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Guideline for small communities on risk-based drinking water management in Romania

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Introduction

The present „Guideline for small communities on risk based drinking water management in Romania" was developed within the frame of the project „Water and Sanitation Safety Planning in Romania, Albania, and FYR Macedonia (WatSanPlan)" FKZ16EXI2247A, funded by the German Ministry for Environment and Nuclear Safety. The project is a continuation of a former one concerning the development of „Compendium for Water and Sanitation Safety Planning in a Rural Community", guideline translated in several languages, including Romanian (www.wecf.eu/english/publications/2017/Revised-Compendium.php).

The aim of the project is to raise awareness about water, sanitation, hygiene and health in rural areas of Romania and Macedonia, do capacity building among schools and local authorities and stakeholders, and develop Water Sanitation Safety Plans for selected villages in each country.

The project was under the management of Women Engaged for a Common Future (WECF), an international network of over 150 women's and civil society organizations implementing projects in 50 countries, and advocating globally to shape a just and sustainable world.

WECF advocates for „Safe Water and Sustainable Sanitation for All", supporting the implementation of decentralized, safe sustainable and affordable sanitation systems for rural areas and promoting in particular access to safe water and sanitation for schools. WECF and partners represent civil society in the UNECE Protocol on Water and Health process and advocate for an integrated and sustainable approach to water resource and river basin management.

At local level, the project was managed by Aquademica Foundation Timisoara a professional organization aiming to bring together specialists working in the field of environmental protection within the regional water operators in Romania, and also involving personalities in Romanian universities and abroad, to develop professional capacities in the field. Thanks to German partners, Aquademica is also able to use the German know-how. The project implementation has benefited by a letter of support from the Romanian Ministry of Health.

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Chapter 1 What is a Water Safety Plan?

1.1 Brief history about the WSP development road

The first World Health Organization (WHO) publication dealing specifically with drinking-water quality was published in 1958 as International Standards for Drinking Water. In 1984-85, the 1st edition of the WHO Guidelines for Drinking-Water Quality (GDWQ) was published. It was recommended in 1995 that the GDWQ undergo a rolling revision process. During the revision of the WHO Guidelines for Drinking-water Quality leading to the 3rd edition, the value of the Water Safety Plan (WSP) approach has repeatedly been highlighted. The potential for water safety plan application has been evaluated in a series of expert review meetings in Berlin (2000), Adelaide (2001) and Loughborough (2001) [1].

"*The most effective means of consistently ensuring the safety of a drinking-water supply is through the use of a comprehensive risk assessment and risk management approach that encompasses all steps in water supply from catchment to consumer. In these Guidelines, such approaches are called Water Safety Plans (WSPs)*". The words above open Chapter 4 of the 3rd edition of the WHO GDWQ (2004) and capture the philosophy of the WSP approach. The chapter describes the principles of the WSP approach rather than being a guide to their practical application. This is why in 2009 it was published the "Water Safety Plan Manual, Step by Step Risk Management for Drinking Water Suppliers" by the joint effort of WHO and International Water Association (IWA). The aim of this Manual is to provide that practical guidance to facilitate WSP development focusing particularly on organized water supplies managed by a water utility or similar entity [2].

1.2 The legal frame of WSP implementation, presently available for the EU Member States

The legal frame on drinking water quality at the European Union level is represented by the Directive on the quality of water intended for human consumption 98/83/EC that aims to protect human health from adverse effects of any contamination of water by ensuring that it is wholesome and clean [3]. The Directive lays down the essential quality standards at EU level, a total of 48 microbiological, chemical and indicator parameters that must be monitored and tested regularly, and it is based on WHO drinking water guideline. The '98s edition of the Directive doesn't specifically link water quality at source with water quality at consumer's tap, and the management procedures along the chain between the cause of water contamination and its effect on human health.

The consolidated text of the Directive with its latest amendments included in the Directive 2015/1787/EU, has specifically introduced the risk assessment and risk management practice which is actually the concept of the Water Safety Plans [4]. The risk assessment referred in the Directive is based on the general principles of risk assessment set out in relation to international standard EN 15975-2 concerning "security of drinking water supply, guidelines for risk and crisis management"[5].

Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with the Directive 2015/1787/EU within two years of its entry into force, meaning by the year 2017. The timescale for Member States to comply with the provisions of the Directive is of five years of its entry into force, by the year 2020.

1.3 Main steps of developing a generic WSP

Water Safety Plans are considered by the WHO as the most effective means of maintaining a safe supply of drinking water to the public. Comprehensive risk assessment and risk management analysis forms the backbone of these plans, which aim to steer management of drinking water-related health risks away from end-of-pipe monitoring and response. The principles and concepts of other risk management paradigms are extensively drawn upon in WSP design, including the multi-barrier approach and hazard analysis and critical point (HACCP)[6].

In order to produce a plan, a thorough assessment of the water supply process from water source to the consumer's tap must be carried out by the water provider. Hazards and risk should be identified, and appropriate steps towards minimizing these risks are then investigated. Stakeholders' communication and cooperation is vital for the success of WSP's implementation.

The development and implementation of WSP approach for each drinking water supply is as follows:

- Set up a team and decide a methodology by witch a WSP will be developed
- Identify all the hazards and hazardous events that can affect the safety of water supply from the catchment, through treatment and distribution to the consumers' point of use
- Assess the risk presented by each hazard and hazardous event
- Consider if controls or barriers are in place for each significant risk and if these are effective
- Validate the effectiveness of controls and barriers
- Implement an improvement plan where necessary
- Demonstrate that the system is consistently safe

- Regularly review the hazards, risks and controls
- Keep accurate records for transparency and justification of outcomes [2].

Chapter 2 Guideline for small communities on risk based drinking water management

2.1 Particularities of drinking water supply in rural localities of Romania

According to Eurostat, Romania has the lowest rate among all EU's Member States with 62% of population connected to public drinking water supply [7]. There are major disparities among urban and rural areas concerning the coverage with services of water supply and sewage. In rural areas, only 28.7% of inhabitants have access to public drinking water supply, in comparison with urban areas were the connections reach 93.8% of inhabitants [8]. The urban population is connected to sewerage networks in proportion of 87.7%, while the rural population is connected only up to 8.2%. The lack of water supply is one of the criteria that places Romania on the poverty map of the European Union, the most affected being the rural communities.

Water supply systems in rural localities are considered to be small water in supply zones (WSZs), and they are described in the Report prepared by the National Institute of Public Health in 2010 [9]. Small WSZs are classified according to the volume of water supplied as CAT1 (10-100m^3/day), CAT2 (100-400m^3/day), and CAT3 (400-1,000m^3/day). In Romania, there were registered 2,049 small WSZs, out of which 961 belong to CAT1, 834 to CAT2, and 254 to CAT3. The population supplied by each category is of 995,959 inhabitants in CAT1, 1,905,124 in CAT2, and 1,036,699 in CAT3. Ground water is the source for the majority of the systems (78.71-92.39%).

The quality of the water supplied is compliant with the requirements of the legislation as follows: 56.29% in CAT1, 55.99% in CAT2, and 50.00% in CAT3. In all types of small WSZs the monitoring frequency is much lower than the legal requirements. The parameters that are more frequently non-compliant are: Colony count 22°C, Coliform bacteria, E. coli, Enterococci, Turbidity, Colour, Conductivity, pH, Oxidisability, Ammonium, Chloride, Iron, Manganese, Nitrate, and Nitrite. Among the microbiological parameters the highest percent of exceeding is represented by Enterococci, and among the physico-chemical parameters by conductivity, followed by nitrates and ammonia [9].

There is no public available record about water related diseases connected with small WSZs.

2.2 Present legal requirements on implementation of WSP in Romania

The EU Drinking Water Directive 98/83/EC sets minimum quality standards for water intended for human consumption (drinking, cooking, other domestic purposes), in order to protect the consumers from contamination. Its Annexes II and III were amended by the Commission Directive (EU) 2015/1787 of 6 October 2015. In particular the Annex II had to be aligned with Water Safety Plan approach which is based on risk assessment and risk management principles, that are internationally recognized principles on which the production, distribution, monitoring and analysis of parameters in drinking water is based [10].

The Directive 2015/1787/EU was transposed into Romanian legislation by Ordinance no. 22 of 30 August 2017 for amending and completing the Law no. 458/2002 on the quality of drinking water.

According to Chapter III, Risk Assessment, art. 7 „Water Safety Plans will become mandatory for drinking water supply systems, collective or individual, providing on average an amount of water greater than 1,000 m^3/day or serving more than 5,000 people, starting with January 1^{st}, 2021”.

Art. 8 refers at small WSZs saying that „Drinking water systems, collective or individual, providing on average a quantity of water less than 1,000 m^3/day or serving less than 5,000 people will optionally enter Water Safety Plans, as a good practice of operating the system”.

In conclusion, Water Safety Plans are not compulsory for the small water in supply zones (WSZs), but rather a good operating practice to assure the safety of the drinking water provided to the consumers.

2.3 Main steps of developing WSP for a small centralized drinking water supply

The WSPs for a small centralized drinking water supply systems located in rural area, very often has to be accomplished with limited technical, financial, and human resources in comparison to professional water operators serving big cities or urban areas in general. Simplified tools have to be developed to translate the formal WSPs into a format that is meaningful and accessible for communities to use [11]. The international experience acquired show that WSPs can be developed and implemented for small community managed water supplies, and they improve the sanitary condition and water quality at source and at the consumer end point. The guideline recommendations of this chapter are based on specific bibliographic references and the results of the pilot study presented in chapter 3. It was chosen a village located in the western part of Romania that could be considered representative for a rural area located in central and Eastern Europe to validate the guideline recommendations.

Water Safety Plan ensures safe supply of drinking water by: (i) Knowing and documenting the entire supply system; (ii) Identifying where and how issues could arise; (iii) Constructing barriers and management systems to prevent problems; (iv) Ensuring all system components work properly.

The drinking water sector is increasingly aware of the limitation of the end-product testing for ensuring the consumers’ safety. Hazard Analysis and Critical Control Points (HACCP), the principle grounding the WSP's development, identifies and manages significant hazards at key points in the water production process. The main role of HACCP analysis is to understand the risks associated with each stage of drinking water production process, focusing on process's control from raw water to tap water, and thus reducing at minimum the risk values for the end product, and increasingly building the consumers' trust [12]. The overview of the Water Safety Plan development is shown in table 1.

Table 1 Matrix of WSP Development

WSP Development Steps	Main components of the drinking water supply system			
	Water Source	Treatment station	Distribution network	Tap water
Information gathering	Type of catchment, the water source	Charts, treatment processes, capability, control	Diagrams, flow direction, equipment, storage tanks, the status of valves	Type of premises, distribution network materials
Hazard Identification in critical points	Sources of pollution, climate	Catchment area, reagents used in treatment, materials used, the ineffectiveness of treatment, power failures	External contamination, flow fluctuations, unauthorized connections, back siphonage	Siphonage, leakage from pipelines, hygiene
Risk Assessment	Likelihood and consequences of pollution	Likelihood of having an ineffective treatment, the consequences of inefficiency	Likelihood of failure, consequences	Likelihood of occurrence, consequences
Control Measures	Catchment and reservoir management	Treatment process, process monitoring, warning systems, shutdown of water supply to the network	Operational procedures, approved materials, valve status	Sealing elements, treatment to remove plumbo-solvency, education
Monitoring of Control Measures	Pollutants' points of discharge, raw water quality	Raw water, treatment process, disinfected water supplied to the network (end product)	Flow, pressure, residual disinfectant concentration	Inspection of the premises

WSP Development Steps	Main components of the drinking water supply system			
	Water Source	Treatment station	Distribution network	Tap water
Actions in case of exceeding the Maximum Admissible Concentrations (MACs)	Stopping the takeover of water from source, adjusting the treatment process	Stopping the takeover from water source, adjust the treatment process, the treatment plant closing	Water discharge, flushing pipes, advising people to boil water	Advising consumers

(Source, WHO)

Following the above matrix, the whole water supply system has to be analyzed in its critical points, and risk scores have to be established for each part of the chain, according to the risk matrix shown in table 2.

The key of establishing the scores of likelihood is the following: **5** - almost certain, means a daily occurrence of a hazardous event; **4** – likely, is once a week; **3** – moderately likely, is once a month; **2** - unlikely, is once per year; **1** – rare, once every 5 years [10].

The guidance on how to set the scores for severity of the hazardous event or in other words the consequence of the impact on human health is the following: **Catastrophic** means potentially lethal to large population; **Major** is for potentially lethal to small population; **Moderate** means potentially harmful to large population; **Minor** is potentially harmful to small population, and **Insignificant** means no impact or not detectable [10].

Table 2 Risk Matrix

Severity/Consequence's Impact / Likelihood		Insignificant	Minor	Moderate	Major	Catastrophic
		1	**2**	**3**	**4**	**5**
Almost certain	**5**	**5** (L)	**10** (M)	**15** (H)	**20** (VH)	**25** (VH)
Likely	**4**	**4** (L)	**8** (M)	**12** (H)	**16** (VH)	**20** (VH)
Moderately likely	**3**	**3** (L)	**6** (M)	**9** (M)	**12** (H)	**15** (H)
Unlikely	**2**	**2** (L)	**4** (L)	**6** (M)	**8** (M)	**10** (M)
Rare	**1**	**1** (L)	**2** (L)	**3** (L)	**4** (L)	**5** (L)

(Source, WHO)

Following these criteria the range of risk scores is between 1 and 25. After risk assessment of the drinking water supply system in critical point, various actions are recommended according to the size of the risk's scores, classified as following: low risk (score 1-5), medium risk (score 6-10), high risk (score 12-15) or very high risk (score 16-25).

Actions to be undertaken:

- **Low risk:** management will be carried out according to routine procedures which will be regularly reviewed.
- **Medium risk:** there is a need to act and plan.
- **High risk**: priority actions are needed to immediately reduce the danger.
- **Very high risk**: urgent action is needed to prevent danger, for example water supply interruption, warning people to boil water, restrictions in use, and priority actions for immediate danger reduction.

HACCP that is at its origin a food safety management system, and that was embraced for the development of WSP, can control the microbiological, chemical and physical hazards in order to obtain a safe drinking water. Safe guarding the quality of drinking water is very important for every treatment plant, but especially for the small supply systems which are mainly community based operated.

Water Safety Plan based on risk assessment and risk management principles is a powerful and simple to use management tool for reducing risk from water supplies, emphasizing on system process control and effective management actions.

2.4 Main steps of developing WSP for a very small individual drinking water supply

Very often in rural areas of Romania, water is supplied to the inhabitants both by small centralized systems that operate in parallel with individual water systems represented by dug well with hand pump or windlass or borehole with hand pump, private owned, or public ones belonging to the whole community. This is why, further on it is described a HACCP analysis for the development of a WSP for such an individual drinking water supply. This is also described in WECF's Compendium as a good practice involving school children.

The model of a WSP for a well is part of the WHO Guideline (see table 3), and is also part of the Romanian legislation in place "The Norms of Surveillance, Sanitary Inspection and Monitoring of the Quality of Drinking Water and the Procedure for Sanitary Authorization of the Production and Distribution of Drinking Water, Annex 1, File no. 3. Sanitary inspection of the public fountain" [13].

Table 3 Risk analysis form for dug well with hand pump or windlass

Specific diagnostic Information for Assessment

Risk

1. Is there a latrine within 10m of the well? Y/N
2. Is the nearest latrine uphill of the well? Y/N
3. Is there any other source of pollution within 10m of well? Y/N (e.g. animal breeding, cultivation, roads, industry etc)
4. Is the drainage faulty allowing ponding within 2m of the well? Y/N
5. Is the drainage channel cracked, broken or need cleaning? Y/N
6. Is the fence missing or faulty? Y/N
7. Is the cement less than 1m in radius around the top of the well? Y/N
8. Does spilt water collect in the apron area? Y/N
9. Are there cracks in the cement floor? Y/N
10. Is the hand pump loose at the point of attachment to well head? Y/N
11. Is the well-cover insanity? Y/N

Total Score of Risks …./11

Risk score: 9-11 = Very high; 6-8 = High; 3-5 = Medium; 0-3 = Low

Actions: **Low risk** – water is good; **Medium risk** – water is acceptable; **High risk** - test water, seek specialist advice, temporarily use another source of water; **Very high risk** - do not drink water until you eliminate the causes of contamination

(Source, WHO)

2.5 Developing cooperation among the main stakeholders

The development of Water Safety Plans (WSPs) for small systems should be based on a thorough understanding of the relationships between risk factors and contamination events. Training of community operators is critical to the success of the WSP, and the understanding gained from the assessments provides a sound basis for addressing these needs.

For the rural communities located near big cities, the cooperation with regional water operators might be a solution to build capacity, and to solve their daily operational issues.

Considering the Romanian legislation and institutional set up, the major stakeholders involved in drinking water supplies are the following, together with their indicative roles: water producer, public health authority, and environmental protection authority.

WSP Team includes representatives of key stakeholders: Water Producer, Public Health, and Environmental Protection, supported by local and regional authorities. The water producer normally has the leading role. Cooperation and exchange of information are vital, establishing communication channels as part of the plan.

- **Water Producer** takes into account the risks within the catchment area, draws up the water supply map, identifies and manages the risks from the water intake to the building socket, develops WSP, implements and documents the management and monitoring systems.
- **Public Health Authority** collaborates with the water producer to identify health hazards, performs the audit of the water supply system, investigates possible water related diseases, advises the population and building administrators to maintain water safety in indoor networks, and oversees small water supply systems.
- **Environmental Protection Authority** supports WSP introduction policies, and development in terms of risk identification in the water catchment area, supports WSP from the point of view of risk management in the water catchment area, understands the process of WSP's elaboration.

Irrespective of the size of the water supply system, the Water Safety Plan is:

- the future tool for quality and safety of water
- the best practice at international level
- provides significant benefits for quality assurance
- is included in the revised version of the Drinking Water Directive.

Chapter 3 Pilot study

The study case presented in this chapter is a risk analysis of a small water supply system in a rural area of Romania, with the aim to set up a model to educate and engage the local community in developing and taking ownership of operational management of their drinking water, using the Water Safety Plan as the tool for establishing a preventive management. WSP was developed in 2017 within the frame of the project FKZ 16EXI119-1 "Water and Sanitation Safety Planning in Romania and FYR Macedonia", funded by the German Ministry for Environment, Nature Protection and Nuclear Safety.

The objectives of the pilot study were: (i) To raise awareness about WSP and its significance for good management of drinking water supply systems; (ii) To establish the WSP team in the village; (iii) To collect basic information; (iv) To assemble the information and carry out the risk analysis; (v) To formulate recommendation for completing the information, developing and implementing the future WSP.

The methodology to achieve the scope of the pilot study regarding development of a WSP for the small centralized drinking water supply in a rural community, is based on field visits for on-site assessment, data collection based on interviews using the questionnaires included in the WSSP Compendium, water sampling and laboratory analysis of the samples, risk analysis using scores, and recommendations for WSP further development and implementation.

The commune is located on the upper side of Bega River, and it is formed by four villages with a total population of 1689 (2012), and 629 households (2012); the total area of the commune is 41.86km^2. It was decided to apply a HACCP system as a model for developing and improving the quality of drinking water in the pilot village [14]. In Romania, the main components of a centralized drinking water supply system for a rural area are described in the "Normative on the design, execution and operation of water supply and sewerage systems. Indicator NP 133 – 2013" developed under the coordination of the Ministry of Regional Development and Public Administration (MDRAP) [15].

The 1st step of the pilot study was to contact the local authorities and people interested to be part of the WSP-team in charge with the safe supply of drinking water in the village. The criterion to assembly the team was to include members with appropriate expertise in microbiology, chemistry, water quality and local operations, with a mix of technical and organizational skils within the team [16]. The assembled team included 7 members as follows: the mayor as head of the team, the person in charge of operating drinking water treatment and supply, the chemistry and biology professor, the local project promoter, the manager of the local bakery industrial unit, the healthcare assistant, and the environmental protection responsible at the Village Hall.

The team leader presented a draft product description, intended product use and process flow diagram for the team members to discuss. Then, the necessary legislation for drinking water and the microbiological and chemical parameters as well as the essential steps of treatment for the production of safe drinking-water were determined, and the HACCP principles were discussed for the drinking water supply system in the pilot village [17]. The analysis started with the identification and evaluation of the significant health hazards from the water source to the final steps of treatment processes, and water distribution to the consumers.

The main elements of the analysis concerning the source of drinking water in the pilot village are summarized in table 4.

Table 4 Risk analysis of the drinking water source

	WATER SOURCE (catchment used since 2007)
Information gathering	**Ground water source** – 2 deep boreholes located on Bega riverside: (F1 at 152 m depth, near the treatment station, F2 at 150 m depth, and 206 m far from F1, at the village limit. Abstraction layers are separated by clay and sandy clay. The boreholes are covered. Water is pumped. Water contains ammonia in a concentration of 2-2,22mg/l.

	There is a hydro geological study to set up the sanitary protection zones carried out by Water Basin Administration Banat (26.07.2012). It is established a 10 m sanitary protection area with strict regime, but the fence is broken. There are old test reports for water characterization (since 2005).
Hazard Identification in Critical Points	**Agriculture** – microbiological (cow and sheep farms – manure) and chemical contamination (nitrates, pesticides) **Industry** – chemical and microbiological contamination (bakery industrial unit, and wood processing factory) **Roads** (19 km) & **Railways and Railway station -** chemical contamination; most likely pesticides **Households** – microbiological contamination (only 5-10% of the households have septic tanks; sewage system with waste water treatment plant that doesn't work) **Recreational areas** - microbiological contamination (arboretum park and station park)
Risk Assessment	Microbiological contamination: Severity = 4; Likelihood = 5; **Risk score = 20 (VH)** Chemical contamination: Severity = 3; Likelihood = 4; **Risk score = 12 (H)**
Control Measures	Management of catchment area and reservoir
Monitoring the Control Measures	Monitoring the pollutants' discharge points, and raw water quality
Actions in case of exceeding MACs	Adjusting the treatment process

VH = very high; H = high

Analysis of data on source and catchment area shows that:

1. Ground water source contains ammonia exceeding MAC
2. Boreholes have a fenced sanitary protection zone, but fence is broken
3. Test reports from hydro-geological study are incomplete for characterizing raw water quality (e.g. no microbiological test report for water)
4. There are no test reports to confirm or infirm the real level of contamination.

The risk score for microbiological contamination was estimated at 20 (VH), and for chemical contamination at 12 (H). Very high/high risk scores require urgent/priority actions and control measures such as:

1. Manage polluting activities within catchment area; continuous communication with National Administration of Romanian Waters (ANAR) and Environmental Protection Agency (APM)
2. Register chemicals that are used
3. Control human activities
4. Control waste water discharge
5. Regularly inspect catchment area
6. Repair fence of sanitary protection zone
7. Monitor water quality at discharge points of industry
8. Monitor raw water quality more regularly and for parameters of interest (e.g. twice a year during autumn and spring)
9. Acquire information as basis for the adjustment of treatment process, especially disinfection.

The conclusion of the analysis of the water source is that the next component of the drinking water supply system – treatment station, has to act as an important barrier to stop contamination to reach the consumers.

The risk analysis at level of the treatment station is summarized in table 5.

Table 5 Risk analysis of the water treatment station

	WATER TREATMENT STATION (is used since 2007)
Information gathering	Adduction pipe from borehole to the station is made of HDPE, length 473m; Mono-block treatment plant, flow 3.53 l/s; Container with 2 contact tanks with sodium hypochlorite as disinfectant, and 3 fast filters with granular active carbon. There is an operating manual; maintenance is outsourced to a consultancy company located far away from the village.
Hazard Identification in Critical Points	Microbiological and chemical contamination (nitrates and pesticides) from the catchment area; Ammonia exceeding the MAC in the raw water; Power failure once at 3-4 months for 2-3 min up to several hours; Because of ammonia there is a high consumption of disinfectant being difficult to assure the free residual chlorine (disinfection marker); The use of pesticides in the catchment can generate a situation in which the active carbon is reaching faster its adsorption capacity; Power failure – likelihood of having an ineffective treatment, especially for disinfection with the consequence of supplying into network water that is not under control. Water analysis at the exit of the treatment station is not carried out regularly (according to monitoring program), not even for free residual chlorine.
Risk Assessment	Microbiological contamination: Severity = 4; Likelihood = 5; **Risk score = 20 (VH)** Chemical contamination: Severity = 3; Likelihood = 3; **Risk score = 9 (M)**

	WATER TREATMENT STATION (is used since 2007)
Control Measures	Check water demand for chlorine and the efficiency of the sodium hypochlorite; Check if the active carbon is outworn; Daily check (automatic) control of free residual chlorine at the exit of treatment station; Treatment process monitoring, warning systems, automatic/manual shutdown of water supply to the network if necessary.
Monitoring the Control Measures	Raw water quality, treatment process, disinfected water quality supplied to the network (final product).
Actions in case of exceeding MACs	Stopping the takeover from water source, adjust the treatment process, the treatment plant closing if necessary.

VH = very high; M = medium

The analysis of the data on drinking water treatment station for which the National Regulatory Authority for Community Utilities Services (ANRSC) issued a license for an operating class 3 (for a number smaller or equal to 50,000 residents), valid until 16.03.2017 for the water service in village, shows that:

1. Microbiological contamination from catchment area needs careful disinfection; Ammonia exceeding the MAC in raw water, use of sodium hypochlorite and power failures indicate the likelihood of ineffective treatment, especially for disinfection, resulting in water that is not under control being supplied into the network.
2. Chemical contamination (pesticides) from the catchment area might fasten the reach of adsorption capacity of active carbon.
3. Estimated microbiological and chemical contamination and its removal by treatment it is hard to be either confirmed or denied due to lack of records/ test reports on water quality.

The risk score for microbiological contamination was estimated at 20 (VH), and for chemical contamination at 9 (M). Very high risk score for microbiological contamination requires urgent actions, and medium risk score for chemical contamination requires acting, planning and preparing as follows:

1. Optimization of treatment process and automated control
2. Approval and control of reagents and materials used in treatment; availability of reserves (including a power generator)
3. Regular monitoring of quality of raw water and drinking water at the exit of water work, especially for the level of free residual chlorine.

The conclusion of the analysis of the water treatment station is that it is not properly operated, and its role of an important barrier in front of the contamination is not effective in assuring the consumers' safety. That is the situation met in Romania in many rural areas with centralized drinking water supply [9].

The analysis of the drinking water distribution network in the pilot village is summarized in table 6.

Table 6 Risk analysis of the distribution network

	DISTRIBUTION NETWORK (is used since 2007)
Information gathering	Length of drinking water supply network of the commune is 19.2 km, distributed as follows among the 4 villages: 8.2 km, 5 km, 2 km, and 4 km. Stainless steel storage tank for treated water above the ground (200mc), is located within the sanitary protection area; water flows by gravity from storage tank into the distribution network; 8226 m distribution network made of HDPE; 19 street taps; 90% of the households are connected; maintenance is carried out by 2 persons with high school; electricity interruptions (minutes – 5 hours).
Hazard Identification in Critical Points	Water within the supply network is not protected by the residual disinfectant. Plastic pipes are in favor of the bio film formation, and microbiological growth. Power failures generates interruption in water supply, which can raise a hazard if the pipes of the network are broken (no information about this issue) and the pressure decreases; high water consumption/ day/ person might suggest leaks but also the use of water for watering the vegetable garden).
Risk Assessment	The description of the situation suggests a risk of microbiological non-compliance (including the exceeding of the oxidability/COD) that is not confirmed by the 2 test reports that were available. The monitoring program approved by public health authority is not followed or the records were not properly kept and handed to the project team. Microbiological contamination: Severity = 4; Likelihood = ?; **Risk score = ? (not known)** Chemical contamination: Severity = 3; Likelihood = ?; **Risk score = 9 (M)** the assumption is that the risk is the same as at the exit of the treatment station
Control Measures	Operational procedures, approved materials, valve status
Monitoring the Control Measures	Water flow, water pressure, residual disinfectant concentration
Actions in case of exceeding MACs	Discharge, flushing pipes, advising people to boil water

Analysis of the data on the distribution network shows that:

1. There is no free residual chlorine in the water supplied to consumers, and there is no protection against microbiological growth.
2. Test reports for microbiological quality of water show no exceeding of limit values. Although there is no free residual chlorine in the network, the amount of organic matter exceeds the MAC, and plastic pipes favor biofilm formation, microbiological parameters show no exceeding, situation that couldn't be explained based on the available data.
3. Test frequency of water quality is too low, and too few parameters are checked to really characterize the final product supplied to consumers.
4. Water consumption based on answers to 18 questionnaires is in range of 6.66 – 50l/person/day (mean value = 18 l) by comparison with data on which the monitoring program is based, showing a range of 125 – 303 l/person/day. This might suggest the existence of leaks in the supply network.
5. Electricity interruption may cause pump failure and pressure drop in the network.

There are no sufficient data to estimate the microbiological risk. The assumption regarding chemical risk is that it stays in the best case as it was at the exit from the water work after treatment stage, but might increase within the supply network (insufficient information). Risk score for microbiological contamination is unknown. For the risk score for chemical contamination the assumption is that it remains the same as it is on exiting the treatment station 9 (M).

Risk score for microbiological contamination is unknown, and medium risk score for chemical contamination (best case scenario) require acting, planning and preparation as follows:

1. Provide partial protection against microbial contamination by assuring residual disinfectant
2. Maintaining positive pressure in the distribution system
3. Maintenance of the distribution system
4. Introduction of backflow prevention devices
5. Ensure integrity of storage and distribution systems
6. Adequate procedures for repairs and subsequent disinfection of piping.

Providing a safety barrier against contamination after treatment during the transport of water is the last chance in stopping the contamination to reach the consumers.

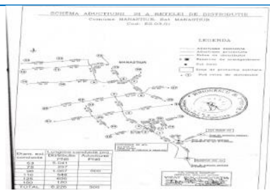
The analysis of the tap water is summarized in table 7.

Table 7 Risk analysis of the tap water

	TAP WATER (Consumer, product's end point)
Information gathering	Type of premises: factory bakery, wood processing factory, railway station, 2 schools, 2 kindergarten, 5 sanitary institutions, 2 cultural institutions, 629 households (90% of households are connected to centralized water supply), 1689 persons. Distribution network materials: HDPE, length 19,2 km.
Hazard Identification in Critical Points	Not identified, no information about siphonage, leakage from pipelines, hygiene.
Risk Assessment	Not enough information. Microbiological contamination: Severity = 4; Likelihood = ?; **Risk score = ? (not known)** Chemical contamination: Severity = 3; Likelihood = ?; **Risk score = 9 (M)** the assumption is that the risk is the same as in the distribution network
Control Measures	Regulation of sealing elements (gaskets), education
Monitoring the Control Measures	Inspection of premises
Actions in case of exceeding MACs	Advising consumers

No water related diseases were recorded at the medical unit of the pilot village.

The overview of the risk analysis along the drinking water supply system of the pilot village is shown in figure 1.

			
CATCHMENT Risk score (m) = **20** (VH) Risk score (c) = **12** (H)	**TREATMENT** Risk score (m) = **20** (VH) Risk score (c) = **9** (M)	**DISTRIBUTION** Risk score (m) = **?** Risk score (c) = **9** (M)	**CONSUMER'S TAP** Risk score (m) = **?** Risk score (c) = **9** (M)

Legend: m – Microbiology, c – chemistry; VH – very high, H – high, M – medium, ? - unknown

Figure 2 Water Supply System in pilot village and Risk Scores along the supply chain

The situation illustrated by the synthetic data in figure 2, shows that the main barrier in front of the contamination coming from the quality of the water source, and meant to stop the risk to reach the consumers doesn't work properly, and immediate actions have to be undertaken.

The risk's score for microbiological hazards is the same for the raw water and treated water, and the risk's score for chemical hazards is likely to be slightly reduced but this cannot be proven because of the lack of the test reports.

The supply system is not properly operated and there is no record of the critical situations that might occurred along the time, and the way in which they were solved.

Based on the results of the overall risk analysis for the drinking water supply system in the pilot village the main recommendations are:

- Immediate measures to control the microbiological risk and to control the free residual disinfectant have to be taken
- Technical assistance on the process of water treatment is recommended, especially by the Regional Operating Company (ROC)
- Displaying work instructions for operating the treatment plant, and periodic checks
- Regular training of staff, especially for the particular situation where a local form of association undertakes the responsibility for the provision of drinking water to people, as in the pilot village
- Daily checking of free residual chlorine (with rapid kits, e.g. Merck – Chlorine test, catalog no. 114801, range of concentrations 0,1-2mg/l Cl_2) and adjustment of the disinfectant dose, if necessary
- Putting into operation the wastewater treatment plant
- Restricting grazing areas so that animals no longer exist in the catchment area
- Communication and cooperation with all stakeholders in the catchment.

If appropriate control measures are in place, then the water must be safer. However, if an incident occurs, by investigating the causes, new control measures may be established or the existing ones can be improved. Control measures will be developed and improved based on the assessment of all system's threats. Control measures should be reviewed to be updated and improved by Water Safety Plan team experts, not by incidents!

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