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THE IMPORTANCE OF GREEN SPACES AND SOIL QUALITY IN THE URBAN ECOSYSTEM – A PRELIMINARY CASE STUDY: CLUJ-NAPOCA MUNICIPALITY

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ABSTRACT. The rapid expansion of urban spaces in Romania's major cities has led to various problems such as land-use changes, new patterns of regional attractiveness, landscape fragmentation, environmental impacts, and the depletion of natural resources like natural land and local native soils. This has resulted in an important change in the dynamics, quality, and quantity of urban green spaces, ecosystems, and local native soils. The importance of green spaces and soil quality in the urban ecosystem is significant for various environmental, social, and economic reasons. To determine whether the urban ecosystem is green and friendly, we conducted a preliminary study to quantify the extent and quality of green spaces in Cluj-Napoca. We also compared this data with various European data. Additionally, we preliminary analysed the soil quality in Cluj-Napoca's two major urban parks to determine whether urbanization has a positive or negative impact on soil quality.

Key words: *Urban parks, soil quality, space consumption, Cluj-Napoca city.*

INTRODUCTION

Urbanization is the process of rapid population growth and infrastructure development in urban areas. This process presents a dual challenge: the need for urban expansion and the preservation of environmental quality. In large and emergent Romanian cities, it is of utmost importance to maintain green spaces and soil quality. These elements play a pivotal role in balancing urban development with environmental sustainability.

Green spaces, encompassing parks, gardens, and urban forests, serve as crucial components of the urban ecosystem. Beyond their aesthetic appeal, they contribute to the physical and mental well-being of urban dwellers, providing havens for recreation, relaxation, and community engagement. Furthermore, green spaces and native soil act as vital carbon sinks, mitigating the impacts of climate change by sequestering carbon dioxide and promoting biodiversity within urban landscapes.

Within the urban ecosystem, the native soil serves as the foundational substrate and its quality is a key determinant of the health and resilience of green spaces. The impacts of urbanization, including pollution, compaction, and altered nutrient cycles, pose challenges to soil health. Understanding and managing soil quality in urban areas are essential for fostering sustainable development, ensuring the longevity of green spaces, and safeguarding the overall urban ecosystem.

This preliminary case study focuses on the Cluj-Napoca Municipality, a major urban centre in Romania. As fast urbanization continues to shape the city's landscape, it becomes imperative to assess the state of green spaces and soil quality within its boundaries. Through this preliminary case study, we aim to explore the interplay between urban development and environmental quality, shedding light on the importance of preserving green spaces and maintaining soil quality as integral components of a resilient and sustainable urban ecosystem.

Population growth and urban space consumption

The reality of our days reveals a continuous expansion of cities, especially of metropolitan areas, towards regions that were not urbanized until recently. More confusion arises from the fact that until 30 years ago these bordering spaces were unbuildable or non-urbanizable – such as river meadows, steep or slanting slopes, orchards, areas with associated forest vegetation, areas isolated from the *build-up areas ABC* - networks of water-sewage, electricity, and gas (Baciu et al, 2021).

An architectural and administrative uncertainty between urban and rural areas was gradually created, with the emergence of the metropolitan system. Local decision-makers and planning committees are tasked with the challenge of stopping uncontrolled urban development. Despite efforts to mitigate environmental harm (the consumption of agricultural land, soil and green spaces), the influence of real estate interests remains overpowering.

By introducing various agricultural lands into the inner city, which were previously owned by the people, it was anticipated that the economic output of the land would increase by 100 times. This phenomenon has made a lot of people rich over the last 20 years without creating any added value (Bienala Națională de Arhitectură, 2023; figure 1).

The expansion of the inner city can result in the poor functioning of the entire administration system of Cluj-Napoca Municipality (as shown in figure 1). In addition, it can cause blockages, and congestion, and put stress on the environment and human health. This phenomenon is known as urban stress which is subtle yet damaging.

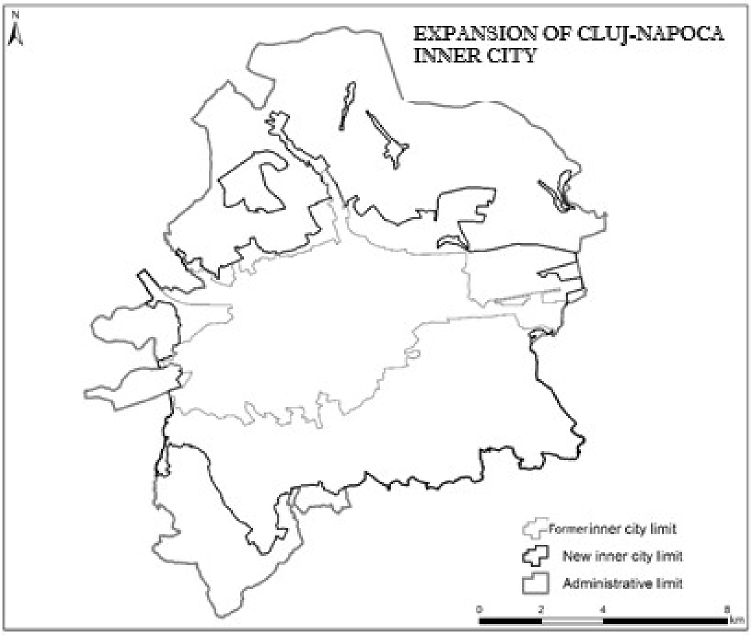

Fig. 1. *Expansion of Cluj-Napoca inner city between 2000 and 2023*

The presence of this reality can be observed in major cities and metropolitan regions, which experience both temporary and permanent population and labour force dynamics. The current evolution of the big cities, presenting a permanent attraction and thus, an overpopulation process, ultimately justifies the expansion of the inner city and the consumption of the natural space (Raffestin, 2012). According to all urban planning theories, we need a functional city with shorter distances and efficient land use, rather than a sprawling city that consumes space and creates suburbs (Gehl, 2012).

The explosive growth of the population in the first metropolitan ring is the most significant feature of the definitive change in agricultural clusters (Baciu et al, 2018, 2021). The population of the area has increased due to immigration from various parts of the country, making it a diverse and heterogeneous community. Florești is a good example of this, with its population growing from 7,470 inhabitants in 2002 to 46,535 inhabitants, a staggering increase of over 523% (as shown in table 1 and figure 2). The commune is currently the most densely populated rural settlement in Romania, and it is extensively studied from a socio-economic perspective.

Table 1. *The evolution of population between 2002 and 2022 within the communes in the vicinity of Cluj-Napoca*

Nr. Crt.	Communes	Inh. 2002	Inh. 2011	Inh. 2022
1	**Apahida**	8785	10685	15391
2	**Baciu**	8139	10317	12983
3	**Chinteni**	2786	3065	3717
4	**Feleacu**	3810	3923	4409
5	**Floresti**	7470	22813	46535
6	**Gilău**	7861	8300	9112

The period from 2002 to 2020 was characterized by a significant change in land usage in the first ring of the Cluj-Napoca metropolitan area. This change was conduct to an increase in non-agricultural land surface in most of these administrative units. The rise in non-agricultural land surface

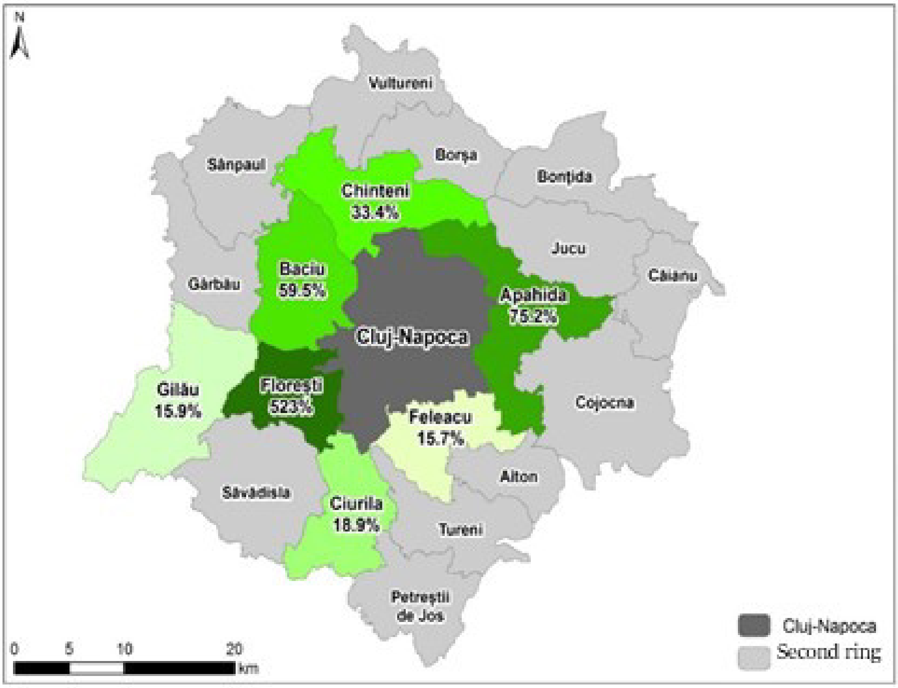

Fig. 2. *Population evolution (per percent) in the first ring of metropolitan area Cluj from 2002 to 2022 (adapted from Baciu et al., 2021)*

was a consequence of the pressure from real estate investors on local decision-makers to release land in built-up areas. The most affected communes were Florești, which experienced a 70% increase in urbanization, Chinteni, which saw a boom in residential real estate investment starting in 2011-2012, and Feleacu, which recorded a 20% increase due to new infrastructure projects and the real estate trend near the commune center. The local policymakers have a friendly approach towards real estate investors. The new General Urban Plan of Chinteni commune, which is yet to be approved, proposes a generous surface area of 3685 Ha for the built-up area. If approved, this would be the most significant urban growth in the metropolitan communes since 1990. Between 2002 and 2020, the non-agricultural land growth was 16.7% (Baciu et al., 2021; table 2, and figure 3).

Table 2. *The evolution of agricultural and non-agricultural land between 2002 and 2022*

Nr. Crt.	Communes	S. total (Ha)	Agric. 2002 (Ha)	Agric. 2022 (Ha)	Non Agric. 2002 (Ha)	Non Agric. 2022 (Ha)	Difference 2002-2020 Non-agriculture (Ha)	Difference 2002-2022 Non-agriculture (%)
1	**Apahida**	**10602**	9102	**9396**	1250	**1206**	**-44**	**-3.5**
2	**Baciu**	**8751**	5890	**5559**	2724	**2827**	**103**	**3.8**
3	**Chinteni**	**9651**	7455	**7242**	2064	**2409**	**345**	**16.7**
4	**Feleacu**	**6196**	4094	**3724**	2059	**2472**	**413**	**20.1**
5	**Florești**	**6074**	4397	**4129**	1141	**1945**	**804**	**70.5**
6	**Gilău**	**11682**	3898	**3740**	7756	**7840**	**84**	**1.1**

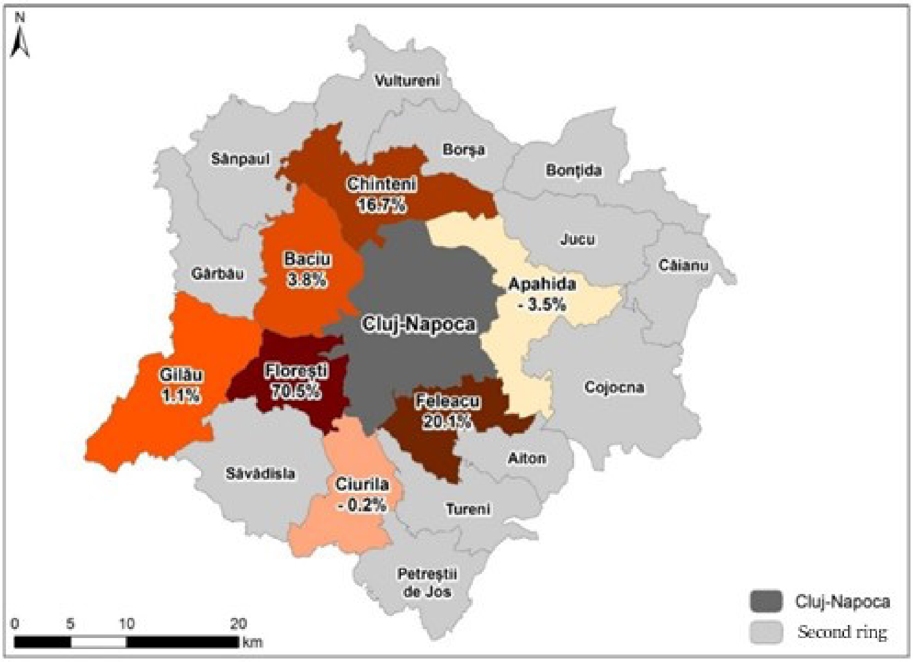

Fig. 3. *The evolution of non-agricultural land (per percent) in the first ring of the Cluj metropolitan area from 2002 to 2022 (adapted from Baciu et al., 2021)*

The importance, distribution and quality of urban parks

Urban parks and ecosystems play a crucial role in mitigating climate change and reducing the heat island effect. The haphazard construction of cities, along with industrial gas and car emissions, is causing urban heat islands and often, fog within the urban spaces. Studies conducted in urban areas have revealed that green spaces play an important role in their capacity to sequester carbon dioxide. In fact, in cities like Mexico City, green areas can sequester up to 1.4% of carbon dioxide emissions, while in Vancouver, this figure goes up to 1.7%. This is more than what human activities produce (Tan Yok et al., 2020). One positive aspect of urban air is its ability to ventilate, reducing the urban heat island effect. While it is widely accepted that improving green spaces leads to ecological and social benefits, their fragmentation or disappearance remains an ongoing concern (Florență, 2022). Cities benefit from a variety of green spaces, including natural spaces like cemeteries, grassy roundabouts, and even parking lots. These spaces can easily contribute to improving statistical data in many studies.

Urban development in the Cluj-Napoca Municipality has brought about significant transformations in both native urban soil and green spaces, marking a complex interplay between human infrastructure and the natural environment. Urban parks are the largest green spaces that can be associated with nature. According to Iliescu's theory (2003), a park must occupy an area of more than 20 hectares to be considered an urban park. Also, the weight of the component elements must be distributed as follows: - planted and grassed areas 66-77%; alleys 10-12%; parts of water 5-10%; sports fields 5-8%; constructions 3-4% (Florincescu, 1999; Iliescu, 2003). In reality, urban planning and landscape aesthetics greatly combine these percentages. For example, the Central Park of the Cluj-Napoca municipality totals 13.6 Ha (*Parcul Central Cluj - Obiective Turistice, Cluj.com, 2019*), with 8.9 Ha of green spaces (planted and grassed spaces), which means 65%. The central body of water (Lake Chios) represents 1.1 Ha (i.e. 8%). Instead, the alleys cover 2.9 Ha, and together with the gutters occupy around 3 Ha. Thus, pedestrian paths consume 21% of the park's surface, because they are also dedicated to green mobility (bicycles). Constructions occupy 0.2 Ha - 1.4%, children's playground and sports activities areas take up to 0.07 Ha - 0.5% (according to *Spații verzi; Cluj-Napoca, 2023*), being far from the standards set out by Florincescu (1999) and Iliescu (2003).

To summarize, Central Park is mostly covered by trees and grass, followed by alleys, water, sports areas, hedges, and constructions, as shown in figure 4. It is worth noting that particular attention is given to pedestrians, which is a common trend throughout the city center. In several locations, alleys are used as a means of accessing parking or as a pathway for cyclists and pedestrians (Machado-León, 2020).

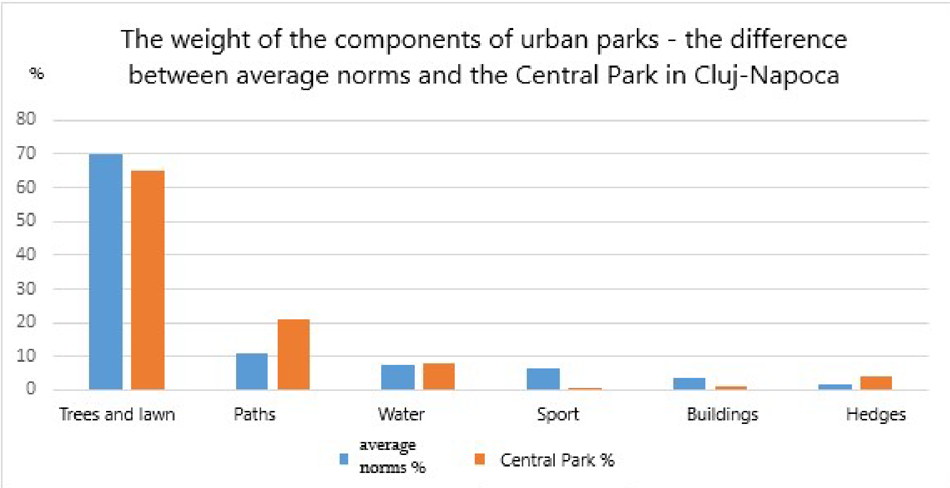

Fig. 4. *The weight of the component elements of urban parks (comparison between average norms and Central Park in Cluj-Napoca)*

The distribution of urban parks around the city is uneven, which poses a problem in ensuring equitable access to public green spaces for residents (see figure 5). Urban parks often feature outdated landscape designs that have been in place for more than 40 years. However, some newly developed or renovated residential areas, such as those located on the eastern side of Cluj-Napoca city, boast modern urban parks (Gheorgheni – Iulius Mall or Pădurea Clujenilor Park).

It is important to note that not all urban parks in Cluj, such as the Botanical Garden, Tetarom Park, or Parcul Sportiv, have the same accessibility or open park character as Central Park. Therefore, the Central Park model cannot be generalized to all urban parks in the city. Cluj has a total of 16 urban parks, while Timișoara has 23, Iași has 12, and Bucharest has 59. Cluj-Napoca Municipality, with 114 hectares, has the highest ratio between total population and parks surface among the larger cities in Romania, with 3.57 square meters per inhabitant. This is compared to Timișoara's 2.58 square meters per inhabitant, Iasi's 2.26 square meters per inhabitant, and similar to Bucharest's 3.68 square meters per inhabitant, which has urban parks covering 776 hectares (Baza de date urbane – Citadini, 2021).

Fig. 5. *The uneven distribution of urban parks in Cluj-Napoca (Source: Google Earth, 2023)*

From a different perspective, the situation of green spaces can be seen as a much broader and more generous category. Green spaces are not just limited to parks and gardens, but also encompass all natural urban elements, regardless of their size or location. This expanded acceptation recognizes the inherent value of various features that contribute to urban biodiversity, environmental sustainability, and overall human well-being. These spaces are divided into two categories:

1. Green spaces within localities, including parks, gardens, squares, green strips, street alignments of trees, plantations around public facilities, landscaping in the premises of institutions, zoos, botanical gardens, plantations related to cemeteries, flower plantation bases, arboriculture, and other plantations (Florență 2022; Iliescu, 2003).

2. The green spaces outside the localities serve as recreational areas and can include forest parks, recreational forests, plantations along the transportation routes, and protective plantations. Some other green spaces such as tree nurseries and research institutions' green areas can also be found outside the localities. In Romania, the global indices for inner-city green spaces range between 9-26 sqm/inh (Iliescu, 2003; table 3).

Green spaces and their native soils are essential components of the Cluj-Napoca Municipality, both within and outside of the urban ecosystem. Within the urban ecosystem, they play a crucial role in ensuring environmental resilience, supporting biodiversity, regulating microclimates, and providing recreational and social spaces. Beyond the urban ecosystem, they are important for connecting to surrounding areas, improving water quality, preserving cultural and historical significance, and mitigating the impact on the local climate.

Table 3. *Norms of green spaces (according to Iliescu, 2003)*

Norms for green spaces/inh in rural and urban areas		
Type of area	Number of inhabitants	Index green spaces/inh (sqm/inh)
Rural areas	5,000 - 10,000	5 -7
	10,000 -20,000	8 - 10
Urban areas	Under 20,000	9 - 13
	20,000 - 50,000	12 - 16
	50,000 - 100,000	14 -20
	Over 100,000	17 - 26

Currently, these norms fall short of the green space norms set by the European Union, which suggest a minimum of 30 sqm/inh. Furthermore, these norms are well below the UN's standards for large cities, which recommend a minimum of 45 sqm/inh (according to *UN-Habitat - Module 6, 2020*). In reality, many major European cities fail to meet minimum space requirements per inhabitant. For example, Stockholm has 41.6 sqm/inh, Prague has 35.7 sqm/inh, Dublin has 32.9 sqm/inh, London has 19.2 sqm/inh, Paris has 14.6 sqm/inh, Sofia has 14.4 sqm/inh, Lisbon has 9.6 sqm/inh, and Bucharest has 7.1 sqm/inh (*The European Commission, ec.europa.eu, 2021*).

In national statistics, there is a term called "public recreation space" which refers to the number of square meters of public outdoor recreation space per capita. These figures differ from European statistics. As of 2021, Bucharest has 21.35 sqm/inh, Cluj-Napoca has 25.39 sqm/inh, Timișoara has 15.74 sqm/inh, and Iași has 18.64 sqm/inh (*INS TEMPO Online, 2022*; *Baza de date urbane - Citadini, 2021*). It's important to note that when calculating certain indicators, such as population, the results can differ depending on whether you're looking at the stable population or the resident population.

In 2021, Cluj-Napoca Municipality had a stable population of 320,547 inhabitants, but the resident population was only 286,598. This means that the indicator calculated for the resident population of Cluj-Napoca is expected to significantly improve, reaching 28.4 square meters per person. If we take into account the continuous growth of the inner city and the addition of green spaces, such as the southeast area of the municipality shown in figure 1, this figure could be further improved to 30 square meters per person.

Cluj-Napoca is also known for its commitment to green initiatives. The city is part of the one hundred climate-neutral cities initiative in Europe, which aims to achieve climate neutrality by 2030. In line with this goal, the city administration has pledged to plant 100,000 mature trees by 2030, with 20,000 of them planted along the new bank of Someșul Mic River. Additionally, two hectares of green meadow space will be allocated to this initiative. These efforts are part of the city's plan to become one of the one hundred pioneering cities in the world that aim to reduce greenhouse gas emissions generated by local government management to zero (European Commission's Directorate-General for Research and Innovation in 2022).

The analysis of some soil quality indicators in urban parks

Analysing soil quality indicators in urban parks is crucial for assessing the impact of urbanization on the environment. Urbanization can introduce various stressors to soil, such as pollution, compaction, and altered nutrient cycles. To assess the quality of soil in two of Cluj-Napoca's main parks - Central Park (CP) and Sports Park (SP) - we conducted soil analysis, focusing on bulk density, soil organic carbon, and texture. We collected five samples from each park (1-5 from CP and 6-10 from SP) and recorded the values in table 4. The samples were taken from 10 different locations within the parks, including grassy areas and areas with flowering plants, at a depth of 0-20 cm.

To measure the soil bulk density, we used a metal ring with a known volume. We first dried the soil samples for 24 hours at 105°C, then weighed them to obtain their total dry mass. We then calculated the bulk density by dividing the dry mass by the volume. In CP, the mean value of this parameter was 1.13 g/cm^3, while in SP it was 1.04 g/cm^3.

According to the USDA (1987), for optimal plant growth, the soil bulk density should not exceed 1.20 g/cm3. None of the soil samples analysed had a bulk density greater than this limit. Thus, the density of soil in Sports Park ranges from 1.07 to 1.20 g/cm^3, while it ranges between 0.92 to 1.21 g/cm^3 in Central Park. We have compared the results we obtained with the standard for soils in the Cluj area, which was established in an experimental polygon of the University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca (USAMV) located in the eastern part of the city (Hoban, 2008).

According to Hoban's (2008) analysis, the average density of the soil samples in the experimental area ranged between 1.14 and 1.25 g/cm3. This indicates that the soils in the central urban parks are not compacted and have favourable physical-hydraulic properties, which makes them suitable for supporting urban floral elements.

Soil organic carbon (SOC) is an important factor that can influence other soil properties and is considered one of the most important soil quality indicators (Wiesmeier et al. 2019; Zhao et al. 2014; Kumar and Hundal, 2016).

Urban green spaces and parks with vegetation have a higher probability of accumulating soil organic carbon (SOC) compared to non-vegetated soils (Cambou et al. 2012; Bae and Ryu, 2020). Some studies suggest that the type of vegetation and tree species can impact SOC due to differences in litter decomposition and root production (Takahashi et al. 2008; Lu et al. 2021).

Table 4. *The values of soil parameters in urban parks*

Samples	Texture	Bulk density (g/cm^3)	SOC (g/cm^2)	Clay (%)
1	**Sandy clay**	1.19	0.43	30.63
2	**Clayey sand**	1.19	0.28	29.03
3	**Sandy clay**	1.07	0.25	31.59
4	**Sandy clay**	1.12	0.26	39.59
5	**Sandy clay**	1.08	0.38	32.55
6	**Clayey sand**	1.20	0.33	20.40
7	**Clayey sand**	1.05	0.14	14.01
8	**Clayey sand**	1.16	0.35	20.40
9	**Clayey sand with gravel**	0.91	0.30	16.24
10	**Clayey sand**	0.92	0.47	19.76

*Gray – soil samples from CP and white- soil samples from SP

We analysed soil organic carbon using the Loss on Ignition method. Soil samples collected from SP have values ranging from 0.14 to 0.47 g/cm^2.

The low values can be explained by continuous urbanization, which induces soil degradation, and soil sealing, and depletes the soil's organic carbon pools (as suggested by Raciti et al. 2012; Wei et al. 2014; Lu et al. 2020). Another critical factor influencing the SOC content is the warm temperature (Davidson and Janssens, 2006) which accelerates the microbially-mediated mineralization rate (Liu et al., 2019) and soil respiration rates (Shi et al., 2020). It is well known that the rapid urbanization process induces a dramatic change in atmosphere structure near the surface (Estoque et al., 2017) and in thermal properties of urban land (Portela et al., 2020; Yu et al., 2020).

CONCLUSIONS

Fast urbanization poses several challenges, often associated with the modernization of socioeconomic life and the regional appeal of large Romanian cities. While local decision-makers strive to control limits on urban growth that do not disrupt the daily routines of residents, architects, and real estate firms seek to accelerate the rate of urban growth beyond city limits and into the metropolitan area. This is also happening in Cluj-Napoca, where many urban issues are arising due to the consumption of natural space and agricultural land. The main cause is urbanization, characterized by increased human activity, infrastructure development, and fast changes in land use, which can have significant consequences for soil health and the quality of green spaces. For instance, new residential areas are built on peripheral and agricultural land and native soils and there exists a permanent conflict between expanding urban fabric and preserving green space and fertile soil.

Within this context, we preliminary evaluated soil quality in two major urban parks in Cluj-Napoca City (Central Park and Sports Park). An analysis of soil samples has revealed a correlation between analysed indicators of soil quality and the process of urbanization. The decrease in soil organic carbon and an increase in soil density are real outcomes of the adverse impact of urbanization on local environmental factors.

This study will continue with the analysis of soil quality in other green spaces located within urban and periurban spaces of the city to assess the pressure of urbanization on these environmental components. By systematically assessing these soil quality indicators, we can gain valuable insights into the impact of urbanization on urban park soils and implement targeted strategies for sustainable soil management and environmental planning in urban and periurban areas of Cluj-Napoca City.

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EXPLORATION AND VALORIZATION OF CULTURAL LANDSCAPES IN TÂRGOVIȘTE MUNICIPALITY FOR TOURISM DEVELOPMENT

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ABSTRACT. The study encompasses an analysis of the specific elements of cultural tourism in the Municipality of Târgoviște and their attractiveness among tourists. This analysis highlights the main cultural landmarks located in the Municipality of Târgoviște, such as churches, monuments, museums, cultural buildings, etc., which have been constructed over time and contribute to the local history and the beauty of the area. With adequate infrastructure and promotion, these landmarks could form the foundation for new development strategies for the Municipality. The study reveals both the analysis of elements with genuine tourist value and the main objectives that need to be achieved for the further development of the area.

Key words: *Târgoviște Municipality, cultural landscape, tourism valorisation, touristic potential.*

INTRODUCTION

Tourism began to grow both economically and socially in the latter half of the 20th century. Historians note that the urge to explore and discover new places has been present since ancient times. However, back then, travel was primarily focused on expanding power, conquering new territories, or engaging in trade (Bran, 1996). Over the years, the activity of tourism took shape, and among the main purposes of travel were: religious tourism, students' trips to university centres, spa tourism etc. (ibid.).

According to the World Tourism Organization, there are three types of tourism (UNWTO, Annex 2): *domestic tourism* (refers to tourism activities undertaken within a country by residents of that country); *inbound tourism* (refers to all visits within a country by non-residents of that country) and *outbound tourism* (refers to visits by residents of a country outside that country) (Eurostat, Glossary: Tourism).

Tourism is a multifaceted economic activity that can be analysed from various perspectives, resulting in numerous specific classification criteria. It can be systematically categorized by considering factors such as tourists' mobility, marketing methods, travel frequency, purpose of the trip, age of tourists, and other criteria. These factors often intersect due to the inherent cross-cutting nature of tourism. One of the classifications of tourism is represented by the socio-economic specifications of demand, and cultural tourism is part of this category, defined as follows: "Cultural tourism is that type of tourism practiced by tourists for the purpose of visiting the sights that are found in a particular area" (Honey, 2008). This category also includes: urban, rural, religious, adventure, ecotourism and agrotourism (ibid.).

Târgoviște, the former capital of the Romanian countryside, is a treasure trove of cultural landscapes reflecting a rich and diverse history. From medieval vestiges to Brâncovenetian architecture, the city is distinguished by a cultural heritage that has shaped the region's identity over the centuries. In today's context, when cultural tourism is becoming increasingly relevant, exploring and capitalizing on these cultural landscapes is a key opportunity for local tourism development. Tourism revitalization will not only attract visitors but will also support the local economy, promote heritage conservation and strengthen community identity. With well thought-out strategies and through collaboration between authorities, the private sector and local communities, Târgoviște has the potential to become a reference point on the cultural tourism map of Romania and Central and Eastern Europe.

This article aims to analyse the ways in which the cultural landscapes of Târgoviște can be effectively explored and exploited to stimulate the development of tourism, thus contributing to the creation of an attractive and sustainable destination for tourists from all over the world.

FEATURES OF TÂRGOVIȘTE MUNICIPALITY

1. Physical-geographical characteristics

Târgoviște used to be a royal residence, and since 1961 it is a municipality and the administrative seat of the whole county. For more than three centuries, Târgoviște was one of the most important economic, political-military and cultural center of the Romanian Country. Situated on the border between the hilly sub-Carpathian hilly area and the plains, the city of Târgoviște is located on the Ialomita valley, situated on a terrace whose height is about 260 metres. This is the road that in the past linked Transylvania and the Danube, on the route Rucăr - Câmpulung - Târgoviște - Târgșor - Brăila, the role of this road being a commercial one.

The municipality of Târgoviște has a favourable geographical position, about 60 km from Sinaia and about 75 km from Bucharest, the capital of the country. The Rucăr-Bran corridor, which has become an axis of mountain agritourism, is located in the vicinity of Târgoviște (Bran, 1996). In terms of population, Târgoviște municipality has 66,965 inhabitants, which represents about 14% of the population of the whole county (Recensământul Populației și Locuințelor, 2021).

2. Short history

Most of the economic, social and cultural activities take place in the city of Târgoviște, the county seat of Dâmbovița. For three centuries, from 1396 to 1714, Târgoviște (formerly known as Valahia) was the capital of Wallachia. In 1714, the country's capital was moved to Bucharest, and Târgoviște became less attractive (Dumitrescu et al., 2012).

Under the rule of Nicholas Mavrocordat in the 18th century, the institutions of the captains and vicars were abolished and replaced by that of the ispravnic. *Zapcii* and *vătafii de plai* had important roles in local administration and the security of roads and borders. Târgoviște became an important city when Mircea cel Bătrân took the seat of the throne. The city was influenced by Saxons, Venetians and Genoese. The Saxons founded the city of Câmpulung, influencing the transition to the urbanization of the southern Carpathian region. Târgoviște's development continued under the reigns of Matei Basarab and

Constantin Brâncoveanu, and the 15th century brought major territorial changes due to Ottoman intervention and subsequent treaties, such as the Peace of Adrianopol in 1829 (Pehoiu and Oproiu, 2008).

ANALYSIS OF ELEMENTS THAT HAVE TOURIST VALUE WITHIN THE CULTURAL LANDSCAPE

In 1993, the World Tourism Organization defined cultural tourism as "a form of tourism whose main purpose is to broaden the horizon of knowledge through the discovery of cultural, artistic or architectural heritage" (Gheorghilas, 2011). By means of cultural tourism, anthropic resources are valued, which is why this type of tourism can include both urban and rural-ethnographic tourism.

In Romania, Ordinance no. 68/26.08.1994 and Law no. 41/1995 establish the main categories of monuments, as follows:

- monuments and archaeological sites;
- architectural monuments and groups;
- architectural and town-planning reserves, memorial buildings, monuments and memorial groups;
- monuments of fine arts and memorials;
- technical monuments;
- historic sites;
- parks and gardens.

Cultural tourism entails exploring regions, countries, and cities through themes such as history, religion, art, language, ethnicity, and gastronomy. Individuals engaging in cultural tourism typically belong to higher socio-professional groups or possess a medium to high level of education, including students and intellectuals (Gheorghilaș, 2011).

There is a strong connection between urban and cultural tourism, as cities frequently offer the most numerous and intriguing cultural attractions, such as historical and religious buildings, museums, monuments, and memorial houses.

The Council of Europe's Framework Convention on the Value of Cultural Heritage for Society defines cultural heritage as "a group of resources inherited from the past which people identify, independently of their affiliation, as a reflection and expression of their continuing appreciation of their values, beliefs, knowledge, and traditions. It includes all aspects of the environment resulting from the interaction between people and places over time" (Dümcke and Gnedovsky, 2013).

According to the definition provided by the World Tourism Organization, "cultural tourism is a type of tourism activity in which a visitor's primary motivation is to learn, discover, experience and consume the tangible and intangible attractions/products of a tourist destination" (UNWTO website).

The component elements of cultural tourism are: art, architecture, historical and cultural heritage, literature, music, culinary heritage, lifestyle, value systems, beliefs and traditions (Boboc et al., 2019).

Based on the leisure definition provided by the Association for Tourism and Education, cultural tourism is perceived as "a movement of people to cultural attractions that are located away from their residential address in order to accumulate new information and experiences to fulfil cultural needs" (Boboc et al., 2019, p. 982).

At national level, the legislative framework regulating the protection of historical monuments is Law 422 of July 18, 2001, republished. According to Article 1, paragraph 2, "historical monuments are real estate, buildings and land located on the territory of Romania, significant for national and universal history, culture and civilization" (Law 422/2001).

Religious and pilgrimage tourism is a specialized subset of cultural tourism, where individuals' journey to sites of worship. These travels are motivated by various factors, such as the desire to explore new places of worship or to participate in specific festivals or holy days. In Dâmbovița County there are numerous places of worship of tourist importance, and among the best known are the following:

Monumental Complex Dealu Monastery is one of the most important religious monuments in Romania, Monumental Complex Dealu Monastery is located in the Aninoasa commune, north of the municipality of Târgoviște. Dealu Monastery was built during the reign of Mircea cel Bătrân, being documented in 1431. Later, between 1499-1502, Radu cel Mare built a new construction, the facade of which was painted during the reign of Neagoe Basarab (1514). During the 16th-19th centuries, the rulers who succeeded the Romanian rulers, such as Radu Mihnea (1614), Constantin Brâncoveanu (1713, who painted the monastery for the second time and covered it with brass) and Gheorghe Bibescu (1845-1846), were concerned with its care. The Romanian scholar Nicolae Iorga, visiting the Dealu Monastery church at the beginning of the 20th century, described it as "a marvel of oriental art".

The Dealu Monastery was the first printing press in the Romanian Lands and the first book in Walla Walla Walla was printed. It was also here that Petru Cercel founded the first literary court, which functioned according to the Western model. Between 1508-1512, books such as “Liturghier” (1508), “Octoih” (1510) and “Evangheliar” (1512) were printed. One of the largest burial places in the country is located in the pronaos of the Dealu Monastery, where the voivores, ladies and church ladies are buried. Well-known personalities such as Vlad Dracul (father of Vlad Tepes), Radu cel Mare and Mihai Viteazul rest here. The Monastery Museum houses valuable collections of old books, as well as a wooden cross gilded in silver gilt (Tourist Guide, REGIO).

The Archiepiscopal and Metropolitan Cathedral - Târgoviște is known by locals as “Mitropolia” and was one of the most important religious buildings built in Wallachia during the Middle Ages. The construction lasted about 2 decades, it was started during the reign of Radu cel Mare (he reigned from 1495-1505) and was completed by the ruler Neagoe Basarab in 1520. Later, during the reign of Radu Paisie, the church was covered with lead and painted. The rulers Constantin Brâncoveanu and Matei Basarab took care of the church, and during their reigns the cathedral was repaired. In the 19th century, more precisely in 1821, the etherists led by Alexandru Ipsilanti stripped the cathedral and took the lead, and this action led to the destruction of the paintings and the vaults of the building. Moreover, in 1889 the church was completely demolished, and the present church does not replicate the old church. In 2009, the relics of St. Nifon, the patriarch of Constantinople and metropolitan of Wallachia, were brought and placed in the nave of the Archbishop’s Cathedral. Today, in the Metropolitan’s park there are still the ruins of the chilies from the reign of Matei Basarab. Behind the church are located the ruins of an alleged tunnel that connected Mitropolia to the Chindiei Tower. The Mitropoliei Park is located in the center of Târgoviște and in its vicinity there is the Tricolor Square (where the statue of Mircea cel Bătrân is located), the Plateau of the Cultural Center of the Trade Unions (where the statue of Mihai Viteazul is located) and the old and historical center of the city (Tourist Guide, REGIO).

Sfântul Nicolae Andronești Church, Târgoviște: in 1527 the Church of St. Nicolae Andronești was built by the great vornic Manea Perșanu, during the reign of Radu de la Afumați. Later, during the reign of Matei Basarab (17th century) the church was rebuilt (Tourist Guide, REGIO).

Târgul Church, Târgoviște: at the beginning of the second half of the 17th century, in 1654, on the site of a church built in the 16th century, the Târgoviște Church was founded by the scholar Udriște Năsturel. At the end of the 17th century it was painted and the expense was borne by Dinu Bogasieru.

Over time, the church was constantly repaired. The porch was added in the 18th century. Geometric and floral decorations made by sgraffito and coloured in red, blue and scarlet adorn the facades of the church, combining elements of local architectural tradition with elements that came from Moldova, with the construction of the Stelea Monastery. In the specific architecture of the church, we can observe a number of specifically Moldavian elements (Tourist Guide, REGIO).

MUSEUMS AND MEMORIALS

The National Museum Complex "Curtea Domnească" - Târgoviște includes 16 museums and memorial houses of real historical importance. These are: The Monumental Ensemble "Curtea Domnească", the Museum of Dâmbovițeni Writers, the Museum of Printing and Old Romanian Books, the History Museum, the "Vasile Blendea" Museum, the Art Museum, the "Gheorghe Petrașcu" Workshop House, the Pucioasa Ethnography and Folklore Museum, the Brancovenesc Ensemble of Potlogi, the "Gabriel Popescu" Workshop House in Vulcana Pandele, the I. L. Caragiale, Ethnographic Museum "Prof. Dumitru Ulieru" in Pietroșița, Ialomiței Cave in the Bucegi Mountains, Museum of the Evolution of Man and Technology in the Paleolithic, "Casa Romanței" Târgoviște, Cavalry Officers School "Ferdinand I" known rather as "Place of the execution of the Ceausescu couple".

The Princely Court covers an area of 29,000 square meters and is the best-preserved medieval ensemble in Romania. From 1396 to 1714, the Princely Court functioned intermittently and in turn fulfilled several roles: it was the residence and seat of the prince for 33 rulers (the first prince was Mircea cel Bătrân and the last one was Constantin Brâncoveanu). During the reign of Mircea cel Bătrân, the nucleus of the Princely Court was established, thus being the first buildings that were intended for the residence of the ruling family over Walla Walla Wallachia. During the reign of Vlad Țepeș, the Princely Court was enlarged and the Chindiei Tower, a watch and control tower, was also built. Under the careful guidance of the voivode Petru Cercel, between 1583-1585, several fortifications were built. The Great Court Church was also built during this period, as well as the first aqueduct. The first royal garden was also created, outside the Court, facing the Ialomita river. Over time, buildings erected earlier were constructed and repaired. Thus, during the reign of Matei Basarab, the manor houses were repaired, the enclosure wall was doubled and a Turkish bath was built. Constantin Brâncoveanu was the ruler who carried out the last significant works of the Princely Court, on the one hand, the previously constructed buildings were repaired and on the other hand, new extensions took place (Tourist Guide, REGIO).

Dâmbovițeni Writers' Museum, Târgoviște: Remarkable personalities of the 19th-20th centuries have passed through the doors of the Dâmbovițeni Writers' Museum in Târgoviște, such as Titu Maiorescu, Ion Luca Caragiale, Emil Gârleanu, and many others. The house was built between 1897-1898 and became a museum in 1967. It is based on three sections: a first section represents the Middle Ages, when Târgoviște was the country's first centre of culture; the second section is the poets who were part of the national revival movement, and the third is represented by writers "born either under its sign, or brought to life, in Târgoviște, for a moment or for eternity" (Tourist Guide, REGIO).

Printing and Old Romanian Books Museum, Târgoviște: Reorganized in the Dionisie Lupu House, the Printing and Old Romanian Books Museum is located in the Printers' Court of Târgoviște. On the ground floor of the building there are five halls where one of the most important crafts existing since the Middle Ages is illustrated in different forms, namely printing. The exhibition presents the printing activity that developed from the 16th century until the 19th century, a moment that marks the end of the evolution of the old Romanian book, both in Târgoviște and in other centers in the country. In the exhibition hall there are books printed in various European cultural centers such as Vienna, Leipzig, Rome, London, Poland, Paris, Amsterdam, as well as a model of a printing press that was created in 1778 (Tourist Guide, REGIO).

The Museum of History, Târgoviște, is located near the Voivodeship Court, in an area of historical importance. At the beginning of the 20th century, the Palace of Justice was built, today declared a historical monument, which is one of the most important buildings of neoclassical architecture. On the first floor of the building there is a permanent exhibition of the Museum of History, where the Romanian space specific to the period between the Palaeolithic period and 1918 is highlighted. Thus, the exhibition includes a series of material evidence proving the existence of the population of Geto-Dacian origin. The exhibition also provides information about the Romanian medieval states, with an incursion into what Walla Wallachia meant and its specificity.

The museum also includes a space dedicated to the rulers of Walla Walla Wallachia, such as Vlad Țepeș, Petru Cercel, Mihai Viteazul, Constantin Brâncoveanu, where there are elements specific to medieval culture such as: decorative art, various typographic ornaments, lapidary, woodcuts.

The History Museum also has sections presenting the most important events that took place in the 19th century: the revolution led by Tudor Vladimirescu, the Union of the Romanian Lands realized by Alexandru Ioan Cuza, the War of Independence fought at the end of the 19th century (Tourist Guide, REGIO).

Vasile Blendea Museum is also known as “Angela Georgescu” House. The museum is a monument of Romanian architecture specific to the 18th century. It was restored at the beginning of the 21st century. The Emilia and Vasile Blendea collection, consisting of works of fine art (paintings, graphics, sculptures, drawings), as well as memorial pieces (letters, manuscripts, photographs), is housed in the Museum (Tourist Guide, REGIO).

Art Museum, Târgoviște: The current building of the Art Museum was built to serve as the headquarters of the Dâmbovița County Prefecture. The plan of the building was realized by the architect Baldassare Vignossa Giovani and dates from the end of the 19th century. The building is not imposing, being relatively small in size, but its sumptuous interior is particularly sumptuous, with ceilings, stuccowork and walls painted with various geometric and vegetal motifs.

Specific elements of Romanian art, such as religious paintings, icons, frescoes, period furniture, as well as modern and contemporary works of art that are part of Romania’s heritage can be found at the Art Museum in Târgoviște (Tourist Guide, REGIO).

Gheorghe Petrașcu Studio House, Târgoviște: Gheorghe Petrașcu lived between 1872-1949 and was a Romanian painter and academician. He built his house in 1922, attracted by the patriarchal city, the peace and calm of the ruins of the Princely Court. Gheorghe Petrașcu drew his inspiration mainly from Nicolae Grigorescu, but created a new, original style. His main paintings are: “Entrance to the Princely Court of Târgoviște”, “The Cauldron with the Tavern Tavern Keepers”, “View of Târgoviște”, “House after the Rain”, “Portrait of a Boy”, “House in Venice” (Tourist Guide, REGIO), all of which and many others can be seen at the “Gheorghe Petrașcu” House and Workshop in Târgoviște.

The National Museum of the Romanian Police in Târgoviște is the only museum with this profile in our country and was inaugurated in 2000. The museum is located in the same enclosure as the Art Museum and the History Museum, near the Domnești Court. The museum contains numerous exhibits showing the stages of development of the Romanian Police, as well as the evolution of the institution internationally.

The Gate of Bucharest is one of the four gates through which the old 16th-century fortress of the seat of the city was entered. Its reconstruction was carried out relatively recently, after 1897, when its foundations were unveiled as a result of the construction of a new boulevard (figure 1).

Fig. 1*. The Gate of Bucharest (author's personal archive)*

THE POTENTIAL FOR TOURISM VALORIZATION OF THE ELEMENTS OF THE CULTURAL LANDSCAPE

Tourism promotion is essential for the development and sustainability of Dâmbovița County as a tourist destination, with multiple economic, social and cultural benefits. Among the most important reasons for promoting tourism in the county are:

a) *Increased economic revenue*: tourism generates substantial income for a destination through tourist expenditures in hotels, restaurants, shops, transportation, and attractions. These revenues can facilitate infrastructure development and enhance public services.

b) *Job creation*: the tourism sector creates numerous employment opportunities across various fields such as transportation, tour guiding, and retail. This can reduce unemployment and provide jobs for local communities.

c) *Infrastructure development*: the rise in tourism can drive investments in local infrastructure, including roads, airports, public transportation, and health and safety facilities. These enhancements benefit both tourists and residents.

d) *Promoting culture and heritage:* tourism can aid in preserving and promoting cultural and natural heritage. The revenue generated can be allocated for the maintenance and restoration of historical sites, museums, and nature parks.

e) *Diversification of the economy:* tourism offers an alternative income source, reducing reliance on a single industry.

f) *Improved quality of life*: the economic and social advantages of tourism can lead to an overall improvement in the quality of life for local communities by providing better access to services and infrastructure.

g) *Promoting peace and international understanding*: tourism fosters cultural and social exchange, helping people understand and appreciate different cultures and lifestyles, thereby promoting peace and international understanding.

h) *Stimulating entrepreneurship*: increased tourism can encourage entrepreneurial activities and the growth of small local businesses such as guesthouses, restaurants, guided tours, and souvenir shops.

In conclusion, tourism promotion is crucial for the economic, social and cultural development of Dâmbovița County. It helps to attract visitors, create jobs and preserve heritage, thus contributing to the general well-being of the local community

In the rows below are highlighted statistical information on tourist overnight stays and arrivals in tourist accommodation facilities, accommodation capacity and existing tourist accommodation facilities in Târgoviște Municipality. The analysed period is of ten years, between 2013-2023 and the following categories are considered: hotels, hostels, apartments and rooms for rent and tourist pensions.

According to the National Institute of Statistics, ***overnight stays*** are defined as follows: “a tourist overnight stay is the 24-hour interval, starting from the hotel hour, for which a person is registered in the record of the tourist accommodation space and is provided with accommodation on account of the tariff for the occupied space, even if the actual length of stay is less than the mentioned interval. Overnight stays related to extra beds installed (paid for by guests) are also taken into account" (INS, 2024).

According to the data in the graph below we can observe that in terms of tourist overnight stays in tourist accommodation facilities in the Municipality of Târgoviște in the period 2013-2023, most overnight stays took place in hotels, while in the last period the number of overnight stays in tourist guesthouses started to increase (figure 2).

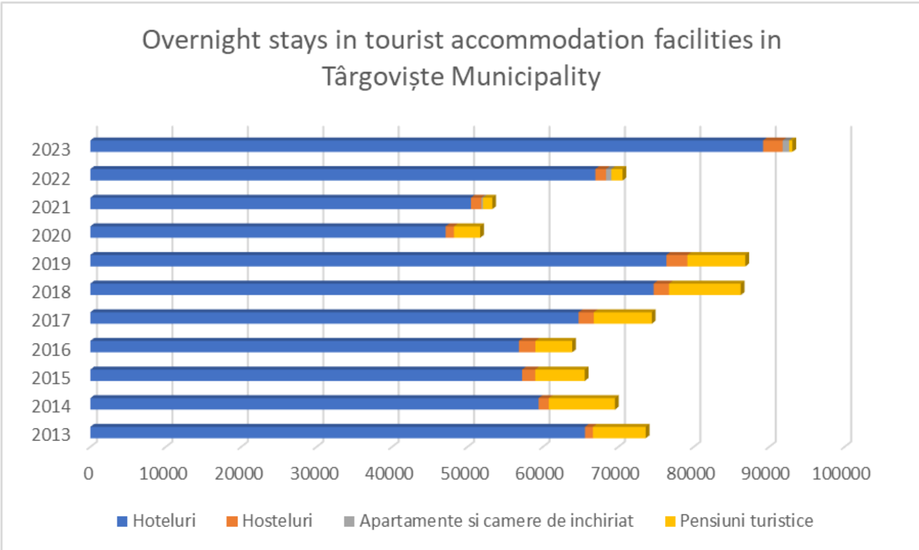

Fig. 2. *Overnight stays in tourist accommodation facilities in Târgovişte Municipality (National Statistical Institute, 2023)*

According to the National Institute of Statistics of Romania, ***tourist arrivals*** refer to persons of Romanian or foreign nationality travelling for a period of less than 12 months and spending at least one night in a tourist accommodation unit located outside the area of place of residence, and the reason for the trip is determined by recreational activities (INS, 2023).

According to the chart below (figure 3), we observe that similar to overnight stays in tourist establishments, hotels and tourist guesthouses are the most frequented by tourists who choose to spend at least one night in the Municipality of Târgoviște.

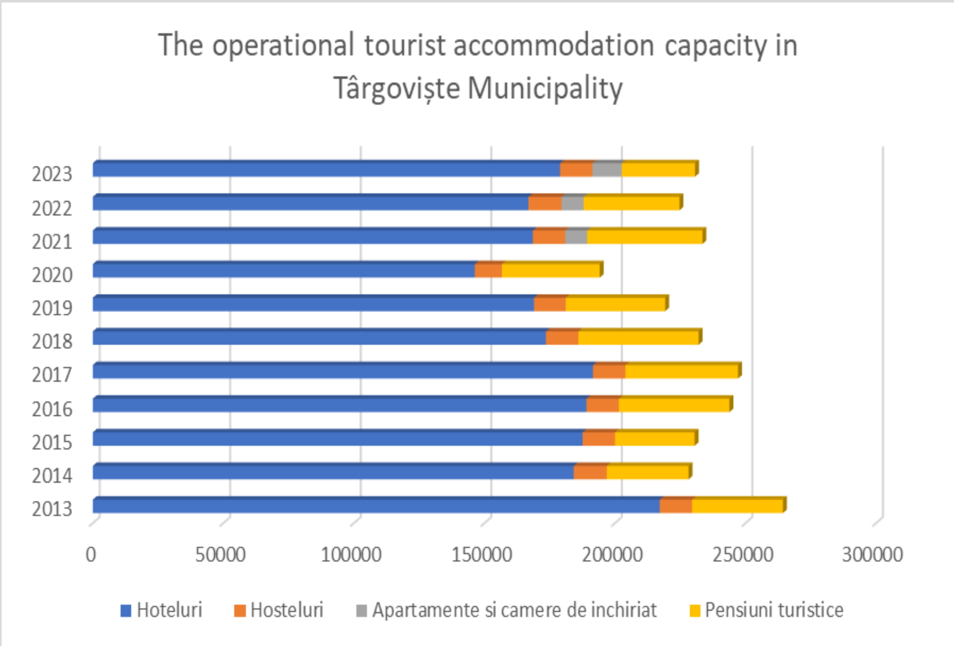

Fig. 3. *Tourists' arrivals in tourist accommodation facilities in Târgovişte Municipality (National Statistical Institute, 2023)*

Tourist accommodation capacity is defined by the NSI as the total number of tourist accommodation places that are approved and classified as tourist accommodation structures with tourist accommodation function. This definition includes places in existing structures, including additional beds that can be installed when necessary (INS 2018). In the Municipality of Târgoviște, the accommodation capacity of hotels has been decreasing in the period 2013-2023 (for example in 2013 the number of available places in hotels was 217,134 places, while in 2023 there were 178,968 places, a decrease of 17. 57%). A decrease also occurred in the number of available places in tourist pensions (in 2013 the available places in tourist pensions approved in Târgoviște Municipality were 34,792, while in 2023 the availability of accommodation expressed in places was 28,085) (figure 4).

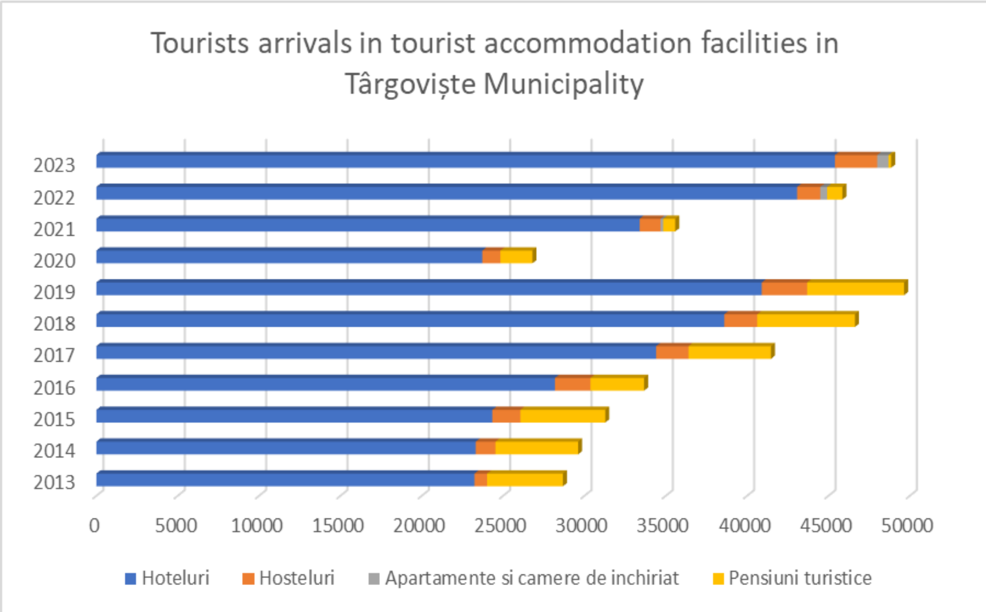

Fig. 4. *The operational tourist accommodation capacity in Târgovişte Municipality (National Statistical Institute, 2023)*

The definition provided by the NPS of tourist accommodation structure with tourist accommodation functions is: "any construction or arrangement, which provides on a permanent or seasonal basis the accommodation service and other specific services for tourists" (INS, 2018). In the period 2013-2023, in Târgoviște Municipality there were between 13 and 17 tourist accommodation structures in terms of hotels and between 5 and 8 in the case of tourist guesthouses. Hostels numbered 2 (constant for the period analysed), while apartments and rooms for rent have appeared since 2020, also numbering 2 (figure 5).

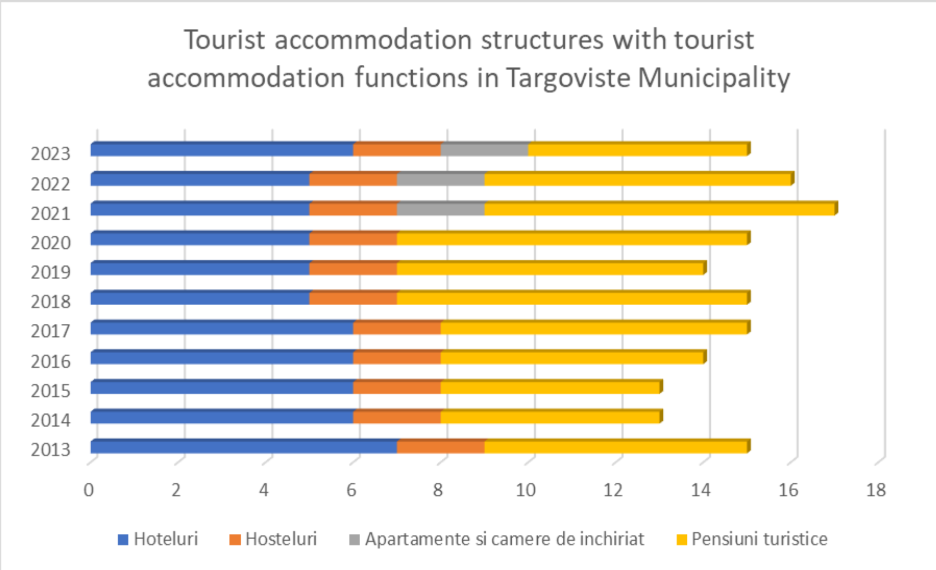

Fig. 5. *Tourist accommodation structures with tourist accommodation functions in Târgovişte Municipality (National Statistical Institute, 2023)*

CONCLUSIONS

All these elements identified, analysed and presented above facilitate tourist access and exploitation, currently in a relatively modest way, but which can represent, as a whole, the basis of a new integrated development strategy for the Municipality of Târgoviște.

Thus, in line with the development strategy of Dâmbovița County, which also provides for tourism exploitation, we propose the following appropriate interventions for the development of the tourism sector based on the following SWOT analysis:

Strengths

●Rich historical and cultural heritage: Târgoviște has numerous historical monuments and cultural sites, such as the Curtea Domnească, the Chindiei Tower and old churches.

●Existing tourist infrastructure: There are already tourist facilities such as hotels, hostels, restaurants and various leisure activities.

●Proximity to Bucharest: Târgoviște is close to Bucharest, about 80 kilometres.

●Attractive natural landscapes: The area offers varied natural landscapes that can be integrated into tourist circuits.

Weaknesses

● Lack of effective promotion: Târgoviște is not sufficiently known nationally and internationally as a tourist destination.

● Inadequate road infrastructure: Roads and access to certain tourist attractions can be hampered by various factors.

Opportunities

● European funding: Access European funds for tourism infrastructure development and heritage conservation.

● Public-private partnerships: Working with the private sector to attract investment and develop new tourism facilities.

● Developing cultural and eco-tourism: investments in these two types of tourism can bring new visitors.

● Digitization and online promotion: Using social networks and websites to promote tourist attractions.

Threats

● Competition from other tourist destinations: Other cities and regions with similar attractions may attract more tourists, so attention is drawn to other locations.

● Heritage deterioration: Lack of conservation measures can lead to deterioration of historic sites.

In order to capitalize on the cultural landscapes of Târgoviște, it is essential to focus on effective promotion, infrastructure development and strategic partnerships. By addressing weaknesses and capitalizing on opportunities, Târgoviște can become an important tourist destination in Romania.

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RISK ASSESSMENT OF HAZARDOUS WASTE MANAGEMENT PROCESS

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ABSTRACT. Urbanization and industrial activities are responsible for the increasing quantities of wastes each year leading to environmental and health consequences. Wastes are also generated from household, commercial, agricultural or medical activities industrial, mining or metallurgical sectors. Hazardous wastes can be identified as any solid, liquid, or gaseous waste that, in its chemical and physical characteristics, represents a potential harm to human health and/or the environment. Therefore, it requires specific management, such as compliance with the EU Waste Framework Directive for waste prevention and reduction. This study explores the hazardous waste management process to identify potential hazards during the treatment phase. It analyses the risk to the population using the qualitative preliminary hazard analysis (PHA) method and performs consequence analysis using Effects modelling software. The results of the PHA indicate a low to moderate risk, if specific safety measures are applied. The most severe accident scenario may result in reversible effects outside the establishment over short distances. These analyses can support decision-making in land-use and emergency planning procedures.

Key words: *hazardous waste, risk assessment, PHA method.*

INTRODUCTION

After the Chinese ban on imported waste in 2017, many countries around the world, such as the UK, US, and member states of the EU, have realized the importance of changing their waste management policies and moving towards an advanced level of recycling instead of seeking an alternative importer for their waste (Wen et al., 2021). The growing population and urbanization, along with economic and industrial growth, were the main factors that increased the demand for raw materials, and in turn, increased the waste generated each year, especially hazardous waste, which can endanger human health and the environment when improperly managed. The traditional ways of waste disposal have become ineffective and can't cope with the high level of environmental contamination. Poor waste management would certainly contaminate the natural environment and hinder economic development (Kaza et al., 2018).

Wastes have different characteristics and therefore belong to various categories. The most common way of classifying waste is based on their source, environmental impact, and physical state. Waste sources can include households, industrial facilities, commercial establishments, mining or agricultural operations, residues from construction activities, or medical sector (Zhang et al., 2022; Xu et al., 2019).

Environmental impact categorizes waste into two main categories: hazardous and non-hazardous. Physical state provides another method of waste categorization, where waste can be classified as solid, gaseous, or liquid (Amasuomo and Baird, 2016; Zhang et al., 2022).

Solid waste includes municipal solid waste (MSW), industrial waste, and hazardous waste (HW) (EPA, 2022). MSW encompasses organic and inorganic waste resulted in urban areas. Organic waste can be further categorized as fermentable, non-fermentable, or putrescible. Fermentable and putrescible wastes decompose rapidly, while non-fermentable waste resists decomposition and breaks down slowly (UNEP, 2015).

Industrial waste is a type of solid waste that is not classified as hazardous waste, resulting from manufacturing processes. It may include materials such as rubber, plastic, glass, clay, stones, water treatment by-products, steel, iron, organic and inorganic chemicals, and other waste generated by industrial activities, excluding the oil and mining industry (EPA, 2022).

Hazardous waste (HW) can be defined as any solid, liquid, or gaseous waste that, due to its chemical and physical characteristics, such as toxicity, flammability, or ecotoxicity, poses a potential threat to human health and/or the environment, necessitating specific management practices (Hyder, 2012). Classifying waste as hazardous is a complex process, and therefore, the United States Environmental Protection Agency has developed regulations to determine whether a waste falls under the hazardous waste definition (EPA, 2022). Hazardous wastes include acids, alkali, asbestos, inorganic cyanide, non-ferrous metals, and mineral oils (Yang et al., 2020). Moreover, metallurgical and chemical industries, such as of pesticides, fertilizers, sulfuric acid and ammonia, are the main generators of hazardous waste (Peizhe and Leisheng, 1993). Cooking oil is another source of hazardous waste that presents challenges in the disposal and landfilling process due to its high annual generation from households, restaurants, and industries (Hosseinzadeh-Bandbafha et al., 2022). Incineration residues and household wastes such as batteries are also included in this category. These types of wastes are subject to specific regulations and restrictions (Hyder, 2012), such as the European Regulation No. 1272/2008 (EP and EC, 2008) and the EU Waste Framework Directive (WFD) for waste prevention and reduction (EP and EC, 2018).

This study aims to explore hazardous waste management to identify potential sources of hazards that may arise during the treatment and disposal processes of hazardous wastes at a HW management plant in Romania. The objectives of the study include identifying hazards through qualitative Preliminary Hazard Analysis (PHA) method and quantitatively calculating the consequences of potential accidents using EFFECTS software. The results of the study can support decision making for land-use planning and emergency planning processes.

European Regulations on Chemicals and Wastes

Industrial accidents can result in environmental contamination and pose risks to human health due to the release of hazardous substances both inside and outside the industrial facility. Additionally, explosion or fire accidents can also cause property damage, further threatening environmental safety (Hollá et al., 2021).

After the accident in the Italian city of Seveso (1976) and the release of dioxins, in 1982 the Seveso I Directive (Directive 82/501/EEC) was adopted. This directive required member states of the EU to identify the probable risks associated with industrial activities, particularly those in dangerous industries, with the aim of preventing similar accidents and taking preventive measures.

Following the Bhopal accident in 1984, the Seveso II Directive (Directive 96/82/EC) was introduced with the aim of enforcing a classification mechanism for substances, categorizing them as toxic, flammable, explosive, or environmentally hazardous. Subsequent accidents, including the Enschede fireworks explosion in 2000, the Baia Mare cyanide waste spill in 2000, and the Toulouse ammonium nitrate explosion in 2001, prompted amendments to the Seveso II Directive, all aimed at reducing the consequences of such incidents (EC and EP, 2012; Laurent et al., 2021; Peeters and Vanhoenacher, 2022). Later, the Seveso III Directive (Directive 2012/18/EU), which focuses on the control of major accident hazards involving dangerous substances, was introduced as a result of changes and updates in the European Regulation (EC) No. 1272/2008 on Classification, Labelling, and Packaging of Substances and Mixtures (CLP) (EC and EP, 2012; HSE, 2015; Laurent et al., 2021; Peeters and Vanhoenacher, 2022). Seveso III Directive provides governments with the legislative tools to establish the necessary measures to prevent chemical accidents, and these policies are typically reflected in emergency and land-use planning (Török et al., 2011a). However, this latest directive has faced fundamental criticism on various fronts. For example, issues related to land-use planning in Slovakia have been raised (Hollá et al., 2021), and there are concerns about its ability to ensure a high level of safety to prevent accidents (Laurent et al., 2021). It is worth noting that the Seveso directives fall short in addressing the environmental impact beyond establishment boundaries (Sikorova et al., 2017).

The Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) regulation (EC 1907/2006) aims to reduce the diverse effects of chemical substances in the EU, and to facilitate the movement of hazardous substances while also protecting the human health and the environment, and providing a reference for effective ways of replacing them with less harmful substitutes (EP and EC, 2006).

Additionally, the EU Waste Framework Directive (WFD) for waste prevention and reduction (EP and EC, 2018) lays down measures for preventing the generation and management of waste, by reducing overall impacts of resource use. Its contribution is introducing the waste hierarchy, based on theory of circular economy. Furthermore, the WFD also addresses hazardous waste, which poses significant environmental and health risks, ensuresuring that hazardous waste is managed safely and responsibly, in compliance with established regulations and best practices, to protect both the European environment and its citizens.

Hazard identification and Risk assessment

The improper handling and management of HW can endanger human health and the environment (Peizhe and Leisheng, 1993). HW possess potential hazards, and risk assessment is a tool for determining their impact on human health and the environment (Mari et al., 2009). However, the impact of HW on human health depends on various factors, including the receptor's exposure, duration, frequency of exposure, as well as the individual's weight, age, gender, and occupation (Li et al., 2012).

An explosion of a container containing magnesium alloy debris at Tianjiayi Chemical Co., Ltd. in Xiangshui Industrial Park (Yang et al., 2020) was caused by the illegal storage of HW for more than seven years, without the use of specially designed facilities for its disposal or temporary storage.

Hazard, according to The United Nations Office for Disaster Risk Reduction (UNDRR, 2022), takes different forms, it can be of natural origin, man-made, associated with human factors and socio-natural which results from both natural and human activities such as deforestation and climate change. Risk comprises three major components: the hazardous event with a potential of causing negative consequences; the likelihood of occurrence, which can be calculated from historical data or by using logic tree models; and the vulnerability of potentially affected factors, such as human, environment or infrastructure. Vulnerability refers to the ability to experience adverse consequences when exposed to a hazardous event (Renjith and Madhu, 2010).

Characterizing wastes as hazardous is related to their potential for flammability, corrosivity, toxicity, and/or reactivity. The HW-based risk depends on the type of these wastes, the environmental and physical conditions around it (Das et al., 2012).

Risk assessment is a process which aims to ensure that all possible accident scenarios and their effects are being taken into account and safety measures are imposed to create a safely controlled environment (BSC, 2022; Lindhout and Reniers, 2017). It is a complex process that requires deep knowledge and specialists to conduct such assessment. Moreover, it gives authorities guidelines towards creating their risk management policies and approaches for protecting natural environment, human health, economy, security, technology, infrastructure and others (EFSA, 2012; Gormley et al., 2011). The process of risk assessment serves to raise awareness regarding the importance of health and safety, thereby prompting proactive measures against potential hazards (Minett, 2022).

In the risk assessment all possible components should be accounted in order to conclude an updated complete assessment. Such results can confirm the credibility of the risk assessment in which decision-makers can rely on in prioritizing the intervention (Lindhout and Reniers, 2017). The potential risk from hazardous substances or wastes can't, unfortunately, be reduced to zero. Therefore, it's important to put control on these substances or wastes in order to properly understand their potential consequences (Dhurandher et al., 2015). Laurent et al. (2021) also consider the worst-case scenario that might occur and emergency and land-use planning (LUP) procedures can include also these scenarios.

METHOD AND MATERIALS

Many methods and techniques for risk assessment, such as risk matrices, fault tree and event tree analysis (Ericson, 2005), HAZard and OPerability study (HAZOP) etc., have been developed and many of these techniques are supported also by computerized software.

Qualitative or semi-quantitative methods are applied to identify potential hazards and to categorize the risk levels associated with dangerous substances, or even HW, that may have adverse effects on the environment and human health. Scenario probabilities and consequences are combined within a risk matrix from which the risk can be categorized either accepted, tolerated or unacceptable (Sikorova et al., 2017), These methods help in assessing and managing the risks associated with hazardous materials and wastes, allowing for informed decision-making and the implementation of appropriate safety measures and controls (Sikorova et al., 2019).

A preliminary hazard analysis (PHA) represents an initial phase in the qualitative risk assessment process, in which the hazards associated with the technological process are identified and evaluated and the risk level of each identified threat is estimated in a qualitative manner. The main purpose of the PHA is to identify at an early stage the critical security requirement for the system and to identify the incidents most likely to occur, so that informed decisions can be made about security measures and risk reduction (Ericson, 2005). However, PHA is also suitable for other phases in the lifecycle of an installation, such as operation, maintenance, planned changes etc., offering a general level of understanding on hazards and risks (Török et al., 2011b). Table 1 present the risk matrix used in PHA.

Table 1. *Risk matrix used in PHA (Török et al., 2011b)*

			Consequences				
			Insignificant	Minor	Moderate	Major	Catastrophic
			1	**2**	**3**	**4**	**5**
Likelihood	Improbable	**1**	*1*	*2*	*3*	*4*	*5*
	Isolated	**2**	*2*	*4*	*6*	*8*	*10*
	Occasional	**3**	*3*	*6*	*9*	*12*	*15*
	Probable	**4**	*4*	*8*	*12*	*16*	*20*
	Frequent	**5**	*5*	*10*	*15*	*20*	*25*

Where: Risk = C x L; C – Consequences; L – Likelihood.

Risk levels:

- 1-3: Very low risk – the operator is following normal operational procedures and maintenance;
- 4-6: Low risk – normal operational procedures and maintenance;
- 8-12: Moderate risk – specific operational and maintenance procedures to follow in order to maintain the risk at this level;
- 15-16: High risk – Prompt risk reduction measures to be taken in order to mitigate the risk;
- 20-25: Extreme risk – Immediate risk reduction measures are necessary to mitigate the risk.

The hazard identification and risk analysis process applied for the selected case study, a HW management plant in Ploiești city, Romania, starts with a PHA of the waste treatment process. The main results of this analysis consist in the list of potential accident scenarios and their level of risk. Based on expert judgement, some of these scenarios were selected for quantitative consequence analysis, by using EFFECTS modelling and simulation software v.11, developed by Gexcon.

In order to construct the model, publicly available documents, such as the Site Report (ANPM, 2023a) and the Integrated Environmental Authorization (ANPM, 2023b), have been used as data sources.

In addition to ArcGIS (ESRI-Canada) for spatial analysis was used. The location of the HW management plant is presented in figure 1.

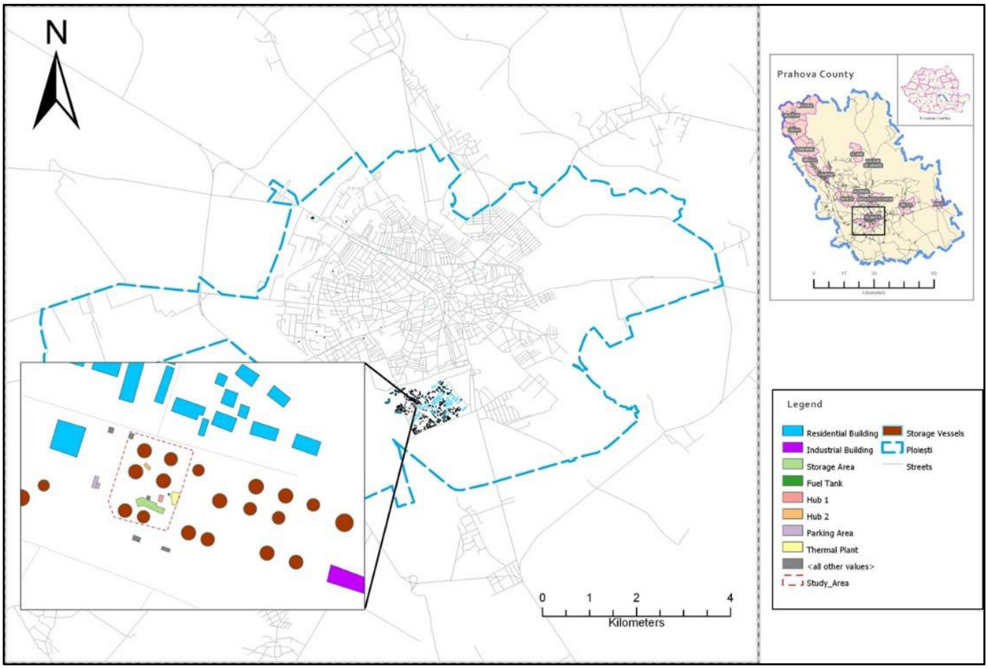

Fig. 1. *Study area location*

Figure 2 presents the HW treatment process flow diagram. The diagram was built up by the authors of this paper, based on the information available in the Site Report (ANPM, 2023a) and the Integrated Environmental Authorization (ANPM, 2023b). Since the information in these two documents is limited and no details on safety systems for accident prevention and consequence mitigation could be found, in the PHA a two-level risk analysis was applied, firstly by considering the absence of such systems and secondly by taking into account possible risk mitigation measures.

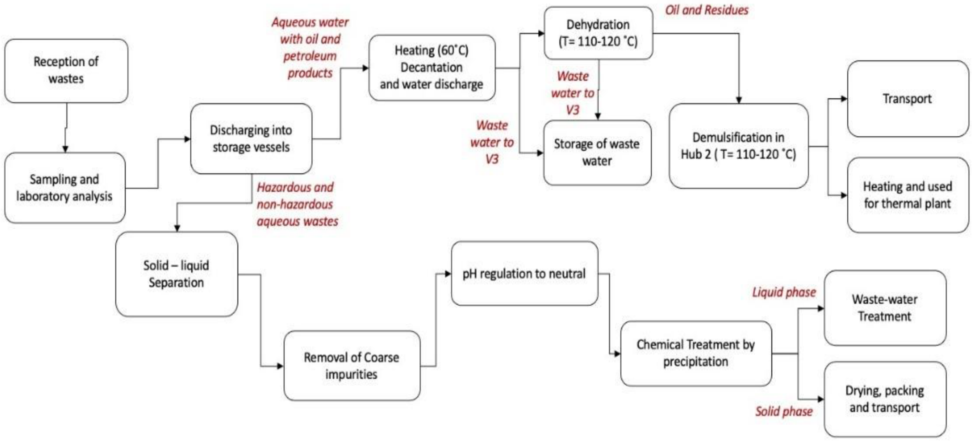

Fig. 2. *Hazardous wastes treatment process flow diagram*

The analysis is focusing on the identification of potential accident scenarios, involving fires and explosion due to HW accidental release or inappropriate process conditions. From this reason, only the HW containing flammable materials, such as oil and petroleum products, were considered in further analyses.

In order to identify the potential hazards of the HW treatment process, the flow diagram was divided into the most important stages as follows:

I. Transfer and discharge of HW into storage vessels: high waste water content, normal temperature;

II. Decantation of oil and petroleum products: high waste water content, temperature: 60 ^{o}C;

III. Dehydration: medium waste water content, temperature: 110-120 ^{o}C;

IV. Demulsification in Hub2: low waste water content, temperature: 110-120 ^{o}C.

RESULTS

An extract with the most important hazards and potential accident scenarios identified during the qualitative PHA is presented in Table 2. The risk are presented in Table 3, where the risk values with “red” text present the situation before applying mitigation measures and with “black” text the situation after the mitigation measures are implemented.

Table 2. *PHA developed for the waste treatment process (Probability - P, Consequences - C and Risk - R)*

No.	Possible Hazard*	Cause	Consequence	Risk before mitigation measures			Possible risk mitigation measures	Risk after mitigation measure		
				P	C	R		P	C	R
I.	**Transfer and discharge of HW into storage vessels**									
A	**Continuous loss of hazardous wastes due to mechanical failure**									
A1	Exceeding the permissible pressure during transfer	- Failure in pump's controlling system - Blockage inside the pipelines or pumps	- An increase in the pressure which might lead to an elimination of hazardous waste - Contamination of soil and emission of toxic wastes into the ecosystem - Potential source of fire or explosion hazard	3	3	9	- Periodic maintenance of equipment and instrumentation - Leakage detecting and collecting systems - High pressure valve to avoid failure due to pressure increase - Pressure indicator, alarm and controller system	2	2	4
A2	Degradation due to corrosion, aging of equipment or vibrations	- Advanced corrosion of the storage vessels - Corrosion of the pipelines - Corrosion of the pumps - Aging of sealing at joints	- Leakage of hazardous liquid wastes - Elimination of hazardous wastes inside the emplacement with possible contamination of the environment	4	3	12	- Periodical maintenance of the vessels and corrosion protection by painting; cathodic protection of vessels and pipelines; - Leakage detecting and collecting systems	2	2	4
II.	**Decantation of oil and petroleum products: high waste water content, temperature: 60 °C**									
B	**Continuous loss of hazardous wastes due to mechanical failure**									
B1	Exceeding the permissible capacity of the decantation unit	- High flow rate of the hazardous liquid wastes into the decantation unit - Blockage at the exit point of liquid wastes from the decantation unit	- Continuous release of hazardous liquid wastes next to the decantation unit and contamination of the environment	3	3	9	- High flow rate indicator, alarm and control - Removal of course parts of the waste by mechanical filters; - Leakage collecting system; - Periodical supervision of the decantation process by operator;	1	2	2

No.	Possible Hazard*	Cause	Consequence	Risk before mitigation measures			Possible risk mitigation measures	Risk after mitigation measure		
				P	C	R		P	C	R
B2	Exceeding the permissible temperature of the liquid waste	- Excess heating of liquid waste and increase of temperature above 60 ºC	- Volatilization of organic components from the petroleum waste; - Potential formation of explosive atmosphere	3	4	12	- Temperature sensor, indicator and alarm;	2	2	4
III. Dehydration: medium waste water content, temperature 110-120 ºC										
C	**Fire or toxic emissions from inside the equipment**									
C1	Exceeding the permissible temperature in dehydration processes	- Failure in the functioning of the temperature control system	- Reaching the flash point of one of the petroleum waste components, leading to a fire inside the dehydration equipment	3	5	15	- Temperature sensor, indicator and alarm; - Installation of fire extinguishing systems; - Ventilation of the building to avoid accumulation of explosive athmospheres.	2	4	8
IV. Demulsification in Hub2: low waste water content, temperature: 110-120 ºC										
D	**Fire or toxic emissions from inside the equipment**									
D1	Exceeding the permissible temperature in demulsification processes	- Failure in the functioning of the temperature control system	- Reaching the flash point of one of the petroleum waste components, leading to a fire inside the demulsification Hub2	3	5	15	- Temperature sensor, indicator and alarm; - Installation of fire extinguishing systems; - Ventilation of the building to avoid accumulation of explosive athmospheres.	2	4	8
D2	Failure in flammable vapor or fire detecting system	- Failure of flammable gas or vapor senzors - Failure of fire detection system	- Accumulation of flammable vapors in Hub2 and increase of pressure - Fire spreading to other equipment	3	5	15	- Periodic maintenance and testing of the sensors	2	4	8

No.	Possible Hazard*	Cause	Conse-quence	Risk before mitigation measures P	C	R	Possible risk mitigation measures	Risk after mitigation measure P	C	R
E	**Vapor cloud explosion inside demulsification Hub2**									
E1	Failure in flammable vapor detecting system	- Failure of flammable gas or vapor senzors	- Accumulation of high concentra-tions of flammable vapors - Explosion of vapors	3	5	15	- Periodic maintenance and testing of the sensors - Ventilation of the building to avoid accumulation of explosive athmospheres.	2	4	8
E2	Insufficient protection against earth-quakes	- Bad design of building or equipment	- Elimination of flammable hazardous wastes into the surround-ings in uncontrolled quantities - Collapse of installations - Potential fire and explosion	2	5	10	- Applying earthquake resistant design; - Protection of utilities against earthquakes; - Specific emergency planning for Natech situations;	1	4	4

Table 3. *Risk matrix of the HW treatment process – without mitigation measures (red text); with mitigation measures (black text)*

			Consequences				
			Insignificant	Minor	Moderate	Major	Catastrophic
			1	**2**	**3**	**4**	**5**
Likelihood	Improbable	**1**	*1*	*2: B1*	*3*	*4: E2*	*5*
	Isolated	**2**	*2*	*4: A1, A2, B2*	*6*	*8: C1, D1, D2, E1*	*10: E2*
	Occasional	**3**	*3*	*6*	*9: A1, B1*	*12: B2*	*15: C1, D1, D2, E1*
	Probable	**4**	*4*	*8*	*12: A2*	*16*	*20*
	Frequent	**5**	*5*	*10*	*15*	*20*	*25*

As it can be noted from the risk matrix, without mitigation measures the risk of the HW treatment process ranges between 9 and 15, representing potential threats that need to be immediately dealt with, by applying prevention measures, stringent operating procedures, periodic maintenance and consequence mitigation measures in case of accidental release of hazardous liquids or vapours.

After introducing mitigation measures, it is evident that the risks have been significantly reduced and are now within permissible levels, categorized as either low or moderate. This indicates that normal or specific operational and maintenance procedures should be followed.

However, the most hazardous stage was identified being the Demulsification in Hub 2, where hazardous wastes are heated up to 120˚C. Therefore, hazards such as flammable vapor release and explosion were identified with the highest risk level and computer simulation via software EFFECTS were carried out in order to quantify the potential consequences on human health (figure 3). The explosion scenario considers the release of

Fig. 3. *Vapor-Cloud Explosion consequence areas from Computer Simulation –Effects*

flammable vapours in the Hub 2 building and ignition of the cloud when it reaches the Lower Explosion Limit. The estimated quantity of Fuel Oil vapours (the material used in the simulations) is 5.6 kg.

The effects of the Vapor-Cloud Explosion are presented in Fig. 3 in terms of buffer zones that differ in their pressure intensity. The overpressure levels have been set based on the provisions of Ministerial Order 156/2017 on the development and testing of emergency plans (MIA, 2017).

Within the zone marked by the orange circle, the overpressure generated by the explosion can reach or exceed 140 mbars, potentially leading to severe consequences for human health, including the risk of fatalities. In the area between the orange and yellow circles, where overpressure falls within the 70-140 mbar range, irreversible effects on human health are anticipated, such as hearing loss due to eardrum rupture and mild lung impairment. In the area between the yellow and blue circles, which extends beyond the site's boundaries, overpressure in the 30-70 mbar range is expected, causing effects such as the breakage of windows and mild health impacts on humans.

In the risk analysis other types of hazards for human health and environment were identified, such as odour levels, noise pollution, potential leakages of petroleum product and oily water leading to groundwater and environmental pollution.

Protective measures for containing the consequences of these hazards have been recommended in the PHA report. The presence of the concrete walls around Hub 2 and the site boundaries are reducing some of the effects of potential accidents and noise pollution.

CONCLUSIONS

Urban activities are the primary drivers of the increasing quantities of hazardous waste generated each year, resulting in significant environmental and health consequences. Hazardous waste possesses specific harmful properties that necessitate specialized management. In this study, it was demonstrated that the analysed process does not pose a significant risk. Furthermore, the site does not fall under the provisions of the Seveso Directive, and the hazardous waste contains a high-water content, exceeding 70%. However, some stages of the treatment process may present accident risks.

Nevertheless, uncertainties in the study are still associated with the hazardous wastes content and its flammability, as well as the precise dimensions of the hub where an explosion could occur. The presence of concrete walls serves as a protective layer in the event of a Vapor-Cloud Explosion, potentially containing the consequences within the site area and ensuring that the nearby population remains unaffected by this type of accident.

The results of such risk assessment studies can facilitate decision making in land-use and emergency planning procedures.

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THE IMPORTANCE OF USING MULTIPLE WATER SOURCES AND BACK-UP SYSTEMS FOR WATER SECURITY – CLUJ-NAPOCA AREA

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ABSTRACT. This article examines the water sources and treatment techniques applied in the area of Cluj-Napoca, Romania. Alternative sources, including both surface and subsurface sources, are emphasized. The circumstances are compared with those of similar companies in Romania or abroad, to evaluate CAS's operational environment and its potential impact on water security. Additionally, the paper analyses the main legal provisions aimed at securing the groundwater harvesting system (including the one located between Florești and Cluj-Napoca. Finally, the author proposes measures to secure the water supply to consumers.

Key words: *water sources surface subsurface treatment.*

INTRODUCTION

Water is an extremely important resource and a necessary condition for the social and economic development of the society. Pressure on the water sources is high, and it will continue to increase due to the population growth, improvement of the living standards, climate change, and other factors.

According to the US Geologycal Survey (2020), at a planetary level, water available for consumption is a very small percent compared to the total water volume of the hydrosphere, and it is unevenly distributed. Thus, needs are not met everywhere. Therefore, each water source needs protection and appropriate management.

The present work aims to make a contribution to increasing water security in Cluj-Napoca area and implicitly to contribute positively to the quality of life of the end-users that benefit of the water supplied by Someș Water Company (CAS). The availability of multiple water sources can restrain the gap between demand and supply (Elliott et al., 2019) and (Nel et al., 2017) attest that the use of multiple water sources is fundamental, particularly in developing countries, and, according to Van Koppen et al., (2020), is relevant not only in terms of water security but in global development and health issues.

In our view, water security is based on 3 pillars/coordinates: accessibility, quantity and quality (figure 1). Affecting any of the 3 elements involves risks for the users of this indispensable product for life. Stringer et al., (2021) have a similar view on the concept of water security, while Shrestha et al. (2018), have a more complex one. Leong (2016) states that defining water security is much more difficult to achieve because it can be viewed from different perspectives.

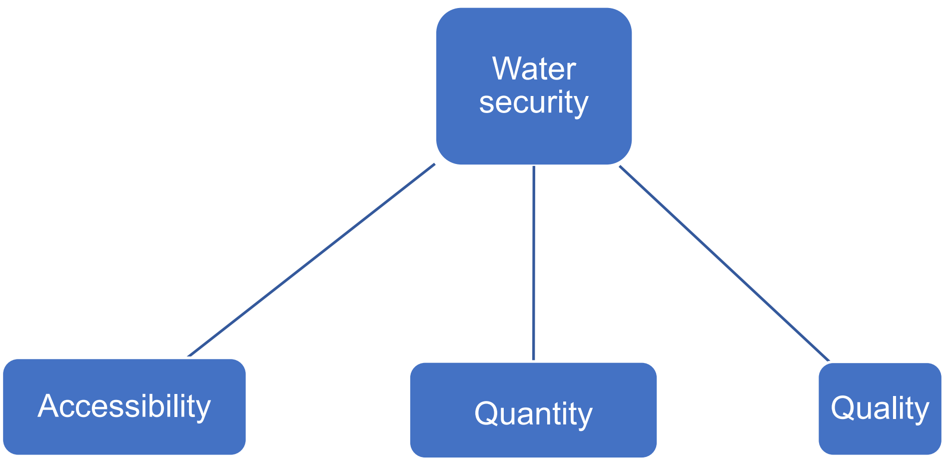

Fig. 1. *Author's concept regarding water security*

On the other hand, from the perspective of Zhou et al. (2023), water security is an interconnection between demand (caused by anthropogenic activities) and supply (generated by climate change and consumption reduction policies/technologies).

According to the previous authors, the following threats can affect water sources:

- climate change, terrorism and sabotage – may affect all of the 3 pillars (Gosling and Arnell, 2013; Falconer, 2022);
- lack of diversity of water sources – can affect the quantitative pillar;
- pollution or poor monitoring of water sources – can affect the quality pillar;
- corruption, political interests or legislative deficiencies – whose impact is more difficult to analyse.

This article focuses on the importance of having access to multiple water sources in the area of Cluj-Napoca, thus addressing the risks on the quantity, and, secondarily, on the accessibility of water sources that satisfy customer's needs.

HYPOTHESES AND OBJECTIVES

Our approach is based on the hypothesis that the existence of multiple water sources increases the security of water supply to the customers.

The objectives of the work are:

a. To evaluate the importance of the groundwater source that supplies the municipality of Cluj-Napoca, and analyse of the main threats and the legislation that should address them.

b. Comparing the Someș Water Company's strategy with other companies from the same sector in Romania and abroad, regarding the plurality of water sources.

METHODOLOGY

Current situation review – Relevant case studies

In order to develop a pertinent analysis regarding the importance of water sources diversity in the municipality of Cluj-Napoca, a comparative analysis will be conducted to assess the current situation in this area and compare it with other regions in Romania and abroad.

The current situation in Cluj-Napoca

Over time, as the population has increased, every public utility system has endeavoured to fulfil the requirements of its recipients. The water management system of Cluj city was also subject to this. According to the water supply operator Compania de apă Someș (2020), in 1882, when the city had a population of 35,000 residents, the Water and Sewerage Plant was established. It obtained its water supply from the "Bărnuțiului Garden", which provided 1,700 m^3 per day, and the "Carolina" hospital reservoir, with a capacity of 140 m^3. The plant also had a water distribution network that spanned 4.4 kilometres, and a sewage network that covered 0.13 kilometres.

The "*Floresti*" groundwater source became operational in 1900, resulting in a production increase of 7,500 m^3/day. Furthermore, a reservoir with a capacity of 2,000 m^3 was also put into operation. The city's water network reached a total length of 42.3 kilometres for distribution and 20.6 kilometres for sewerage pipes. After an interval of 19 years, the "Șapca verde" capture front was activated within the "*Florești*" groundwater harvesting area. The Water and Sewerage Plant was established as a Public Authority in 1930. Simultaneously, the Grigorescu Plant commenced operations, along with the *Captația I* capture front near Florești. In a period of 10 years, the city of Cluj has expanded its network to cover a total of 160 kilometres of distribution, 79 kilometres of sewerage, and has established 6,950 connections to accommodate its population of 116,500 individuals A daily production of 18,500 cubic metres of water was achieved.

With the establishment of the treatment plant at Gilău in 1973, Lake Gilău became the primary water source for the city, supplying approximately 60,000 cubic metres per day.

The official inauguration ceremony of the Tarnița raw water intake (figure 2) occurred on May 7, 2009. This event marked the transition of Lake Tarnița, which has a capacity of 70 million m^3, to become the primary source of raw water for the Cluj zonal system. As a result, lakes Gilău and Someșul Cald were designated as backup sources.

Upstream from the Cluj-Napoca municipality there is a string of 5 lakes (figure 3), with different volumes (Hidroconstructia 2020): Fântânele (212 mil. m^3), Tarnița (70 mil. m^3), Someșul Cald (7,5 mil. m^3), Gilău 4 mil. m^3 and Florești 2 (1 mil. m^3).

Fig. 2. *Tarnița raw water intake and its protective buoys*

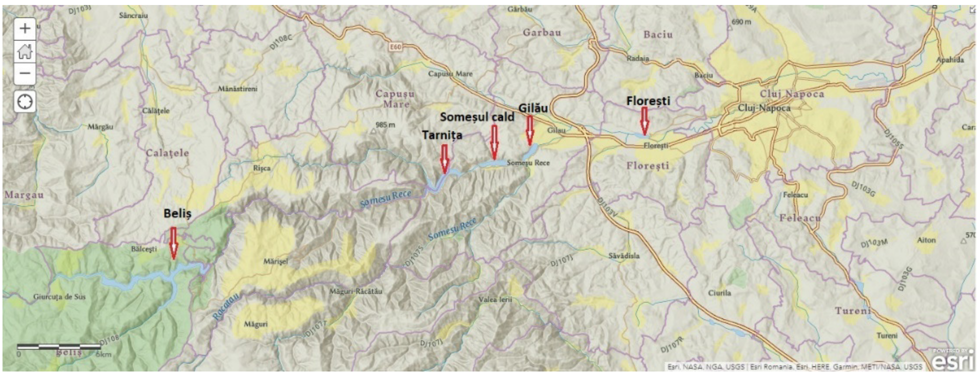

Fig. 3. *Lakes located upstream of the municipality of Cluj-Napoca (Hidroconstructia 2020)*

It is noteworthy that on October 14, 1992, the "Someş" Water Company (formerly referred to as the Cluj County Water-Sewerage Autonomous Administration) opened the first and only Water Museum in Romania. The museum is located in the groundwater collecting area near Florești. This source continues to supply water to the residents of Cluj-Napoca municipality. An approximate flow rate of 650-800 litres per second is acquired from this subterranean source. This product is then combined with water from the Gilău station at the Grigorescu pumping station.

The Someș Water Company primarily relies on the Lake Tarnița as its main water supply in the Cluj-Napoca region. The Gilău source is conserved as a reserve, while the Lake Someșul Cald serves as a backup for times when there is excessive turbidity or inadvertent pollution in the Gilău reservoir. In addition, the groundwater supply from Florești, where the Water Museum is located, is currently being utilised.

According to data from the CAS, the majority of water released to the beneficiaries in 2021 came from Lake Tarnița, ranging from 79.32% to 94.61%, as shown in figure 4. However, in September 2021, only little over 25% of the water was supplied from Lake Tarnița, with the remaining 70.4% coming from Lake Gilău. Moreover, water from this lake was used only in October 2021, accounting for 12.52% of the total usage, and in May 2021, accounting for 1.24%. The source of Someșul Cald is accessed on a monthly basis, albeit in limited quantities ranging from 1.69% to 11.69%. Its usage is most pronounced during the summer season. The Florești groundwater source consistently provides a minimal amount of water to the overall water supply of citizens, ranging from 1.29% to 2.71%.

According to the data received from the CAS (C. d. Someș 2024), the capacity of the Florești source is directly influenced by the amount of precipitation and the level of the Someș Mic River, and the yield may vary between 650-850 litres per second. Moreover, CAS states that the Florești source has an annually contributes of 25% to the total water supplied. Our conclusion is that the Florești source operates at a low level, but its potential is much higher, meaning that it can make a major contribution to securing the supply of water to the population.

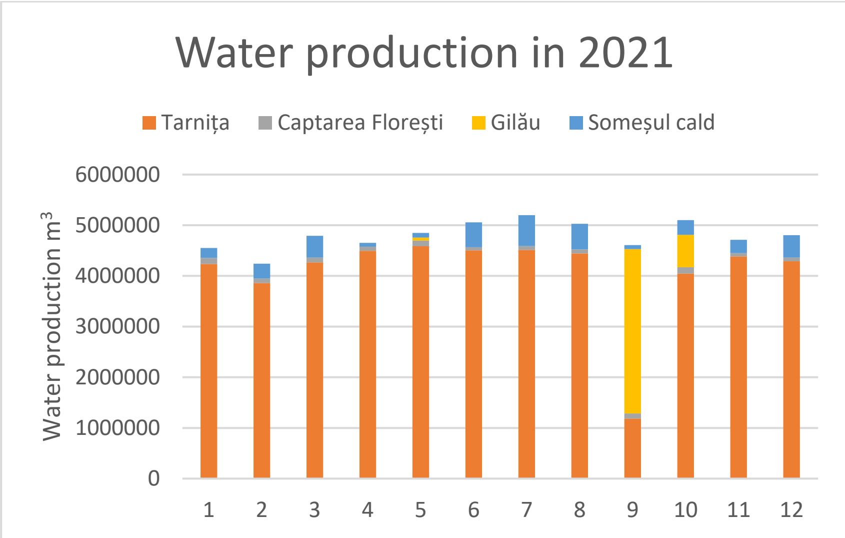

Fig. 4. *Water production 2021*

The Florești groundwater source is vulnerable to several threats. The mass-media (Monitorulcluj, 2017; Acualdecluj, 2020) has circulated ideas of changing the area into a park that can be accessed by citizens. Recently, the plans for the building of the upcoming road ring around Cluj-Napoca, which will be located adjacent to the sanitary protection zone, were initiated. Figure 5 depicts the trajectory of the forthcoming road. It is evident that, despite the challenging terrain, the route will adhere to the left side of the Someșul Mic River, so avoiding the designated protection area (highlighted in red). This approach aims, at least in theory, to comply with the current legal regulations.

The local authorities have signed a financing agreement to enhance the efficiency of the groundwater source. This agreement entails the refurbishment of more than 100 wells, over 19 kilometres of drainage and piping, the renovation of the chlorination system, and the implementation of a new SCADA monitoring and control system for the Florești groundwater collection system.

The majority of the funding for this project comes from European sources, and the project is scheduled to be completed by 2024 (zcj.ro, 2022). According to the beneficiary (C. d. Someș 2024), these works will not result in an augmentation of production capacity. Furthermore, the Someș Water Company operates according to a strategic plan that seeks to enhance the distribution and sewerage networks. Utilising a mathematical model and informatic tool as decision support can be highly advantageous for water resource management, particularly in cases where there is a combination of surface and groundwater resources (Pacheco and Pissarra, 2023; Yin et al., 2023).

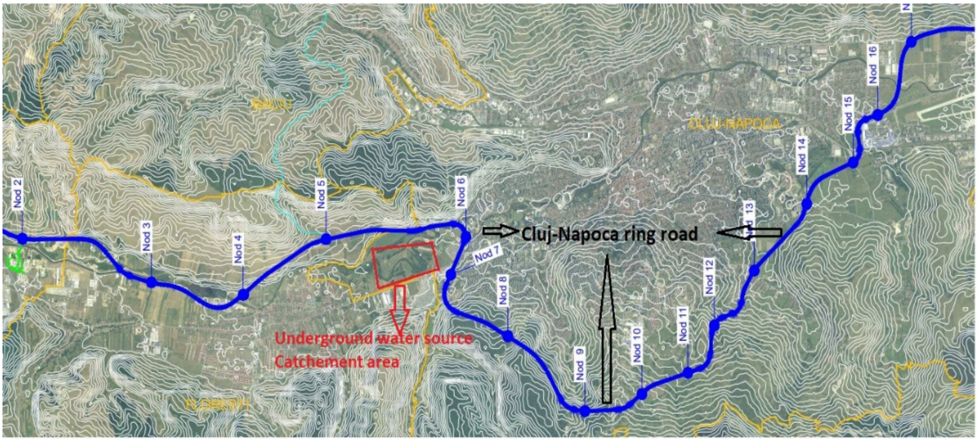

Fig. *5.* *Cluj-Napoca ring road* (G4media.ro, 2019) *vs. Floresti groundwater collection area*

Regulatory system

The water regulatory framework in Romania consists of a series of laws, Government Decisions, EU directives, and other related regulations. Among the most relevant are the Water Law 107/1996 and HG 930 of August 11, 2005 for the approval of the Special Norms regarding the nature and size of sanitary and hydrogeological protection zones.

By decision of the Cluj County Council no. 147 of 15.11.1994, Lake Tarnița was declared a protected natural area. Additionally, by order 951 of July 5, 2021 issued by the Ministry of Transport and Infrastructure, the use of boats that use fossil fuels directly or indirectly (generators) is prohibited. Furthermore, it is prohibited to sail within 200 m of the dam (which includes the area of the water intake tower).

The extension of the protection zones is established according to Annex no. 2, which is an integral part of the law 107/1996. Relevant data for the analysed area can be found in table 1.

Table 1. *Protection zones extension*

Protection zone extension along water courses			
Watercourse width (m)	10-50	51-500	Above 500
Protection zone width (m)	15	30	50
Protection zone extension in lakes			
radially, on the shore			(100 m)
radially, on the shore where the outlet is located			25 (m)

Regarding the groundwater collection system from Florești and the projects that could influence it, it's worth mentioning some of the most important legal regulations in force designed to ensure its protection against such intentions. Acting in accordance with 107/1996 and HG 930/2005 (especially Art. 26 and 27), building the Cluj Metropolitan Ring Road within the groundwater collection area is not allowed. Although some similar areas in the Netherlands (a country subject to the same legal provisions established by European legislators) also fulfil the function of a relaxation area, this area cannot be transformed into a recreational area, with pedestrian or bicycle lanes, located at safe distances (minimum 20 m) from the collection wells, as required by the National Administration of Romanian Waters (2017). The high number of wells and their layout make the sanitary protection zones overlap, resulting in an extended area that must be protected against external interventions.

Case studies (from Romania and abroad*)*

Apanova – Bucharest is 73% owned by the French company Veolia (Apanova, 2020).

Surface sources: multiple catchments on Dâmbovița and Argeş Rivers. Treat the water in the three treatment stations:

- Arcuda station – source: River Dâmbovița, commissioned in 1892 – capacity 650,000 m^3/day.

- Roșu Station – source: River Argeș, put into operation in 1970 – capacity of 520,000 m^3/day.

- Crivina Station – source: River Argeș, commissioned in 2006 – capacity of 260,000 m^3/day.

Treatment process: Filtration (grating), Coagulation/flocculation, Sand bed filtration, Ozonation, Chlorination.

Compared to the Someș Water Company, Apanova only uses surface sources. It should be noted that, in order to secure their supply, two sources are being used and the water is treated in several stations.

Brașov Water Company - owned by the Municipality of Brașov and the County of Brașov, with 42% each, the rest being owned by the cities of Rupea, Ghimbav and the communes of Apața, Hălchiu, Harman and Sânpetru (Compania de Apă Brașov, 2020).

Surface sources:

Lake Târlung, the most important source that covers more than 90% of the supply system; Lake Dopca, the water supply source for consumers in the Rupea, Racoș, Dopca area.

Groundwater:

• the Harman – Prejmer groundwater collection area: it includes 45 wells that operate at a depth of 40 m and are equipped with submersible pumps, with a total capacity of 1900 l/s (property of the Brașov National Land Improvement Agency);

• Măgurele groundwater collection area: with 3 deep wells, serving only Poiana Brașov;

• the Ghimbav groundwater collection area: includes 3 wells drilled at a depth of 45 m, with a total capacity of 26 l/s;

• the Stupini-Sânpetru-Hărman groundwater collection area: includes 30 wells operating at a depth of 150 m, with a total capacity of 810 l/s.

Treatment process: Pre-treatment, Chemical dosing, Sand bed filtration, Chlorination.

Comparing the Brașov Water Company with the one in Cluj, certain similarities can be noted: the existence of a main surface accumulation type source (Lake Târlung vs. Lake Tarnița) as well as a groundwater collection system (with a higher flow rate than Florești).

Apa Canal Sibiu SA – 99.89% owned by Sibiu Local Council, the rest being owned by 29 other local councils (Apă Canal Sibiu S.A., 2020).

Groundwater:

The groundwater collection system from Lunca Ştezii started to operate in 1879, with a yield of 900 litres/minute, enough to cover the consumption of the approximately 20,000 inhabitants of Sibiu at that time.

In 1909, the aqueduct from Păltiniș was put into operation, transporting water from an array of springs in the Şanta area. The network was developed in 1922 and 1928, when the springs from the Dăgneasa and Cotorăşti area were captured.

Surface sources:

In 1965, a reservoir was built on River Cibin, upstream from the town of Gura Râului, and also a water treatment station near the town, close to Poplaca. The treatment capacity of the "Dumbrava" plant was 480 l/second, being increased, following further expansion works, in 1977, to 900 l/second.

Surface water accumulations:

In 1979, a new adduction with water coming from the Gura Râului Reservoir, a hydropower complex that could store 15.5 million m^3 of water, was put into operation.

Compared to the situation in Cluj, the one in Sibiu evolved in a similar way. Although springs were used at the beginning, later on, a surface source of accumulation type + hydropower complex was put in place.

Alba Water Company – SC APA CTTA SA ALBA (SC APA CTTA SA Alba, 2020); the company's shareholders are the Alba County Council and the local councils from the 11 municipalities and towns of Alba County (Alba Iulia, Abrud, Aiud, Baia de Aries, Blaj, Câmpeni, Cugir, Teiuș, Zlatna, Ocna Mureș, Sebeș).

Surface sources:

Surface water facilities:

Obrejii de Căpâlna reservoir (River Sebeș) (3,000,000 m^3/capacity).

Petrești treatment plant, with a total capacity of about 75,000 m^3/day works at about 23% of capacity. It provides water to approximately 30% of the residents in the municipality of Alba Iulia.

Sebeşel treatment plant has a total capacity of 86,400 m^3/day, and it is working at about 40% of capacity. It supplies water to approximately 44% of the population of the municipality of Alba Iulia, 89% of the municipality of Blaj, 56% of the municipality of Aiud, 60% of the city of Ocna Mureș and 70% of the city of Teiuș.

Mihoiesti reservoir (on River Aries), and Mihoiesti Câmpeni treatment plant, has a total capacity of 11,232 m^3/day, and it is working at about 38% of capacity. It supplies water to approximately 55% of the population of Campeni.

The Râul Mare Cugir treatment plant, with a total capacity of 35,510 m^3/day, works at 28% of capacity. It supplies water to approximately 65% of the population of Cugir.

Buninginea – Abrud treatment plant has a total capacity of 2,851 m^3/day, and it works at 28% of its capacity. It supplies water to approximately 67% of the population of Abrud.

The Zlatna treatment plant – total capacity of 57,024 m^3/day – is operating at 3% of capacity. Powers approx. 63% of the population of Zlatna.

The Hărmăneasa – Baia de Ariesș treatment plant - total capacity of 432 m^3/day - is working at 39% of capacity. Powers approx. 9% of the population of Baia de Aries.

The Tarina – Baia de Arieș treatment plant - total capacity of 1,720 m^3/day - is working at 29% of capacity. Powers approx. 37% of the population of Baia de Aries

Compared to the CAS, the counterpart in Alba treats the water needed by the municipality of Alba Iulia in two stations, also fed from a surface reservoir, this being the only source for the respective area.

Oradea Water Company (SC Compania de Apă Oradea SA, 2020).

Groundwater:

The company uses 5 water plants located on the two banks of the River Crișul Repede, in the northeastern part of the city, with a total installed pumping capacity of 2,100 l/s. The raw water is collected from the shallow aquifer through drains. In order to enrich the underground water layer, the 23 basins fed by River Crișul Repede through the adduction pipes from the catchments are used.

The existing technology also allows the use of surface water, captured from the River Crișul Repede and then treated accordingly. This solution is a backup one, preferring underground water, which is also of better quality and cheaper, requiring only chlorination as treatment.

The entire catchment system, water adductions, enrichment basins, infiltration fields, water plants are located in a protection zone with a severe regime with an area of approximately 280 ha.

Compared to CAS, Oradea Water Company has a totally different approach. Although it has only one source, which is of underground type (or, if necessary, of the underground/surface hybrid type), the security of the supply is ensured by 5 treatment stations.

APASERV Satu Mare SA was established in 2004, being a joint stock company. The shares are owned by 52 administrative-territorial units from Satu Mare county, the majority shareholder of the company being the municipality of Satu Mare (Apaservsm, 2020).

Groundwater:

Currently, the drinking water supply for the municipality of Satu Mare is provided by the groundwater contained in the alluvial cone of the River Someș through the existing catchments.

Groundwater collection is carried out by pumping from the Mărtinești-Noroieni-Micula collection system, composed of 60 wells (46 of which are usable) - with a maximum collection capacity of approximately 850-900 l/s.

Water treatment is done by: aeration, filtration for demanganization and deferrization, chlorination.

The situation in Satu Mare is different from that in Cluj-Napoca, as groundwater only is used.

SC VITAL SA Baia Mare was established as a commercial company in the summer of 1997, following the reorganization of RASP URBIS Baia Mare, keeping the same activity profile: the provision of water and sewage services to users in the area of operation (Vital, 2020).

Surface sources:

Surface water accumulations:

The treatment plant of Baia Mare (950 l/s capacity) is supplied with raw water from the Strâmtori-Firiza reservoir through the Berdu buffer lake downstream of the dam. In addition, the Ferneziu micro-plant and the Blidari treatment plant are also used.

Treatment process: Filtration (grating), Coagulation/flocculation, Sand bed filtration, Chlorination.

Compared to CAS, VITAL SA uses raw water from two reservoirs, which is treated in a single station.

SC Aquabis S.A – Bistrita is mostly owned (89.9%) by the Bistrita County Council, together with 12 local councils in the county (Aquabis, 2020).

Surface sources:

Surface water accumulations: Colibiţa reservoir.

Running water sources: the Rivers Bistrita Ardeleană, Anies, Rebra, Someșul Mare.

Treatment process: filtration (grating), coagulation/flocculation, filtration through sand basins, chlorination.

Compared to Cluj, there is no groundwater source in use.

APA PROD S.A. Deva was established in 2001. The company manages 19 water collection stations, 15 water treatment stations, 4 chlorination stations, 54 water storage complexes and 51 water pumping stations. The length of the supply mains is 184.5 km, and the distribution networks exceed 1090 km (Apaprod Deva, 2020).

Groundwater:

In 1941, the construction of a water plant began - the Horogos Water Source, located north of Deva. The source was built in two stages: the first in 1941, and the second in 1962. Water capture at this source was done from a phreatic aquifer, by means of 14 drilled, shallow wells.

Surface sources:

Running water collection

In 1963, it was decided to create a new water supply source in the village of Batiz, on the left bank of the River Strei.

Surface water accumulations:

In the period 1984-1985, the Orlea Water Source was built, having its intake on the Hațeg reservoir.

Treatment process: Filtration (grating), Coagulation/flocculation, Sand bed filtration, Chlorination

Compared to their counterparts in Cluj-Napoca, Apa Prod Deva had a similar evolution of raw water capture. If initially groundwater was used, currently the main source is surface accumulation.

The Aquatim – Timișoara company is owned by the Timișoara Local Council (99%) as well as by other local councils or the County Council (Aquatim, 2020).

Groundwater:

In 1914, the water plant no. 1 (currently - Urseni water treatment station) which treats and distributes water collected from underground – 600 l/s.

In 1991, the Water Plant no. 5 (currently - Ronat Water Treatment Station), as a secondary source of deep water.

Surface sources:

In 1959, the water plant no. 2, captures and treats water from River Bega at the (initial) capacity of 115.7 l/s. – currently 1,380 l/s

In 1982 - Plant no. 2 is expanded by building in the same location the Plant no. 2-4 (currently the Bega Water Treatment Plant) – 900 l/s.

Compared to CAS, which uses raw water from an accumulation, the counterparts in Timișoara capture water from River Bega. For technical reasons, they have several treatment plants, compared to those in Cluj who have only one. The only similarity is given by the capture from underground sources as well.

From abroad:

PWN – The Kingdom of the Netherlands (PWN, 2020)**.**

Surface sources:

Lake Ijessel - where the River Rhine flows.

Groundwater:

The sand dune area – underground slow filters Heemskerk area – which provides 45% of the water needed by the customers.

Annually, the company supplies 112 million m^3 of water to its 1.7 million customers.

The company uses 4 treatment plants: Andijk, Heemskerk, Bergen and Wijk aan Zee.

- the one from Andijk (Ijessel source), which uses the treatment scheme: grates coarse filtration - the use of resin that absorbs organic material and NO^3/Ceramic membrane microfiltration (this represents a pretreatment that replaces the classic coagulation/flocculation/sand basin filtration technology) - advanced oxidation (H_2O_2+UV) - filtration through biologically activated carbon.

- The one in Heemskerk (Ijessel source, 50 km away) which uses the treatment scheme: coagulation/flocculation/filtering + biologically active carbon (as well as pretreatment) - advanced oxidation (H_2O_2+UV) - infiltration through dunes. In parallel, there is an ultrafiltration/reverse osmosis line (Kamp et al., 2000). Once the water is excessively purified, it is mixed with water that is collected from the nearby dunes, so that it can be consumed by the beneficiaries (edie.net, 2011).

Slow filtration through the sand dunes (approx. 30 days) – a natural area (Natura 2000 site) of approx. 7300 ha, of which only 5% is used for filtration. Although the dunes represent only 0.5% of the surface of the Netherlands, over 50% of the country's biodiversity can be found in this area (Dutchnews, 2018). The water infiltrated into the dunes also comes from Lake Ijssel.

Compared to CAS, the Dutch from PWN use only one source of water, Lake Ijssel, but the treatment process takes place in 4 stations, and the technology used is clearly advanced to that applied in Cluj-Napoca.

Waternet – The Kingdom of the Netherlands (Waternet, 2020)**.**

Surface sources:

The Bethune polder – from where the pumped water is treated at the station in Loenderveen. In cases of drought, water is supplied from the Amsterdam-Rhine canal.

Lek Canal – Bethunepolder catchment area near Maarssen. The canal is fed by the River Rhine. After a coagulation/flocculation/sand bed type pretreatment, the water is pumped into the dune system (slow filters) Amsterdamse Waterleidingduinen – filtration time approx. 3 months (near Haarlem), refiltered through sand to remove algae, then pumped to the Leiduin treatment plant. Here, the water is subjected to a treatment process by ozonation (15 minutes), softening (up to 7.8 German degrees) and filtration through biologically activated carbon. Annually, 70 million m^3 of water is filtered through the respective dunes.

Compared to Compania de Apa Someș, Waternet, like PWN, uses water from River Rhine. They have two sources, and the treatment process is different, much more advanced than the one in Romania.

New York table (New York City water supply system, 2020).

It consists of 2 lake arrays:

- Croton, east of the Hudson River – composed of the following lakes: Boyds Corner, West Branch, Glaneida, Gilead, Middle Branch, Bog Brook, East Branch, Diverting, Craton Falls, Titicus, Kirk, Amawalk, Muscoot, Cross River, New Croton and Kensico.

- Catskill/Delaware west of the Hutson River – composed of the following lakes: Cannonsville, Pepacton, Schoharie, neversink, Rondout, Boys Corner, West Branch and Ashokan.

From the two rivers, water reaches the city through three aqueducts: Croton, Catskill and Delaware. The water company delivers daily over 3.75 million m^3 to 10 million customers.

Its treatment consists of: coagulation/flocculation, sand filtration and a double disinfection: chlorination and UV.

It is of interest that until 2007, a water supply system consisting of 67 wells, from where the water reached 43 stations and several storage tanks, also operated in the SE of Queens. The system was put into operation in 1887, until 1996 it was owned by the private Jamaica Water Supply Company (JWS).

RESULTS AND SUGGESTIONS

Someș Water Company is an entity that has undergone changes over time, aiming to meet the specific demands of its consumers and adhere to legislative regulations concerning water quality.

From a quantitative point of view – supply security is ensured using raw water from the Lake Tarnița, with the Lakes Gilău and Someșul Cald as reserves. Underground catchments have not been abandoned, although their contribution is low. On the other hand, their potential is higher, being able to provide up to 25% of the water requirement, at least for short periods. The groundwater collection area between Florești and Cluj-Napoca, although comparable to the dune area in Holland, must remain restricted to the public, due to water quality protection and safety reasons. The legislation in force protects this area against building initiatives.

Analysing the raw water sources and the number of treatment stations, the Someș Water Company's strategy compared to that of other similar companies in Romania, can be classified as follows:

- similar: Brașov Water Company (using a lake as the main source and groundwater as a secondary source), SC. Apa Prod SA Deva (initially they captured water from underground sources, later from a well, and finally, from a reservoir).

- partly similar: Apa Canal Sibiu (using a lake as the main source and springs as secondary sources), SC APA CTTA SA Alba (uses water from only one lake to supply the municipality of Alba Iulia, without secondary sources; on the other hand, the treatment takes place in two stations), VITAL SA Baia Mare uses raw water from two reservoirs, which is treated in one station, Aquabis (uses raw water from a reservoir for the municipality of Bistrita, without groundwater extraction).

- different: Apanova Bucharest (takes water from two rivers, using 3 treatment stations), Oradea Water Company (takes groundwater from the banks of the River Criș, but purifies it in 5 stations), SC. APASERV Satu Mare SA (has only one groundwater source), Aquatim Timișoara uses both surface and groundwater, and 5 treatment stations are in operation.

As shown by the previous comparison, most water companies in Romania use an existing reservoir from their area as their main water source, especially in the hilly/mountainous area, where such hydrotechnical constructions are easier to build. The three examples that do not benefit from such a source are in lowland areas.

Another important aspect is that 4 of them have two or more treatment plants, which is a big plus for the supply security in case one of them should fail. A possible breakdown of the Gilău water treatment station would represent an absolutely critical situation for CAS, which would not be able to deliver the necessary water using only the Florești source. As for the treatment process, it is identical, except for Apanova, which also applies ozonation. For economic reasons, the treatment process must be chosen according to the raw water quality. Thus, water from a higher quality source requires a less intrusive treatment process.

Before comparing the Someș Water Company with the foreign counterparts listed in the previous chapter, it should be noted that these are much larger companies (in terms of number of end-users), and some are true pioneers in terms of the technology.

Thus, it can be seen that the counterparts in New York have abandoned groundwater, focusing strictly on the lakes from the upstream area. The existence of 3 water aqueducts that supply hundreds of treatment stations ensures the continuity of the supply in case one of these elements is taken out of use. As for the treatment process, it is similar to the one in Bucharest, having an ozonation step in addition to what the Romanian companies generally use.

On the other hand, as far as Dutch companies are concerned, the situation differs almost entirely. Since chlorination is no longer used as a disinfection method in the Netherlands, the relevant companies have adapted their treatment technology and modernized the distribution systems. Thus, PWN was the first company in Europe to implement processes such as ultra-filtration/reverse osmosis, advanced oxidation such as H_2O_2/UV or filtration through resins (to reduce organic material and nitrate)/micro – filtration through ceramic membranes.

Both PWN and Waternet utilises River Rhine (which ends up in either Lake Ijssel or the canal) as their main water source. In order to secure the water supply, treatment takes place in several stations. Complementary to the technological process itself, a large amount of water is infiltrated into sand dunes where it is naturally purified for several tens of days, thus increasing its quality in a cheap and non-invasive manner. The treatment process utilised in Romania is also used by the Dutch companies as a pre-treatment stage for the rest of the technological process. Because water culture is deeply rooted in the Dutch tradition, water companies continuously invest in research in order to develop innovative technologies. At the same time, it keeps the old treatment plants as backup options in case the new plants would fail.

In the process of optimizing/developing new treatment technologies, companies try to look to the future to understand what challenges might arise. Representative in this sense is the vision of PWN, which in their 2019 activity report expressed their concern about how global warming will affect the quality of the water source from Lake Ijessel, due to salinity increase. At the same time, a pilot process to build floating solar panel farms on Lake Ijssel to produce renewable energy was started. Romania's advantage in this sense is given by the fact that most of the hydrotechnical constructions are also equipped with turbines, thus the lakes are water sources and also green energy sources. Regarding the disinfection component of the treatment process, the use of chlorine can have beneficial effects in force majeure situations such as anthrax contamination (Raber and Burklund, 2010) because such spores can also be transmitted through drinking water (CDC, 2023).

It is important to mention that these companies operate in a country with a strong economy, which can afford to invest in technology in order to provide their citizens with a high-quality product.

A final important factor to consider is the particularity of the water sources. Whether we are talking about CAS, the counterparts from Romania or abroad, they are obliged by the existing regulations to supply a product that falls within the quality parameters. As a rule of thumb, the quality is good in the case of groundwater sources, but gaining access to it requires more resources.

Suggestions

Taking into account all the above-mentioned aspects (the existing situation in the area served by the CAS, as well as the policy pursued by some of its counterparts), the author proposes a series of measures, intended to contribute to strengthening the concept of water security, from the supply perspective. They will be grouped into 3 major directions: water sources, treatment and distribution (see table 2).

Table 2. *Measures proposed by the author*

Target item	Proposed measures
Water sources	- creation of supplementary intakes in the other available lakes - modernization and expansion of groundwater sources - keeping remote sources as backup sources - protecting the sources against external threats
Treatment	- construction of secondary stations - creation of new, parallel flows - modernization and expansion of existing treatment plants - increasing station security
Distribution	- the construction of secondary aqueducts. - securing the existing water aqueducts - classify the distribution network as a state-secret - efficient and innovative management - building large distribution basins along the network

The duality or plurality of water sources ensures the necessary volume in exceptional or *force majeure* situations. Regarding surface sources, the status of Lakes Gilău and Someșul Cald (as reserve water sources) significantly contributes to securing supply. They contribute to the accessibility and quantity pillars. We believe that the implementation of water intakes in each lake would not only increase the volume of water available, but would give the operator the opportunity to opt for the water that has the best quality at a given time, avoiding thus the limitations given by changes in the physical/chemical/biological parameters of a source at a given time, changes that would make water treatment inappropriate, or would involve high costs. Moreover, a larger volume would ensure water for the future customers of CAS, given the expansion of the distribution network in Sălaj county as well. Last but not least, according to the specialists from The Royal United Services Institute (2010) the availability of a large volume of water helps protect customers in the event of chemical or biological terrorist attacks, according to the principle "the solution is dilution".

Underground sources must continue to be a back-up solution, even if their contribution is reduced. In the case of CAS, this is important as there is no dependence of the Florești source on the Gilău water treatment plant, the only one operating in the area. Underground sources should be upgraded and expanded where possible. Additionally, new groundwater collection areas can be identified, especially in isolated areas, where there are no distribution systems or prospects for expanding the existing ones. Currently, such sources provide water to the towns of Jibou and Cehu Silvaniei (C. d. Someș, Casasomes.ro 2023).

Although the water main towards Sălaj county is under construction, we believe the Vârsolț source, which currently supplies the municipality of Zalău and the town of Șimleul Silvaniei, must be maintained as a reserve source in the future. Despite the fact that the water from this reservoir does not have the same quality as that from Lake Tarnița, it is the only major source in the area, which can be used in case the future main aqueduct suffers a major failure.

The existence of a sufficient number of water sources, or the construction of new ones, is the first condition for securing water supply. Furthermore, they must be subject to advanced protection measures to protect them from threats such as: pollution, terrorism or sabotage. The authorities should implement additional measures to reduce the risk of accidental or intentional pollution of water sources (e.g. securing and expanding sanitary protection zones, improving waste and wastewater collection systems in the vicinity of water sources, increasing controls, awareness activities, etc.). The war in Ukraine highlighted the importance of protecting critical civil infrastructures (energy or water), which are often the target of armed attacks or sabotage. Thus, the author believes that the water infrastructure must be considered a strategic objective, and thus benefit from increased protection: armed guard and video surveillance. In addition, the intelligence services must constantly watch over threats (hybrid or terrorist), which can target such objectives.

CONCLUSIONS

The existence of several water sources is an element that significantly contributes to securing the supply of beneficiaries. Groundwater collection systems are important backup options in case of major damage to the main systems. Regarding the Someș Water Company, the main vulnerability identified would be the existence of a single water main, which supplies the only existing treatment plant. A failure of any of these two elements would leave a large part of the Cluj-Napoca population without water.

For these reasons, the author proposes a series of measures, intended to contribute to strengthening the concept of water security, clustered in 3 major directions: water sources, treatment and distribution.

The Someș Water Company managed to adapt to local conditions (raw water sources, their quality, the supplied population, etc.). Despite the identified vulnerabilities, the company brilliantly fulfils its mission to provide its customers with safe water that complies with the national quality norms. Moreover, through the distribution network modernization programs, it is intended to reduce losses and maintain optimal water quality throughout the system.

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A COMPARISON BETWEEN WATER RELATED STRATEGIES – LEADING TO A PROPOSED ROMANIAN WATER SECURITY STRATEGY

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ABSTRACT. This article makes a comparative analysis between the National Strategy for Water Management in Romania draft (which is in the final steps of being approved), the Someș Water Company (CAS) master plan, the Romanian national management plan related to the Danube's River basin portion in Romania and the strategies of the authorities from England and those from the USA, which have a focus on water security. A comparison between the different paradigms of these 5 parties will be made, that will represent the basis of the author's proposal for an alternative National Water Security Strategy in Romania. At the end, the necessary recommendations will be made for the development of such a strategy as well as other recommendations in case it will not be developed.

Key words: *national water security strategy plan, concept of water security, water in Romania, water as an economic good, water quality in the environment.*

INTRODUCTION

Since water is a vital resource, individuals, communities or countries have always thought of measures to ensure water security. If on an individual level, people have found simple solutions to solve specific needs, on a macro level, countries have legislated to clearly establish how water can be used. However, there are countries or legal entities that decided to develop strategies in order to provide predictability, a *modus operandi* and accelerate the measures that must be implemented to ensure water security (Bakker, 2012) (Grey and Sadoff, 2007) (Shrestha et al., 2018) (Siskaa and Takara, 2015).

This article presents different (statal / company based) views on the concept of water security, views that have a direct impact on policy in the field. The strategies developed by the United States of America, England and the Someș Water Company (CAS) from Romania will be analyzed. It is important to mention that Romania is in the process of implementing a National Strategy for Water Management (NSWM).

Hypotheses and objectives

This article starts from two hypotheses. The first was that large state entities would develop water security strategies with a global impact. The second assumption is that smaller states will implement a national strategy that will coordinate the individual or joint efforts of water operators to achieve their objectives.

The objectives of this article are:

- to identify and compare water security strategies of some large, medium-sized state actors and Romania (through its regional operators).

- to identify those elements that can form the basis of an alternative Romanian water security strategy, a strategy that will later be put into practice by operators and local decision-makers

METHODS AND MATERIALS

In order to achieve the established objectives, public data and specialized literature were consulted, and, in the end, 5 distinct entities were chosen, three being state actors and two regional one.

United States of America

Although, at least at the declarative level, water security is important for each state, the actions by which it is ensured differ. One of the strongest signals in this regard is provided by the United States of America, which in 2017 developed a global water strategy, and in 2021 mentioned the importance of water security in the country's national security strategy (USA 2021). They have assumed the role of world leader with the vision of creating a safer world, where both the quantitative/qualitative people needs and the economic and environmental ones are satisfied, while managing to effectively deal with floods and drought (Brouwer et al., 2008) (Group World Bank, 2016).

Thus, if we take a look at USA's Strategy (USA, 2017), it can be seen that, in its 70 pages, 4 major objectives are established:

- Increasing access to drinking water and sanitation services,
- Water resources management – focused on the protection of fresh water sources
- Promoting cooperation regarding shared waters
- Strengthening the financing and institutions of the water sector.

The first objective aims to reduce mortality caused by lack of water or sanitation services, in conjunction with combating epidemics caused by Zika or malaria. This is to be achieved by increasing access to potable water. This way, the premises of more stable and responsible governments can be created, which through a domino effect, would lead to the reduction of conflicts, well-being, the reduction of social tensions that could lead to revolutions or could represent a suitable area for the recruitment of terrorists.

The second objective resides in the impact of pollution, increased demand or the drying up of some water sources could have on the GDP of some countries, which, according to the World Bank Group (2016), could decrease by 6-15%.

The third objective aims to reduce conflicts by promoting cooperation on shared water resources. According to the United Nations (USA, 2017), there are more than 260 river basins and 600 aquifers shared by two or more countries. Moreover, according to the United Nations Environment Programme (UNEP, 2002), in many of these cases there is no formal agreement or institutional relationship between the parties to regulate the use of these shared water resources. The US government intends to work to strengthen the political will for cooperation and to promote the development of agreements and mechanisms that support the cooperative management of shared water resources in regions where water is or may become a source of conflict.

The last objective is to strengthen the financing and institutions of the water sector. The US government will seek to strengthen governance, financing, and institutions in the water sector at all levels, with the goal of reducing dependence on donors and external actors. In order to act on the basis of the elaborated strategy, 5 measures are considered:

- providing technical assistance,
- investing in sustainable infrastructure and services,
- promoting science, technology, innovation and information,
- mobilizing financial resources,
- diplomatic approaches or strengthening partnerships, of intergovernmental organizations and the international community.

In fact, to implement this strategy, 17 institutions will work together, as shown in table 1, each with clearly defined tasks. This interdepartmental department will meet monthly in Washington DC as well as in countries where the US conducts missions.

Table 1. *Agencies contributing to the implementation of the global water strategy*[1]

Means of involvement	**Strategic objectives**			
	Objective 1	**Objective 2**	**Objective 3**	**Objective 4**
Technical support	CDC, DOI, EPA, MCC, NIST, USACE, USAID, USDA	DOI, EPA, MCC, NIST, USACE, USAID, USDA	DOI, DOS, EPA, USACE	DOI, EPA, MCC, USAID
Sustainable infrastructure and services	DOI, EPA, MCC, USAID	DOI, EPA, MCC, USAID, USDA	DOI, EPA	DOI, EPA, MCC, USAID
Science, Technology & Innovation	CDC, DOI, EPA, NASA, USAF, USAID	DOI, EPA, NASA, NOAA, USAID, USACE, USAF, USDA	DOI, EPA, NASA, NOAA, USACE, USAF	DOI, EPA, NASA, USAF, USAID
Resource mobilization	MCC, OPIC, USAID	MCC, OPIC, USAID	DOS	MCC, USAID
Diplomatic involvement	DOS	DOS	DOS	DOS

[1] CDC-Centers for Disease Control and Prevention; DOI – U.S. Department of the Interior (U.S. Geological Survey and/or Bureau of Reclamation); DOS – U.S. Department of State; EPA – U.S. Environmental Protection Agency; MCC – Millennium Challenge Corporation; NASA – National Aeronautics and Space Administration; NIST – National Institute of Standards; OPIC – Overseas Private Investment Corporation; USAID – U.S. Agency for International Development; USACE – U.S. Army Corps of Engineers; USAF -U.S. Air Force; USDA – U.S. Department of Agriculture

England

The Governments strategy (Affairs, 2008), addresses in its 98 pages, a number of aspects regarding water in that area. These include: demand, supply, water quality, surface water drainage, coastal and river flooding, greenhouse gas emissions, water charging, regulatory framework and innovation as well as development of implementation measures.

As for demand, it has undergone a change in recent decades, representative being the decrease in water consumed by industry and the increase in water used by the growing population of the country, which ended up using approx. 52% of treated water.

Besides speeding up the water metering, a series of measures are suggested by which the population can reduce water consumption to 130-120 l/day. Moreover, the authorities have imposed standards for new buildings so that the volume of water consumed is reduced. A series of programs have been implemented through which the industry can also reduce its consumption by approx. 20% by 2020, but without compromising on quality and hygiene. As for agriculture, in 2008 it was estimated to use only 1% of water resources. Furthermore, estimates indicated that the need for irrigation water would increase by up to 20% in 2020 or 30% in 2050. Thus, the authorities developed a guide to best practices for irrigation and invested in research aimed at reducing water use in production of new crops or generate superior techniques/ technology.

Losses are another big problem in English distribution networks, many of which date back to the era of Queen Victoria. Although they managed to reduce their losses by 33% in the period 1994-2008, approx. a quarter of the water was being wasted at the time the strategy was drawn up.

In terms of delivery, the strategy foresees a series of measures including: creation of new water sources as well as optimization of the management of existing ones, regional collaboration of water companies, where possible, using water resources more sustainably especially during periods of drought.

Water companies were advised to conduct their own analyzes of customer demand and assess the impact that climate change or other factors might have on supply capacity in order to identify the best ways to reduce consumption (Alavian et al., 2009) (Ching, 2016) (Hallegatte et al.,2007) (Stringer et al., 2021) (Takaffuji et al, 1997) (Zhou et al., 2023) (Velazquez, 2006).

Contingency planning is another chapter mentioned in the English strategy. Thus, water companies must meet the legal requirements to deal with emergency situations and carry out guarding, protection and supervision of installations. Moreover, they must collaborate with other responders to improve emergency preparedness. These plans include alternative water delivery solutions in the event of a main failure.

Another crucial chapter is water quality improvement. Exemplary in this respect are the measures to reduce phosphates in cleaning products. Another measure is pollution taxation, according to the “polluter pays” principle, which aims to recover the costs of treatment and disposal. In relation to pollution from agriculture, The England Catchment Sensitive Farming Delivery Initiative (ECSFDI) has been established which aims to manage land in order to control the diffuse pollutant emissions. According to the strategy, the focus must be on chronic polluters, especially diffuse ones at the expense of point pollutions because it affects a large part of rivers, groundwater, and over half of the lakes. Nitrates remain the most common pollutant in the environment, but great emphasis is also placed on those substances that have the ability to persist or (bio)accumulate.

Groundwater is crucial in maintaining water balance in nature by feeding rivers and wetlands during droughts. So, to protect this resource, a new groundwater directive was implemented with the aim of reviewing and improving the measures.

Regarding water quality, an important aspect mentioned in the strategy is the fact that water must be safe at the point of supply, i.e. at the tap of the final consumer.

Another chapter of the English strategy concerns surface water drainage, especially when 40% sewage system is used for both waste water and meteoric water. Therefore, many solutions were put in place, among which the extension of sewerage systems or the usage of sustainable drainage systems that copy the capture, slow infiltration and storage process of nature.

A separate chapter specific to English strategy is flooding in river or coastal areas. It led to the “Make space for water” policy which is leaving room for the implementation of pilot or national projects to reduce the risks caused by floods

Another chapter is represented by CO_2 emissions. The English authorities have determined that the water industry as a whole, produces less than 1% of total CO_2 emissions, but despite this, they aim to reduce this impact. Among the objectives drawn when the strategy was drawn up, there is a 60% reduction in total emissions by 2050, and with regard to the water industry, the authorities were considering increasing the percentage of energy coming from renewable resources from 5% to 20 % in 2020.

A separate chapter is the invoicing of the supplied water. At the time the strategy was drawn up, on average, only 30% of households were metered by water meters, the percentage varying between 7% and 66% depending on the supplying company. So, the English authorities and companies in the industry decided to implement measures to double customer metering by 2030.

A distinct chapter of the strategy is the regulatory framework, competition and innovation. As the water industry is monopolistic in nature, regulation is required, which is provided by 3 entities: Ofwat (the Water Regulatory Authority), the Drinking Water Inspectorate and the Environment Agency, each with a well-established role.

All policies are developed with the interests of consumers in mind, who are represented in relation to water companies by the CCW (The Consumer Council of Water). It is desired to increase the degree of innovation in the industry by stimulating competitiveness / competition as well as by liberalizing the market.

The current situation in Romania and Cluj-Napoca area

Romania, through the Ministry of the Environment, developed a draft of the National Strategy for Water Management (2024) (NSWM), which is currently taking the necessary steps to be completed and ratified. In this material, the term “water security” appears only twice.

The strategy is composed out in 8 chapters spread over 65 pages.

The first presents the purpose of developing the strategy, in conjunction with the European and global context.

The second chapter presents the current situation of water in Romania (resources, legal and institutional framework, as well as that of the human resources involved).

In the third chapter, the vision, principles and objectives of the strategy are highlighted.

The 4 objectives are focused in two directions: water management and legislation & institutional organization, each one based on 3 specific objectives. The 4 objectives are:

- Integrated management of water resources to ensure the sustainable use of water resources. A series of recommendations from the EU as well as quantitative and qualitative water monitoring activities are presented.

- Management and protection of water resources in order to achieve and preserve the good condition of surface and underground water and prevent its deterioration. It aims to reduce and avoid pollution of water sources. The development of a subsumed Strategy regarding water supply, collection and treatment of waste water is being considered.

- Reducing water-related risks in the context of climate change (water shortage and drought, erosion of banks and cliffs; destructive actions of floods) on the population, economic activity, environment and cultural heritage. The emphasis is on flood protection, presenting the 3 stages through which Romania will implement Directive 60/2007/C.E. regarding flood risk assessment and management.

- Development of the legislative, organizational and scientific framework in the field of water management

Chapter 3 is incompletely elaborated, but it is intended to focus on water in relation to the population (where there are some desired goals to be achieved, such as connection to water and sewage), energy, industry, agriculture, ecotourism and the environment.

Chapter 4 presents a series of measures and actions aimed at:

- Development of water monitoring measures and data exchange through international platforms

- Water related works aimed to satisfy water needs of the users and achieve/maintain environmental objectives. These lack concreteness, being rather objectives of other strategies or plans.

- Rehabilitation, maintenance and modernization of existing works. Although the importance of such measures is highlighted, there is no mention of who is responsible, the implementation period, the way of implementation or the sources of funding.

- Non-structural measures for the development, sustainable use and protection of water resources: such as the restoration of longitudinal and lateral connectivity of water bodies or the creation of afforestation in vulnerable areas.

- Consolidation of water education (through a collaboration between educational units and the Romanian National Water Administration), training and professional development of human resources in the water sector.

- The responsible participation of all interested parties, communities and local authorities in the implementation of measures and actions in the field of water.

Chapter 5 covers the process of strategic planning in the field of water and the development of public policies. In this sense, the aim is to create a national action plan with the aim of translating the National Strategy for Water

Management into reality. Details regarding the parties involved in achieving certain strategic objectives, the implementation period and the sources of funding are presented in the 3rd annex of the strategy.

Chapter 6 presents the expected results, which, in fact, represent the achievement of the strategy's objectives.

Chapter 7 lists the funding sources: European ones, loans or the state budget.

The last chapter is intended to evaluate the stage of strategy implementation and monitor progress.

National Management Plan Related to the National Portion of the Danube River Basin (NMPPNPDRB)

Previously, Romania developed a National Management Plan Related to the National Portion of the Danube River Basin (NMPPNPDRB), which was updated in (2021). Its content is vast (two volumes: 448 pages + 411 annexed pages) – 9 chapters, through which the Romanian state aims to:

1. Presents the hydrographic areas/basins of Romania;

2. Characterize surface and underground waters - the main categories of water, the pressures on them, the evaluation of the anthropogenic impact on the state of water bodies are presented.

3. Identify protected areas. This chapter classifies protected areas according to their use: drinking water, protecting economically important species, important for habitat, recreation, or areas sensitive to nutrient and nitrate pollution.

4. It presents the way in which the state of the waters is monitored and characterized. Surface and groundwater monitoring networks and programs (quantitative and qualitative) are presented. A characterization of underground and surface water bodies is also done (chemical status assessment, predictions).

5. Define environmental objectives;

These are broken down into 3 objectives for:

• groundwater – reaching good quantitative chemical states;

• surface waters – achieving good ecological and chemical status for natural water bodies, good ecological potential and good chemical status for heavily modified and artificial water bodies.

• protected areas – achieving the objectives provided by the specific legislation.

6. Make an economic analysis of water use;

The analysis is based on economic data at the level of watersheds, taking into account general indicators such as: population, GDP, gross value added and the correlation of these indicators with the use of water both at the resource level and at the service level (water supply, sewage and wastewater treatment).

7. Presents programs of measures as well as exceptions to environmental programs

The Water Framework Directive establishes a legal framework for protecting, conserving and improving the status of all waters and protected areas, preventing deterioration and ensuring the long-term sustainable use of water resources. This defines two categories of measures: "basic", which are minimum compliance requirements and consist of those measures required by the implementation of Community legislation for water protection, and "additional" measures, being those measures identified and implemented in addition to the basic measures. Part of the measures can be found in 19 national plans and strategies, which have a greater or lesser impact, directly or indirectly, on water.

The chapter also presents the levels of implementation of measures in different projects that have an impact on water.

8. It addresses climate change and the impact it may have.

The main conclusions are that: the water exploitation index (WEI) indicates a relatively low water stress/deficit, of approx. 4%. After analyzing the variation trends of the meteorological parameters and the simulations of the flow evolution, with the exception of the Someş River, whose flow is expected to increase by approx. 6.2%, all other large rivers of the country will decrease in flow.

The forecasted water requirement for 2030 in the Someș-Tisa River basin will be in a slight decrease in the urban environment, from 102.96 million m^3 in 2020 to 102 million m^3 in 2030 and in a slight increase in the rural environment, from 88.30 million m^3 in 2020 to 88.96 million m^3 in 2030. Additionally, the water requirement for industrial use is expected to increase from 91.77 million m^3 in 2020 to 113.50 million m^3. Similarly, the water requirement for irrigation is expected to increase from 0 million m^3 in 2020 to 1.30 million m^3 in 2030. In zootechnics, the expected effect will be the opposite, with the water requirement decreasing from 17.38 million m^3 in 2020 to 16.56 million m^3 in 2030.

9. Presents aspects of public information and participation.

It presents the legal basis according to which citizens can inform themselves and consult with the authorities. These activities are undertaken by the 11 water basin administrations, which implement the procedures in order to carry out the activity of information and consultation of the interested factors regarding each important stage in the implementation process of the Water Framework Directive.

The Someș-Tisa Water Basin Administration (ABAST) and the Someș Water Company (CAS) do not have a proper strategy regarding the security of water or water sources, but various management plans.

Someș Water Company Master Plan

The Someș Water Company is a regional operator of water supply, collection and purification, which serves approx. 750,000 customers located in Cluj and Sălaj counties. As communicated to the general public (SA, 2022), the operator informs the public that it is acting on the basis of a master plan (SA 2006) elaborated in 2006 and updated in 2012, aimed at aligning with the requirements of the European Directives in the field of water, sewage and treatment services, as well as expanding the water supply and sewage networks in Cluj and Sălaj counties, investments valued at approx. 800 million euros.

According the Ministry of the Environment (2021), in 2018, in the ABAST area, the amount of population connected to water and sewage services was as follows: 72% of the population connected to drinking water, 51% of the population connected to the sewage system and 50% of the population connected to the sewage treatment plant.

The CAS has a Master Plan is structured in 12 chapters, the content of which is public, with the exception of chapter 11, which refers to the complete plans of the networks, information of strategic importance that is not intended for the public. The material is vast, the 11 chapters have over 1,000 pages + appendices.

The general objective of the Master Plan aims to identify and prioritize investment needs at the lowest costs in order to comply with European Directives and fulfill Romania's commitments at the accession time in the European Union. Investment planning is done according to the Terms of Reference, over a period of 25 years starting in 2015, when the first stage ends.

Thus, it can be concluded that the CAS strategy is built on the idea of making investments through which to achieve all its proposed objectives.

The respective master plan is based on 8 objectives:

1. Improving drinking water quality for its customers
2. Providing water to all consumers;
3. Significant reduction of water losses;
4. Reduction of maintenance and operation costs;
5. Balancing water supply systems;
6. Reducing the number of breakdowns and increasing the level of satisfaction of customer requirements;
7. Elimination of pollution of the environment and watercourses;
8. Improving the performance of operational, financial and environmental management.

The total cost for capital investment, reinvestment, operation and maintenance, for the expansion and rehabilitation of water and wastewater systems in the CAS operating area calculated for the period 2011-2040 was estimated at 1.74 billion euros (at 2011 value) and can increase up to 2.18 billion euros depending on the value of the currency exchange rate, of which approx. 0.95 billion is just new investment.

RESULTS AND PROPOSAL

It is important to highlight the fact that the previous chapter analyzes, on one hand, strategies (USA and England), and on the other, management plans (Romania and Compania de Apa Someș). The difference is noticeable from the initial reading of the materials. The strategies of the western countries are shorter, more comprehensive, easier to understand and assimilated by readers, environmental specialists, representatives of local authorities, commercial companies or individuals. Strategies have simple language and indicate the broad lines of action, based on objectives set at a strategic level. Additionally, it clearly indicates the responsibilities of the parties involved. On the other hand, the management plans used in Romania are exhaustive, cumbersome, long and are written using a technical language. They require specialized training to be followed and understood, a fact that complicates the efforts of those beneficiaries/local institutions that have to implement them.

Authors proposal regarding the elaboration of the Romanian Water Security Strategy (RWSS)

The authors propose the development of a national strategy regarding water security in Romania. As a starting point, one can start from England's strategy, which should be adapted to Romania's situation and needs. Later, this can be transcribed into a plan of measures, that can be enforced at a national or local level, whose implementation will lead to the achievement of the desired outcomes: delivery of safe water where is needed and in a sufficient amount. In the end, the adequate measures should be taken before wastewater is released back into the environment.

Thus, the Romanian Water Security Strategy (RWSS) must have some defining characteristics: it must focus on customers and environments needs, it must be developed in compliance with the European and national legislation, it must be easily adapted to future needs and it must give autonomy to those who implement it, in accordance with their own particularities (geographical, social, economic, etc.).

Additionally, RWSS should be based several principles: legality, transparency, accessibility, predictability, accountability, evidence-based justification and guidance. The strategy must be developed in a simple manner, easy to follow, understand and assimilated by all concerned parties.

To ensure its success, the Ministry of Environment should be responsible for the development, implementation and monitoring of RWSS.

The authors propose the following structure:

1. Water in Romania – present and future.

In order to have an up-to-date picture of the actual situation regarding water in Romania, the Ministry of Environment must facilitate the provision and centralization of data from a multitude of authorities and operators. In order to ensure uniform collection and analysis, it would be advisable to create a digital platform, in which those who report should follow a specific format and at a predefined interval of time. The opportunity and the possibility of such an approach can be financed through non-reimbursable EU funds.

The list of authorities that should contribute must include: the National Institute of Statistics, the National Meteorological Administration, the country's Water Basin Administrations, water and sewer operators, sanitation operators, the Environmental Protection Agency, the Environmental Guard, Mining Authority Ministry of Energy (hydropower production) etc. Based on the collected data, real-time analyzes can be made so that decisions can be taken in order to minimize or eliminate risks. Moreover, predictions can be made, ideally for a larger period of time, approx. (30 years) on the future challenges of water and its security. A contribution to this chapter can be made by the Romanian Universities as well.

2. Water demand

From the consumers perspective, one of the pillars of water security is the ability to deliver the needed product it in the required quantity and where it is needed. It would be ideal to assess water requirement throughout the national territory, depending on the season and the consumers: domestic, industrial or agricultural. Water and sewer operators as well as the National Meteorological Administration play a crucial role in analyzing current demand.

Predicting future demand is as important as knowing current water needs. Here, the National Institute of Statistics also plays an important role, which can make assumptions about future demographic concentrations and evolutions.

When analyzing water needs, a particularity proposed by the author is taking into account vulnerable social categories. Since access to water is a basic right, but this process comes with costs, authorities must assess the risk of ill-payments, and come up with solutions.

First of all, knowing the hydrological potential of water sources is important, in order to assess the ability to deliver this product at any time of the year, without syncope. Thus, each area must be subject to a hydrological balance sheet. Of course, the classification of water sources is equally important, being directly proportional to the time through which they can regenerate. If lakes can accumulate water from precipitation relatively quickly, infiltrations that feeds underground sources takes time. Responsible for this element of RWSS must be the national meteorology agency, water basin administrations and water and canal operators, who must have a continuous dialogue to avoid situations of *force majeure*.

A measure proposed by the author would be the creation of new water sources, where the situation allows it. Drilling can be done where there are unused underground sources, new reservoirs can be built, treatment plants can be supplied from other existing reservoirs in the area, provided that their water complies with the quality indicators. In exceptional cases, in coastal areas, reverse osmosis stations can be set up, if there are no other more economically accessible water sources.

Treatment systems are those intermediate elements between sources and distribution systems. Their strategic importance regarding water security comes down to 2 indicators: the maximum deliverable capacity and the quality of the water post treatment. Water and sewer operators are responsible for these systems. The author's opinion is that, if the operators serving a certain area operate only one treatment plant, they must develop secondary capacities, able to take over the load in case the main plant breaks down. These can consist either in other stations or in creating parallel flows in the main station, thereby increasing its capacity.

Distribution is the last element of a water supply system. From a strategic point of view, water operators, as the entities responsible for these systems, must ensure that the water will not alter its quality during the time it is transported to the customers. For this to happen, a series of steps must be followed:

- First of all, it is imperative to know the exact situation of the distribution systems.
- After an analysis of the old segments, strategic decisions can be made, whereby projects are constantly implemented to modernize the existing distribution systems. Thus, it is possible to opt for the use of pipes made of materials that do not rust and that hinder the formation of biofilm.
- The use of intelligent sensor systems, which can alert operators in real time regarding the occurrence of breakdowns situations.
- The system must be operated at a high pressure, which, in the event of a failure, prevents elements from the environment from entering the distribution system.

Such projects may be subject to financing mechanisms with non-reimbursable funds.

This chapter must distinctly address the supply of consumers already connected to centralized water supply systems and those who currently do not benefit from such utilities. Through non-reimbursable financing, it is possible to ensure the expansion of the current distribution systems, or the construction of new ones, where this is economically feasible and where European legislation requires it.

From the author's perspective, the interconnection of water and sewer operators would significantly contribute to ensuring water supply in dry periods, when the sources of some operators would fail to supply the needed volume.

3. Water quality in the environment

Water quality in the environment must be addressed from several points of view: raw water that's going to be treated for consumption, the resulting wastewater and water as a resource for agriculture, industry or tourism (recreational activities).

First of all, a high-quality water source stands at the basis of the water security concept. In addition to the legal obligation to respect certain physical, chemical and biological parameters, it is ideal that water should have the best possible quality, which involves less intensive treatment.

In order to ensure the water quality, continuous monitoring is needed, and when/where the situation requires it, coercive measures must be implemented. Monitoring must remain the responsibility of the water basin administrations and the Environmental Guard, which must have a permanent dialogue with the water operators. In the case of remote sources (such as springs or wells), monitoring must be done by the Public Health Directorate. Ideally, this should be done on its own initiative, not at the request of citizens.

In addition to monitoring, water quality must be safeguarded by a series of protective measures that ensure the limitation of accidental or intentional water pollution situations. In addition to the minimum measures required by the law, the water basin administrations and/or local authorities in the areas where the water sources are located can implement additional protection measures to reduce pollution. Moreover, awareness activities regarding water sources protection will actively contribute to the reduction of pollution. Such activities can be undertaken individually, by certain authorities, or they can be the subject of inter-institutional projects, intended to cover certain large areas or the entire national territory.

The concept of water quality in the environment must also be addressed from the perspective of waste water, which is to be returned to natural receptors. Water must meet certain legal standards. The water and sewer operators as well as the Environmental Guard must be responsible for this monitoring. The situation at national level is far from ideal, according to the Ministry of Environment report (2021). Water and sewer operators must implement expansion or construction projects of sewer systems and treatment plants. Ideally, sewage systems should be separated from rainwater catchment systems. Regarding the situation of households that use septic tanks, the Environmental Guard must ensure, within the limits of its capabilities, that these systems are compliant and do not contaminate underground or surface water.

European funding is the easiest solution for modernizing, expanding or building sewage systems and treatment plants. For this reason, the author’s opinion is that the implementation of such projects must not fall strictly on the shoulders of water operators, but must be a joint effort, where the Ministry of Investments and European Funds can also contribute.

Water has also a recreational role. For activities involving bathing, it is important to ensure the necessary quality. Its monitoring must fall under the responsibility of the Directorate of Public Health.

The water needed for agricultural purposes must also meet certain quality standards, in order not to endanger the health of the population. The Environmental Guard could do the monitoring, especially if water from certain anthropogenic activities is used.

Similarly, water must have a certain quality if it is used in industrial activities. Since each technological process requires water of a certain quality, quality monitoring should be carried out by economic operators, through their own resources. In exceptional cases, when the water parameters exceed the norms of the legal framework, economic operators must notify the competent authorities.

4. Water as an economic good

According to Siskaa and Takara (2015), too much or too little water affects the economy and even has a directly correlated impact in the GDP of a developing country.

For this reason, it must be properly managed in order to have a high added value on the economy and people's lives.

On one hand, unrestricted access to water is a constitutional right, but, like any public service, it must be a self-sustainable one, to ensure the continuity of deliveries, at the required quality standard. Thus, setting a fair price that covers all the costs of producing, distributing, collecting and purifying water is mandatory.

Since water, like any other resource, is limited, it is imperative to implement management measures that limit losses and ensure its judicious use or reuse.

Of course, setting a price and implementing measures to manage water as a good is strictly the prerogative of water and sewage operators. For this reason, the author's opinion is that they must have a high degree of autonomy in order to make the best decisions. Moreover, they must also obtain a profit margin from the activity undertaken, in order to be able to co-finance investment or research and development projects.

Non-compliance with the legislation norms must be sanctioned according to the law, which is why the Environmental Guard must act according to the "polluter pays" principle.

Since water is an indispensable good for life and its quality, the author suggests performing an analysis regarding the opportunity of establishing preferential prices for disadvantaged or vulnerable categories. Aid schemes can also be a solution, similar to those that exist in the energy sector. This is where the Ministry of Labor and Social Solidarity could make its contribution.

Moreover, since water is a strategic sector, the author's opinion is that the majority of the social capital of water and sewage operators must be owned by local or county councils.

5. Floods

Flood management is the subject of a separate strategy, which is based on HG 846 from 2010, where the National Administration of Romanian Waters and the Inspectorate for Emergency Situations play a crucial role. All operational measures and those responsible for implementation are mentioned in the respective Government decision.

In addition to the measures provided for in the respective normative act, the author opinion is that, in order to prevent such calamities, it is necessary to implement projects for maintaining and expanding protective dykes and dredging of riverbeds, activities that could benefit from European funding and which would fall under the responsibility of water basin administrations and the Ministry of Investments and European Funds. Moreover, the efforts to combat deforestation upstream must be increased, a responsibility that can be shared between the forestry departments and the Ministry of Internal Affairs, and where possible, reforestation measures must be implemented.

Such situations of *force majeure* can negatively influence the quality of water sources, its treatment and distribution to consumers. In order to minimize the negative impact felt by the population, the author proposes that the local authorities and the Inspectorate for Emergency Situations must be equipped, on the one hand, with a greater number of cisterns to bring water from safe sources, and on the other hand, to use compact mini-water treatment plants to provide drinking water for disaster-affected areas. Such treatment systems must meet certain conditions: to be easily transported, fitted, operated and maintained, to be reliable, to be able to operate in series according to the need for water production, to be affordable, and have a stock of spare parts as well as a spare parts distributor in the area, if needed.

6. Greenhouse gas emissions

Although the water industry is not by nature a big polluter (has low greenhouse gases emissions), efforts to combat climate change are on the agendas of many countries, which is why it is important for RWSS to address this aspect as well.

Local water operators are responsible for active measures in this regard. Their activity, as well as other human activities, is one that produces greenhouse gases. Thus, they must launch projects to reduce their CO_2 or CH_4 emissions. Again, the author's opinion is that they must set a percentage (target) to be achieved, but they must have decision-making autonomy regarding which measures can be implemented and have economic support to do so.

Moreover, the author has additional suggestions: the use of technologies that require less operating energy, energy purchase from renewable sources, implementation of green energy production systems (solar, wind or hydro) where possible (roof of buildings, adjacent spaces). In addition, an increasing efficiency of wastewater treatment plants should be aimed at, by obtaining a higher production of CH_4, which would later be used for own energy consumption.

The author also proposes the implementation of awareness activities, through which the population is presented with the benefits of reducing water consumption. Besides direct savings for customers, a reduction of CO_2 production will occur, since less operational energy will be required.

7. Competition and innovation framework.

Research & development (R&D) activities have a crucial role in the economy development and in the overall progress of a society. The lack of such programs condemns a state to fall behind technologically, or to spend considerable larger sums to acquire technology and knowledge. Since Romania is not a rich state, the author's opinion is that innovation is the optimal way to reduce the gap between itself and the western countries.

Research & development activities were constantly underfunded in Romania. Moreover, they always had a predominantly theoretical character, with little impact on the market. In order to change this, the Romanian Government developed the National Plan for Research, Development and Innovation 2022-2027, budgeted with 60 billion lei from various sources. This is structured in 10 projects, two of which could also target projects related to the security of water sources. Thus, through the "Human Resources" project, exceptional researchers (doctoral students, post-doctoral students or young researchers) can be attracted to the national research system, and, through the "Research in areas of strategic interest" program, new technologies can be developed in the field of water treatment, distribution and purification.

The author proposes, through RWSS, the creation of a trio, which ensures the creation of technology for the market, with a high and immediate impact, thus moving from theoretical to practical research. The 3 elements of the winning formula are:

1. The beneficiary entity, be it public or private. These could include water and sewer operators who want to improve their services & technology. They must be the funders of the research projects, and subsequently, the beneficiaries of the results.

2. Research institutes or universities. These represent the platforms that ensure the “meeting” between beneficiaries and PhD students, their role being to provide the infrastructure (laboratories, consumables) and know-how (by purchasing subscriptions to large electronic bookstores, e.g. Elsevier).
3. The doctoral student. It goes without saying that human resource is the most important.

Through such a win-win-win formula, Romanian water and sewer operators could finance, at low costs, research and development projects aimed for their needs. Research institutes or Universities would have a constant portfolio of requests and increase their institutional brand by constantly delivering research articles and technologies that would be immediately implemented in the market. Doctoral students would have the opportunity to do research with a practical purpose, to be paid during this time (including by the beneficiaries), and, subsequently, they have the opportunity to work for the entities that supported the research projects (beneficiaries or universities).

Strategies and plans: a comparative analysis

By comparing the 5 materials (4 studied and one proposed by the author), the author tried to capture the differences and common visions, as shown in the figure 1. At the center are common ideas, mentioned in one form or another in both strategies and management plans. Separately, some elements on which additional emphasis is placed in the 5 materials are indicated.

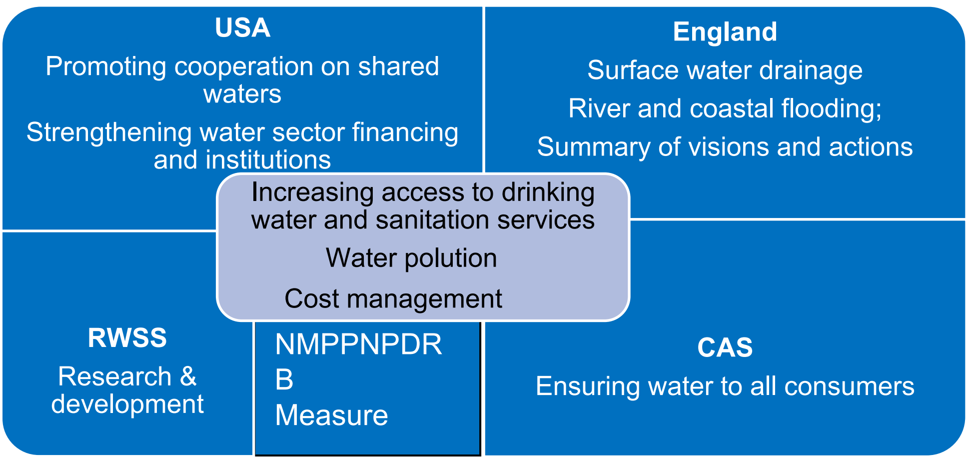

Fig. 1. *Comparison (differences/commonalities) between the analyzed strategies*

Comparing the author's proposed RWSS and the draft NSWM, some common approaches can be observed, as shown in table 2.

Table 2. *Comparison of RWSS vs. NSWM*

Specifically RWSS	Common aspects	Specifically NSWM
1. Water as an economic good 2. Greenhouse gases	1. Assessment of the current water situation 2. Research & Development 3. Floods 4. Water supply and quality	1. Strategic planning 2. Implementation, evaluation and process monitoring 3. Sources of funding

CONCLUSIONS AND RECOMMENDATIONS

This article compares completely different paradigms on the concept of water security, with the final objective of identifying some elements that can represent the foundation of a future Romanian national strategy on this subject.

The US water security strategy is one with global impact, through which this state projects its national interests, being also a foreign policy tool. For this country, the importance of water security is mentioned in the National Security of the state.

In the case of England, this state has developed a national strategy, which clearly sets out for water companies the objectives to be achieved, while leaving them a measure of autonomy to identify their best approaches.

The Romanian state does not have a national strategy regarding water security. However, it is in the process of completing and implement a water management strategy. In addition, Romania developed a national management plan for the national portion of the international river basin of the Danube River, which undergoes updates every few years. It has a very broad content and general character. The lack of early strategies has left it up to the water companies to develop their own action plans if they see fit.

For these reasons, the author of the article has several recommendations:

I. Romania, through the Ministry of the Environment, should develop a national Romania Water Security Strategy, in the spirit of European or national legislation. The author has developed and proposes a strategy model, focused on 8 chapters. This strategy can be complementary to the National Strategy for Water Management, which is in the process of being finalized and implemented.

II. If the Romanian state will not develop a national strategy, the CAS water operator should develop its own strategy based on the Master Plan created in 2006. The strategy must be public, transparent, easily assimilated and implemented, comprehensive and adapted, both to the customers, as well as the partners involved in the ongoing projects.

III. In the future, depending on the evolution of certain factors such as global warming, pollution, demographic changes, or the regional security status etc. the security of water sources should be a part of Romania's National Security Strategy. Such a policy, like the one already implemented in the USA, would enable other institutions to jointly use their resources in order to achieve the desired objectives regarding protection, treatment, judicious use and purification of wastewater, thus contributing to the quality of life of Romanian citizens.

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MEDICAL WASTE MANAGEMENT BEFORE AND DURING THE COVID-19 PANDEMIC IN ROMANIAN HOSPITALS

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ABSTRACT. The proper management of medical waste is very important, throughout its life cycle, from correct collection to final recovery or disposal. The hazardous potential of this waste needs to be known by all those who handle it to protect their health, the health of the general public, and the environment. Studying them with a view to their correct management also aims to reduce the potential risks that may arise from their improper handling. The objective of the paper was to present the influence that the COVID-19 pandemic has had through the increased amounts of waste generated by health facilities to limit the spread of the virus and to treat patients infected with SARS-CoV-2. The work of the health units mainly focused on measures to limit the spread of the virus through the use of personal protective equipment, testing of the population, treatment of patients infected with SARS-CoV 2 and other patients who needed other types of medical services. To highlight how the pandemic influenced the amount of medical waste produced, three health facilities of various types were analyzed: an Infectious Diseases Hospital, a Municipal Hospital, and a hospital for a small-medium city. Data from the months when the pandemic waves started were used and compared with similar months in previous years. Hazardous medical waste disposal costs were estimated and graphs were plotted to show the unprecedented increase in the amount of medical waste generated during the SARS-CoV 2 - Covid-19 pandemic.

Key words: *pandemic, SARS-CoV 2 (COVID-19), hazardous waste, protective equipment, medical waste management.*

INTRODUCTION

Services that provide care and health to the population, whose main objective is to reduce health problems through the activities carried out in medical practices, generate significant quantities of waste, which, based on their properties, can be classified as non-hazardous or hazardous waste for human health and the environment.

The waste resulting from healthcare activities, as hazardous waste, presents a multitude of risks with a high potential for infection and injury to medical staff and other people who come into contact with it, as well as to the economic agents involved in its management. For hazardous waste, these risks may be higher than for other types of waste classified as non-hazardous and generated from the same type of activities.

A poor management system for the management of medical waste poses a risk to healthcare staff, both patient care staff (as doctors and nurses) and ancillary healthcare staff (as carers and cleaning staff), waste disposal staff, patients, and their relatives. Improper disposal of medical waste can also lead to environmental contamination.

A poor system can increase the costs of managing medical waste by increasing disposal costs due to large quantities of waste that, if not properly sorted, will be disposed of as hazardous waste, in addition to costs related to the payment of damages to employees, sick leave, or possible penalties for non-compliance with legislation. Costs of medical waste management can be reduced, and hazards caused by the presence of hazardous medical waste by implementing appropriate waste management measures, starting with proper collection of the waste, depending on its type and hazardousness.

The SARS-CoV-2 pandemic has also changed people's behaviours, from rigorous hygiene to the use of disposable items, which has also led to an increase in the amount of waste produced, with a significant impact on ecosystems (Silva et.al., 2021).

In addition to controlling the spread of COVID-19, managing large quantities of plastic and medical waste has been a major challenge for the current waste management and disposal system (figure 1).

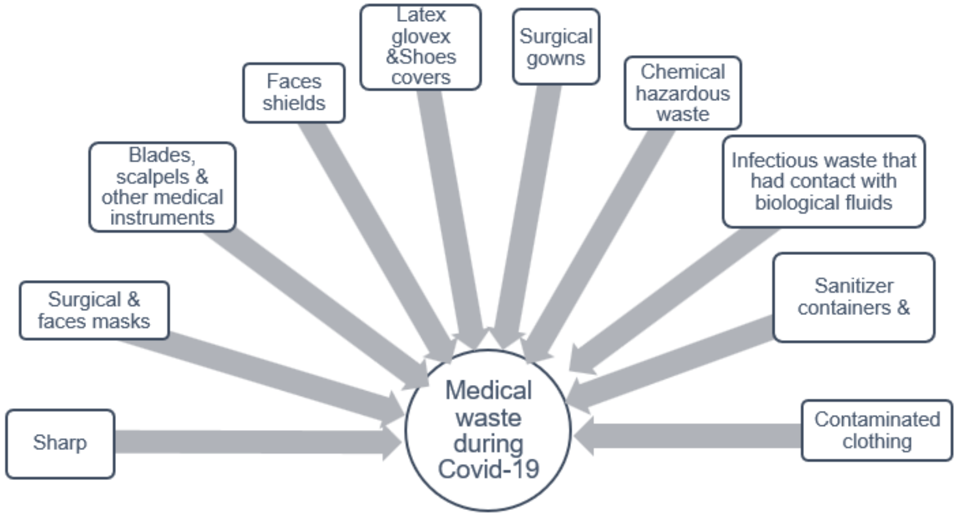

Fig.1. *Biomedical waste generation during COVID-19 (after Dehal et.al., 2022)*

Increasing amounts of medical waste can become a problem for health and the environment as it is a source of infection. The increase is largely due to the use of disposable personal protective equipment.

Globally, an estimated 129 billion masks and 65 billion gloves were used each month (Prata et al., 2020).

MEDICAL WASTE MANAGEMENT IN ROMANIA

In Romania, the management of hazardous medical waste began during the Second World War, and in the 1950s, the first disposal facilities, crematoria, were built to deal with the risks generated by medical waste. The term 'medical waste' began to be used after 1970. A significant change in medical waste management occurred after 1989. To align with European standards, the Order of the Minister of Health No 219/2002 was issued, containing for the first time the "Methodology for Data Collection for the National Database". After 10 years, another order on the management of medical waste was issued, the Order of the Minister of Health No. 1226/2012, which approved the technical norms on the management of waste from medical activities and the methodology of data collection for the national database on waste resulting from medical activities (Curea et.al, 2021).

From an environmental point of view, the management of medical waste in Romania is carried out according to the European List of Waste (LoW), transposed into Romanian legislation by the Government Decision, GD 856/ 2002, updated several times in recent years. According to the LoW and the order of the Ministry of Health, hazardous medical waste codes are found in category 18 and depending on the subcategories they belong to, they can be collected and packaged only in containers accepted by the rules in force (Table 1, after Curea et.al., 2021; Order 1226/2012, GD856/2002).

Table 1. *Types of packaging and containers used for medical waste and their characteristics (after Curea et.al., 2021; Order of the Minister of Health No. 1226/2012; GD856/2002)*

Waste code	Packaging	Example of packaging
18 01 01 **& (18 01 03*)** sharps	Sharps waste identified by 18 01 01 and 18 01 03* shall be collected separately in the same rigid plastic container resistant to mechanical action.	 
18 01 02 **(18 01 03*)** Body parts and organs including blood bags and blood preserves	Pathological waste falling under code 18 01 02 (18 01 03*), destined for incineration, must be collected in rigid cardboard boxes with a polyethene bag inside, which must be securely closed, or in rigid plastic boxes with a tight-fitting lid, bearing a yellow marking, specifically designed for this category of waste and disposed of by incineration.	 
18 01 03* wastes whose collection and disposal is subject to special to prevent infection	For infectious wastes which are not sharps identified with 18 01 03*, cardboard boxes containing yellow polyethene bags or polyethene bags marked yellow or yellow shall be used.	  

Waste code	Packaging	Example of packaging
18 01 04 wastes whose collection and disposal are not subject to special requirements to prevent infection (for example dressings, plaster casts, linen, disposable clothing, diapers)	To be collected in black bags marked Non-hazardous waste	
18 01 06* chemicals consisting of or containing hazardous substances	Chemical hazardous wastes from sanitary facilities identified by code 18 01 06* are collected in special containers, marked according to the hazard (“Flammable”, “Corrosive”, “Toxic”, etc.).	
18 01 07 chemicals other than those mentioned in 18 01 06	Non-hazardous chemical waste identified by 18 01 07 from sanitary facilities shall be collected separately in the original packaging. In the case of waste from diagnostic equipment containing dangerous chemicals in negligible concentrations, the instructions specific to the equipment shall be followed. This waste shall be recovered or disposed of as non-hazardous waste.	
18 01 08* cytotoxic and cytostatic medicines	Waste resulting from the administration of cytotoxic and cytostatic treatments represented by used syringe bodies with or without needles, bottles and infusion systems, contaminated soft materials, contaminated personal protective equipment, etc. must be collected separately, packed in safe disposable containers with lids and disposed of separately.	

Waste code	Packaging	Example of packaging
18 01 09 medicines other than those mentioned in 18 01 08	This waste is collected in cardboard boxes with bags inside.	
18 01 10* amalgam waste from dental care	Dental waste identified by code 18 01 10* represented by dental amalgam shall be collected separately in sealable containers and taken back by authorized firms for recovery.	

The stages of the medical waste management system in Romania

Step I: After identifying the types of waste generated in the health facility, they will be classified in one of the categories presented in GD no. 856 / 2002, on waste management records and for the approval of the list of waste, including hazardous waste and the assignment of a waste code, respectively in Order no. 1226 / 2012 for the approval of the Technical Standards on the management of waste resulting from medical activities and the Methodology for data collection for the national database on waste resulting from medical activities (figure 2).

The stages of the medical waste management system in Romania are the following:

- Step I. Identification of sources of medical waste generation and types of waste generated
- Step II: Collection of medical waste
- Step III Packaging of medical waste
- Step IV. Temporary storage of medical waste
- Stage V. Transport of healthcare waste
- Step VI: Treatment and disposal of waste arising from healthcare activities
- Step VII. Recording the quantities of waste generated by healthcare establishments
- Step VIII. Staff training and education
- Step IX. Drawing up the plan for the management of healthcare waste
- Step X. Implementation of a hazardous waste management system for healthcare waste

Fig. 2. *The stages of the medical waste management system in Romania*

Step II: Collection is a very important step because if hazardous waste is mixed with non-hazardous waste, it can contaminate them. Disposal costs will also increase, as hazardous waste requires different, more careful management and the possibility of environmental contamination, which will pose a risk to the personnel handling it and ultimately to the population. These are the reasons why producers of medical waste are obliged to collect medical waste separately at the place of production to facilitate the specific treatment/ disposal of each type of waste, an obligation imposed by legislation.

An additional responsibility for medical waste generators is to avoid mixing different types of hazardous waste or combining hazardous waste with non-hazardous waste. If the collected waste is not segregated by each hazardous type or is mixed with non-hazardous waste types, the entire quantity of waste is treated as hazardous waste, with increased costs for waste management.

Step III*:* The packaging/container in which the collection is made and comes into direct contact with hazardous waste from medical activities is disposable and is disposed of with the contents.

The codes used for the packaging/containers in which medical waste is collected are: (i) yellow for hazardous medical waste (according to art. 7 and 8 of Order no. 1226 / 2012); (ii) black for non-hazardous waste (according to art. 7 Order no. 1226 / 2012).

Step IV: Temporary waste storage should be carried out according to the categories of waste collected at the place of production. In each hospital or health care facility, there must be a space for the temporary storage of medical waste, consisting of two appropriately sized compartments, one for hazardous waste and the other for non-hazardous waste.

Step V: The transport of hazardous medical waste within the premises of the medical facility where it was produced is done on a separate route from that of patients and visitors. Hazardous medical waste is transported using special trolleys or mobile containers. Both the vehicles and the mobile containers used for the transport of medical waste are cleaned and disinfected after each use at the place of unloading, using authorized biocidal products, as demonstrated by a written document. The transport of hazardous medical waste outside the healthcare establishment where it was produced is carried out by an authorized economic operator for the management of such waste.

Step VI*:* The processes and methods used for the treatment and disposal of waste resulting from medical activities must not endanger the health of the population and the environment, and it is necessary to ensure the rapid and complete destruction of factors with the potential to harm the environment and the health of the population.

The methods used for the disposal of waste resulting from medical activities in Romania, according to the legislation, are incineration, thermal decontamination at low temperatures, and finally, landfilling for those wastes that have become non-hazardous through the previously applied treatments.

Step VII: Each establishment that is a producer of waste is obliged to keep separate records for each category of waste. For this purpose, a person designated by the coordinator of the environmental health protection activity keeps records of waste by type and is responsible for filling in the forms provided for in the legislation drawn up by the Romanian Ministry of the Environment. Medical units submit an annual report on their waste management activity following the methodology laid down in the legislation drawn up by the Romanian Ministry of Health.

The forms for the transport and disposal of hazardous medical waste leaving the health facility for disposal purposes shall be drawn up and completed in compliance with the provisions of Government Decision No. 1.061/2008 on the transport of hazardous and non-hazardous waste on the territory of Romania.

Step VIII: Each healthcare facility is required to provide training and continuing education for employees on medical waste management in any of the following: (a) upon hiring; (b) upon taking on a new job assignment or moving to another job; (c) upon introduction of new equipment or modification of existing equipment or introduction of new technology; (d) upon recommendation of the person designated to coordinate the waste management activity resulting from the existing health care facility, who has found irregularities in the application of the code of procedure or upon recommendation of the environmental health protection activity coordinator; (e) periodically, whether or not changes in the medical waste management system have occurred.

Staff involved in the management system of hazardous medical waste should be familiar with: the types of waste produced in the health care facility; the risks to the environment and human health at each stage of the medical waste disposal cycle; the medical waste management plan, with internal regulations and codes of procedure for the segregated collection by category, temporary storage, transport and disposal of hazardous medical waste, and the procedures/protocols applicable in the event of accidents or incidents occurring in the waste management activity.

Studies carried out by various researchers have concluded that successful management of medical waste requires additional thinking and planning by all actors involved in the waste cycle. Workers and managers need to receive information, materials, support, and appropriate training to ensure the safe management of medical waste. At the same time, proper management of infectious disease materials needs to be developed to close identified gaps so that rapid and correct action can be taken to ensure public safety. In general, staff involved in medical waste management have information on how to manage this waste, but there is also a need to improve the education of workers on the management of this type of waste, the risks to which they, the population (directly or indirectly), and environmental factors are exposed. This improvement could be achieved through information and education courses, seminars, brochures, and guides as explicit as possible and with clear examples (Le et.al., 2018, Bhagawati et.al., 2015, Çalıs et.al., 2014).

***Step IX**:* All healthcare facilities or other medical waste generators are required to draw up a medical waste management plan. The medical waste management plan must include information about the healthcare facility, the current situation regarding medical waste management, and measures to reduce the quantity of waste generated.

***Step X**:* For efficient management of the waste resulting from the medical activity, solutions are proposed, such as: educating the staff involved, followed by the implementation of a plan to reduce the quantity of waste.

The measure of particular importance is source separation by waste type because they have different properties (Dehghani et al., 2019). To minimize medical waste, one can (i) choose products that generate less waste (e.g., packaging); (ii) choose suppliers that will take containers in which certain substances have been delivered to be reused as packaging; (iii) prevent waste, choose the waste treatment administration procedure, and correct the dosage of substances used in cleaning and disinfection (Padmanabhan & Barik, 2019).

Hsu et al. (2021) presented the results of an audit, conducted in an emergency unit in a community hospital in the U.S. in January 2020, which clarified the composition of medical waste produced in the emergency unit, and improved the disposal of this waste to reduce carbon emissions and disposal costs. The waste, the quantities generated, and their hazardousness were determined and classified. The conclusion, which is also valid in other countries, was that the implementation of audits in wards and medical units can improve the medical waste management system by reducing medical waste, with a direct contribution to reducing environmental impact and greenhouse gas emissions.

Methods used for the disposal of hazardous waste from medical activities in Romania

The main method of disposal of hazardous medical waste is incineration. Through incineration, medical waste is burned in incinerators at high temperatures (generally above 1000^{0}C) (Order 756/2004, approving the technical regulation on waste incineration) and the flue gases are purified before reaching the atmosphere. The result of the incineration process is ash, which will have a substantially reduced volume compared to the initial volume of the medical waste. Following incineration, the initially hazardous medical waste becomes biologically inert, and the various pathogens contained in it are destroyed.

Modern incinerators also have systems for recovering the thermal energy produced by burning waste. Some waste has calorific power that helps the process. This energy can be partly reused in the incineration system, but the remaining energy must be recovered as either thermal or electrical energy. The main incinerators used for the destruction of medical waste are (i) pyrolytic, (ii) fixed or mobile grate incinerators with post-combustion chambers, and (iii) rotary kilns.

For less hazardous medical waste, such as sharps, protective clothing, and others, thermal decontamination can also be used, at much lower temperatures than those used for incineration and therefore less expensive (Ilyas et al., 2020).

Thermal decontamination at low temperatures can be done by exposing for 30-120 minutes the shredded waste to (i) hot air disinfection; (ii) moist heat (steam) disinfection; or (iii) microwave disinfection. (Order 1226/2012). Decontamination of medical waste is carried out after the waste has been crushed into small pieces and also an initial decontamination step to make the operation more efficient. The temperatures used for decontamination are most often between 100 – 300^{0}C (Order 1226/2012) the aim being to destroy the biological agent.

Waste landfilling is the last acceptable waste management solution in Europe. Medical waste cannot end up in landfills in the form it comes from health facilities because it produces a biological and chemical hazard to the environment and human health. Medical waste can only be disposed of in landfills after pre-treatment to ensure its biological neutralisation (see fig.3).

It can be seen that of the technologies presented by Thind et al. (2021), autoclaving is the technology with the lowest construction and operational costs and also the lowest environmental impact. The treatment technology is accepted in Romania by Order 1226/2012 and can be chosen for the part of the medical waste, as it involves much lower costs than incineration.

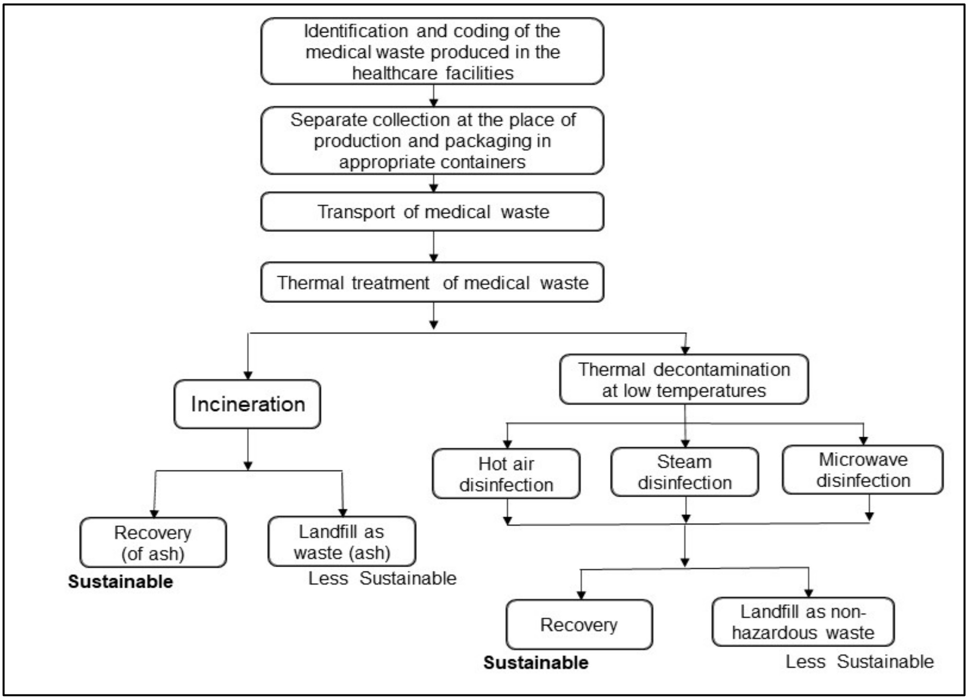

Fig.3. *Methods used for the disposal of hazardous waste from medical activities in Romania*

Thind et al. (2021) made a comparison between different methods of acceptable thermal treatment of medical waste, which they summarized in Table 2.

Table 2. *Comparison between thermal treatment methods of medical waste (Source: Thind et.al., 2021)*

Tip of technology	Capacity	Installation costs	Operation cost	Pollution (air & water)	Volume reduction
Autoclave	●●●●	●●	●●●	●	●●
Microwave	●●	●●	●●	●	●●
Incineration	●●●●●	●●●●	●●●●	●●●●●	●●●●●
Pyrolysis	●●●	●●●●●	●●●●●	●●	●●●
Plasma	●●●	●●●●●	●●●●●	●●	●●●
Chemical disinfection	●●●	●●●	●●●	●●●	●●●

Estimated costs of medical waste management in Romania

The costs vary, depending on different factors that influence the waste management calculation values (table 3): (i) the amount of waste generated by the health facility; (ii) the costs of packaging, transport, and infrastructure; (iii) the operating conditions of the disposal equipment.

An example of a calculation of the costs generated by the treatment/ disposal of medical waste is presented below, choosing the technique of treatment by decontamination at low temperatures, data provided by AKSD Romania, a company specialized in hazardous waste disposal, which has implemented environmental management systems (ISO 14001), quality management (ISO 9001) and occupational health and safety management (OHSAS 188001).

Table 3. *Cost of disposal of 1 kg of hazardous waste by thermal treatment at low temperatures (Source AKSD Romania)*

Month / year 2021	Amount of waste treated		Water consumption [m^3]	Cost/m^3 drinking & waste water	Natural gases consumption [m^3]	Cost/m^3 natural gases	Electricity consumption [kWh]	Cost/ 1kWh	Cost/1kg municipal waste treatment	Cost/1 kg hazardous waste treatment
	entry [t]	exit [t]								
August	122	126	8370	8.09	6241	2.43	6689	0.26	0.89	1.44
July	130	146	11044	8.09	7565	2.43	7625	0.26	0.89	1.18
*The waste coming out of the steriliser is heavier, by 5-10 %, depending on the type of waste (whether it retains water or not).										

Medical waste management during the new SARS-CoV-2 pandemic

The COVID-19 pandemic has put countries' healthcare systems to the test, including because of the huge amount of medical waste generated. Treatment systems, especially incinerators, were stretched to the limit, and the average daily amount of medical waste from infected patients was well above the average daily amount of medical waste from before the COVID-19 pandemic. Thind et al. (2021) studied the effects of the generation of medical waste during the pandemic period on the environment, showing the variation of medical waste generation according to the number of cases (figure 4). Because of the large amounts of waste generated, the emissions to the environment from waste incineration and other infectious waste treatment processes have been substantial, and the massive releases of heavy metals and other pollutants resulting from these types of activities have begun to become hazardous to human health (Thind et al., 2021).

The city of Wuhan in China generated nearly 247 tonnes of medical waste per day at the peak of the pandemic, almost six times more than before the pandemic. The frequent use of personal protective equipment and its mostly plastic composition led to the overuse of waste management systems and sometimes their failure.

In order to dispose of this amount of waste safely and as quickly as possible, the Chinese authorities installed 11 mobile incinerators and took strict measures to dispose of this amount safely. Improper management of medical waste not only impacts the environment through pollution but also impacts the health of the population through the spread of infectious diseases (Singh et al., 2020). Peng et al. (2020) also presented some medical waste management practices during the COVID-19 pandemic.

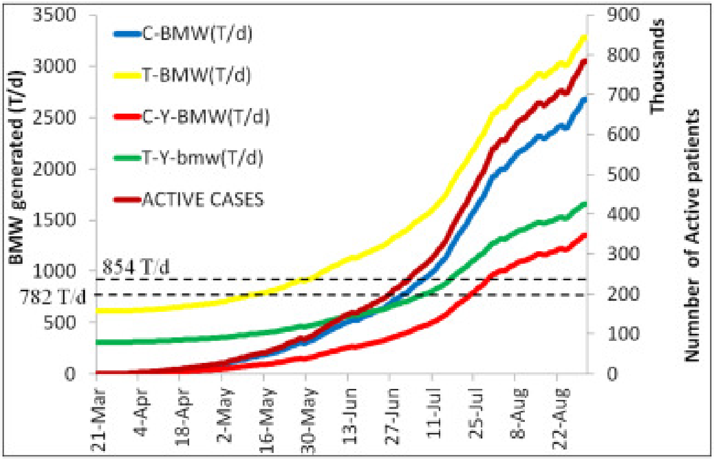

Fig. 4. *Daily generation of different types of biomedical waste in India during the pandemic (Thind et al., 2021)*

They consider that standardisation and strict implementation of medical waste management related to COVID-19 should be carefully considered to reduce the risk of the epidemic in hospitals (Peng et al., 2020).

The first case of a patient infected with Sars CoV-2 was reported in Romania on 26 February 2020, a Romanian citizen confirmed in Gorj County, that a patient appeared after contact with an Italian citizen who visited Romania at that time (Dascalu, 2020; Mihai, 2020).

Already on 14 March, more than 100 cases of infected persons were reported in Romania, and because the increase in the number of cases became worrying, a state of emergency was declared (Dascalu, 2020, Mihai, 2020). The evolution of the number of cases in Romania in spring 2020 (27 February - 5 June 2020) is shown in figure 5.

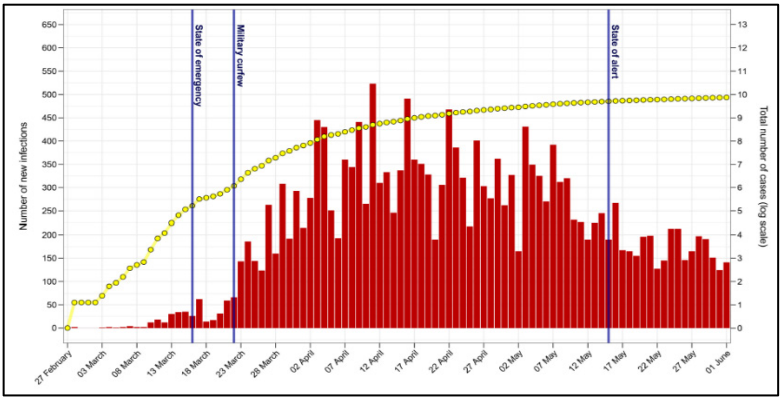

Fig. 5. *The Romanian COVID-19 epidemic from 27th February to 1st June 2020 (Souce: Dascalu, S., 2020)*

Figure 5 shows the daily number of confirmed cases, and the total number of cases (logarithmic scale), according to the graph made by Dascalu, based on data published by the Romanian Ministry of Internal Affairs.

CASE STUDY

The case study starts by comparing the total amounts of hospital waste produced in ten healthcare facilities situated in the NW part of Romania over 5 years from 2017 to 2022, a time that included the COVID-19 pandemic. The three health units analysed were the following (table 4).

The COVID-19 pandemic had a significant impact on the amounts of waste generated by health facilities, as shown in the graph presented (Fig. 6). The amounts of waste from the different health facilities assessed were variable in the pre-pandemic years, depending on the type of health facility, its size, and the number of patients assessed. However, it can be seen that the quantities of medical waste generated in the pre-pandemic years were in most cases well below the quantities of waste generated during the two pandemic years evaluated.

Table 4. *Medical units surveyed on quantities of waste generated in the period 2017-2022*

	Type of hospital	**Number of beds**
Hospital 1.	Infectious diseases hospital	191
Hospital 2.	Municipal hospital	527
Hospital 3	City hospital	226

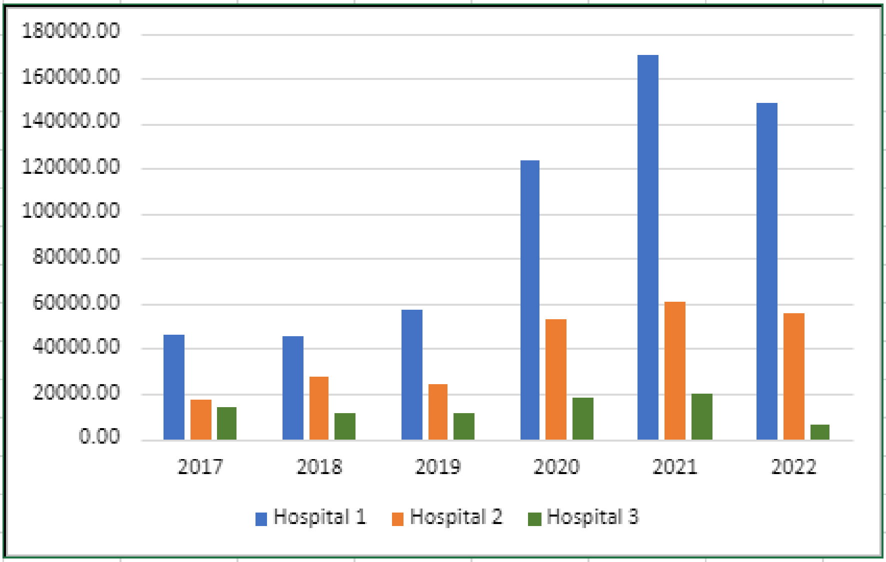

Fig. 6. *Total quantities of medical waste from the 3 sanitary units in the period 2017–2022 [kg/year]*

Because some health facilities, such as some dental practices or other specialised surgeries that sometimes only offered online consultations, were temporarily closed or restricted in their activity, the amount of waste during the pandemic decreased.

In the post-pandemic year, 2022, the amount of medical waste generated has decreased compared to the pandemic years. However, they are still above the values recorded in the pre-pandemic years. The explanation may lie both in the continued use of more protective equipment than previously employed and in the registration of more patients in hospitals, as individuals with less serious health conditions avoided, during the pandemic, routine check-ups in health units, unless absolutely necessary.

The following presents the evolution of the quantities of medical waste in the pandemic compared to previous years. During the SARS-CoV-2 pandemic, the amount of medical waste increased significantly. Table 5 lists the amounts of the principal waste streams produced at three hospitals in the northwest of Romania that treat SARS CoV-2 virus patients: sharps waste (code 18 01 01); and infectious hazardous waste in contact with blood or other biological fluids (code 18 01 03*). For comparison, the quantities of medical waste from the same hospitals in the years before the pandemic, i.e. from 2017 onwards, are shown.

Table 5 lists the amounts of the principal waste streams produced at three hospitals in the northwest of Romania that treat SARS CoV-2 virus patients: sharps waste (code 18 01 01); and infectious hazardous waste in contact with blood or other biological fluids (code 18 01 03*). For comparison, the quantities of medical waste from the same hospitals in the years before the pandemic, i.e. from 2017 onwards, are shown.

The first SARS-CoV-2 infected patient registered in Romania was on 26 February 2020, and the first pandemic peak registered was in November 2020. The next pandemic peaks in Romania were in March 2021, in October 2021 and in February 2022. The pandemic peaks in Romania were determined using data from the dedicated online platform for COVID-19, supported by Amazon Web Service (AWS), Sage Group and the University of West Timisoara, which was last updated on 14 November 2022 (https://covid19.geo-spatial.org).

The months in which pandemic peaks were recorded in Romania were those used as reference months for comparing the resulting medical waste quantities, namely February, March, October and November for a 5-year interval. All three hospitals analysed received patients infected with SARS CoV 2, starting in 2020.

As can be seen from the data presented in Table 5, there was a significant increase in the amount of waste generated in the months when the pandemic waves started, compared to similar months in previous years. In Table 5. the values indicating the maximum amounts of waste are highlighted, by colouring the respective table cells. These quantities are due to the use of a very large number of personal protective clothing items such as: disposable masks, both surgical and FFP2/FFP3/N95, face shields, goggles, protective suits, booties, and disposable waterproof aprons.

Individual protective equipment had a well-defined use regime, the most frequently exchanged being protective masks. Personal protective equipment was changed at certain intervals or as needed. A complete set of equipment contained booties, overalls, two pairs of disposable hand gloves, a protective mask, a visor and/or goggles.

Before the pandemic, the hospital ward profile and the number of patients admitted were the only factors affecting medical waste amounts.

Table 5. *Comparison between the quantities of medical waste resulting from 3 Romanian hospitals, from 2017 to 2022, using as reference periods the months in which pandemic peaks were recorded*

Reference month	Categories of waste (by waste code) considered [kg]					
	Infectious diseases hospital [191 beds]		**Municipal Hospital** [527 beds]		**City Hospital** [226 beds]	
	Waste produced 18.01.01 [kg]	Waste produced 18.01.03* [kg]	Waste produced 18.01.01 [kg]	Waste produced 18.01.03* [kg]	Waste produced 18.01.01 [kg]	Waste produced 18.01.03* [kg]
Feb-2017	154.00	3053.00	0.00	509.00	89.00	777.00
Feb-2018	164.00	3240.00	168.46	2323.51	94.00	892.00
Feb-2019	132.00	4166.00	49.47	885.07	83.00	646.00
First patient 26.02.2020	158.00	4143.00	192.34	2309.83	76.00	673.00
Feb-2021	177.20	12807.00	116.70	3290.36	33.50	994.00
The 4th peak 01.02.2022	263.00	14890.00	276.75	4747.97	51.00	448.00
Mar-2017	188.00	3497.00	43.40	851.70	149.00	1060.00
Mar-2018	157.00	3597.00	171.07	2368.27	88.00	1003.00
Mar-2019	159.00	4471.00	29.03	893.32	66.00	678.00
Mar-2020	123.20	5529.10	19.92	637.49	81.00	795.00
The 2nd peak 25.03.2021	254.00	18173.00	171.18	5290.27	48.50	1901.00
Mar-2022	263.40	11991.00	251.59	3219.25	44.00	389.00
Oct-2017	150.50	3950.50	158.40	2445.45	53.00	789.00
Oct-2018	123.00	4078.00	82.04	1495.81	64.00	648.00
Oct-2019	148.00	4391.00	0.00	465.65	138.00	767.00
Oct-2020	133.80	14218.00	208.78	6491.81	20.00	1214.00
The 3rd peak 21.10.2021	368.00	19778.00	57.13	6029.93	83.50	4290.00
Oct-2022	311.80	11321.00	274.26	3450.96	44.00	418.00
Nov-2017	146.00	3336.00	155.92	2409.34	90.00	1101.00
Nov-2018	106.00	3080.00	52.72	1310.93	57.00	653.00
Nov-2019	136.00	4366.00	121.60	1635.03	70.50	546.00
The first peak 06.11.2020	148.80	13328.20	215.59	7649.43	21.50	3200.00
Nov-2021	385.00	19664.00	176.69	5855.03	65.00	999.00
Nov-2022	304.90	12280.00	251.92	3224.16	28.00	338.00

Table 6. *The effects of the COVID-19 pandemic on the costs incurred by health facilities for the disposal of hazardous medical waste*

Reference month	**Waste disposal cost** [lei]					
	Infectious diseases hospital [191 beds]		**Municipal Hospital** [527 beds]		**City Hospital** [226 beds]	
	Waste disposal cost for 18.01.01	Waste disposal cost for 18.01.03*	Waste disposal cost for 18.01.01	Waste disposal cost for 18.01.03*	Waste disposal cost for 18.01.01	Waste disposal cost for 18.01.03*
Feb-2017	221.97	4396.32	0	732.96	128.16	1118.88
Feb-2018	236.39	4665.60	242.58	3345.85	135.36	1284.48
Feb-2019	190.26	5999.04	71.24	1274.50	119.52	930.24
First patient 26.02.2020	227.74	5965.92	276.97	3326.16	109.44	969.12
Feb-2021	255.41	18442.08	168.05	4738.12	48.24	1431.36
The 4th peak 01.02.2022	378.72	21441.6	398.52	6837.10	73.44	645.12
Mar-2017	270.72	5035.68	62.50	1226.45	**214.56**	1526.40
Mar-2018	226.08	5179.68	246.34	3410.31	126.72	1444.32
Mar-2019	228.96	6438.24	41.80	1286.38	95.04	976.32
Mar-2020	177.41	7961.90	28.68	917.99	116.64	1144.80
The 2nd peak 25.03.2021	365.76	26169.12	246.50	7617.99	69.84	2737.44
Mar-2022	379.30	17267.04	362.29	4635.72	63.36	560.16
Oct-2017	216.72	5688.72	228.10	3521.45	76.32	1136.16
Oct-2018	177.12	5872.32	118.14	2153.97	92.16	933.12
Oct-2019	213.12	6323.04	0	670.54	**198.72**	1104.48
Oct-2020	192.67	20473.92	300.64	**9348.21**	28.80	**1748.16**
The 3rd peak 21.10.2021	**529.92**	**28480.32**	82.27	**8683.10**	120.24	6177.60
Oct-2022	448.99	16302.24	**394.93**	4969.38	63.36	601.92
Nov-2017	210.24	4803.84	224.52	3469.45	129.60	**1585.44**
Nov-2018	152.64	4435.20	75.92	1887.74	82.08	940.32
Nov-2019	195.84	6287.04	175.10	2354.44	101.52	786.24
The first peak 06.11.2020	214.27	19192.61	310.45	11015.18	30.96	4608.00
Nov-2021	**554.40**	**28316.16**	254.43	8431.24	93.60	1438.56
Nov-2022	439.06	17683.20	**362.76**	4642.79	40.32	486.72

After the onset of the pandemic, this calculation was no longer valid, as the existing medical waste management infrastructure faced challenges related to the collection, transportation, and treatment of 4-5 times higher quantities of medical waste than before.

In general, the highest quantities of medical waste were recorded in October and November 2020 and 2021, possibly also due to the overlap of pandemic waves on top of the seasonal autumn flu.

Similarly to the increase in the amount of waste in pandemic years, the costs incurred for the disposal of hazardous waste from the site of health facilities were, in most cases much higher in the months and years of the pandemic. The only exception is the high cost at the city hospital assessed, and that was likely due to an increased number of patients during the pre-pandemic seasonal flu periods.

As is shown in Table 6, in general, significant increases in the amount of hazardous medical waste have resulted in significant disposal costs for this waste, severely impacting health facility budgets.

DISCUSSIONS

The COVID-19 pandemic has been a challenge to humanity as a whole, as it has been handling every issue that has emerged since the pandemic began. The SARS-CoV-2 virus posed a serious threat to Romania's and the world's medical hazardous waste management systems at the time. In certain instances, the amount of medical waste rose by 400% during peak times. Due to the identical storage facilities, businesses that specialize in the disposal of hazardous medical waste faced pressure, and economic agents were forced to reconsider when to implement new technical advancements.

Current governments have not been able to tackle this issue because numerous high-risk diseases have been eradicated in many nations in recent decades. Because of the medical waste, among other reasons, the pandemic has had a devastating impact on the infrastructure and economies of several countries.

In countries where the hazardous medical waste management system was poor and had untrained staff and insufficient infrastructure, the waste stream was not well defined, and this also put pressure on the environment. In some cases, large quantities of hazardous medical waste were collected and had to be disposed of as soon as possible. Non-hazardous waste and plastic waste also resulted in large quantities overloading the waste streams. Poorly enforced legislation, infrastructure, unfamiliarity, and the novelty of the virus were other factors that created unmanageable challenges for hospitals, waste management companies, and authorities, in addition to problems common to the whole population.

Since at the onset of the Covid-19 pandemic, the knowledge about the mode and extent of transmission of the infection were not fully known, excessive protection of staff and the population was achieved through the overuse of personal protective equipment, leading to an overload of waste management systems due to large quantities of medically hazardous waste.

These increases in the quantities of hazardous medical waste have had a significant impact on hospital budgets, which, in addition to the costs of disposing of hazardous medical waste, have also accumulated expenses for the purchase of medical equipment used to treat infected patients, the large quantities of disinfectants used, and personal protective equipment. Before the outbreak of the pandemic, in many hospital wards, in addition to the classic personal protective equipment, only disposable gloves, caps, and in some cases, protective masks were used to treat patients. During the pandemic, treating a patient infected with SARS-CoV-2, in addition to personal protective equipment, was much more complex in all hospital wards. This led to significant increases in medical hazardous waste, as could be seen in the previous sections.

Based on the data provided, which only included the months when the pandemic waves began and was compared to similar months in prior years, the amount of hazardous medical waste produced by health facilities in NW Romania increased by 260% following the onset of the pandemic (February 2020) in comparison to the same period in 2019. The costs of treating them also increased, which put a big strain on the budgets of hospitals that also had to provide protective equipment or medicines needed to treat patients. It should also be stressed that this cannot be extrapolated to all health units in Romania, but only to those health units that were nominated as COVID support hospitals, where only COVID cases or suspected patients were treated. These were the hospitals with the maximum load. Probably a better distribution of patients to more hospitals would have benefited the staff employed in these hospitals, the comfort of patients, and the overloading of some hospital collection points with waste.

CONCLUSION

Healthcare facilities, medical diagnostic laboratories, treatment centres, and other economic operators providing healthcare services generate waste, some of which, depending on their composition, are classified as non-hazardous and others as hazardous to the environment and public health.

The increase in hazardous waste in Romanian hospitals treating Covid-19 infected patients was largely due to the large volume of personal protective equipment used, sanitary materials used in screening and treating patients or preventing the spread of the virus (Covid tests, waste from antibody vaccination of the population), and the shift of household waste produced by infected patients from the non-hazardous to the hazardous waste category. The fact that hospitals designated to treat patients with COVID-19 worked continuously at full capacity throughout the pandemic was another reason for the increase in waste.

The problems of managing hazardous waste and plastic waste have not been exclusive to hospitals, neither in Romania nor in other countries in the world. Thus, the correct management of hazardous medical waste must be regulated at the level of the localities and the population. Also, large quantities of plastic, including plastic masks, are causing problems in many places around the world and are becoming sources of environmental pollution. More efficient treatment methods for hazardous medical waste to increase its recovery potential and decrease the percentage of hazardous medical waste going to landfills would also be welcome.

Further research would be useful to highlight some of the lessons learned throughout the pandemic. The provision of flexible “toolkits” with hazardous waste management procedures and programs designed to meet the challenges that arise at different times, even when the situation has many unpredictable aspects, such as the COVID-19 pandemic, would be useful for all stakeholders involved in waste management and beyond.

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OCCURRENCE OF ALKALINE WATERS IN THE SOUTHERN APUSENI MOUNTAINS (ROMANIA) – RESULTS OF A PRELIMINARY SURVEY

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ABSTRACT. Consumption of alkaline water by the general population has increased over the past two decades, as certain customers value this type of water for its presumed ability to promote health. In spite of the commercial interest for natural alkaline water sources suitable for drinking purposes, relatively few scientific publications related to the occurrence of these waters are available. This article presents the results of a preliminary survey for alkaline water in the Southern Apuseni Mountains. This region has been selected as study area due to the presence of limestones and ophiolitic rocks, very often in contact with each other, both having the potential to bring the pH of natural waters to the alkaline range. A total of 78 sampling points, represented by streams, lakes, springs and dug wells have been investigated, and the physico-chemical common parameters were measured in the field. Alkaline water with pH above 8.0 has been found in almost 29 sampling points, out of which 7 points had a pH above 8.5. Most of the points were represented by surface running water. The prospective areas, as identified by this survey, correspond to Trascau Mts., and to the western (predominantly ophiolitic) part of the Metaliferi Mts. The data included in this paper may represent the starting point for a systematic survey and for a detailed study of the potential alkaline water resources in the study area.

Key words: *alkaline water, ophiolites, limestones, Apuseni Mountains.*

INTRODUCTION

Natural alkaline water, generally with pH in the range 7.5 – 9.5, represents a field of growing interest for the water bottling industry, as part of the consumers consider they may provide health benefits. Although there is commercial interest in this type of water, there are relatively few published papers dealing with alkaline waters for human consumption. The chemical features of groundwater, including the pH, are strongly influenced by the type of rocks the water is travelling through, being the result of complex water-rock interactions occurring along the water pathway. Ophiolites and limestones are rocks that are recognized for their ability to confer an alkaline character to waters with which they come into contact (Etiope et al., 2017; Papp et al., 2017; Giampouras et al., 2019). The chemical composition of the alkaline waters in these cases is dominated by the bicarbonate and calcium cations (related to limestones) or magnesium (related to ophiolites). Under particular conditions, the pH may even be higher, exceeding 10.0 or even 11.0, and in this case the water becomes hyperalkaline, the ionic composition is dominated by calcium and hydroxyl, and it is not suitable for human consumption.

High pH may also occur in endorheic lakes in arid climates, which are prone to the accumulations of salts. Waters with a certain content of dissolved salts continuously or temporarily recharge such lakes, and the salt concentration is increasing as a result of the evaporation. Such particular lacustrine environments may show remarkably high values of the pH, sometimes exceeding 11.0. As an example, the Eras Lake, located in Central Spain, is a brackish to saline, highly alkaline lake, with pH up to 11.3 (Cabestrero et al., 2018). In SE Romania, Movila Miresii endorheic lake has pH values above 9.0 (Voicu et al., 2017; IBF, 1961-1973). Such alkaline lakes are suitable for bathing, and some therapeutic effects are recognized.

Taking into account the massive occurrence of ophiolites and limestones in the Southern Apuseni Mountains the geological premises for the genesis of alkaline waters are met, as shown by Nicula & Baciu (2019). Geothermal manifestations are also known in the study area (Orășeanu, 2020; Nicula et al. 2021), an aspect that could intensify the processes of water-rock interaction and increase the level of alkalinity in the water (Xia et. al., 2020).
The current study intends to identify water sources with high pH, to identify the distribution and variability of the pH values in the concerned area, and to assess the prospective zones for more detailed studies.

STUDY AREA

Geologically, the Southern Apuseni Mountains represent a distinct portion, with particular features, of the Apuseni Mountains. The North Apuseni Mountains correspond to the outcropping area of the Tisia block, and mainly consist of medium or low-grade metamorphic rocks, with some granitic intrusions. This basement is covered by Permian-Mesozoic sedimentary formations (Săndulescu, 1984). By contrast, the Southern Apuseni correspond to the eastern Vardar mobile area (Schmid et al., 2020). They include ophiolitic units represented by tholeiites (Middle Jurassic) and calc-alkaline magmatic rocks (Late Jurassic to Early Cretaceous) (Mutihac, 1990). The tholeiitic series are present in the western part of the study area, and are dominated by basalts, intruded by gabbros and gabbro-peridotite bodies. The calc-alkaline series occur in the central and eastern part, and include basalts, basaltic andesites, and some acid rocks as dacites and rhyolites. The ophiolites are locally intruded by granitoids (Cioflica et al., 2001). The clockwise rotation of the Apuseni Mountains during the Middle Miocene led to the opening of graben-like basins on the western side of the mountains, that are filled with Miocene sediments. As a result of the extension, calc-alkaline extrusive magmatism has occurred contemporaneously (Seghedi, 2004).

All the sampling points are located in the Southern Apuseni Mountains (figure 1), predominantly along valleys, in depressionary areas. Two distinct zones were investigated. The north-eastern zone overlaps the following geomorphological units: Culmea Hășdate (P1 – P4 and P18 – P20), Colții Trascăului (P13 – P16), Trascău Depression (P5, P6 and P11, P12), Culmea Bedeleu P7, Sălciua Depression (P9), Ocoliș-Poșaga Depression (P8), Aiudului Hills (P17 and P10), Vlaha-Hășdate Depression at the boundary with Feleac Hill (P22 – P27). Most of the points (51 points in total) were tested within the southern area, north of the Mureș Valley. The geographical distribution of the investigated points, by geomorphological units, in the southern zone is the following: the Husului Mountains (P28 – P52), the Măgureaua Mountains (P53 – P59, P73 – P75 and P77, P78), the Brad Depression (P67 – P70 and P76), Găina Mountain (P71, P72), Săcărâmb Mountains (P60 – P63 and P65), and three other points (P64 – P66) towards the eastern part of the study area, in the Almaș-Bălașa Depression.

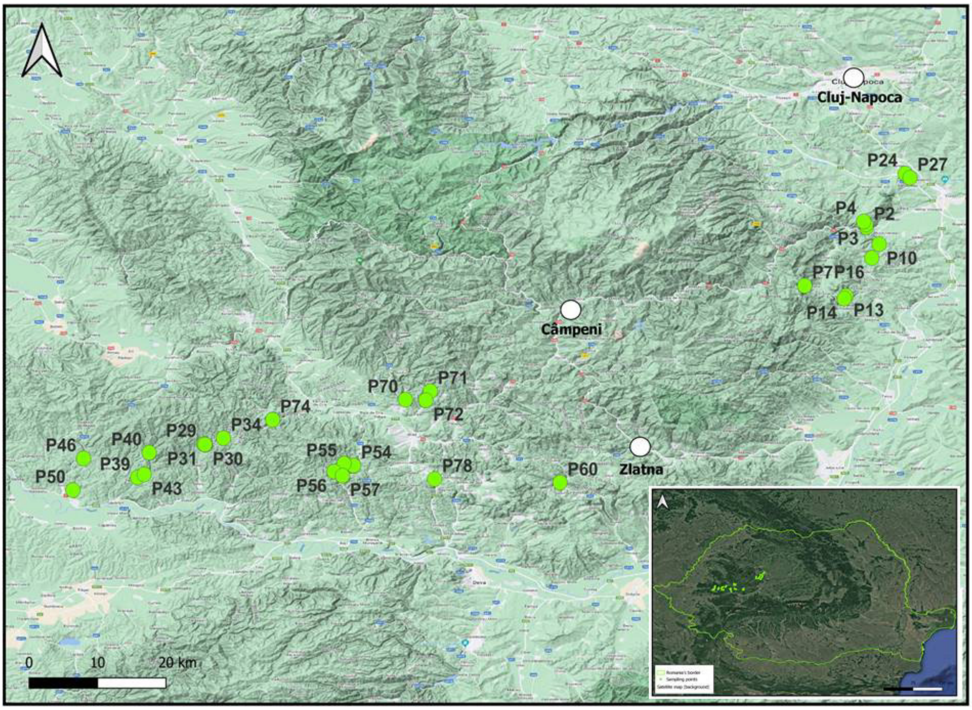


Fig. 1. *Geographical distribution of the sampling points*

Table 1 lists the sampling points, including their coordinates, the water source type (spring, stream, or well), and the measured pH.

Table 1. *Distribution and features of the sampling points.*

Sample ID	Site	Type	pH	Coordinates	
				N	***E***
P1	Spring near road to Buru	spring	7.31	46.51614	23.59192
P2	The lower waterfalls	stream	8.33	46.50842	23.64048
P3	Middle Borzești Gorge	stream	8.40	46.51356	23.63948
P4	The upper waterfalls	stream	8.14	46.51871	23.63517
P5	Spring in centre Rimetea	spring	7.43	46.45319	23.56738
P6	Well in the centre of Izvoarele village	well	7.08	46.40006	23.54016
P7	Point upstream basins (Izvoarele village)	stream	8.21	46.40272	23.52422
P8	Spring near road Sălciua	spring	7.33	46.45518	23.46761
P9	Șipote waterfalls	waterfall	7.77	46.40571	23.45998
P10	Upstream Moldovenești	stream	8.23	46.478016	23.664321

Sample ID	Site	Type	pH	Coordinates	
				N	***E***
P11	Big spring to Găvane	spring	7.83	46.37378215	23.60265164
P12	Small spring to Găvane	spring	7.80	46.37378225	23.60266812
P13	Stream after pine section	stream	8.50	46.3842286	23.6021629
P14	At Gavane	stream	8.51	46.37943	23.598975
P15	Spring in Podeni	spring	7.47	46.43079	23.63027
P16	Stream between Podeni and Pietroasa	stream	8.02	46.452699	23.650518
P17	Spring between Pietroasa and Moldovenesti	spring	7.58	46.477684	23.66272
P18	Hășdate stream Cheile Turzii 1	stream	7.8	46.56505778	23.6768071
P19	Hășdate Stream Cheile Turzii 2	stream	7.82	46.5643716	23.6842254
P20	Hășdate affluent (left)	stream	7.89	46.56232521	23.69103606
P21	Affluent Racilor stream	stream	7.24	46.60997647	23.70441082
P22	SpringTureni	spring	6.7	46.61597606	23.70649234
P23	Spring Cheile Turenilor	spring	6.96	46.60591395	23.71153263
P24	Racilor stream	stream	8.08	46.60547319	23.71282127
P25	Shallow spring	spring	7.37	46.60064863	23.71702568
P26	Affluent Racilor stream (right)	stream	7.65	46.5969597	23.7191388
P27	Affluent Racilor stream (stone quarry)	stream	8.12	46.5978715	23.7221041
P28	Spring Roșia Nouă	spring	7.31	46.1166526	22.3980453
P29	Stream after spring (P28)	stream	8.56	46.1165346	22.3987048
P30	Pond Roșia Nouă	pond	8.24	46.1152165	22.4011229
P31	Petriș stream in Roșia Nouă	stream	8.46	46.1156634	22.4006482
P32	Well Roșia Nouă	well	7.42	46.1167275	22.4021612
P33	Petriș stream downstream Obârsia	stream	7.76	46.1274422	22.4349795
P34	Affluent Petriș stream	stream	8.55	46.127221	22.4352019
P35	Roșia Noua spring	spring	6.83	46.11386988	22.40136358
P36	Well in Corbești	well	7.10	46.0866038	22.3888061
P37	Affluent Petriș stream (Corbești)	stream	7.55	46.078117	22.384998
P38	Petriș stream	stream	7.65	46.0493681	22.3882655
P39	Spring in Temeșești	spring	8.10	46.0560954	22.2742753
P40	Upstream Troas affluent	stream	8.3	46.1009959	22.2962234
P41	Troaș stream	stream	7.62	46.1013846	22.2961787
P42	Troaș affluent downstream	stream	7.60	46.0805159	22.3003221
P43	Troaș stream downstream Săvârșin	stream	8.10	46.0615179	22.2868142
P44	Julița stream downstream Slatina de Mureș 1	stream	7.88	46.1560409	22.1825789
P45	Julița stream downstream Slatina de Mureș 2	stream	7.71	46.1308698	22.1751594
P46	Affluent Julița stream	stream	8.24	46.090331	22.173169
P47	Spring downstream Julița	spring	7.36	46.0653764	22.1451813
P48	Well in Julița	well	6.9	46.0545446	22.133562

Sample ID	Site	Type	pH	Coordinates	
				N	*E*
P49	Bălcescu stream	stream	7.67	46.035404	22.106122
P50	Stejar stream	stream	8.06	46.033025	22.153194
P51	Cerbia stream	stream	7.05	46.0385959	22.4476029
P52	Spring	spring	6.82	46.0379853	22.4479596
P53	Spring on the roadside	spring	7.23	46.0743243	22.6765123
P54	Șarpe stream	stream	8.66	46.07753423	22.67930534
P55	Sârbi stream	stream	8.73	46.081039	22.661577
P56	Sârbi stream downstream Valea Poienii	stream	8.68	46.066849	22.642652
P57	Vișa spring	spring	8.36	46.05927768	22.65841995
P58	Sârbi stream upstream of Vorța	stream	7.86	46.030896	22.667898
P59	Sârbi stream in Valea Lungă	stream	7.83	45.984276	22.683951
P60	Geoagiu stream downstream Almașu	stream	8.52	46.04686	23.066191
P61	Spring in the forest	spring	7.53	46.046919	23.064608
P62	Voia downstream spring	spring	7.72	46.040195	23.055581
P63	Spring in Voia	spring	7.42	46.035768	23.04588
P64	Almășel stream	stream	7.32	46.0535626	23.0760686
P65	Bălașa stream	stream	7.56	46.0790215	23.0666046
P66	Ribișoara spring 1	spring	7.46	46.041913	23.072566
P67	Ribișoara spring 2	spring	7.07	46.1998411	22.7758753
P68	Well in Ribișoara	well	7.10	46.2164464	22.7745376
P69	Ribița stream base of the gorge	stream	7.55	46.228845	22.770022
P70	Ribița stream	stream	8.41	46.1966692	22.776397
P71	Junc stream downstream Dumbrava	stream	8.09	46.212113	22.823147
P72	Junc stream downstream Crișan	stream	8.45	46.195795	22.814543
P73	Vața stream upstream	stream	7.62	46.128577	22.507714
P74	Vața stream downstream	stream	8.49	46.1603619	22.5276124
P75	Spring in Căzănești	spring	7.60	46.1631897	22.5339477
P76	Luncoiu stream	stream	7.61	46.068456	22.7903386
P77	Vălișoara spring	spring	7.25	46.0531961	22.830805
P78	Căian stream downstream Vălișoara	stream	8.07	46.0531348	22.8310603

MATERIALS AND METHODS

The background information was obtained from the literature and from the available geological and hydrogeological maps. These data were used to produce the workplan and to establish the potential transects. The transects were outlined by using specific software as Quantum GIS and

Google Earth. The field investigations consisted of four campaigns that mainly targeted the ophiolitic areas defined in the background analysis stage. The north-eastern zone was investigated during three field campaigns focusing on the areas Hășdate-Tureni, Bedeleu, and Trascău. The southern zone was investigated during one campaign, that targeted the whole ophiolitic region located north of the Mureș valley. Field campaigns were carried out during the period 31.10.2022 – 14.05.2023.

During the field stage, the transects were tracked, and in-situ measurements of the collected water samples were carried out using the multiparameter portable meter WTW 350i. The following parameters were measured in-situ: temperature, pH, redox potential and electrical-conductivity; the salinity and TDS were derived from the latter. Water samples were taken from selected points of interest in order to carry out further analyses in the laboratory. Geographical coordinates were recorded for each sampling point. The Geo Tracker application was used to mark sampling points and other field data. In the final stage, the obtained data were systematized and interpreted in order to obtain an overview of the alkaline waters' distribution in the study area.

RESULTS AND DISCUSSIONS

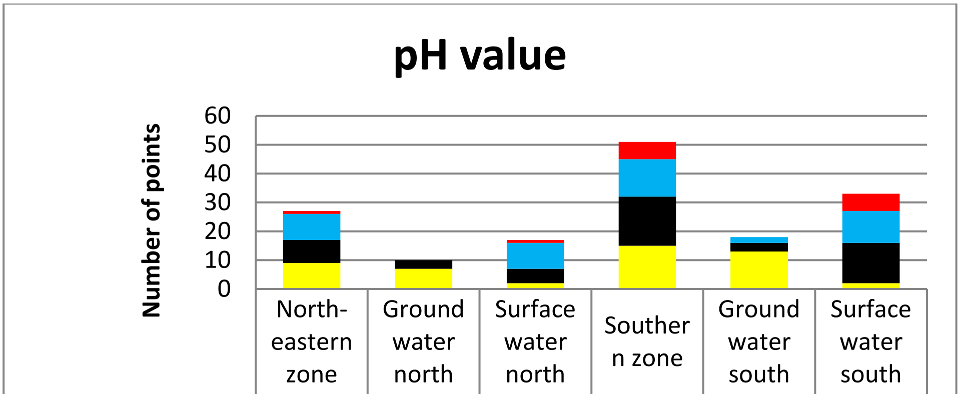
The total number of points investigated in this study is 78. All types of water sources that could have an alkaline character, or can provide information on the genesis and distribution of alkaline waters were considered. Depending on the source type, the sampling points consist of 5 wells, 23 springs and 50 collection points are represented by surface running waters (streams).

The electrical conductivity of the water samples is generally low, varying in the range of 119 to 631 μS/cm, and reflecting the low dissolved solids content. The temperature of the springs and wells is relatively constant, being around 10°C in the case of springs, and around 12°C for dug wells. Of course, the temperature was variable in the case of surface waters, fluctuating between 2.8°C and 15.1°C, in accordance with the air temperature.

The pH was measured in all the 78 investigated points, out of which the pH exceeded the value of 8.5 in 7 points, all of them representing groundwater, it was in the range of 8.0 to 8.5 in 22 points (2 groundwater and 20 surface water), between 7.5 and 8.0 in 25 points (5 groundwater and 20 surface water), and below 7.5 in 24 points (20 groundwater and 4 surface water). Figure 2 shows the statistical distribution of the measured pH values for the investigated water sources.

The spatial distribution of the sampling points in relation with the geological background is represented in figures 3 and 4. As shown in figure 3 and 4, the distribution of points where waters with high pH were measured, extends over the ophiolitic complex. The hypothesis of the current research, inferring that the ophiolitic areas are potential generators of alkaline waters, was confirmed. The number of springs that were identified in the ophiolitic areas is low, as these rocks exhibit low permeability, and therefore, scarce conditions for the accumulation of groundwater. However, in the north-eastern zone, the ophiolites are in contact with Jurassic limestones, that are able to accumulate important amounts of water. Additionally, the limestones are prone to yield neutral-alkaline waters, usually with pH in the range 7.0 to 8.0.

Values of the pH above 8.5 were measured in 7 locations, all of them corresponding to surface running water. Their parameters measured in the field are presented in Table 2. The pH values measured in running waters in the ophiolitic areas allow us to presume that groundwater in the same areas would be even more alkaline.



	North-eastern zone	Ground water north	Surface water north	Southern zone	Ground water south	Surface water south
above 8.5	1	0	1	6	0	6
between 8 - 8.5	9	0	9	13	2	11
between 7.5 - 8	8	3	5	17	3	14
below 7.5	9	7	2	15	13	2

Fig. 2. *Statistical distribution of the measured pH values.*

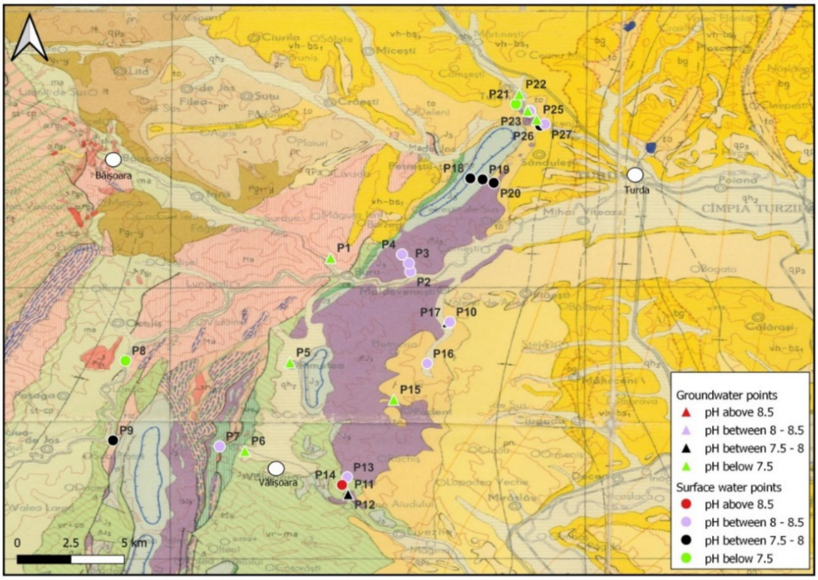


Fig. 3. *The pH values of the investigated water sources in the southern zone. The ophiolitic complex in magenta on the geological map. Background: The geological map of Romania 1: 200,000 (Geological Institute, 1967)*

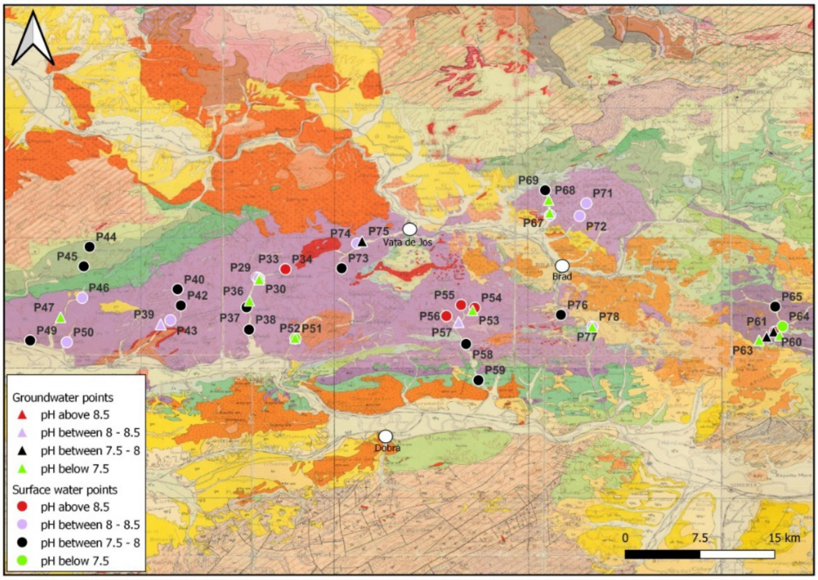


Fig. 4. *The pH values of the investigated water sources in the north-eastern zone. The ophiolitic complex in magenta, and Jurassic limestones in light blue on the geological map. Background: The geological map of Romania 1: 200,000 (Geological Institute, 1967)*

Table 2. *Physico-chemical in-situ measurement results for the most alkaline water sources*

Sample ID	Site	pH	Temperature	Salinity	Conductivity	TDS	Redox potential
			(°C)	(‰)	µS/cm)	(mg/l)	(mV)
P14	At Gavane	8.51	3	0.1	314	200	-77.6
P29	Stream after spring (P28)	8.56	12.7	0.1	412	261	-83.3
P34	Affluent Petriș stream	8.55	11.7	0	293	187	-83.1
P54	Șarpe stream	8.66	11.8	0.1	299	192	-90
P55	Sârbi stream	8.73	14.1	0	278	177	-95.6
P56	Sârbi stream downstream Valea Poienii	8.68	13.3	0	266	172	-91.1
P60	Geoagiu stream downstream Almașu	8.52	12.1	0.1	312	201	-81.6

We include here a brief description of the water points where pH values above 8.5 were measured. Point P14 is located north of Poiana Aiudului. The water sample was collected from the stream that flows towards the locality, a stream that crosses an area with limestones and ophiolites. This is the only point in the north-eastern zone of the study area that shows a pH above 8.5. In the southern zone, a first point identified and placed in this category is P29. This point is located in the Roșia Nouă area on a tributary stream of the Petriș stream. The geological substrate is ophiolitic, but the springs and wells in the area do not have a pH above 8. It is noteworthy that the water sample taken from the Petriș stream (P31) had a pH of 8.46. Also in the same area, on a left tributary of the Petriș stream located between the Roșia Nouă and Obârsia, point P34 was sampled, with a pH of 8.55. Also, in the southern part of the study area within the Metaliferi Mountains near the village of Vișca, 3 points with alkaline waters were found, identified as P54, P55 and P56. All these samples were taken from streams that cross areas with ophiolitic substrate. This group of points had the highest pH values in the entire study. They are located on different streams, and are not influenced by each other. Similar to the situation previously presented on the parallel valley from Roșia Nouă, waters with a higher pH are found in running water bodies and not in springs. However, it is worth noting that the most alkaline spring identified in the current research was measured in the town of Vișca (P57; pH=8.36).

A general remark on all points with high alkalinity concerns the low electric conductivity (266 – 412 µS/cm) and implicitly low TDS (172 – 261 mg/l). A general characteristic observed in the studied area is the compact texture of the rocks and the lack of deep fissures or fractures that would allow the circulation of fluids.

CONCLUSIONS

The data obtained in the present research confirm the potential of the Apuseni Mountains to generate alkaline waters, related to the ophiolitic substrate. About 30 points with waters with pH above 8 were identified in the field. Most points with alkaline waters were sampled in streams that flow through areas with basic rocks. Generally, ophiolitic areas generated waters with a higher pH than areas with a mix of limestone and ophiolite. The measured values of the pH in streams decrease when crossing lower areas, mainly consisting of detrital sedimentary rocks. The pH of waters from wells is around 7, they are dug in low areas with Quaternary alluvium, and likely do not interfere with the bedrock, mostly consisting of compact ophiolitic rocks.

The compact structure of the bedrock does not favour the accumulation of groundwater, thus the number of springs in the area is very limited. The pH of the identified springs is below 8.0. Very likely, the pathway of groundwater that generates the tested springs is shallow, being confined to the superficial deposits, without intercepting the ophiolites. No hyperalkaline waters (with pH above 9.0) have been identified until now in the Southern Apuseni Mountains. As the ultramafic rocks are only locally developed, detailed investigations in the target areas could identify also this kind of waters.

The contacts between the ophiolitic rocks and limestones could provide more favourable environments for the accumulation of alkaline groundwater. By continuing this research, other areas with alkaline water potential can be identified and more information can be provided about the areas preliminary investigated in the current study (identification of additional sources, detailed characterization of the chemical composition).

Following these preliminary investigations, it can be stated that the study area has the capacity to generate alkaline waters, potentially with economic value. The areas with higher potential seem to be the north-eastern zone (Tureni – Buru – Trascău – Poiana Aiudului), and in the southern zone, Roșia Nouă – Vișca area. A detailed hydrogeological characterization of these areas may reveal exploitable alkaline water resources.

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