BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi" din Iași
Volumul 71 (75), Numărul 3, 2025
Secţia
CHIMIE şi INGINERIE CHIMICĂ
DOI: 10.5281/zenodo.17357581

A CRITICAL ANALYSIS OF DRINKING WATER QUALITY POLICIES AND REGULATIONS IN ROMANIA

BY

MĂDĂLINA-ELENA ABALAȘEI and CARMEN TEODOSIU*

"Gheorghe Asachi" Technical University of Iași, "Cristofor Simionescu" Faculty of Chemical Engineering and Environmental Protection, Department of Environmental Engineering and Management, Iași, Romania

Received: June 17, 2025
Accepted for publication: September 20, 2025

Abstract. Drinking water quality is essential for maintaining human health and ecological balance. Therefore, implementing standards and legislative directives/ordinances is important to protect human health. Water regulations play a crucial role in the efficient management of water resources, particularly in clean water and sanitation. This analysis evaluates the main water quality parameters regulated by national and European standards and highlights the problems related to the implementation of water quality standards in Romania. This study presents the main limitations of the standards related to underestimation of risks associated with emerging toxic contaminants, the adoption of inadequate limit values for current public health requirements, inadequate analytical techniques at international level or protocols, and existing tools for their monitoring.

The conclusions of this analysis in the Romanian context indicate deficiencies in several synthetic chemicals and biological species. The implementation of regulations and standards is essential for sustainable water management, and regional and international partnerships are key solutions to overcome these obstacles.

Keywords: drinking water quality, monitoring, water policies, EU Directives, water resources management.

*Corresponding author; *e-mail*: carmen.teodosiu@academic.tuiasi.ro

1. Introduction

The depletion of water resources due to urbanization, climate change, industrial and agricultural activities, and pollution has a negative impact on the physical-chemical and biological characteristics of water; hence, there is a global concern for safe water supply, human health, and ecosystem balance (Tsoukalas and Tsitsifli, 2018).

Drinking water contaminants pose a major threat to human health; thus, the provision of safe drinking water is one of the most important research directions for mankind, representing a defining issue for developed countries (Ashbolt 2015), and a main objective for developing countries that do not have a well-defined legislative framework (Tsaridou and Karabelas, 2021).

Statistical modeling has revealed that global population growth (100% increase since 1970) directly correlates with water demand surges, highlighting storage infrastructure as a critical limiting factor (Vörösmarty *et al*., 2000).

Drinking water quality is a major concern worldwide, leading to the development of European Union (EU) legislation. The first common EU directive on drinking water quality was issued in 1980, European Drinking Water Directive (80/778/EEC), which is in line with the World Health Organization (WHO) guidelines. This directive was transposed into national law by 15 countries that were part of the European Economic Community at that time.

Directive 98/83/EC on the quality of water intended for human consumption was issued in 1998, five years after the entry of Directive 80/778/EEC into force was repealed. The main objectives of this directive were the establishment of strict standards for a series of microbiological, chemical, and organoleptic water parameters, and the regular monitoring of water quality by national authorities. However, this directive also had a series of limitations; for example, the transposition of the directive and its application was uneven, it did not include all new or emerging contaminants, and public authorities lacked transparency (Lucentini *et al*., 2016).

The review of 98/83/EC started in 2018, later in 2019 the review process was completed and in 2021 Directive (EU) 2020/2184 came into force. The revision of this Directive (Directive 98/83/EC) was initiated in response to the need to update the European legislative framework regarding the quality of drinking water. The main aim of is to ensure an optimal level of protection of public safety by adapting the parameter values to the latest scientific evidence, integrating new parameters relating to emerging pollutants, and strengthening the prevention-based approach and risk assessment in water safety management.

The main new features of Drinking Water Directive (DWD 2020/2184) are as follows: adoption of a risk-based approach, in line with the principles of the Water Safety Plan, along the entire supply chain, including the domestic system from meter to tap, assessing and updating certain quality standards, particularly in terms of adding new parameters and modifying their values in a more restrictive manner and for others in a more permissive manner, identification of possible emerging pollutants present in the sources, require effective and transparent information for citizens on the quality conditions of the tap water supplied, which is necessary to increase consumers' confidence in the water supply network (Dettori *et al*., 2022)

As a member state of the European Union, Romania is aligned with all European Union policies and strategies in the field of drinking water quality and has adopted all necessary instruments to support the water resources management system intended for human consumption.

In Romania, drinking water quality legislation has evolved significantly over the last few decades from the general regulations of Water Law 107/1996 (Legea 107/1996) to modern risk-based approaches. Law 458/2002 (Legea 458/2002) marked an important milestone by aligning with European requirements and has been supplemented and amended several times.

As of 2023, Romania has transposed Directive (UE) 2020/2184 through Emergency Ordinance 7/2023 (EO 7/2023), bringing profound reform to its monitoring and control system. The new legal framework emphasizes the protection of public health, transparency, and the elimination of risks such as lead in networks. Thus, the national system has been modernized for sustainable and preventive drinking water management.

To ensure the quality of drinking water, EU member states have been supported in implementing and monitoring the main quality standards to produce superior quality water and protect human health. The main standards are listed in Annex I of DWD. A total of 48 chemical and microbiological parameters were set at the EU level, which is mandatory for drinking water distributed to the population. At the same time, to ensure the optimal quality of treatment, distribution, and monitoring of drinking water, Member States may, based on the principle of subsidiarity, add additional monitoring parameters, together with the corresponding limits (Lucentini *et al*., 2016; Hartmann *et al*., 2018).

A survey conducted in early 2006 revealed notable progress in providing access to safe drinking water: 87% of the world's population consumed water from certified and controlled sources, a significant improvement from 77% in the early 1990s (Tsoukalas and Tsitsifli, 2018). Although over 90% of the world's population is now supplied with water from controlled sources, an estimated 2.3 billion people still suffer from drinking water-related diseases. Over the past three decades, both developed and developing countries have experienced significant drinking water contamination, causing health problems for consumers (Hamilton *et al*., 2006; Tsoukalas and Tsitsifli, 2018).

Although significant progress has been made towards the implementation of the DWD 2020/2184, standards, regulations, and techniques to detect emerging contaminants, according to WHO, 3.4 million people die annually because of water-related diseases, the majority of whom are children. Thus, the development of new water treatment technologies could reduce the incidence of diseases globally by 4% (Pandey *et al*., 2014).

The regulation of drinking water services involves the setting of essential technical requirements by competent authorities. These include the definition of the water quality parameters to be monitored, frequency of sampling, delimitation of points of compliance, and specification of accepted analytical methods for monitoring water quality.

Water suppliers play a decisive role in providing safe drinking water and must ensure the monitoring and assessment of drinking water quality using appropriate standards, methods, and equipment (Tsoukalas and Tsitsifli, 2018).

In the context of this review, an assessment of DWD 2020/2184 and national legislation on implementation of regulations and standards will be conducted, considering issues related to waterborne diseases, emerging contaminants, and their impact on the quality of human life. Starting from the primary objective of protecting human health, this study identifies the shortcomings of the existing standards, regulations, and their implementation. Although a legal legislative framework is in place, there is an urgent need that has been identified to review the current regulations to adapt them to current challenges.

Issues related to standards and regulations also need to be addressed from the perspective of overall water management, including the infrastructure of water distribution systems, and the adaptation and development of new analytical techniques to determine new emerging contaminants using adapted instruments.

2. Analysis of EU and national legislation of water quality parameters of the regulatory framework

Providing safe drinking water involves understanding and managing the associated risks. Assessing the potential risks to human health requires careful monitoring of the physical, biological, and chemical constituents of drinking water (da Luz and Kumpel, 2020). The quality of drinking water is essentially defined by chemical, microbiological, and radiological parameters as well as factors related to its sensory acceptability, such as color, taste, and odor.

The Water Framework Directive (Directive 2000/60/EC) is the cornerstone of the European Union water policy, establishing a comprehensive framework for the protection of inland surface waters, transitional waters, coastal waters, and groundwater. Its main objective is to achieve "good ecological and chemical status" for all water bodies through an integrated river basin management approach, emphasizing prevention, sustainable use, and public participation in decision-making. Although the Directive does not directly regulate drinking water quality parameters, which are addressed separately by the Drinking Water Directive (98/83/EC, replaced by Directive (EU) 2020/2184), it provides the ecological and regulatory foundation for the protection of water sources used for human consumption. However, despite significant progress in institutional alignment and policy integration, persistent challenges remain, particularly regarding diffuse agricultural pollution, insufficient infrastructure in rural areas, and the limited application of risk-based and adaptive management approaches. Consequently, while the transposition of Directive 2000/60/EC has advanced Romania's compliance with EU environmental objectives, its full implementation continues to require substantial technical, financial, and governance effort.

The EU Drinking Water Directive, 2020/2184, on the quality of water intended for human consumption and Emergency Ordinance 7/2023 (EO 7/2023) include limit values for several chemical substances, which are in line with the values imposed by the WHO guidelines (https://www.who.int/teams/environment-climate-change-and-health/water-sanitation-and-health/water-safety-and-quality/drinking-water-quality-guidelines?).

Table 1 lists the main chemical contaminants included in the DWD 2020/2184 and EO 7/2023. According to the regulations, several differences have been observed between the limits imposed by the DWD 2020/2184, EO 7/2023 and WHO guidelines. Thus, several parameters provide lower values than those proposed by the WHO, whereas the opposite can be observed. For a few chemicals, the limits imposed are higher than those imposed by WHO.

Table 1
Comparison of parametric limit values for some chemical contaminants

Parameter	Maximum permissible limit DWD 2020/2184	Maximum permissible limit EO 7/2023	WHO Maximum permissible limit
	μg/L	μg/L	μg/L
Acrylamide	0.10	0.10	0.5
Arsenic	10	10	10
Barium	-	-	1300
Cadmium	5.0	5.0	3.0
Chlordane	25000	25000	0.2
Chlorite	25000	25000	700
Chromium (total)	25	25	50
1,2-dichloroethane	3.0	3.0	30
Endrin	-	-	0.6
Fluoride	1500	1500	1500
Lead	5	5	10
Selenium	20	20	40
Vinyl chloride	0.5	0.5	0.3
Uranium	30	30	30
Nitrite (as NO_2^-)	500	500	3.000
Nitrate (as NO_3^-)	50.000	50.000	50.000

Chemicals such as nitrates, nitrites, fluoride, and arsenic in natural waters cause serious health problems. According to Directive 91/676/EEC, nitrites are the most common chemical contaminants found in groundwater sources. Consumption of water containing more than 50 mg/L NO_2^- is dangerous to human health, especially for children under 5 years of age (Sehlaoui *et al*., 2022).

Arsenic and synthetic chemicals have a much more serious impact on human health than those mentioned above because they do not alter the organoleptic properties of drinking water. Their detection in the absence of complex analytical techniques makes it difficult to determine their presence, and people may consume contaminated water in the absence of warnings. Inorganic contaminants, such as chromate, pose serious problems, particularly in hard water sources (Tsaridou and Karabelas, 2021).

Over the last decade, contaminants such as synthetic or natural chemicals and micro-organisms, which are not included in monitoring programs or have been included only gradually, especially in the last 10 years, are of concern because there are no clear conclusions about their harmful effects on the environment and human health due to exposure to contaminated water. The main categories of contaminants of concern are per- and polyfluoroalkyl substances (PFASs), endocrine-disrupting compounds (EDCs), pharmaceuticals and cosmetics (PPCPs), microplastics and nanoplastics, and industrial and commercial compounds (ICCs).

This list includes 48 substances or groups of substances, some of which, such as polyaromatic hydrocarbons (PAHs), perfluorooctane sulfonic acid (PFO_S), and heptachlor, have been integrated into the new Drinking Water Directive in 2020 with specific limit values.

However, medicines for human and veterinary use are not yet defined as priority substances in the EU, even though there are proposals for quality standards at European and national level for certain compounds. Existing EU legislation on environmental risk assessment and degradation of pharmaceuticals appears insufficient to fully eliminate their risk to the environment and thus to water and drinking water (Tsaridou and Karabelas, 2021; Campo *et al*., 2016).

Per- and polyfluoroalkylated substances (PFASs) are a group of synthetic chemical compounds present in numerous household items, cleaning products, food packaging, and water-repellent or anti-wicking treatments (Campo *et al*., 2016). These substances have been included in the European DWD, with limit values of 0.5 µg/L for total PFAS and 0.1 µg/L for a subset of PFAS.

In national legislation, these parameters have been included by means of OUG 7/20203, which provides a limit value of 0.5 µg/L for total PFAS and 0.1 µg/L for a subset of 'total PFAS' substances. According to the provisions of this ordinance, these parameters will be monitored from 2024, based on technical guidelines developed by the European Commission. Member States must comply with their limit values, respectively 0.5 µg/L and 0.1 µg/L, by 12 January 2026.

Simultaneously (DWD 2020/2184; EO 7/2023), it has been established that the present parameters 'Total PFAS' and 'PFAS Sum' can be analyzed both or only one of them.

Water disinfection has been successful in preventing waterborne diseases and inactivating pathogens. Chlorination is the most used technology because of its low cost and high effectiveness in pathogens control. According to data provided by WHO, in 2022, 30 countries worldwide reported cases of waterborne diseases, of these about 350,000 were diseases such as cholera, dysentery, typhoid fever caused by lack of access to safe drinking water (WHO, 2022)

Microbiological indicators are mainly used for water quality monitoring and human health impact assessment. At the EU level, several regulations have been stipulated through directives, including the selection of the main pathogens. Water pollution with fecal matter constitutes a public health problem in developed countries, particularly in developing countries (Verani *et al*., 2019; Richiardi *et al.,* 2023; WHO, 2022).

According to estimates by the World Health Organization (WHO), the consumption of contaminated drinking water is responsible for approximately 485,000 diarrheal disease-related deaths each year (WHO, 2021). In developed countries, the incidence of water-related diarrheal diseases is lower because of the implementation of disinfection treatments, hygiene and sanitation measures, and strict regulations on water quality (WHO, 2019).

However, in 2021, seven member states of the European Union (EU) reported 12 outbreaks of waterborne infections linked to the consumption of drinking water from the network, wells, or other sources. In addition, data reported by the Centers for Disease Control and Prevention (CDC) through the National Outbreak Reporting System (NORS) show that, in 2021, 54 outbreaks of waterborne diseases were documented, of which 15 were directly associated with the consumption of drinking water. They accounted for 41% of the reported cases (214/518), nearly 53% of hospitalizations (56/105), and 70% of deaths (7/10). Infections caused by waterborne enteric pathogens continue to be a major global public health problem (Richiardi *et al*., 2023; Saxena *et al*., 2015).

The DWD 2020/2184 and EO 7/2023 regulations set limits for relevant contaminants in treated water without requiring full monitoring of all potentially hazardous substances unless the specific risk assessment of the supply system indicates the need to do so.

To this end, the EU defines a 'core list' of mandatory parameters that should be constantly monitored, regardless of the context. It includes 12 key indicators, including *Escherichia coli*, intestinal enterococci, coliform bacteria, and total colony count at 22°C. Disease outbreaks caused by protozoan parasites and etheric viruses are associated with the consumption of contaminated water (Ashbolt, 2015; Verani *et al*., 2019). Currently, neither the DWD 2020/2184 nor the EO 7/2023 includes quality parameters for known pathogens.

Although they have been detected in numerous water sources, ether viruses, particularly human adenoviruses responsible for a wide range of infectious pathologies, are mentioned in DWD 2020/2184 but are not included as mandatory parameters in water quality monitoring. In the national legislation EO 7/2023, human adenoviruses are not included in the list of mandatory parameters for drinking-water monitoring.

In a study by Anversa *et al*., (2019), the bacterium *Pseudomonas aeruginosa*, considered an indicator of post-treatment contamination, was detected in water samples with residual chlorine concentrations ranging from 0.20 to 2.0 mg/L, demonstrating the resistance of this species to conventional water treatment processes (Tsaridou and Karabelas, 2021). Contamination of water with this bacterium can cause skin and ocular infections in healthy individuals, and acute bacterial infestations in immunocompromised patients (Anversa *et al*., 2019).

According to DWD 2020/2184 and EO 7/2023 (Table 2), the pathogenic bacterium *Pseudomonas aeruginosa* is no longer considered a mandatory parameter for determining drinking water quality.

Table 2

Comparison of parametric and risk-based values for selected biological contaminants

Parameter	Limit value WFD 2020/2184	Limit value EO 7/2023
E. coli	Obligatory parameter, Annex I, Part A. Limit: 0 CFU/100 mL	Obligatory parameter, Annex I, Table A. Limit: 0 CFU/100 mL
Coliformi	Control parameter, Annex I, Part B. Limit: 0 CFU/100 mL	Operational control parameter, Annex 1, Table B. Limit: 0 CFU/100 mL
Legionella spp.	Obligatory parameter in priority buildings, Annex I, Part C. Threshold: 1000 CFU/L	Obligatory in priority buildings, Annex 3, Part C. Threshold: 1000 CFU/L
Cryptosporidium parvum	Not an obligatory parameter but mentioned in the source risk assessment.	Not an obligatory parameter; it occurs only in the context of risk assessment (Art. 7, 13)
Giardia lamblia	Not an obligatory parameter but mentioned in the source risk assessment.	Only on recommendation of the authorities, depending on source and local conditions
Pseudomonas aeruginosa	Not an obligatory parameter but mentioned in the source risk assessment.	Not an obligatory parameter. Yes, for bottled water, hospitals

Parasites such as *Cryptosporidium parvum* (Crypto) and *Giardia lamblia* (Giardia) are associated with water quality, and the transmission of these diseases is associated with suboptimal water treatment. According to a study (Betancourt and Rose, 2004), these pathogens were responsible for drinking water problems, and *Giardia lamblia* cysts were found to be more resistant to removal and inactivation by conventional water treatment than *Cryptosporidium parvum* oocysts.

Naturally occurring radionuclides are normally present in drinking water in varying amounts, exhibiting significant seasonal variations; thus, monitoring of some regulated species may be inadequate due to aquifer composition and changes (Tsaridou and Karabelas, 2021).

Regulations on radiological contaminants were originally established by Directive 98/83/EC, and outside the scope of this Directive, maximum values were stipulated by the Commission Recommendation of 20 December 2001 on the protection of the public against exposure to radon in drinking water, which is a reference document for Directive 2013/51/EURATOM.

This directive allows water operators to set limit values for radon in the range 100-1000 Bq/L, according to the new DWD 2020/2184, the proposed limit for radon is 100 Bq/L. In national legislation, the EURATOM Directive was transposed by HG 301/2016, later supplemented by EO 7/2023 which faithfully transposes the DWD and EURATOM requirements for radioactive substances.

Table 3

Comparison of parametric and reference values for selected radiological contaminants

Parameter	Limit value DWD 2020/2184	Limit value EO 7/2023
Total alpha activity	Screening value: 0.1 Bq/L	Limit: 0.1 Bq/L
Total beta activity	Screening value: 0.5 Bq/L	Limit: 0.5 Bq/L
Radon	Not directly regulated in DWD	Monitored according to HG 301/2016, if relevant in the catchment area
Tritium	Reference value: 100 Bq/L	Limit: 100 Bq/L
Indicative effective dose (IDE)	Mentioned by reference to EURATOM: 0.10 mSv/year	Transcribed in Romanian legislation also as 0.10 mSv/year

3. Evaluation of the implementation of quality standards

In Romania, authorities face the same water quality problems as in other countries, with water quality being affected by several human and natural influences. Thus, Romanian particularities in this field are represented by a specific geographical and economic environment.

However, there is no universally accepted set of standards. The existing standards and regulations play an important role in the implementation of monitoring and assessment programs. Thus, standards form a solid basis for technical regulations.

Standards are documents developed and approved by recognized bodies, providing guidelines or characteristics for products or processes, usually adopted on a voluntary basis (Marx *et al*., 2022). Regulation is a document issued by enabling authorities and presents the specific characteristics of the product obligatory (Tsaridou and Karabelas, 2021). Standards and regulations also need to be addressed from an integrated water management point of view, including both technical aspects such as the infrastructure of water distribution systems and the adaptation and development of new analytical techniques to determine new contaminants using instruments adapted to current requirements (Tsaridou and Karabelas, 2021).

Developing countries that do not have a legal framework to regulate the application of standards are provided in the form of guidelines that water operators apply to provide safe water (Kroehler, 2014).

Analyzing the implementation of the standards involves both a preventive and corrective approach, considering the drinking water supply system from source to consumer (Fig. 1).

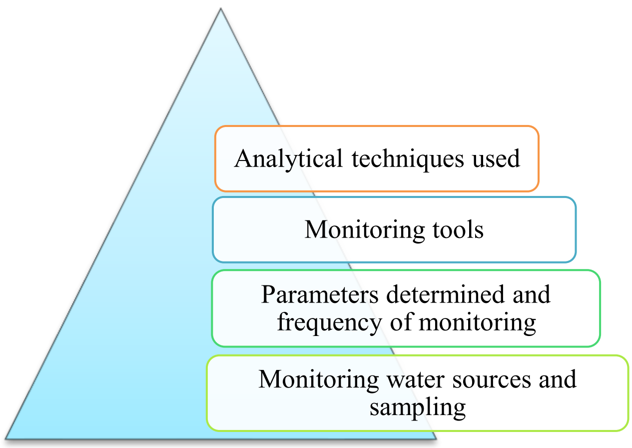

Fig. 1 – Multi-criteria assessment on the implementation of standards.

WHO guidelines on drinking water quality are the basis for regulations established worldwide. The EU legislative framework provides regulations on water quality, from abstraction to the final point of consumption (consumer), and these regulations are regularly reviewed.

The WHO identified several weaknesses in DWD 2020/2184, particularly in the standards on non-regulated contaminants, and raised the issue of monitoring enteric pathogens and *Legionella* bacteria, making recommendations on the inclusion and monitoring of six chemical parameters and, in some cases, three endocrine disruptors (Ashbolt, 2015; Tsaridou and Karabelas, 2021; Molnar *et al*., 2021).

In 2015, the European Food Safety Authority (EFSA) added to the DWD 2020/2184 only one endocrine disruptor out of the three recommended by WHO, namely bisphenol A with a parametric value of 2.5 µg/L. Bisphenol A, is included in the EO 7/2023, which transposes DWD 2020/2184 on drinking water quality. At the same time, recommendations have been made regarding the inclusion of nonylphenol and β-estradiol (17β-estradiol) in the EU Commission's watch list. These substances do not have a mandatory parametric value but only an indicative value (nonylphenol - 0.3 µg/L and 17β-estradiol - 0.001 µg/L (1 ng/L) (Tsaridou and Karabelas, 2021).

Under DWD 2020/2184, only a limited number of the emerging contaminant classes listed in Section 2 were not included in the current regulations. Studies reveal that there are substances not regulated in DWD 2020/2184 and in Government Emergency Ordinance 7/2023 (OUG 7/2023), the latter have been determined in surface water, groundwater, water resulting from the treatment processes, thus highlighting the impact of human activities, industrialization, urbanization and climate change on the environment and aquifers, and therefore, a frequent review of standards and modification of limit values for known toxic contaminants is required (Fig. 2).

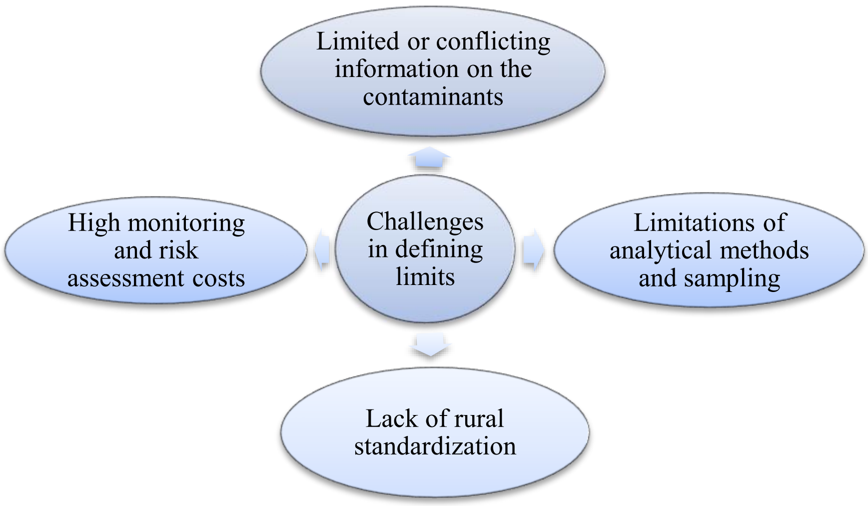

Fig. 2 − Main challenges in determining limits for emerging contaminants and pathogens.

In DWD 2020/2184 it is noted that in previous versions, preventive safety planning and risk-based approaches were integrated only to a limited extent, which led to a number of shortcomings such as: reactive not preventive responses (lack of identification of the main weaknesses of the water supply system, *e.g.* outdated infrastructure led to problems in supply of safe water to consumers), insufficient monitoring (monitoring systems are based on standard parameters imposed by the legislation in force, without taking into account local conditions or the specific risks of each water source), inefficient allocation of resources (investments and efforts are distributed evenly, not in proportion to the risks level), poor coordination between water providers and authorities which has led to a number of inefficiencies in crisis situations, lack of a proactive approach to water safety.

At national level, the traditional approach to drinking water safety has generally been a reactive one, focused on compliance with the quality parameters set by the legislation, without a systemic preventive vision. This is accentuated by the fact that Romania is increasingly confronted with phenomena such as droughts, diffuse agricultural pollution or emerging contaminants (*e.g.* microplastics, pesticides), but preventive measures are not yet an integral part of water source management (Teodosiu *et al*., 2018).

At the same time, communication with the public on water quality is often limited to press releases from water suppliers or hard-to-access reports, which does not contribute to public awareness and involvement. Technical staff involved in water resources management often do not receive continuous training in new risk assessment practices or implementation of water safety plans.

At both national and international levels, the Water Safety Plan (WSP) is a systematic approach to managing water safety risks and is recognized as a modern and effective method of reducing the health risks associated with drinking water consumption. Rigorous preparation and proper implementation of the WSP is essential to protect consumers. The most important element of a WSP is monitoring and operational management, as these are fundamental to control the treatment process and to ensure consistent and safe water quality (Tsaridou and Karabelas, 2021; Kroehler, 2014).

In Romania, the implementation of these plans is still at an early stage, despite the obligation assumed by the transposition of Directive (EU) 2020/2184. Although WSPs are institutionally recognized, their effective implementation is limited by legislative, technical and financial factors.

Currently, the national legislative framework does not provide sufficient detailed provisions for the development, auditing and regular updating of WSPs. For this reason, most water operators adopt a formalized approach, focusing on administrative compliance rather than on effective integration of risk management principles into operational processes. Also, the lack of clear methodological guidelines and the absence of examples of good practice at local level contribute to the uneven application of these plans (https://www.anrsc.ro/).

At the operational level, there are significant difficulties in the availability of data for risk assessment, as well as in staff training. Many facilities lack trained specialists in water safety or risk analysis, and existing monitoring systems are often technologically outdated. These limitations are particularly reflected in rural areas and small communities, where financial and technical capacity is low and investment in upgrading infrastructure is delayed.

Water Safety Plans contribute significantly to improving risk management in the drinking water sector. Benefits observed include increased quality of service through more effective monitoring of water sources, increased compliance with legal requirements and reduced complaints from end-users. These plans also help develop the operational capacity of the staff involved. However, their implementation may be limited by the absence of a clear legislative framework, deficiencies in monitoring infrastructure, lack of experience in complex risk assessment and insufficient institutional support (Tsoukalas and Tsitsifli, 2018).

In addition to the applicable general guidelines, the International Organization for Standardization (ISO) has over the years developed a number of standards relevant to the management of drinking water services, including ISO 24510:2024 and ISO 24512:2024.

These standards provide water operators with guidance on good practice in the day-to-day operation of drinking water facilities, including recommendations for crisis management. In parallel, the Hazard Analysis and Critical Control Points (HACCP) system is used in the technological processes of water systems, aiming to identify and control potential hazards that may compromise the safety of the final product, Table 4 shows the main benefits and difficulties resulting from the implementation of HACCP (Tsoukalas and Tsitsifli, 2018).

Table 4

Benefits and limitations of HACCP implementation in the European water utilities sector

Country	Benefits	Challenges
Bulgaria	Improving drinking water quality Employee awareness Reduction of potential hazards	Lack of staff Limited staff experience Unsuitable materials
Germany	Better understanding of the water supply network Preventing dangerous incidents	Resource and Cost Constraints Complexity of Water Supply Systems
Spain	Improved drinking water quality Establishing an adequate monitoring system for critical parameters Prioritizing hazards	Limited staff experience in hazard identification and risk assessment Limited staff experience Insufficient training on HACCP methodology among operators
France	Improving drinking water quality	Lack of Standardization Across Utilities

		Limited awareness and prioritization of HACCP at the municipal level
Romania	Increase compliance with legislation Improving drinking water quality Better understanding of risk management Faster response to failures Creating a system for recording deviations Raising employee awareness	Lack of staff Limited staff experience Lack of external audit Inadequate control by health authorities Insufficient training on HACCP methodology among operators

The literature points to an ongoing concern about the suitability of microbiological indicators used for the assessment of drinking water quality (DWQ), in particular regarding the selection of reference organisms characterizing the biological composition of water sources. Conventional indicators, such as *Escherichia coli*, enterococci and coliform bacteria, are considered insufficient as surrogates for pathogens with increased resistance, such as human enteric viruses, *Pseudomonas aeruginosa*, *Giardia lamblia* or *Cryptosporidium spp*., and are of limited relevance for a full characterization of microbiological risk (Verani *et al*., 2019; Betancourt and Rose 2004; Anversa *et al*., 2019; Pandey *et al*., 2014).

As regards chemical contamination, inconsistencies have been identified between limit values set at European level for certain compounds (e.g. cadmium, vinyl chloride) and WHO guidelines, which raises additional concerns in the context of the new DWD (EU) 2020/2184. Similarly, the regulation of radioactive substances, in particular the permitted concentrations of radon (100 - 1000 Bq/L), remains a matter of dispute, in relation to the reference value of 100 Bq/L set out in Directive 2013/51/EURATOM (Weinhold, 2012).

In addition, the current regulatory values for radionuclides are set on the basis of the impact on the adult population, not adequately covering the potential risks to vulnerable groups such as children and infants. Romania, as a Member State of the European Union, faces specific difficulties in the full transposition and consistent application of these standards, including in terms of strengthening the monitoring infrastructure and increasing institutional capacity to manage emerging risks associated with the quality of drinking water.

Ensuring and distributing safe drinking water requires, in addition to the set of standards and regulations implemented by each water operator, the implementation of systematic monitoring strategies, such as Water Safety Plans which are developed on the basis of a detailed assessment of the risks associated with the river basin and specific infrastructure of the supply system (Gunnarsdottir *et al*., 2020).

These plans should incorporate scenarios for potentially major disruptive events, including technical failures, accidental or intentional contamination and extreme natural events.

Adequate implementation of regulated monitoring measures is essential to ensure the safety and quality of drinking water. Adequate monitoring, consistently implemented along the entire water pathway- from abstraction, treatment and distribution to the point of consumption - is essential to effectively manage planned or unforeseen processes that may adversely affect the quality of drinking water.

Lack of such control, both spatially and temporally, can compromise water safety parameters and lead to major risks to human health. The current state of drinking water distribution networks, together with their intrinsic characteristics including the age and material composition of the infrastructure, the development of anaerobic conditions, low concentrations of residual disinfectants and the large surface areas available for pathogen colonization are critical factors that amplify the risk of microbial contamination (Stefanelli *et al*., 2018). This underlines the urgent need to develop and implement robust contaminant early warning systems capable of ensuring early detection and effective management of threats to drinking water quality (Fig. 3).

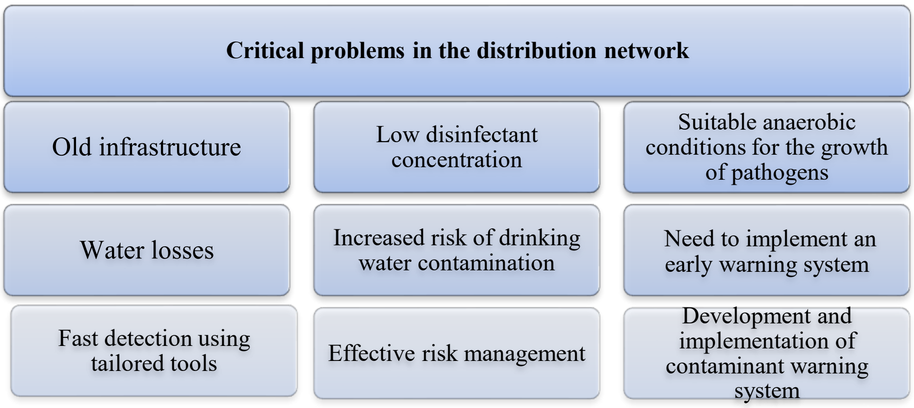

Fig. 3 − Critical issues and intervention strategies in the drinking water distribution network.

According to the EO 7/2023, it can be observed that Romania has made progress in implementing analytical and technical methods that are in accordance with ISO standards or with internal standards used in determining and monitoring water quality, thus ensuring the accuracy and reliability of data obtained. However, at the national level, Romania continues to face substantial challenges in implementing water quality standards aligned with EU directives.

These difficulties are particularly pronounced in rural and peri-urban areas, where outdated infrastructure remains a persistent problem, leading to inefficiencies in water supply and possible contamination (https://documents1.worldbank.org/curated/en/114311530025860150/pdf/127630-REVISED-W18010.pdf).

This is exacerbated by the fragmented nature of water quality monitoring services, which are often distributed between different institutions with overlapping responsibilities, leading to a lack of coherence and delays in response (https://environment.ec.europa.eu/law-and-governance/environmental-implementation-review_en).

Another structural problem is the under-funding of the water supply sector, both in terms of financial investment and human resources. Local authorities often lack technical expertise and administrative capacity to ensure compliance with EU requirements, in particular those stemming from the Drinking Water Directive.

These limitations are further compounded by inefficient enforcement mechanisms that lack the capacity to ensure timely accountability and intervention (Fig. 4).

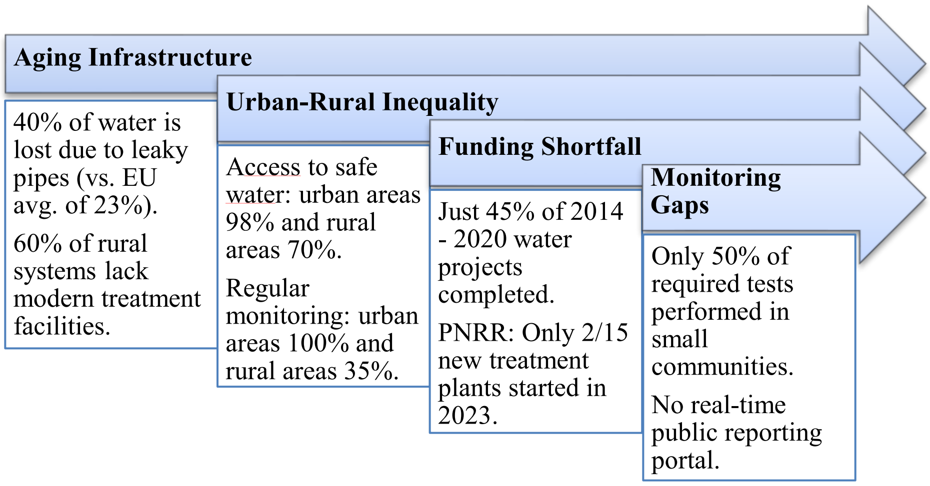

Fig. 4 – Key challenges in implementing water policy in Romania (source: https://www.anrsc.ro/alimentare-cu-apa-si-canalizare/starea-sectorului-de-apa-si-apa-uzata-la-nivel-national-in-anul-2023/).

Ambiguities between central and local government agencies create overlaps or gaps in responsibilities, thus contributing to delays, inconsistent decision making or outright inaction in addressing emerging water quality risks (OECD, 2019).

4. Conclusions

This analysis highlights significant problems with drinking water quality standards and regulations, and how they are implemented at the national and international levels. A number of gaps were found in the regulations and standards of key microbiological contaminants, including *Cryptosporidium, Giardia, Legionella, enteric viruses, Pseudomonas,* and chemical contaminants, such as polyaromatic hydrocarbons (PAHs), perfluorooctane sulfonic acid (PFOS) and per- and polyfluoroalkylated substances (WHO, 2022; Payment and Locas, 2011; Hu *et al*., 2016).

This study highlighted the major uncertainties in the limit values set for several chemical contaminants. These uncertainties may be caused by methodological variations in risk assessment, lack of necessary infrastructure to monitor these substances, inconsistencies in the adoption of international legislation transposed through standards and regulations. In this context, a regular review of standards and their updates based on the latest scientific evidence is essential to protect public health (WHO, 2022; WHO 2017).

A key challenge identified in this study was the reporting of the microbiological indicators. In both national and international legislation, these parameters are presented in general categories (by class) rather than on an individualized basis. One of the most significant constraints is the extended duration of the analyses, which can range from several hours to several days in many cases. The processing time directly influences the responsiveness of the entire monitoring system. This approach may limit the accuracy of microbiological risk assessments and the effectiveness of targeted interventions for drinking water quality.

Another critical issue identified in this review relates to the shortcomings of currently available or approved analytical techniques for the determination of hazardous chemicals and of microbiological contaminants. Methodological limitations, low sensitivity of some methods, and lack of complete standardization may affect both the accuracy of the results obtained and the ability to detect emerging contaminants with potential impact on public health (Liu *et al*., 2025).

Therefore, rigorous monitoring of drinking water quality is of increasing importance. Such an approach is essential not only to ensure compliance with national and European standards but also to effectively protect public health against emerging chemical and microbiological risks.

Given the current shortcomings in standards and regulations, the implementation of a risk-based approach, as required by the Drinking Water Directive (EU) 2020/2184, is fully justified. This new paradigm allows for more flexible and contextualized water quality management and tailoring control measures to the specifics of each supply system. The main responsibility for carrying out risk assessments and implementing the monitoring system lies with the economic operators, drinking water suppliers, and distributors. This delegation of responsibility raises questions about the technical, institutional, and financial capacity of all operators, especially those in rural areas or those with poor infrastructure, to effectively implement these requirements (WHO, 2022).

Authorities must prioritize the regular monitoring and assessment of water quality to address the identified challenges. Restoring water to an acceptable level is becoming increasingly difficult without proactive measures.

REFERENCES

Anversa L., Arantes Stancari R.C., Garbelotti M., da Silva Ruiz L., Pereira V.B.R., Nogueira Nascentes G.A., Alves Dantas S.T., Mores Rall V.L., *Pseudomonas Aeruginosa in Public Water Supply*, Water Practice and Technology **14** (3): 732-737, https://doi.org/10.2166/wpt.2019.057 (2019).

Ashbolt N.J., *Microbial Contamination of Drinking Water and Human Health from Community Water Systems*, Curr Envir Health Rpt, **2**, 95-106, https://doi.org/10.1007/s40572-014-0037-5 (2015).

Betancourt W.Q., Rose J.B., *Drinking Water Treatment Processes for Removal of Cryptosporidium and Giardia*, Veterinary Parasitology **126** (1–2): 219-234, https://doi.org/10.1016/J.VETPAR.2004.09.002 (2004).

Campo J., Lorenzo M., Pérez F., Picó Y., la Farré M., Barceló D., *Analysis of the Presence of Perfluoroalkyl Substances in Water, Sediment and Biota of the Jucar River (E Spain)*, Sources, Partitioning and Relationships with Water Physical Characteristics'. Environmental Research **147** (May): 503-512, https://doi.org/10.1016/J.ENVRES.2016.03.010 (2016).

Council directive (EU). Directive (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the quality of water intended for human consumption. Off. J. Eur. Union 2020, 435, 1-62.

Council Directive 2013/51/Euratom of 22 October 2013 laying down requirements for the protection of the health of the general public.

Council directive (EU). Directive 2000/60/EC of the European parliament and of the council of 23 October 2000 establishing a framework for Community action in the field of water policy. Ammended by Commission Directive 2014/101/EU of 30 October 2014. Off. J. Eur. Communities 2014, 327, 1-93.

Council directive (EU)98/83/EC of 3 November 1998 on the quality of water intended for human consumption. Off. J. Eur. Union 330, 5.12.1998, 32.

Dettori M., Arghittu A., Deiana G., Castiglia P., Azara A., *The Revised European Directive 2020/2184 on the Quality of Water Intended for Human Consumption. A Step Forward in Risk Assessment, Consumer Safety and Informative Communication*, Environmental Research 209 (June): 112773, https://doi.org/10.1016/J.ENVRES.2022.112773 (2022).

European Food Safety Authority, & European Centre for Disease Prevention and Control. The European union one health 2021 zoonoses report. EFSA Journal, **20** (12), e07666, (2022).

Gunnarsdottir M.J., Sigurdur M.G., Maria J.F, Clàudia P., Rubén J., Saucedo G., M. José A.M., *Water Safety Plan Enhancements with Improved Drinking Water Quality Detection Techniques*, Science of The Total Environment 698 (January): 134185, https://doi.org/10.1016/J.SCITOTENV.2019.134185 (2020).

Hamilton P.D., Gale P., Pollard S.J., *A commentary on recent water safety initiatives in the context of water utility risk management*, Environ Int, **32**(8): 958-966, doi: 10.1016/j.envint.2006.06.001 (2006).

Hartmann J., van der Aa. M., Wuijts S., de Roda H.A.M., van der H.J.P., *Risk governance of potential emerging risks to drinking water quality: Analysing current practices*, Environmental Science & Policy, **84**, 97-104, https://doi.org/10.1016/j.envsci.2018.02.015 (2018).

Hu X.C., Andrews D.Q., Lindstrom A.B., Bruton T.A., Schaider L.A., Grandjean P., Lohmann R., Carignan C.C., Blum A., Balan S.A., Higgins C.P., Sunderland E.M., *Detection of poly- and perfluoroalkyl substances (PFASs) in U.S. drinking water linked to industrial sites, military fire training areas, and wastewater treatment plants,* Environmental Science & Technology Letters, **3** (10), 344-350, https://doi.org/10.1021/acs.estlett.6b00260 (2016).

https://www.who.int/teams/environment-climate-change-and-health/water-sanitation-and-health/water-safety-and-quality/drinking-water-quality-guidelines? https://www.who.int/publications/i/item/9789240045064.

https://documents1.worldbank.org/curated/en/114311530025860150/pdf/127630-REVISED-W18010.pdf.

https://environment.ec.europa.eu/law-and-governance/environmental-implementation-review_en.

https://www.anrsc.ro/alimentare-cu-apa-si-canalizare/starea-sectorului-de-apa-si-apa-uzata-la-nivel-national-in-anul-2023/.

Kroehler C.J., *Potable Water Quality Standards and Regulations: A Historical and World Overview*, In Handbook of Environmental Chemistry, **30**:1-36, Springer Verlag, https://doi.org/10.1007/978-3-319-06563-2_1 (2014).

Legea nr. 107 din 25 septembrie 1996 legea apelor, publicat în Monitorul Oficial nr.244 din 8 octombrie 1996.

Legea nr. 458/2002 privind calitatea apei potabile, publicată în Monitorul Oficial al României, Partea I, nr. 582 din 30 iunie 2004.

Liu Z., Y Gan., Luo J., Luo X., Ding C., Cui Y., *Current Status of Emerging Contaminant Models and Their Applications Concerning the Aquatic Environment*: *A Review*, Water **17**(1): 85, https://doi.org/10.3390/w17010085 (2025).

Lucentini L., Achene L., Veschetti E., Fuscoletti V., Di Gregorio N. F., Colagrossi R., & Di Benedetto A.,. *Water Safety Plan implementation in Italy*, In: International Symposium on Sanitary and Environmental Vol. **10**, pp. 19-23 (2016).

da Luz, Kumpel E., *Evaluating the Impact of Sampling Design on Drinking Water Quality Monitoring Program Outcomes*, Water Research 185 (October): 116217, https://doi.org/10.1016/J.WATRES.2020.116217 (2020).

Marx A., Depoorter C., Vanhaecht R., *Voluntary Sustainability Standards: State of the Art and Future Research.* Standards, 2(1), 14-31, https://doi.org/10.3390/standards2010002 (2022).

Molnar E., Maasz G., Pirger Z., *Environmental risk assessment of pharmaceuticals at a seasonal holiday destination in the largest freshwater shallow lake in Central*

Europe, Environmental Science and Pollution Research, **28** (42), 59233-59243, https://doi.org/10.1007/s11356-020-09747-4 (2021).

Ordonanța de urgență nr. 7 din 18 ianuarie 2023 privind calitatea apei destinate consumului uman, publicat în Monitorul Oficial nr. 63 din 25 ianuarie 2023.

OECD, *Implementing the OECD Principles on Water Governance: Indicator Framework and Evolving Practices.* OECD Publishing, Paris, France (2019).

Pandey P.K., Kass P.H., Soupir M.L., Biswas S., Singh V.P., *Contamination of water resources by pathogenic bacteria*, Amb Express, ***4***(1), 51 (2014).

Pramod P.K., Kass P.H., Soupir L.M., Biswas S., Singh P.V., *Contamination of Water Resources by Pathogenic Bacteria*, http://www.amb-express.com/content/4/1/51 (2014).

Payment P., Locas A., *Pathogens in water: Value and limits of correlation with microbial indicators*, Ground Water, ***49*** (1), 4-11, https://doi.org/10.1111/j.1745-6584.2010.00710.x (2010).

Richiardi L., Pignata C., Fea E., Bonetta S., Carraro E., *Are indicator microorganisms predictive of pathogens in water?* Water, *15*(16), 2964 (2023).

Saxena G., Bharagava R.N., Kaithwas G., Raj A., *Microbial indicators, pathogens and methods for their monitoring in water environment*, Journal of water and health, **13**(2), 319-339, https://doi.org/10.2166/wh.2014.275 (2015).

Sehlaoui H., Hassikou R., Dakak H., Zouahri A., El Hasini S., Iaaich H., Ghanimi A., Douaik A., *Nitrate Contamination and Associated Health Risks of the Benslimane Groundwater, Morocco*, Environ. Geochem. Health **44**, 4343-4358, https://doi.org/10.1007/s10653-021-01186-5 (2022).

Stefanelli V., Ferrari G., Sampietro M., Carminati M., *Smart Pipe: A Miniaturized Sensor Platform for Real-Time Monitoring of Drinking Water Quality*, 2017 IEEE Workshop on Environmental, Energy, and Structural Monitoring Systems (EESMS), 1-6, 10.1109/EESMS.2017.8052685 (2018).

Teodosiu C., Gilca F.A., Barjoveanu G., Fiore S., *Emerging pollutants removal through advanced drinking water treatment: A review on processes and environmental performances assessmen*t, Journal of Cleaner Production, vol. **197**, Part 1, pp. 1210-1221, https://doi.org/10.1016/j.jclepro.2018.06.247 (2018).

Tsaridou C., Karabelas A.J., *Drinking Water Standards and Their Implementation - a Critical Assessment,* Water (Switzerland*)* **13** (20), https://doi.org/10.3390/w13202918 (2021).

Tsoukalas D.S., Tsitsifli S., *A Critical Evaluation of Water Safety Plans (WSPs) and HACCP Implementation in Water Utilities*, Proceedings, **2**, 600. MDPI AG, https://doi.org/10.3390/proceedings2110600 (2018).

Verani M., Federigi I., Donzelli G.D., Cioni L., Carducci A., *Human Adenoviruses as Waterborne Index Pathogens and Their Use for Quantitative Microbial Risk Assessment*, Science of The Total Environment **651** (February): 1469-1475, doi: 10.3390/ijerph13070733 (2019).

Vörösmarty C.J, Green P, Salisbury J, Lammers R.B., *Global water resources: vulnerability from climate change and population growth*, Science, 2000 Jul 14; **289**(5477): 284-288, doi: 10.1126/science.289.5477.284, PMID: 10894773 (2000).

Weinhold B., *Unknown Quantity Regulating Radionuclides in Tap Water*, National Institute of Environmental Health Sciences, August, 350-365 (2012).

World Health Organization (WHO), *Guidelines for drinking-water quality: Fourth edition incorporating the first and second addenda*, Geneva, Switzerland, https://www.who.int/publications/i/item/9789240045064 (2022).
World Health Organization (WHO), *Compendium of WHO and Other UN Guidance on Health and Environment*; WHO: Geneva, Switzerland, https://www.who.int/publications/i/item/WHO-HEP-ECH-EHD-21.02 (2021).
World Health Organization (WHO), *Guidelines for Drinking-Water Quality: Fourth Edition Incorporating the First Addendum*; WHO: Geneva, Switzerland, https://www.who.int/publications/i/item/9789241549950 (2019).
World Health Organization (WHO), *Water, Sanitation, Hygiene and Health: A Primer for Health Professionals*; WHO: Geneva, Switzerland, https://www.who.int/publications/i/item/WHO-CED-PHE-WSH-19.149 (2019).
World Health Organization (WHO), *Guidelines for Drinking-water Quality: First addendum to the Fourth Edition. Geneva: World Health Organization*, https://www.who.int/publications/i/item/9789241549950 (2017).

O ANALIZĂ CRITICĂ A POLITICILOR ȘI REGLEMENTĂRILOR PRIVIND CALITATEA APEI POTABILE ÎN ROMÂNIA

(Rezumat)

Calitatea apei potabile este esențială pentru menținerea sănătății umane și a echilibrului ecologic. Prin urmare, punerea în aplicare a standardelor și legislației în vigoare sunt importante pentru protejarea sănătății umane. Reglementările privind apa joacă un rol crucial în gestionarea eficientă a resurselor de apă, în special a apei curate și a salubrității. Această analiză evaluează principalii parametri reglementați de standardele naționale și europene și evidențiază problemele legate de implementarea standardelor de calitate a apei în România. Studiul evidențiază principalele limitări ale standardelor datorate subestimării riscurilor asociate contaminanților toxici emergenți și adoptării unor valori limită inadecvate pentru cerințele actuale de sănătate publică, tehnici analitice care nu consideră realizările pe plan mondial, sau protocoalele și instrumentele existente pentru monitorizarea acestora. Concluziile acestei analize în contextul românesc indică deficiențe în cazul mai multor substanțe chimice de sinteză și specii biologice. Implementarea reglementărilor și standardelor este esențială pentru managementul sustenabil al apei, iar parteneriatele regionale și internaționale reprezintă soluții cheie pentru depășirea acestor obstacole.