence of 34 systematic categories, typical to the aquatic ecosystem, part of the following phyla: PROTOZOA, PLATYHELMINTHA-TURBELARIATA, ROTIFERA, NEMATODA, NEMATOMORPHA, ANNELIDA, MOLLUSCA, CRUSTACEA, UNIRAMIA-INSECTA.

Each of these systematic categories is characteristic for a specific area and a specific water quality.

Comparing the samples drawn from the 5 sampling points, representing the three sections (the upper, middle and lower section) it was found that there was a gradual rise in the levels of pollution of the water of Somes River within Cluj-Napoca, reaching a maximum after it passes the city. This demonstrates the contribution of the city to the pollution of the waters of Somes River, pollution that has increased in time.

Quantitative aspects regarding the systematic categories of aquatic invertebrates

Quantitatively, the dominant systematic category varies from one sampling point to another.

Uniramia-Insecta dominated in point I, Annelida in point II, Crustacea in point III, Protozoa in point IV and Annelida in point V.

Realizing a comparative analysis of Annelids, specific for dirty, mezo-polysaprobe water and Crustaceans, specific for clean, oligo-saprobe and β mezo - saprobe water, an increase of the number of Annelids towards the last sampling points and their clear dominance in the last sampling point was observed. At the same time there was a decrease in the number of Crustaceans from the first towards the last sampling point, and their total disappearance in the last two sampling points.

The saprobe system and the water quality of Somesul Mic River

After calculating the saprobity indices (C (p), I (p), IS1 (wave), IS2 (wave), DS (p), and (p)) for Somes river, these indices' values were sorted in the various saprobe classes.

Most indices placed the water quality of Somes River in 2009, in the last saprobe categories, between β-α mezo-saprobe and poly-saprobe.

Still, there was a significant change in water quality over the sample points. There was a change of the saprobity level from Oligo-βmezosaprobe and β-mezosaprobe in the first sampling points (upstream of Cluj-Napoca) to poly-saprobe in the last (downstream of Cluj-Napoca).

4.4.6. Environmental quality of Cluj-Napoca - comparative approach

The discussion on the comparative approach of the environmental quality of Cluj-Napoca was started by the following question: Can Cluj be considered an evolutionary model of recent trends and the state of the environment compared to nation wide urban systems and other urban systems in Europe?

To answer this question, a number of reports and studies of the European Environment Agency and the European Commission have been consulted.

After analyzing the reports and studies of the European Union and the European Commission it can be concluded that, at a national and even a european level for some cities, Cluj-Napoca can be considered an evolutionary model of recent trends and the state of the environment. The qualitative parameters of the state of the environment can be improved by implementing environmental management programs and operational control measures through communication and information at all levels.

5. STRATEGIES AND MITIGATION MEASURES OF ANTHROPOGENIC IMPACT ON THE URBAN SYSTEM

5.1. Planning strategies for the Cluj-Napoca urban system

Planning strategies proposed by Muntean (2005), can be applied to Cluj-Napoca also. Depending on the environmental particularities the following planning strategies may apply:

Sustainable development strategy
Territorial reconversion strategy
Rehabilitation strategy of landscape and environmental components
Land use and resource strategy
Public participation strategy
Priority area delimitation strategy

5.2. Measures to reduce the anthropogenic impact on the environment

Mitigate measures of environmental impacts are divided into general and specific measures.

General measures may be as follows (Muntean, 2005):

- application of sustainable development strategies in the field,
- support of local territorial planning,
- harmonious integration of environmental and socio-economic components locally,
- promotion of alternative and mitigation solutions of environmental disturbances existing in the territory,
- implementing local action plans for environmental management and integrated management of local resources,
- implementing local environmental policies and territorial reconversion of areas subject to impact.

Regional and programmatic measures regarding the improvement of environmental components should be included in an action plan coordinated by the environmental protection agency.

Air pollution mitigation measures can be:

• industrial agencies compliance with current environmental standards
• reducing emission to current legal standards
• reducing traffic emissions
• Promoting non and low-polluting technologies

Measures to reduce pollution of surface and underground waters are:

• monitoring water quality by increased testing and by establishing protective measures and operating conditions in the study and design phase,
• banning sewage water disposal directly into waterways
• upgrading existing wastewater treatment plants,
• listing pollution sources of watercourses administrated by local councils and and establishing a program to neutralize them,
• decommissioning of landfills that affect surface and underground water quality.

Soil pollution mitigation measures lie in implementing hydro-ameliorative works such as: stabilizing slopes, valley consolidation and dam building, agro-terracing, etc., plus preventing land erosion with tilling, planting, and application of crops in strips, etc.

Noise mitigation measures involve the treatment of three aspects:

• A social aspect, which involves the adoption of effective measures to eliminate the effect of social noise;

• A technical aspect, which involves the development of machines and installations whose noise levels do not exceed the allowed limits;

• A healthcare aspect, which involves measures to protect the individual against the harmful effects of noise for an appropriate physical and psychological comfort.

Noise pollution can be diminished by reducing the specific type of noise generating activity:

- limiting vehicle speeds (may be reduced by about 4-5 dB);
- prohibiting traffic on certain routes or at certain times, especially large vehicles;
- bans at certain hours, particularly planes flying during the night;
- insulating buildings near rail traffic.

Conclusions

Elaborating a study focused on the anthropogenic impact on the environment was a challenge on a structural and methodological level. The study area is a space with a very authentic human fingerprint, aspect that has added a plus of complexity to the subject.

The study revealed the main factors through which the urban pressure and the expansion of the built areas showed their presence and analyzed the manifestation trends related to the quality of different element of the urban environment.

In terms of territorial dynamics of the urban system, the period between 1976 and present, is characterized by little controlled development of the built area.

The study aimed to assess an anthropization indicator of Cluj Napoca districts and highlighted the fact that most anthropogenic districts are Marasti, Center, Gară and Mănăştur, while the lowest anthropization is found in Oasului-Valea Chinteniului, Someşeni and Gruia districts.

Following the assessment of the anthropogenic impact on the environment, a number of issues can be highlighted:

- the application of the Adkins-Burke checklist allows the assessment of the implementation alternatives of some projects, based on preliminary studies, which determine the state and condition of the environment in a site or area.
- in the case of the “3500m take off-landing runway” project, the alternative 0 (no project) seems to be the most viable compared to the construction phase and the operational stage. For the construction and operational phases, several situations may arise that could improve in a positive way, the assessment scores.
- in the case of "Modernization of the tramway line" project there is a different situation. In this case, the operational phase is the most viable in a territorial and environmental context, compared to the alternative 0 and the construction alternative.
- the matrix developed by Pastakia and Jensen is a instrument for territorial analysis and assessment that allows a coherent presentation of the assessment of anthropogenic impact on environmental components.
- the total evaluation score obtained by applying the rapid assessment matrix placed Cluj-Napoca in the category “changes/negative impacts”.

The study also aimed at assessing the quality of the atmosphere using lichens as bioindicators of heavy metal content in order to realize a comparison with data from 2000.

Comparing the results obtained from transplanted lichens in 2001, with the current ones, it can be clearly seen that the concentration values of heavy metals in the studied lichens have significantly decreased from 2001 to present.

Analysis of the state of health and quality of natural biotic aquatic (lotic and lentic) environments, from Cluj-Napoca, led to the following conclusion: ccomparing the samples drawn from the 5 sampling points, representing the three sections (the upper, middle and lower section) it was found that there was a gradual rise in the levels of pollution of the water of Somes River within Cluj-Napoca, reaching a maximum after it passes the city.

In the context of sustainable development, Cluj Napoca needs actions big enough to meet the local necessities in a responsible manner and with a solid financial base that would provide long term stability. It is therefore important to have the opportunity to use the european structural funds for important programs of integrated urban development and to apply policies, planning strategies and appropriate measures to reduce the anthropogenic impact.

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