Technical Sciences
Academy of Romania
www.jesi.astr.ro

Journal of Engineering Sciences and Innovation
Volume 11, Issue 1/ 2026, p. 85 - 92

D. Environmental Engineering and Energy

Received ***30 July 2025*** *Accepted* ***11 March 2026***
Received in revised form ***15 December 2025***

Water resources efficiency

CRISTIAN CIULBEA*, IOAN ASCHILEAN

Technical University of Cluj-Napoca, str. Daicoviciu nr.15, Cluj-Napoca, 400114, Romania

Abstract. The problem of water resources is a major global concern, with significant implications for the environment, health and economy. In Romania, this problem manifests itself through quantitative and qualitative deficits of water resources, pollution and their inefficient exploitation.

Keywords: water resources, water cycle in nature, fluidity.

1. Introduction

Main aspects of the water resources problem:
• Quantitative deficit:
There are areas where water resources are insufficient for local needs, especially during periods of drought or in arid areas.
• Qualitative deficit:
Water pollution, caused by industrial, agricultural or domestic discharges, affects the quality of water and makes it unsuitable for consumption or irrigation.
• Water pollution:
Sources of pollution include:
• Nutrient pollution: Nitrogen and phosphorus from agriculture reach surface waters, causing algal blooms and reducing dissolved oxygen.
• Untreated wastewater: Untreated domestic and industrial wastewater contributes to the contamination of water sources.
• Industrial pollutants: Chemicals and heavy metals discharged by industry pollute water.
• Emerging contaminants: Microplastics and pharmaceuticals in wastewater are a growing problem.
• Inefficient exploitation:

*Correspondence address: ciulbeac@yahoo.com

t

Outdated infrastructure, losses in distribution networks and unsustainable agricultural practices contribute to the inefficient exploitation of water resources.
• Impact of climate change:
Droughts, floods and rising temperatures aggravate the problem of water resources, affecting the quality and availability of water.
Solutions and courses of action:
• Infrastructure investment:
Modernization of water treatment plants, water supply and sewage networks, and implementation of efficient irrigation systems.
• Integrated water resources management:
Efficient management of water resources, taking into account all aspects: quantity, quality, multiple uses and protection of aquatic ecosystems.
• Promotion of sustainable agricultural practices:
Reducing the use of pesticides and chemical fertilizers, adopting efficient irrigation techniques and promoting crop rotation.
• Public awareness and citizen involvement:
Educating the population on the importance of water conservation and on everyone's responsibility in protecting water resources.
• Water protection legislation and policies:
Implementation of clear and coherent policies, with strict water quality standards and sanctions for polluters.
• Research and innovation:
Development of new and efficient technologies for water treatment, monitoring water quality and identifying pollution sources.
In Romania, the problem of water resources is acute, and concerted and urgent actions are needed to ensure a sustainable future for water resources.

2. Method: Water resources

Method: WATER RESOURCES: - Atmospheric: water from the Earth's atmosphere - On land: - glacial water - water from the slopes - river water (hydrographic network) - lake water (lakes and closed seas) - groundwater - deep - karst - Oceanic: - seas and oceans
Water resources on the globe: underground: 0.1%; surface: 0.9%; ice caps 2%; Saltwater 97%
Forms in which water is found in nature
In the atmosphere: water vapor, fog, clouds
Precipitation: rain, hail, snow, dew, frost
Glaciers, icebergs
Hydrographic network
Seas and oceans
Aquifers
Transition from one form to another: the hydrological cycle through: evaporation, precipitation, runoff, freezing

Usable water resources world average: 5000 m3/capita/year European average: 3000 m3/capita/year Romania: 1700 m3/capita/year - 0.22% of the world resource - 0.37% of the world population Canada: 110,000 m3/capita/year Australia: 21,800 m3/capita/year Russia: 16,000 m3/capita/year U.S.A.: 10,000 m3/capita/year France: 4,300 m3/capita/year China: 2,800 m3/capita/year Egypt: 90 m3/capita/year

WATER RESOURCES OF ROMANIA • Surface waters: - inland rivers: - length: 79,000 km - average volume: 40 billion m^3 - average flow: 1,250 m^3/s - specific flow: 1,700 m^3/person/year - Danube: - volume 170 billion m^3 – 20∗109 m^3/year belong to Romania - natural lakes: no. 122 (insignificant values) • Groundwater: - total volume: 9×109 m^3/year - usable volume: 6×109 m^3/year • Black Sea water: - cooling processes - desalination (insignificant volumes)

River basin:
The area of land from which all surface runoff flows through a succession of streams, rivers and possibly lakes, towards the sea, in a river with a single mouth, estuary or delta.
Sub-River Basin:
The area of land from which all surface runoff flows through a succession of streams, rivers and possibly lakes, towards a specific point in a watercourse (a river confluence or a lake).
The characteristic elements of a river basin:
Area: [km^2] •Length of coded watercourses: [km] •Water resources: [m^3] •Shape: by the ratio between area and length •Average altitude: [m] •Altitude distribution pattern •Geological structure •Vegetative cover and its distribution on the surface of the basin •Climate •Orientation

The amount of theoretical water resources reaches high values compared to the requirements of this resource. Thus, the total theoretical resource is 136,600,000 thousand m.c., the existing resource according to the degree of development of the hydrographic basins being 40,482,841 thousand m.c. and the requirements of 12,265,698 thousand m.c. In 2006, the total raw water withdrawals in Romania were 5.29 billion m^3. Water withdrawals have decreased from 20.4 billion m^3 in 1990 to 5.29 billion m^3 at present, due to: the decrease in agricultural activity (irrigation); the decrease in industrial activity; the reduction of water consumption in technological processes; the reduction of losses; the application of the economic mechanism in water management. Compared to the current population of the country, a specific resource usable in natural conditions results, of approx. 2660 m3 /capita/year, taking into account the Danube's contribution, respectively a

t

theoretical specific resource, of approx. 1770 m^3 /capita/year, taking into account only the contribution of inland rivers, placing from this point of view our country in the category of countries with relatively low water resources compared to the resources of other countries. The main water resource of Romania is the inland rivers. The water quality monitoring activity was organized in 2006 mainly on the middle and lower water courses (over a length of 27,056 km), where the impact of human actions on the environment, respectively on the water quality, is manifested. Measurements were also carried out in reference sections of the water courses, located especially in the upper areas, where this impact is minimal.

For the physico-chemical assessment of the overall water quality, in each monitoring section, the values with a 90% assurance, respectively 10% in the case of dissolved oxygen, or the average values were calculated for each indicator, and these were compared with the limit values of the quality classes provided by the five-class quality standard, thus resulting in classification in one of the five quality classes. The indicators included in the five-class quality standard were divided into 5 main groups: • the "oxygen regime" group comprising: dissolved oxygen, BOD5, COD-Mn, COD-Cr; • the "nutrients" group comprising: ammonium, nitrites, nitrates, total nitrogen, orthophosphates, total phosphorus, chlorophyll; • the "general ions, salinity" group comprising: dry filterable residue, sodium, calcium, magnesium, total iron, total manganese, chlorides, sulfates; • the "metals" group which includes: zinc, copper, total chromium, arsenic.
The metals lead, cadmium, mercury, nickel were classified as priority substances; • the group „organic and inorganic micropollutants" which includes: phenols, detergents, AOX, petroleum hydrocarbons. Other substances such as PAHs, PCBs, lindane, DDT, atrazine, trichloromethane, tetrachloromethane, trichloroethane, tetrachloroethane, etc. were classified as priority substances. The elaboration of the synthesis of the quality of surface running waters for 2006 was based on the processing of primary data regarding the physico-chemical analyses of waters, data obtained in 842 monitoring sections, located in hydrographic basins. During 2006, the overall quality of surface water, assessed according to the situation of the 842 monitoring sections, was distributed as follows: class I – 31.4%; class II – 46.1%; class III – 15.8%; class IV – 3.7%; class V – 3.1%; which means that depending on the total length of the rivers monitored in 2006 of 27,056 km: 8,051 km were classified in class I quality; 12,565 km in class II; 4,465 km in class III; 1,388 km in class IV and 587 km in class V. Compared to the total coded watercourses of 78,905 km, not taking into account pollution due to the natural background and considering that the length of unmonitored watercourses has water of quality I÷II, it results that 0.7% fall into class V; 1.8% into class IV; 5.7% into class III and 91.8% fall into class I÷II.

Tabel 1. Annual Budget of Continental Waters (Lvovici, 1979 citat de Hornberger et al., 1998)

Continent	Surface	Rain	Leakage	Evapotranspiration	Coefficient
Africa	k ^{2} $30{,}3*10^6$	690	140	550	0,20
Asia	$45*$ IO^6	720	290	430	0,40
Australia	$8{,}7*10^6$	740	230	510	0,31
Europe	$9{,}8*10^6$	730	320	410	0,44
North America	$20{,}7*10^6$	670	290	380	0,43
South America	$17{,}8*10^6$	1650	590	1060	0,36

Running waters represent one of the smallest parts of fresh water. However, man has been using them since ancient times. Every year the Planetary Ocean receives about. 1,200 km^3 of water from rivers. The participation of the hydrographic network differs from one continent to another, depending on a number of factors.
The existence of well-developed river systems in Asia (9 out of the 16 rivers with an annual flow of over 10,000 m3/s) places this continent in first place (30.7%), followed by South America (25.3%), North America (17.6%), Africa (9.7%), Europe (6.8%), Australia and Oceania (5%) and Antarctica (4.9%). In terms of fresh water availability per capita, the situation is completely different: Australia and Oceania, which are in last place (among the inhabited continents) in terms of the volume of water drained, this time take first place with over 106,727 m3/capita/year; follows in order: South America (50,256 m^3/capita/year), North America (22,222 m^3/capita/year), Africa (10,020 m^3/capita/year), Asia (5,743 m^3/capita/year) and lastly Europe (5,302 m^3/capita/year). The world average per capita is 10,804 m3/capita/year.

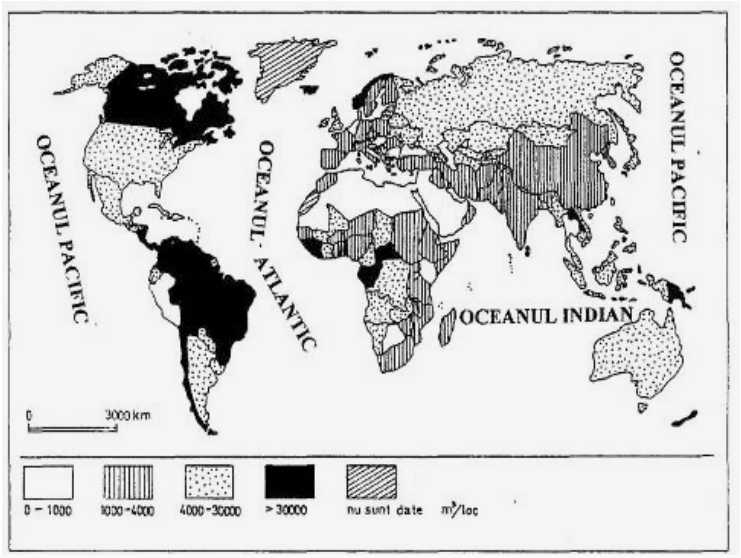

Fig. 1. Earth's water resources related to the number of inhabitants (Ressources mondiales, 1992).

t

However, even within continents, there are very large differences, or even within the same country (Australia, South America, Africa, North America, etc.). In this regard, we can cite the Sahara and Kalahari deserts in Africa, the central deserts in Australia, the Atacama Desert and the Patagonian Plateau in South America, the Mexican Plateau and the Great Basin Plateau in North America, which are far from the average continental index of water availability.

The European continent has the highest availability of fresh water per capita in the western sector of the Scandinavian Peninsula, where the value of this index is over 12 times higher than the continental average. The average is exceeded only by Northern and Eastern Europe, in the high mountainous region of the Alpine-Carpathian-Balkan chain and in some sectors of Western Europe. Values close to the continental average are found in some sectors of Western Europe, the Iberian and Italian peninsulas. The lowest values (two to three times lower) are specific to Central Europe; the latter case is not explained by the lack of water resources, but by the massive concentration of inhabitants, where densities often exceed the value of 200-300 people/km^2. By country, Norway has the highest availability of fresh water per capita, while Hungary ranks last.

The water resources of the rivers in Romania are estimated at 37,000,000,000m^3/year, which means that the value of the availability index per capita is approx. 1,650 m^3. Reality shows that the percentage increases 5 times because the Danube also passes through the territory of Romania, which has an average annual flow at the entrance to the country of 5,300 m^3/s (170,000,000,000 m^3/year). The water requirement in Romania increased from a total of 1.4 km^3 in 1950 to 43 km^3 in 2000 (tab. 2). During the same period, the supply of drinking water was 113 million m^3/year in 1950 and 2.5 billion m^3/year in 1987.

Tabel 2. Romanian Dynamic necessary of water (Zăvoianu, 1993)

Year	Total km^3	From Waters	From Danube	From rivers
1950	1,4	0,15	0,25	1,0
1955	1,0	0,21	0,29	1,5
1960	2,6	0,36	0,34	1,9
1965	4,7	0,50	1,70	2,5
1970	9,1	1,00	4,60	3,5
1975	14,4	1,20	6,20	7,0
1980	20,0	2,10	9,10	8,8
1985	22,0	2,40	10,50	9,1
1990	36,0	L 3,20	18,80	14,0
2000	43,0	4,50	19,50	19,0

3. Discussions and conclusions

The concept of the three "Rs" – reduce, reuse, recycle is often used as a starting point in debates on sustainability and environmental protection. This approach can also be useful when it comes to responsible water use: reducing consumption, reusing water where possible, and only lastly recycling wastewater.
Much of the wastewater from industrial and domestic consumption returns directly to ecosystems, without being treated or reused. Wastewater can be used to produce drinking water, energy, food.
By introducing fewer pollutants into the wastewater collection system, we help protect the environment and drinking water sources. The principle is the same for homes, farms and factories.
There is a need to treat and reuse wastewater while reducing the amount of wastewater produced and the pollutants it contains.
Water must be managed efficiently!

References

[1] Sofronie C., *Managementul integrat al resurselor de apă în bazinul hidrografic Someș- Tisa*, [Integrated Management of Someș-Tisa Water Resource], Hidrotehnica, **42**, 5,1997.
[2] Sofronie C., Bayer C., *Planul de management al apelor în bazinul hidrografic Someș-Tisa*, [*Management Plan of Someș-Tisa Catchment Area*], UTPRESS Printing House, Cluj Napoca, 2012.
[3] Sofronie C., Stoica F., Selagea H. ș.a., *Bazinul Hidrografic Someș-Tisa*, Publisher UT Press, Cluj Napoca, 2013.
[4] Solanes Miguel, Gonzales-Villarreal, Fernando Gonzales*, Principiile de la Dublin privind Apa, așa cum sunt reflectate în Evaluarea Comparativă a Acordurilor Instituționale și Legislative pentru Managementul Integrat al Resurselor de apă*, [*Dublin Principles on Water*, *as Reflected in the Comparative Assessment of Institutional and Legislation Arrangements for the Integrated Management of Water Resources*] published by the Global Partnership of Water, 1999.
[5] Șerban P., *Raport cu privire la Conferința internațională asupra apei și mediului*, Dublin, 1992, Buletinul informativ al R.A. Apele Române, **3**, 1992.
[6] *** *Legea apelor nr. 107/1996*, [*Water Law*] published in the Official Gazette of Romania, Part I, no. 244 in October 1996 with its subsequent amendments and additions: Law no. 310/2004 and Law no. 112/2006, [in Romanian].
[7] *** The Rio Declaration on Environment and Development, Agenda 21, The United Nations Conference on Environment and Development-Earth Summit, Rio de Janeiro, 1992 Published by The Regency Press Corporation, London, 1992
[8] *** *Planul de Management al spatiului hidrografic Somes-Tisa* [*Management Plan of Someș-Tisa Catchment Area*], A.B.A. Someș-Tisa, Cluj Napoca, 2009. Approved by Government Decision no. 80/2011, published in the Official Gazette, Part I, no. 265 bis.
[9] *** Anuarul privind caracterizarea și gospodarirea resurselor de apă pentru districtul de bazin hidrografic Someș-Tisa [Annual book on characterization and management of water resources district Somes-Tisa for 2010 and 2011], A.B.A. Someș-Tisa, Cluj Napoca.
[10] *** Raportul interimar privind stadiul implementării programului de masuri, A.B.A Someș-Tisa, Cluj Napoca [*Interim Report on the Phase of the Implementation of the Programme of Measures*] sent to the European Commission on December 22, 2012, uploaded on the European Water Information System (WISE).
[11] *** Planul de Management al spațiului hidrografic Someș-Tisa, Directia Apelor Someș-Tisa, Cluj Napoca, 2009, aprobat prin HG nr. 80/2011, publicat in MO, Partea I, nr. 265 bis.

t

[12] *** Sinteza cadastrala a B.H. Someş-Tisa, Direcția Apelor Someş-Tisa, Cluj Napoca, 2011
[13] *Managementul integrat al resurselor de apă bazinul hidrografic Someş- Tisa*, Hidrotehnica, **42**, 5, 1997.