Original research

RAPID ASSESSMENT OF DRINKING-WATER QUALITY IN RURAL AREAS OF SERBIA: OVERCOMING THE KNOWLEDGE GAPS AND IDENTIFYING THE PREVAILING CHALLENGES

Dragana D. Jovanović[1], Katarina Ž Paunović[2], Oliver Schmoll[3], Enkhtsetseg Shinee[3], Miljan Rančić[1], Ivana Ristanović-Ponjavić[4], the National Expert Group*

[1] Institute of Public Health of Serbia, Belgrade, Serbia

[2] Institute of Hygiene and Medical Ecology, Faculty of Medicine, University of Belgrade, Belgrade, Serbia

[3] World Health Organization European Centre for Environment and Health, Bonn, Germany

[4] Institute of Public Health of Belgrade City, Belgrade, Serbia

* National Expert Group: Sanja Bijelović, Katarina Spasović, Snežana Gligorijević, Jelka Ranković, Olivera Janjić

Corresponding author: Dragana D. Jovanović (email: dragana_jovanovic@batut.org.rs)

ABSTRACT

Introduction: Access to an adequate water supply is a fundamental human right. However, many challenges are associated with the provision of water through small-scale water supplies (SSWS) in rural areas throughout the pan-European region, including Serbia. Serbia ratified the joint United Nations Economic Commission for Europe and World Health Organization Regional Office for Europe Protocol on Water and Health in 2013 and has fulfilled its main provision by setting national targets and target dates.

Methods: A national survey of SSWS, including drinking-water quality and prevailing sanitary conditions, was undertaken in Serbia in 2016 based on a rapid assessment methodology developed by the World Health Organization. The aim was to overcome knowledge gaps and identify prevailing challenges related to the rural water supply in Serbia. In total, 1318 small-scale water supply systems were inspected and 1350 drinking-water samples were taken.

Results: One third of all water samples were found to be microbiologically contaminated, correlating with identified sanitary risks. Of all investigated supplies, 29.6% of piped system sources and 40.6% of individual supplies required high or urgent action for improvement.

Conclusions: This study highlights the need to improve SSWS in rural areas and identifies the prevailing challenges that need to be addressed by improvement intervention programmes and by further developments in water and health policy.

Keywords: DRINKING-WATER QUALITY, PROTOCOL ON WATER AND HEALTH, RAPID ASSESSMENT, SANITARY RISKS, SMALL-SCALE WATER SUPPLY SYSTEMS

INTRODUCTION

Many challenges are associated with the provision of safe drinking-water through small-scale water supplies (SSWS) throughout the pan-European region *(1)*. SSWS, which include both small centralized (i.e. piped) systems and individual supplies, predominantly provide drinking-water for rural populations *(2)*.

Access to an adequate water supply as a fundamental human right *(3)* is implicitly recognized by Article 74 of the Constitution of the Republic of Serbia *(4)* as the right to a healthy environment and the right to timely and comprehensive information on the status of the environment.

Serbia ratified the Law on the Confirmation of the Protocol on Water and Health to the 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes (hereafter referred to as "the Protocol") in 2013 *(5)* and fulfilled its main provision by setting national targets and target dates aligned with the 2030 Agenda for Sustainable Development, particularly goal 3 ("Ensure healthy lives and promote well-being for all at all ages") and goal 6 ("Ensure availability and sustainable management of water and sanitation for all") *(6)*.

Participation of Serbia in the UN-Water Global Analysis and Assessment of Sanitation and Drinking-Water (GLAAS) and implementation of the Protocol initiated good collaboration among all relevant sectors for evaluating and identifying the knowledge gaps and challenges related to water, sanitation and hygiene. GLAAS is being implemented by the World Health Organization (WHO) with the aim of providing decision-makers at all levels with a comprehensive and thorough analysis of policy frameworks, institutional arrangements, the human resource base and finance streams that support drinking-water, sanitation and hygiene. Data obtained through the GLAAS process in 2013 in Serbia indicated urban and rural disparities in the provision of water, sanitation and hygiene services due to a lack of specific plans for sustaining rural water supply services, regular surveillance, human resource strategies and financing. The main challenges faced by Serbia in providing safe drinking-water in rural areas were: (i) an unsatisfactory level of implementation of the national legislation in the water domain, including improvement and sustainability; (ii) weak enforcement of drinking-water quality surveillance, including inspection of sanitary conditions; (iii) unresolved ownership issues of SSWS, leading to poor operation and maintenance of the systems; and (iv) unsustainable financing *(7)*. A baseline analysis and national consultation on SSWS under the Protocol (supported by the United Nations Economic Commission for Europe and the WHO Regional Office for Europe) identified additional knowledge gaps and areas of poor performance as: a lack of information on the precise number and coverage of SSWS at the national level; inadequate coverage by regular monitoring of drinking-water quality; inadequate coverage of water disinfection; a lack of data on the prevailing sanitary conditions in SSWS; and poor-quality data on drinking-water safety *(8–10)*. All of these issues have huge implications for rural population health: 30 waterborne disease outbreaks in a 10-year period were mainly attributable to SSWS *(11)*. Additionally, these issues can impact social well-being, quality of education, food production and safety, entrepreneurial activities, and all types of investment in rural areas.

There is no official definition for SSWS in Serbia; however, a classification system based on settlement type (i.e. urban and other) is used. Reporting of drinking-water quality is required for all water supply systems that supply more than five dwellings *(11)*. However, household and individual water supplies are currently not regulated in Serbia.

In order to overcome the identified knowledge gaps and lack of consolidated data on the rural water supply, the National Working Group for implementing the Protocol set as a national target a situation analysis (or survey) of drinking-water quality and the prevailing sanitary conditions in the rural water supply.

The analysis was conducted within the "Rapid assessment of drinking-water quality (RADWQ) in rural areas of Serbia" project, with technical support from the WHO European Centre for Environment and Health and the Institute of Public Health (IPH) of Serbia network. The survey was performed to support the implementation of national targets under the Protocol, which prioritizes improvements in SSWS.

The aims of the survey were to overcome knowledge gaps and identify new challenges related to the rural water supply of Serbia by assessing the conditions and performance of a nationally representative sample of SSWS, including drinking-water quality and the prevailing sanitary conditions.

METHODS

SAMPLE SIZE CALCULATION

A nationwide survey was undertaken in rural areas of Serbia in 2016 based on WHO rapid assessment methodology *(12)*.

Two types of water supply technologies were included in the study: (i) piped systems, consisting of a water source and distribution network, serving more than

20 people (according to the *Rulebook on hygienic correctness of drinking-water quality*) *(13)*; and (ii) individual supplies, including shallow wells, captured springs, tube wells or boreholes (either piped or non-piped), providing fewer than five households with drinking-water.

The number of piped systems and individual supplies to be included in the survey in each district of Serbia was calculated using a primary and secondary stratification method, based on: the number of households in rural areas (obtained from census data) *(14)*; the proportion of the rural population supplied by the selected water supply technologies *(15)*; the 2014 annual report on microbiological non-compliance for SSWS *(11)*; and inventories of the number of SSWS in each district (obtained from the local IPH). Although there is no information on the precise number of SSWS at the national level, each local IPH could obtain inventories from local or military authorities.

Data on the proportions of the rural population supplied by the selected water supply technologies were acquired from the Multiple Cluster Indicators Survey *(15)* conducted in 2014: 78.4% was connected to piped systems providing water to the dwelling, yard or plot, whereas 11.8% obtained drinking-water from individual supplies (tube wells [or boreholes], wells or springs). Given that very small proportions of the rural population of Serbia relied on public standpipes (1.1%), bottled water (0.8%), other forms of tap water (0.4%) and other unimproved sources (0.3%) for drinking-water, these forms of water supply were not considered in this survey.

To determine the sample size of the survey, the proportion (P) of SSWS with microbiological water quality exceeding the national standard had to be estimated. The 2014 annual report on microbiological non-compliance for SSWS was used to determine the percentages of piped and individual SSWS with water quality exceeding the national standard *(11)*. Microbiological non-compliance ranged from 1.8% to 84.6% among districts, with a median of about 21%. Given that many non-licensed piped systems may not be regularly monitored, estimates for overall microbiological non-compliance for piped systems are as high as 30%. As individual supplies are not regulated, drinking-water quality from these sources is not monitored on a regular basis, but only at the (very sporadic) request of owners. Most point sources are shallow wells, which are prone to contamination from different sources of pollution such as latrines, unsafe septic tanks and rubbish dumps in the surrounding area, and are also influenced by rainfall and melting snow. Therefore, an expert estimate of 60% for microbiological non-compliance for individual supplies was used. In conclusion, the overall P was calculated using the stated percentages of the rural population connected to piped systems and individual supplies, and estimates for microbiological non-compliance, as follows:

$$P = (0.784 \times 0.30) + (0.118 \times 0.60) = 0.3$$

Finally, the study sample size (n) was calculated using the following equation:

$$n = 4P \times (1-P) \times D/e^2,$$

where the design effect (D) was set at 4 and the acceptable precision (e) at 0.05. Accordingly, a total sample size of 1344 was calculated, which was divided according to the proportions of the population served by the different supply types, resulting in sample sizes of 1168 for piped systems and 176 for individual supplies. During the fieldwork, six additional ad hoc samples were taken from individual supplies.

In order to overcome potential bias resulting from different sizes of water supply systems, large piped systems were subdivided into zones. For this purpose, a single supply zone for a piped system was defined as one with up to 2500 consumers and the maximum size of rural settlement was determined to be 10 000 consumers (i.e. resulting in a maximum of four supply zones). More than one sample was therefore taken for large piped systems (depending on the number of supply zones), so a total 1168 samples were taken from 1136 piped water systems.

The specific piped systems included in the survey and their distribution across districts were selected by proportional weighting *(12)* based on inventories of piped systems obtained from each IPH. The selection process was different for individual supplies. Given the lack of reliable inventories of individual supplies, each IPH selected the most representative individual supplies in the different settlements and municipalities within their districts.

DRINKING-WATER SAMPLING AND ANALYSIS

A drinking-water quality sample from each SSWS visited was analysed for one microbiological indicator (i.e. *Escherichia coli* count per 100 ml water), physicochemical parameters (i.e. ammonia [mg/L], nitrate [mg/L], manganese [mg/L], arsenic [mg/L], residual chlorine [mg/L] in chlorinated supplies only, and pH) and organoleptic parameters (i.e. temperature [°C], colour [platinum-cobalt scale], odour [descriptive], turbidity [nephelometric turbidity units], and conductivity [μS/cm]).

For piped systems comprising one supply zone only, water samples were taken from the point of use; however, for those serving more than 2500 consumers, additional water samples were taken from the source and/or from the distribution network or service reservoir of each SSWS. For individual supplies, all water samples were taken from the water source.

All sampling procedures, including precautions to prevent contamination from the sample point, sample preservation measures and sample transportation, were performed in accordance with the *Rulebook on sampling methods and methods for drinking-water laboratory analysis (16)*. Water quality analysis took place at accredited laboratories of the 23 local IPHs according to national standards issued by the Institute for Standardization of Serbia and the International Organization for Standardization standard 17025 *(17)*. Only two parameters were measured on site: temperature and residual chlorine content (if the water was chlorinated). Results of the laboratory analyses were compared with national standards *(13)*.

SANITARY INSPECTION

Each SSWS visited was subject to sanitary inspection to assess the prevailing sanitary risks. For this purpose, field teams used standardized sanitary inspection forms containing a checklist of questions that are answered by visual observation and user interviews. The sanitary inspection forms were based on templates suggested by the RADWQ methodology and specifically adjusted to reflect the Serbian context *(12)*.

Each form contained 10 questions for assessing the contamination risk for each identified type of water source (i.e. protected spring, borehole with hand or electric pump, dug well with hand or electric pump, open dug well, dug well with windlass and partial cover, and surface water intake) and distribution network. These questions were related to the presence of fencing, the presence of different pollution sources in the surrounding area, technical and construction characteristics/failures, and chlorination practices. Each question was phrased in such a way that a "Yes" answer indicates a potential risk that could threaten the quality of water and a "No" answer indicates that there is either no risk or a negligible risk. The overall sanitary inspection risk score (i.e. the number of "Yes" answers) indicated the risk of microbial pollution for each type of source and water supply.

Microbiological water quality data (*E. coli* count per 100 ml) were combined with sanitary risk scores in a risk–priority matrix *(12)*. *E. coli* counts were categorized as <1, 1–10, 11–100 and >100 per 100 ml, and sanitary inspection scores were categorized as 0–2, 3–5, 6–8 and 9–10. The matrices indicate four levels of water contamination risk (low, intermediate, high and very high) for each water supply facility *(12)*. These matrices helped in assessing the action priority level for each water supply technology to decrease the water contamination risk.

STATISTICAL ANALYSIS

Continuous data are presented as the mean, minimum and maximum, and categorical data as absolute and relative numbers. Differences in water parameters between piped and individual SSWS were analysed using chi-square tests. All analyses were performed using IBM SPSS Statistics software (version 15.0, Chicago, IL, USA). Statistical significance was set at a probability of 0.05.

RESULTS

General characteristics of the investigated piped and individual SSWS facilities are presented in Table 1. Piped systems in rural areas served 500 inhabitants on average, while individual supplies served 14 inhabitants on average. The average age of SSWS of both types was more than 35 years old. Only 12.4% of inspected piped systems were managed by public utilities, representing the only authorized legal entities in Serbia (Table 1).

TABLE 1. GENERAL CHARACTERISTIC OF THE SOURCES OF PIPED SYSTEMS AND INDIVIDUAL SUPPLIES

Parameters	Piped systems	Individual supplies
Investigated SSWS (*n*)	1136	182
Consumers supplied (*n*)		
Mean	500	14
Min – max	2–9500	1–500
Age of water source/facility (years)		
Mean	35.5	38.8
Min – max	<1–144	<1–178
Owner of water supply facility (*n* (%))		
Public utility company	141 (12.4)	0 (0.0)
Local community	280 (24.6)	0 (0.0)
Municipality	9 (0.8)	0 (0.0)
Group of inhabitants	528 (46.5)	0 (0.0)
Private individual	71 (6.3)	182 (100.0)
Other	107 (9.4)	0 (0.0)

Min: minimum; max: maximum.

Microbiological, physicochemical and the overall compliance of drinking-water quality for piped and individual supplies are shown in Table 2. Microbiological and physicochemical compliance figures are similar for both system types. About one third of water samples from both system types did not meet the national standards for *E. coli*. More than 90% of the examined water samples met the national standards for all physical and chemical parameters, except for conductivity and colour. Water samples from individual supplies had significantly lower compliance for turbidity, conductivity, and nitrate and manganese content compared with water from piped systems. Overall physicochemical compliance and overall compliance were significantly lower for individual supplies (28.6% and 16.5%, respectively) than for piped systems (55.6% and 36.9%, respectively; Table 2).

TABLE 2. MICROBIOLOGICAL AND PHYSICOCHEMICAL COMPLIANCE FOR WATER SAMPLES FROM PIPED SYSTEMS AND INDIVIDUAL SUPPLIES

Parameters	Piped systems[a]	Individual supplies[a]	P value
E.coli (count/100 mL)	781 (66.9)	124 (68.1)	0.799
Residual chlorine (mg/L)	539 (99.4)	80 (100.0)	0.581
Colour (Pt-Co scale)	1043 (89.3)	155 (85.2)	0.101
Odour (descriptive)	1140 (97.6)	180 (98.9)	0.269
Turbidity (NTU)	1104 (94.5)	164 (90.1)	0.020
Conductivity (μS/cm)	1043 (89.3)	137 (75.3)	<0.001
pH	1110 (95.0)	172 (94.5)	0.762
Ammonia (mg/L)	1095 (93.8)	165 (90.7)	0.120
Arsenic (mg/L)	1081 (92.6)	175 (96.2)	0.075
Manganese (mg/L)	1099 (94.1)	163 (89.6)	0.021
Nitrate (mg/L)	1093 (93.6)	144 (79.1)	<0.001
Overall physico-chemical compliance[b]	649 (55.6)	52 (28.6)	<0.001
Overall compliance[c]	431 (36.9)	30 (16.5)	<0.001

Pt-Co: platinum-cobalt.

NTU: nephelometric turbidity unit.

[a] Data are *n* (%).

[b] Overall physicochemical compliance is defined as compliance for all of the investigated physical and chemical parameters of water (pH, ammonia, arsenic, nitrate, manganese and residual chlorine levels, colour, odour, turbidity and conductivity).

[c] Overall compliance is defined as compliance of all investigated physical, chemical and microbiological parameters in water (residual chlorine, pH value, ammonia, nitrates, manganese, arsenic, colour, odour, turbidity, conductivity and *E. coli*). NTU: nephelometric turbidity unit.

Sanitary inspection results for the most common sources of piped systems and individual supplies and distribution network are shown in Table 3. Similar contamination risk factors were identified for both piped systems and individual supplies, including unfenced springs, access of animals within 10 m of the source and unsatisfactory technical conditions.

The predominant risk factors for boreholes with electrical pumping that feed piped systems and individual supplies were the presence of pollution sources near to the borehole or pumping mechanism (e.g. latrines, sewers, livestock, roads), access of animals to the borehole and non-functional diversion ditches (Table 3). The most frequently identified sanitary risk factors at distribution networks (piped systems only) were lack of drinking-water chlorination (72.8%), management by unqualified personnel (66.1%) and households with a dual water supply (i.e. connected to both a piped SSWS and an individual supply; 57.9%; Table 3).

Comparative risk–priority matrices for piped systems (sources and networks) and individual supplies are shown in Tables 4–6. This analysis revealed that 29.6% of sources for piped systems, 32.2% of distribution networks and 40.6% of individual supplies required high and urgent action for improvement. Differences in the proportions of different risk categories between piped systems and individual supplies were significant ($P = 0.020$).

TABLE 3. THE MOST PREVALENT IDENTIFIED SANITARY RISKS FOR PIPED SYSTEMS AND INDIVIDUAL SUPPLIES BY TYPE OF SOURCE AND DISTRIBUTION NETWORK

Type of source	Sanitary risk factor	Piped systems[a]	Individual supplies[a]
Protected spring	The area around the spring is unfenced	571 (73.2)	23 (88.5)
	Animals have access to within 10 m of the spring source	483 (61.9)	17 (65.4)
	The diversion ditch above the spring is absent or non-functional	491 (62.9)	18 (69.2)
Borehole with electrical pumping	There is a latrine or sewer within 100 m of the pumping mechanism	135 (60.5)	35 (72.9)
	There is another source of pollution within 50 m of the borehole (e.g. livestock, cultivation, road, industry)	142 (63.7)	28 (58.3)
	The drainage channel is absent or cracked, broken or in need of cleaning	121 (54.3)	31 (64.6)
Distribution network	Drinking-water is not chlorinated	827 (72.8)	na
	Piped system is managed by unqualified persons (i.e. with no formal education in water supply management)	751 (66.1)	na
	Households using a dual water supply (i.e. with parallel connections to a piped SSWS and an individual supply)	658 (57.9)	na

NA: not applicable.

[a] Data are *n* (%) of positive responses, i.e. “yes”.

TABLE 4. COMPARATIVE RISK–PRIORITY MATRICES FOR SOURCES OF PIPED SYSTEMS[a]

E. coli count (CFU/100 ml)	Sanitary inspection score				Total
	0–2	3–5	6–8	9–10	
<1	332 (28.4)	343 (29.4)	99 (8.5)	7 (0.6)	781 (66.9)
1–10	60 (5.1)	88 (7.5)	33 (2.8)	9 (0.8)	190 (16.3)
11–100	44 (3.8)	62 (5.3)	33 (2.8)	13 (1.1)	152 (13.0)
>100	17 (1.5)	21 (1.8)	6 (0.5)	1 (0.1)	45 (3.8)
Total	453 (38.8)	514 (44.0)	171 (14.6)	30 (2.6)	1168 (100.0)

Risk level	Low: no action required	Intermediate: low action priority	High: high action priority	Very high: urgent action priority
Total	332 (28.4)	491 (42.0)	271 (23.2)	74 (6.4)

[a] Data are *n* (%).

TABLE 5. COMPARATIVE RISK–PRIORITY MATRICES FOR NETWORKS OF PIPED SYSTEMS[a]

E. coli count (CFU/100 ml)	Sanitary inspection score				Total
	0–2	3–5	6–8	9–10	
<1	258 (22.1)	407 (34.8)	98 (8.4)	18 (1.5)	781 (66.9)
1–10	19 (1.6)	108 (9.2)	49 (4.2)	14 (1.2)	190 (16.3)
11–100	25 (2.1)	70 (6.0)	47 (4.0)	10 (0.9)	152 (13.0)
>100	7 (0.6)	27 (2.3)	9 (0.8)	2 (0.2)	45 (3.8)
Total	309 (26.4)	612 (52.4)	203 (17.4)	44 (3.8)	1168 (100.0)

Risk level	Low: no action required	Intermediate: low action priority	High: high action priority	Very high: urgent action priority
Total	258 (22.1)	534 (45.7)	289 (24.7)	87 (7.5)

[a] Data are *n* (%).

TABLE 6. COMPARATIVE RISK–PRIORITY MATRICES FOR SOURCES OF INDIVIDUAL SUPPLIES[a]

E. coli count (CFU/100 ml)	Sanitary inspection score				Total
	0–2	3–5	6–8	9–10	
<1	42 (23.1)	52 (28.6)	29 (15.9)	1 (0.5)	124 (68.1)
1–10	6 (3.3)	8 (4.4)	9 (4.9)	0 (0.0)	23 (12.6)
11–100	8 (4.4)	10 (5.5)	5 (2.7)	1 (0.5)	24 (13.2)
>100	2 (1.1)	6 (3.3)	3 (1.6)	0 (0.0)	11 (6.1)
Total	58 (31.9)	76 (41.7)	46 (25.3)	2 (1.1)	182 (100.0)

Risk level	Low: no action required	Intermediate: low action priority	High: high action priority	Very high: urgent action priority
Total	42 (23.1)	66 (36.3)	61 (33.5)	13 (7.1)

[a] Data are *n* (%).

DISCUSSION

For the first time, a systematic evaluation of the situation of SSWS was undertaken in Serbia, using the WHO RADWQ methodology. According to census data, 40.1% of the total population of Serbia lives in rural areas *(14)*. The investigated SSWS supplied more than 439 000 citizens at the time of the survey (data not shown), covering at total of about 15% of the rural population in Serbia.

This study reveals similarities and differences between piped systems and individual supplies. First, both technologies had similar sanitary characteristics and similar contamination risks for drinking-water. The predominant problems for the most common sources of both piped systems and individual supplies were nearby pollution sources and unsatisfactory technical conditions. In addition, the piped system networks were in a poor state of repair and had poor disinfection practices and inadequate management. These results suggest that, in the future, different technical measures and levels of financial investment might be needed for repairing or maintaining piped systems and individual supplies *(1)*.

Second, piped systems and individual supplies had similar microbiological quality. The faecal indictor, *E. coli*, was detected in 33.1% of water samples from piped systems and 31.9% from individual supplies, indicating contamination with human or animal faeces and thus the possible presence of pathogens in drinking-water *(18)*. Nevertheless, there were significant differences in chemical quality between piped systems and individual supplies: physicochemical and overall compliance with national standards were significantly lower for individual supplies than for piped systems.

This brings us to the most important problem for SSWS in Serbia: maintenance and ownership. As reported in the survey, only 12.4% of the piped systems are managed by public utilities, whereas 87.6% are managed by non-authorized rural suppliers, which are not legal entities *(19)*. Activities such as establishing regular drinking-water quality monitoring and sanitary surveillance, implementing national legislation for drinking-water quality, providing sustainable financing, and investing in improvements are only possible when SSWS are managed by legal entities, i.e. public utilities. Additional analysis supports this assumption; for example, water samples from piped systems owned by public utilities comprised only 3.1% of all samples that did not meet national standards for *E. coli* (data not shown).

The novelty of the applied methodology was the use of risk–priority matrices to indicate the level of action priority needed for a given SSWS to decrease water contamination and health risk *(12)*. More than 60% of water supplies had a low-to-intermediate water contamination risk. However, 29.6% of the investigated piped systems and 40.6% of individual supplies required high or urgent action for improvement. Ranking the water facilities in rural areas according to the level of urgency enables local authorities to draw up a list of priorities for improving water quality, assessing investment requirements and providing intervention measures for resolving the problem.

Another study using the RADWQ approach was conducted in rural areas of two districts in Georgia *(20)*. The main water quality and sanitary inspection results were similar to those of the present study: lack of disinfection and sanitary protection zones. Comparative risk–priority matrices for the two Georgian districts showed that 24–40% of water supply facilities were in the high or very high risk category *(20)*.

However, the results of the present study cannot be easily compared with previous official reports on water quality in SSWS systems in rural areas. Monitoring drinking-water quality in rural areas is an integral part of the national programme of health protection from infectious diseases *(21)*, which is conducted by IPHs and by sanitary inspection under the supervision of the Ministry of Health *(22)*. The present study showed that microbiological non-compliance for tested drinking-water samples was approximately 10% higher compared with the regular monitoring programme in Serbia *(11)*. This discrepancy might be explained by the use of different methodologies. In the present survey, random selection meant that many rural SSWS were inspected for the first time *(12)*, whereas coverage by the national programme is limited to SSWS that sign a contract with the local IPH, thus possibly excluding smaller or more remote facilities *(11)*.

CHALLENGES IDENTIFIED DURING FIELDWORK

The field teams conducting the survey faced several challenges from the very start, in particular, lack of information on the number of piped systems and individual supplies, as well as their precise locations. In most cases, the teams could not rely on data reported to the local IPH, but instead obtained information from local authorities and communities. Furthermore, during the course of the survey, the teams realized that some SSWS had been devastated by the floods or consequent landslides of 2014. Unfortunately, the teams sometimes had poor cooperation from the representatives of local communities, possibly caused by fear of sanctions if water non-compliance were proven.

STRENGTHS OF THE SURVEY

To our knowledge, this is the first systematic investigation of individual SSWS covering all rural districts of Serbia. For the first time, the rural population could learn about the quality of drinking-water in their homes, which could contribute to future education programmes in hygiene and sanitation. Users of piped SSWS were informed about their rights to petition local communities to take over the management of these supplies, according to national regulations *(19)*. Finally, the presence of a strong IPH network in Serbia was essential for performing research into water provision by SSWS at the national level. Likewise, the survey helped IPHs to establish systematic baseline information on SSWS in their area of responsibility, elevate attention to the challenges related to SSWS and leverage local action towards their improvement.

CONCLUSION

The results of this survey provide a strong rationale for improving the situation of rural SSWS; it identified challenges to be addressed by intervention programmes and for further developing national water and health policies and regulations. The main problems identified in this study related to poor operation and maintenance of SSWS, a lack of qualified personnel to ensure their safe management and a lack of water disinfection – all in all, resulting in poor drinking-water quality (in particular, due to microbiological contamination) and presenting public health risks to the rural population.

A key intervention towards improving the situation of SSWS is the adoption of water safety plans (WSPs) *(23)*, which have been proven to support safe system management and thus to protect public health. Therefore, important next steps are to create a legal framework for WSP implementation, along with practice-oriented piloting exercises, WSP capacity-building for local operators and IPH staff, and the development of a national roadmap stipulating measures to support the short- and long-term uptake of WSPs.

It is also critical to develop national and local action plans for improving SSWS serving rural populations, including provisions for protecting water sources, technical improvements, water disinfection, regular drinking-water quality monitoring and sanitary inspection by mandated health authorities, and increased awareness-raising among local population and relevant authorities. Establishment of a national inventory of SSWS would provide a systematic overview of the supply situation in rural areas and effectively support implementation of interventions measures.

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