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Experiences from integrating water and sanitation safety planning in small systems in rural Serbia

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ABSTRACT

The WHO recommends a risk management approach to ensure safe drinking-water and sanitation, so-called Water Safety Planning and Sanitation Safety Planning. However, applying these risk management approaches separately in small-scale drinking-water supply and sanitation systems might be challenging for rural communities with limited human, financial, and administrative resources. An integrated approach seems a better option. In this study, an integrated water and sanitation safety planning (iWSSP) approach was developed together with guidance and training material for the practical application of this novel approach. The integrated approach was piloted in three small systems in rural Serbia to identify benefits and suggestions for improvement which can be used for potential future scaling-up. Implementing iWSSP at the pilot sites contributed to a better understanding of both drinking-water supply and sanitation systems. It also resulted in increased awareness, knowledge, and understanding among staff of drinking-water supply and sanitation services. Key experts, including external facilitators, played a crucial role in the implementation of iWSSP. Future scaling-up of the integrated approach could be enabled if more guidance, easy-to-use training materials and templates become available which can be adapted and updated as needed.

Key words: drinking-water supplies, integrated, risk assessment, risk management, sanitation systems, small-scale systems

HIGHLIGHTS

- We developed and tested integrated drinking-water safety planning and sanitation safety planning (iWSSP).
- iWSSP helps small rural systems to better understand how both systems influence each other which supports identifying hazardous events.

INTRODUCTION

In Serbia, as in many other countries worldwide, access to safe drinking-water in rural areas is a challenge (WHO 2017c). Currently, a third of rural water systems in Serbia do not meet standards for microbiological drinking-water quality (WHO 2017c), and more than 60% are exposed to possible contamination from latrines, sewers and other nearby sources of contamination, such as animal farming, agriculture, roads, and industry (Jovanović *et al.* 2022). Citizens living in rural areas have less access to safely managed drinking-water and sanitation compared to urban areas (UNICEF & WHO 2022), and relevant stakeholders in Serbia have taken up activities in small rural systems to improve their situation and gather more information. Examples of activities aiming at improving small systems in Serbia include a rapid assessment of drinking-water quality (RADWQ) in rural areas (Jovanović *et al.* 2017) and a project on ensuring safely managed on-site sanitation systems (SMOSS) (IPH 2021). In rural areas, people mainly rely on small-scale sanitation, such as on-site systems like pit latrines, septic tanks, and small collective sewerage systems with or without wastewater treatment (WHO 2022a). Small (community-managed) systems providing drinking-water to rural populations may include simple piped water systems or a range of point sources, such as boreholes with hand pumps, dug wells and protected springs (WHO 2017b).

The WHO recommends risk assessment and management approaches to ensure safe drinking-water (WHO 2017b) and sanitation (WHO 2018) – Water Safety Planning (WSP) and Sanitation Safety Planning (SSP), respectively. 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 the water supply from catchment to consumer (WHO 2022b). SSPs encompass all steps in the sanitation chain from capture to reuse/disposal and should protect human health from sanitation-related risks, including from reuse of wastewater in agriculture and aquaculture (WHO 2015). WSP takes into account possible contamination affecting the drinking-water, including sanitation (WHO 2022b). SSP also takes into account other exposure routes such as direct contact and different exposure groups. With SSP additional and specific information from the sanitation chain might be collected which poses a threat to the drinking-water supply. Within SSP control measures can be taken which might have a positive effect on the drinking-water quality (WHO 2015). Both WSP and SSP should also be applicable to small systems (WHO 2015, 2022b). Health risks from exposure to contaminated drinking-water can be significantly reduced through applying WSP as shown in Iceland (Gunnarsdottir *et al.* 2012). Winkler *et al.* (2017) described the benefits of the SSP approach which may affect public health such as reducing pollution, eliminating dumping and minimizing the release of hazardous chemicals and materials. However, no further information has been published so far about the health benefits when applying for SSP. WSP has been implemented in more than 93 countries (WHO 2017a), whereas SSP implementation is lagging behind, but a much stronger focus on sanitation is needed (WHO 2022a). In Serbia, both WSP and SSP are scarcely implemented. For rural communities with limited human, financial and administrative resources, the implementation of such approaches is not straightforward and support is required (Herschan *et al.* 2020). In smaller and more local contexts, drinking-water and sanitation management are inevitably interlinked, partly due to their close proximity. The same people might even take care of both systems. An integrated water and sanitation safety planning (iWSSP) approach could be a good context-specific option. Information on an integrated approach and details of its implementation are scarce. Barrington *et al.* (2013) adapted WSP to small systems in rural Nepal by including sanitation and hygiene. Clavijo *et al.* (2020) described water and sanitation safety planning in a metropolitan area in Latin America and another study in South Africa described the barriers of water and sanitation safety planning implementation in rural areas (Murei *et al.* 2022). Huber *et al.* (submitted) developed an integrated climate-resilient water and sanitation safety planning in South Africa. However, there is only limited experience with piloting these integrated approaches and these studies do not specifically address the implementation in small supplies.

The project 'Developing an innovative approach to improving drinking-water and sanitation safety in small systems through integrative management in Serbia' was conducted from April 2021 to May 2022. The National Institute for Public Health and the Environment (RIVM) in the Netherlands acted as coordinator with the Institute of Public Health of Serbia (IPH) and the German Environment Agency (UBA) as project partners. The WHO Regional Office for Europe supported the project but was not an official partner. This paper describes the development and piloting of an integrated approach to water and sanitation safety planning for small systems.

METHODS

Developing an iWSSP approach

The WSP approach for small systems and the SSP approach encompass seven and six systematic steps, respectively (WHO 2015, 2022b), and share similarities in method, purpose and goals. Using these approaches as a starting point, an approach for iWSSP in rural small-scale systems was developed by UBA and RIVM. Integration of both approaches started with aligning and integrating the steps, which resulted in an iterative process cycle to facilitate continuous improvements in drinking-water and sanitation over time, visualizing the circular nature of the iWSSP approach containing six steps (Figure 1). In this study, the reuse of (treated) wastewater was not taken into account as this was not applied in the pilot sites. These iWSSP steps are:

Step 1 – Prepare for iWSSP

Define the objectives and scope of the iWSSP, identify stakeholders and assemble a team. In this step, both drinking-water supply and sanitation should be covered in the objectives and scope. The iWSSP team should be a multidisciplinary team including experts in the field of drinking-water supply and sanitation as well as external stakeholders such as representatives of health authorities, environmental agencies and users.

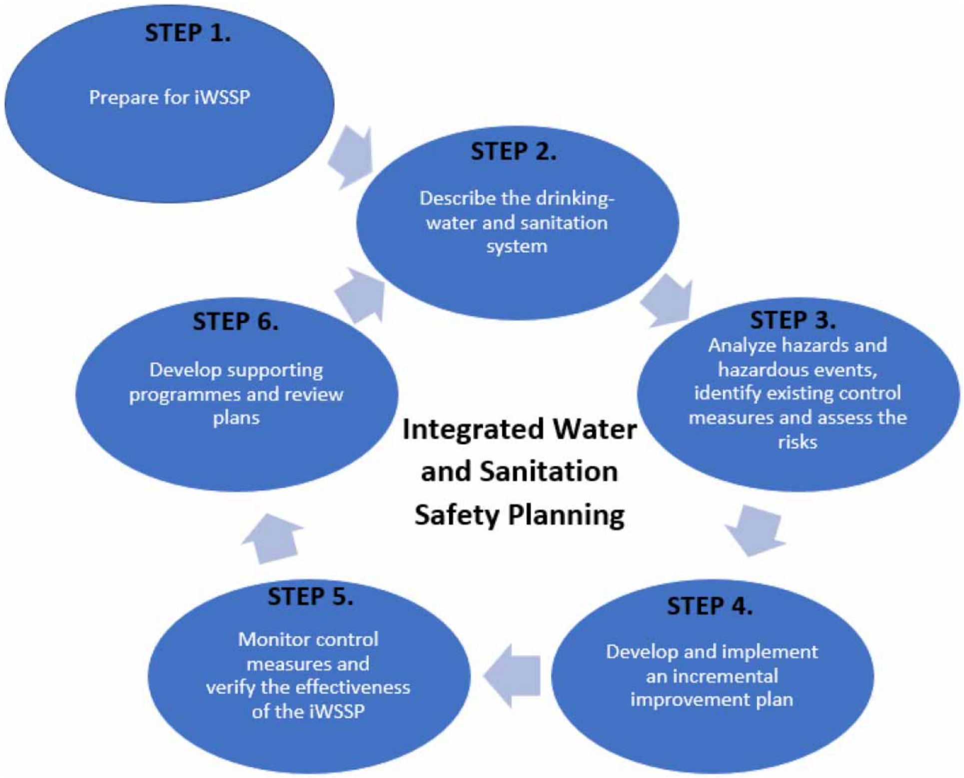

Figure 1 | Six steps of iWSSP.

Step 2 – Describe the drinking-water supply and sanitation system

Accurately describe the drinking-water supply and sanitation system and compare it with the real situation in a site visit. In addition to WSP and SSP, available and newly collected data on drinking-water supply and sanitation are combined to provide insights on interconnections between the systems. Develop combined information documentation such as maps of the drinking-water supply and sanitation system.

Step 3 – Analyze hazards and hazardous events, identify existing control measures and assess risks

Identify biological, chemical, physical or radiological hazards and hazardous events and assess the risk based on severity, likelihood of occurrence, and the effectiveness of existing control measures. In this step, hazards and hazardous events for both drinking-water supply and sanitation are identified. Combined information from step 2, such as maps of the drinking-water supply and sanitation system, also allows teams to identify vulnerabilities and risks based on interconnections. A risk assessment is conducted in a way that the risk levels of both systems can be compared.

Step 4 – Develop and implement an incremental improvement plan

Develop a detailed improvement plan to address all significant risks requiring additional control. The improvement plan focuses on new or improved control measures that prevent, reduce or eliminate the identified risks of both drinking-water supply and sanitation. Those measures can foster positive interactions across both the drinking-water supply and the sanitation system.

Step 5 – Monitor control measures and verify the effectiveness of the iWSSP

Define an operational monitoring plan for important control measures and obtain evidence that the iWSSP as a whole is working effectively. In this step, operational monitoring covers both the drinking-water supply and the sanitation system to check if these are operating as intended at any given point in time. The operational monitoring plan includes actions to eliminate the cause of a non-conformity (non-fulfilment of an operational target) and to prevent recurrence. Verify the effectiveness of the iWSSP by compliance monitoring, auditing or customer satisfaction surveys.

Step 6 – Develop supporting programmes and review plans

Develop supporting programmes that contribute to reaching the iWSSPs objectives and review the iWSSP on a regular basis.

Capacity building

In addition to the development of the iWSSP approach, a series of capacity building activities took place to support piloting the approach:

Sensitization workshop

The sensitization workshop was held on 16 June 2021 in a hybrid in-person and online format. This was hosted by IPH, Belgrade. The workshop was held to create enthusiasm and support for the implementation of iWSSP in small supplies in Serbia. IPH mapped relevant stakeholders for the sensitization workshop and implementation of iWSSP. Twelve national and local stakeholders involved in health, water and sanitation services, environmental protection and infrastructure were identified. The 30 workshop participants represented the identified national and regional stakeholders. Representatives from the WHO regional office for Europe demonstrated the importance of Water, Sanitation, and Hygiene from a public health perspective. The Serbian Ministry of Agriculture, Forest, and Water Management and IPH provided information on the status of drinking-water and sanitation practices in Serbia. International experts from the RIVM and UBA sensitized the participants to the concepts of WSP and SSP through lectures on the key steps and benefits of the approaches, and provided information about the project.

Development of training materials and supporting materials

To achieve an impact on both drinking-water supply and sanitation systems under one integrated approach an acceptable balance between both systems was needed in all steps. To support capacity building and implementation of this iWSSP approach, a concept guidance document, templates and training materials were developed with the aim of integration of drinking-water and sanitation aspects.

Training and capacity building workshop

A 3-day training- and capacity-building workshop took place between the 21 and 23 of September 2021 in a hybrid format, hosted by IPH, Belgrade. The workshop was organized to build sufficient capacity within the implementing teams to execute iWSSPs at the pilot sites in rural Serbia, and to provide information for facilitators to support local iWSSP implementation.

The capacity building workshop had nine participants from the drinking-water and sanitation sector organizations in Serbia. Information was shared by the RIVM and UBA on iWSSP and on the role of facilitators. In total, nine persons were fully trained (five facilitators, three implementers, and one observer). The workshop included lectures, interactive exercises, training of facilitators, and an exchange between attendees of contextual information about each of the pilot sites.

Piloting of iWSSP

Three pilot sites in two rural areas in Serbia were identified and selected for implementing iWSSP (Figure 2).

Pilot sites were selected for differences in sanitation practices and management types for rural small drinking-water supply systems, as well as institutional and community engagement (Table 1).

iWSSP implementation took place following capacity building activities over a period of 9 months, from September 2021 to May 2022, piloting the developed iWSSP approach in all three pilot sites. Facilitators from the IPH of Serbia and regional branches of IPH, who had been trained at the capacity building workshop, together with the local communities, implemented the developed iWSSP approach. The implementation of iWSSP was supported by experts from RIVM.

The progress of iWSSP implementation was monitored and documented regularly for each of the six steps. IPH and RIVM organized fortnightly online meetings throughout the implementation period to share experiences between the facilitators and to discuss progress made and challenges observed by the facilitators. To ensure that experiences, best practices, and challenges were shared between the pilot sites, two peer learning visits were conducted in April and May 2022. During these peer learning visits, teams from one rural area visited the drinking-water and sanitation services of the other area and the teams discussed experiences, best practices, and challenges. In May 2022, during the second peer learning visit, two representatives

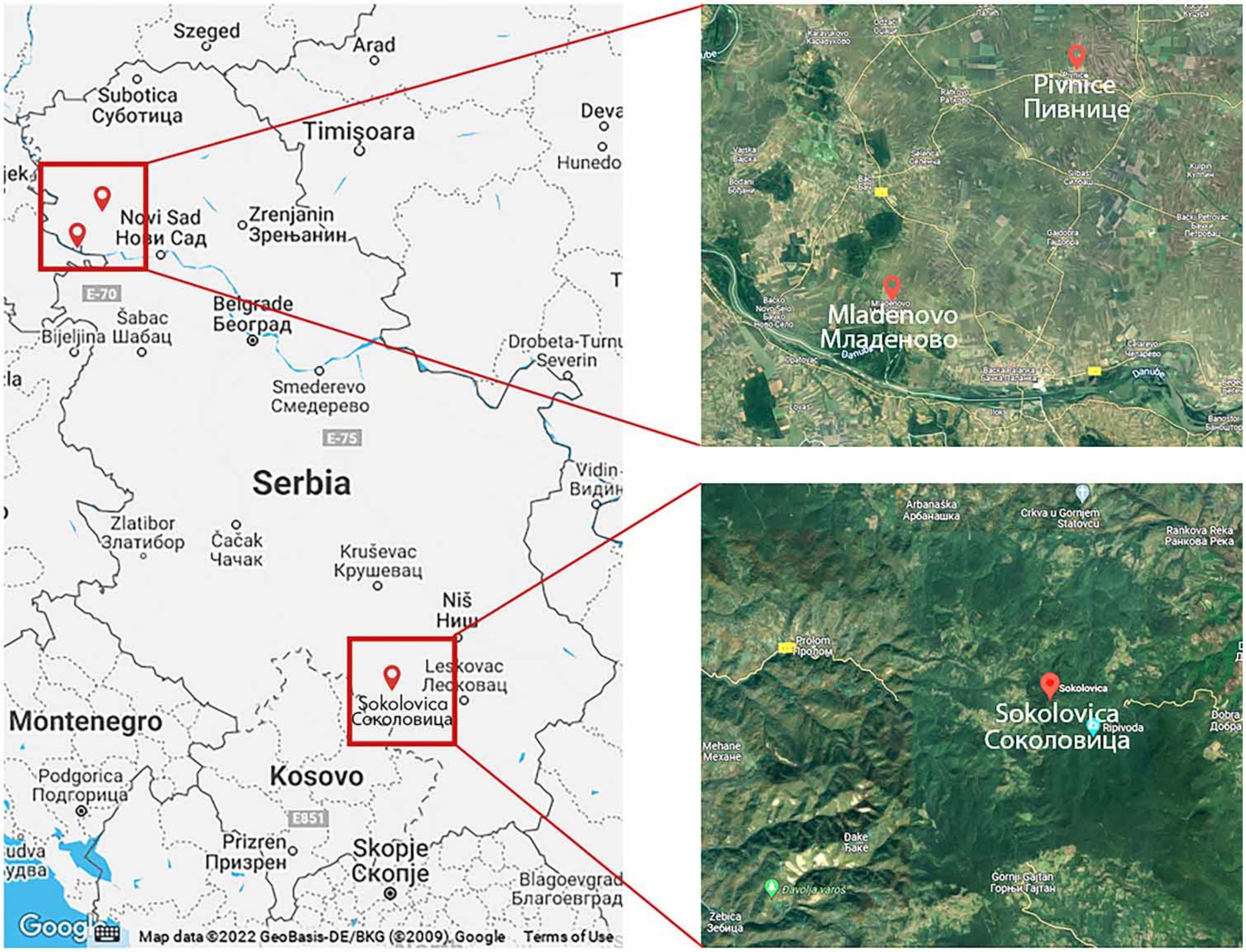

Figure 2 | Map of Serbia with the following three pilot sites: Sokolovica, Mladenovo, and Pivnice.

of each iWSSP team were interviewed by RIVM, using a semi-structured interview, to gather experiences during the implementation.

RESULTS

Capacity building

The sensitization workshop increased knowledge and improved the understanding of participants on the main principles and steps in developing WSP and SSP, and the approaches' integration. Stakeholders from the drinking-water and sanitation sectors recognized the need to introduce SSP in legislation, while WSP has already been addressed in the draft national law on water intended for human consumption. Furthermore, local stakeholders and pilot sites were enthusiastic to implement iWSSP and to become forerunners in the implementation of a new approach for small systems.

Training materials based on the iWSSP approach were developed to support capacity building. The materials contained background information on WSP and SSP, and on the benefits of combining both approaches. The training materials emphasized the need to integrate WSP and SSP, ensuring that both drinking-water and sanitation systems were addressed. This included the development of materials such as PowerPoint presentations and handouts, to explain the iWSSP approach and its six steps in detail. Templates, such as inspection forms, questionnaires, and tables, were developed to collect and document relevant information about the drinking-water supply or sanitation system. Some examples of supporting materials were:

Table 1 | Attributes of iWSSP pilot sites

	Pilot site		
Administrative attributes			
Village	Sokolovica	Pivnice	Mladenovo
Municipality	Kursumliji	Backa Palanka	Backa Palanka
Population	440	3,300	2,600
Drinking-water source	4 natural springs	2 deep wells	3 deep wells
Drinking-water treatment	–	Chlorination	Chlorination
Drinking-water system authority	Community	Public utility company	Public utility company
Sanitation system type	Septic tanks (on-site sanitation)	Septic tanks (on-site sanitation)	Centralized sewer system (80%) Septic tanks (on-site sanitation, 20%)
Sanitation system authority	Private households	Private companies	Public utility company
Physical attributes			
Land area	1,098 km^2	579 km^2	
Relief	Mountains	Flat land	
Landforms	Forest and fields	Fields	
Land use	Agriculture (fruit growing, medical herbs for teas, mushrooms)	Industry (food and wood) and agriculture	

- The template for objectives in step 1, contains objectives for drinking-water supply and sanitation (step 1).
- The guidance document states that stakeholders should be identified from both drinking-water supply and sanitation (step 1).
- A combined system description template to collect data on both systems (step 2).
- Definitions of likelihood, severity and risk that matched for drinking-water and sanitation (step 3, see Supplementary Material S1).
- An Excel sheet was developed to document all relevant information regarding steps 3–5 in a systematic way for both drinking-water and sanitation (Supplementary Material S2).

Materials were translated into Serbian for the implementation of iWSSP at the pilot sites. During the capacity building workshop, the six iWSSP steps including the developed materials were explained in detail. Through familiarizing with the developed templates, participants made a start in using these materials, and gained confidence in explaining them independently to professionals at the pilot sites in the subsequent practical implementation. Facilitators received additional information on their roles and specific tasks to support them in their role in implementing iWSSP at the pilot sites. The capacity building workshop was well received by the facilitators, though it is challenging to conduct the training remotely due to the COVID-19 pandemic. The participant mentioned that 7 h a day is too intensive and tough, with a lot of content, for digital training. The topics were dense and the presentations were given in English, which was challenging for some participants. Training materials were well accepted by the facilitators as they found these materials very well structured and supported with respective tools for understanding and practicing what would be expected in the fieldwork. The participants mentioned that the training and final implementation of iWSSP could contribute to improve conducting their work in a more systematic way. Overall, the participants were very content with the training workshop and eager to start iWSSP implementation at the pilot sites.

Piloting the iWSSP approach in small systems

The iWSSP approach was piloted in three pilot sites in two rural areas in Serbia. For each iWSSP step, the experiences related to the process as well as technical information are described below.

Step 1: Prepare for iWSSP

The iWSSP teams Sokolovica (pilot site Sokolovica) and Backa Palanka (pilot sites Mladenovo and Pivnice) could be established relatively easily due to the stakeholder mapping and sensitization workshop. The teams contained expertise from both drinking-water supply and sanitation. Besides the entities for drinking-water supply and sanitation, the iWSSP team also included national and regional public health officers, local government, and local communities. In Backa Palanka industries were located in the catchment, so representatives from industries were also included. In the selected pilot sites, no challenges were observed in mobilizing the iWSSP teams. The very good relation of IPH with the community and/or utilities probably contributed to the engagement, and furthermore, travel costs were compensated for iWSSP team members for participating in meetings and field visits. The objectives for iWSSP were set by the multidisciplinary iWSSP team and covered both drinking-water supply and sanitation: to ensure safe drinking-water by minimizing contamination of water sources and reducing or removing contaminants. Sub-objectives were set, such as ensuring continuous control of drinking-water and the practice of wastewater disposal and education of legal and natural persons on safe ways of using/producing drinking-water and wastewater disposal.

Step 2: Describe the drinking-water supply and sanitation system

For the system description, information was available in diagrams and/or narrative form at the pilot sites. These were important starting points for the iWSSP teams to collect additional information to provide accurate, relevant, and up-to-date system descriptions, without starting from scratch. More data and information was available for drinking-water and sanitation systems, such as maps or flowcharts, when this was utility-managed compared to community-managed. Furthermore, the utility had more staff and expertise available to collect additional information than the community responsible for drinking-water and sanitation systems. Collecting detailed information for sanitation systems was challenging, especially in the case of on-site sanitation (septic tanks), as they are located on private premises. The iWSSP teams did not have the authority to access private properties. It was technically challenging to create and produce maps on sanitation that included on-site sanitation facilities. It was difficult to create a complete overview of septic tanks in use, or septic tanks which were abandoned but still present. As the utility had more experience with creating maps and flowcharts, more difficulties were observed for the community in creating (integrated) maps.

Integrating drinking-water supply and sanitation system data into one unified map was found to be challenging. A combined map was not created, but to gather information on the interconnections between both systems, the separate maps were jointly examined. The iWSSP teams recognized the need to describe the systems in a comprehensive way. After filling in the system description template, one of the iWSSP teams also described their systems in a shorter way that would provide the greatest contextual fit and practicability for use on location, e.g. to train new staff. The system description contributed to an improved understanding of the drinking-water supply and sanitation systems and resulted in accurate and up-to-date system descriptions in diagrams and narrative form.

Step 3: Analyze hazards and hazardous events, identify existing control measures and assess risks

The iWSSP teams conducted at least one field visit to each pilot site to gather and check information on the system description for the drinking-water supply and sanitation systems. During the field visit the iWSSP teams identified hazardous events and existing control measures. The field visits also contributed to sensitizing and improving awareness and enthusiasm in the communities. The information gained from the field visits enabled iWSSP teams to finalize the system description from iWSSP step 2. For identifying hazards and hazardous events, the following documentation templates were used: sanitary inspection forms (WHO 2020), sanitation inspection forms (WHO 2022c), list of hazardous events (compilation developed for iWSSP within this project) and forms developed under the SMOSS project. Projects such as RADWQ and SMOSS already introduced templates to identify hazardous events that all facilitators were familiar with (Jovanović *et al.* 2017; IPH 2021). Using these well-known forms was easier for the facilitators instead of using a new or additional list of hazardous events. For the three pilot sites, the iWSSP teams needed significant support from facilitators to fill in the template for hazardous events and assess the risks for all identified hazardous events and related hazards in the drinking-water supply and sanitation systems after considering existing control measures. The compilation of hazardous events was comprehensive, and due to the length of the list provided, both iWSSP teams became concerned about the perceived complexity. Adaptation of this template by facilitators through preselection and shortening the list of hazardous events resulted in greater confidence of the iWSSP teams in their ability to complete this task. In total, 77, 47 and 58 hazardous events from the compilation were identified to be present for, respectively, Sokolovica, Pivince and Mladenovo. In Sokolovica, 44 (57%) of the hazardous events were related to the drinking-water supply, and 33 (43%) to the sanitation system. In Pivnice, a similar distribution between the hazardous events related to the drinking-water supply and sanitation were observed, respectively, 60 and 40%, and for Mladenovo, the number of hazardous events were equally distributed with 50% for both systems.

All hazardous events were compiled in one Excel table for which a template for iWSSP steps 3, 4, and 5 was provided, as shown in Supplementary Material S2. In this table, the risk assessment was documented, categorizing each of the hazardous events and the related hazards as high, medium and low risks. Facilitators were needed to provide information on identifying hazardous events using the templates and to support the risk assessment. This emphasises the need for facilitators in implementing iWSSP, as not all communities are used to filling in questionnaires, especially not related to drinking-water and sanitation, and as the risk assessment was too difficult for local communities to complete without external support.

Step 4: Develop and implement an incremental improvement plan

For all combinations of hazards and hazardous events for which the risk was medium or high, the iWSSP teams identified improvements and documented them in improvement plans included in the Excel table (see Supplementary Material S2). The improvement plans triggered the communities to initiate some immediate improvements performed there and then despite no formal budgets within the project to do so, such as cleaning areas around storage reservoirs, locking fences around storage reservoirs, installing vent screens on aeration pipes at the storage reservoirs and changing the shape of storage reservoir aeration pipes by adding a U-turn pipe. These immediate improvements only took place within the drinking-water supply, as the iWSSP team of Sokolovica had the mandate to adapt the system. Both iWSSP teams mainly identified possible mid- to long-term improvements for drinking-water and sanitation systems. Examples of improvements in the drinking-water were renewal or repair of the drinking-water supply network, improving procurement of appropriate equipment, education of staff and raising awareness on source water protection to local self-government. For sanitation, examples of suggested improvements were the introduction of permits for the construction of septic tanks and education on the proper handling of waste in order to protect the health of people both sanitation workers well as the general population. The outcomes of this study reflected the short-term improvements in the Public Utility Company (PUC) 'Kursumlija' that support the operation and management of community-level water supply systems, including Sokolovica. The concrete improvements refer to the overall operation and management of PUC in the development of WSP for this particular water supply system and the enactment of control monitoring.

Step 5: Monitor control measures and verify the effectiveness of the iWSSP

Different types of monitoring were already conducted for drinking-water quality and wastewater at all pilot sites. The drinking-water utility or community conducted operational monitoring by measurements and/or observations, and IPH conducted compliance monitoring to check if the drinking-water quality met the regulations. An operational monitoring plan for drinking-water supply and sanitation was developed by the iWSSP teams. This was based on existing monitoring activities, and new measurements or observations focussing on identified control measures were added. For example, the drinking-water utility in Sokolovica directly increased the frequency of operational monitoring after receiving a field kit for testing turbidity, pH, temperature, and conductivity. Regular checking of turbidity in the drinking-water source and measuring of residual chlorine in the pumping stations throughout the distribution network were implemented after ending the project. In this operational monitoring plan, visual inspections were addressed for both the drinking-water supply and sanitation systems. In the case of inspections of septic tanks, operational monitoring was added to the plan, but needed to be checked with the competent authority. Quality parameters were included for operational monitoring of the drinking-water system.

Step 6: Develop supporting programmes and review plans

Many activities supporting the implementation of iWSSP are undertaken by the drinking-water utilities, communities and/or the local IPH as something that is done often and considered normal. Examples were calibration of equipment, collaboration between IPH and utilities in measurements, communication with local government, and analysis of public health related to waterborne diseases. iWSSP teams provided an overview of programmes that may support the iWSSP approach. The iWSSP teams then developed a plan on how to revise and review iWSSP in the future. During the project, it was possible to revise details about the drinking-water and sanitation system such as adding new information to the system description from field visits, or changes to the iWSSP team as resignations occurred and new employees were hired.

iWSSP implementation was supported by many activities carried out by drinking-water utilities, sanitation utilities, communities, or IPH Serbia, as well as the local authorities. Most of these were routine and commonly practiced activities and were therefore not always regarded as supporting programmes. Examples of supporting programmes were educating employees, the provision of health information on waterborne diseases to residents, collaboration between IPH Serbia and drinking-water suppliers on monitoring, continuous maintenance of defined drinking-water supply and sanitation processes, and communication and awareness of the importance of drinking-water supply and sanitation among legal entities, households, and other stakeholders.

The iWSSP teams agreed to meet every 3 months in the future, and to hold a mandatory meeting after an incident in the drinking-water and sanitation system. The periodic review of the iWSSP was planned to take place annually.

Sharing expertise and best practices

Fortnightly meetings were scheduled between Serbian facilitators and the RIVM during the project period. Progress, experiences, and challenges were discussed in detail, and facilitators appreciated the regular meetings. The meetings supported the implementation as challenges could be troubleshooted and resolved. Frequent meetings provided structure for exchange and contributed positive momentum to the delivery of the project.

Peer learning visits were conducted to share expertise, lessons learned and experiences between the iWSSP teams and local communities of the three pilot sites. In April 2022, a peer learning visit took place in Sokolovica. Twelve people participated in this visit: Sokolovica iWSSP team (5); Backa Palanka iWSSP team (5); IPH (1) and RIVM (1). The mayor of Kursumlija and the director of the drinking-water supply system of Kursumlija attended at the end of the first day. In May 2022, a peer learning visit was arranged in Backa Palanka (Mladenovo and Pivnice). Fifteen people participated in this meeting: the Sokolovica iWSSP team (5); the Backa Palanka iWSSP team (9) and IPH (1). Due to practical reasons and COVID restrictions, not all team members could join the visits. Both drinking-water supply and sanitation experts joined each visit. Participants of these visits found it useful to observe the processes in a different setting and were able to learn more about the drinking-water and sanitation systems in other places, and how their peers dealt with (similar) challenges. Moreover, peer learning visits triggered the iWSSP teams to critically review their risk assessments and monitoring plans. This subsequently contributed to improvements in their respective iWSSPs.

DISCUSSION

The integrated approach was piloted in three small systems in rural Serbia. This approach was conducted to increase knowledge and understanding of the drinking-water supply and sanitation system and its vulnerabilities among staff. Similar findings were observed by Van den Berg *et al.* (2019) who described that the implementation of WSP contributed to a greater understanding of the drinking-water supply. By integrating drinking-water and sanitation safety planning, improved safety can be achieved through a better understanding of both systems, how they are interrelated, and how they can influence each other.

The representatives of the iWSSP teams mentioned that they were positive about the multi-disciplinarity and multi-stakeholder involvement in the teams. The teams could provide an evaluation of the entire water cycle, including drinking-water supply and sanitation. Similar findings were observed by Clavijo *et al.* (2020) and it was shown that the absence of collaboration between different stakeholders could be a barrier to iWSSP implementation (Murei *et al.* 2022). Due to the presence of diverse stakeholders in the iWSSP teams, improved communication and collaboration were observed between the often siloed drinking-water and sanitation domains, which is also a benefit of WSP implementation (WHO 2017a).

WHO reported that policy and regulatory instruments serve as critical drivers for WSP implementation (WHO 2017a). Also, Schmiege *et al.* (2020) described that formal rules together with the conditions that affect the achievement of objectives (enabling environment) at the policy level are required for effective country-wide scaling-up of WSP implementation. In Serbia, WSP has already been addressed in a draft new law on water intended for human consumption, but SSP is not addressed in legal regulations. In this project, the drinking-water and sanitation sectors recognized the need to introduce SSP in legislation. Specific policies and regulatory drivers strongly support the implementation of iWSSP and scaling-up (Clavijo *et al.* 2020), after this project has been completed. Inequality in financial power is described as one of the barriers to iWSSP implementation (Murei *et al.* 2022). Financial support is critical for successful WSP implementation in order to avoid additional burdens on communities with limited financial capacity (WHO 2016). In this project, a budget was available for capacity building, organizing meetings, transport, and external support to implement iWSSP at the pilot sites. Already some improvements have been made and intend to improve more in the near future. The short-term improvement made for operational monitoring showed its results and effectiveness during a recent emergency situation i.e. flooding in the region in June 2023, affecting drinking-water sources with flooded water and raised river levels. Based on improved monitoring, turbidity has been tested regularly allowing timely information for the operational team to react and temporarily exclude certain sources with increased turbidity from the system. However, for larger improvements external funding sources are needed. Herschan *et al.* (2020) described that building on achievements and existing activities is cost-effective and sustainable. This was experienced in several iWSSP steps in this project. Therefore, attention should be placed on what is already done and practiced by the relevant stakeholders and how their existing practices fit into the iWSSP steps. During the implementation phase, it was possible to build on day-to-day practice to show that iWSSP could work in synergy with current routine processes without requiring extra human, material and financial resources. Outcomes of iWSSP can support management in better decision-making for medium- to long-term investments in the drinking-water supply and sanitation system. In this way, it became clear that iWSSP builds upon established daily practices and strongly supports the continuation of iWSSP after its initial introduction, as also document for WSP (Herschan *et al.* 2020).

According to the representatives of the iWSSP teams, it was useful to combine available information on drinking-water supply and sanitation services to identify or better understand possible risks. However, we experienced that integrating drinking-water supply and sanitation was difficult as the systems are managed in different ways and physical overlap is limited. Lack of comprehensive and integrated assessment of drinking-water supply and sewerage at the pilot sites was observed. This was caused by the existing arrangement of systems and organizations in public utility companies in which jobs on drinking-water and sewerage are separated and do not overlap. Furthermore, in some rural areas public drinking-water supply systems are not managed by a utility, but by local communities, and nobody is responsible for the operation with on-site sanitation. At the pilot sites, less information was available on sanitation and fewer activities were observed related to sanitation. Implementing iWSSP in Sokolovica was difficult due to a lack of mandate for inspecting on-site sanitation systems to observe the system and identify hazards and hazardous events. Although Clavijo *et al.* (2020) suggested that using risk assessment tools, such as iWSSP, could provide a more standardized approach toward the assessment and management of on-site systems, we experienced that in pilot sites with only on-site sanitation, integration was less popular. Besides the use of an integrated approach in small supplies in rural areas, it might be applicable in urban areas as well as described by Clavijo *et al.* (2020). Theoretically, it would be beneficial to combine both approaches, especially in rural areas with limited resources. However, it is difficult to determine if iWSSP is more beneficial when compared with separate WSP and SSP implementation, as this was not investigated in this project. Therefore, it would be useful to compare pilot sites where both WSP and SSP have been implemented separately with pilot sites where an integrated approach was used. In this study, we did not assess the impact on water quality, sanitation practices and management. In future studies, it would be useful to measure the impact and include auditing implementation.

In Serbia, climate change was identified as a significant threat to the provision of safe drinking-water, given the high frequency of flooding in the last 15 years and the number of affected river basins (Anonymous 2017). Smaller drinking-water supply systems in rural areas are particularly vulnerable to climate change. Notably, as these supplies often rely on a single water source, they are sensitive to torrential rainfall and flooding or droughts (Serbia 2014). Including climate change into iWSSP would be needed to create resilience to climate change. Huber *et al.* (submitted) provide options for accessing climate information to improve climate resilience of the drinking-water supply and sanitation services. In this study, the reuse of (treated) wastewater was not taken into account as this was not applied in the pilot sites. However, when water scarcity increases due to climate change or urbanization reuse of water might be considered.

Training tools that are locally appropriate and available in local languages support the implementation of the WSP (van den Berg *et al.* 2019; Schmiege *et al.* 2020). Before scaling-up the implementation of iWSSP in Serbia, it is recommended to revise and update the templates based on the feedback and experiences from this pilot project. It is recommended that templates be specific for small systems. They should also remain flexible enough to allow the integration of resources such as photos, tables, and written text. Templates should be generalized, which would allow better consideration of the variety of drinking-water supply and sanitation systems present in small rural supplies, as well as in settings beyond Serbia. As an extension of this project, training and supporting materials will be updated. In the future, the supporting materials can be improved based on new experiences and lessons learned incrementally. Implementation of iWSSP in small communities in rural areas requires the support of well-trained facilitators. This was achieved through a train-the-trainer approach in which key experts were trained as facilitators to such a level that enabled them to implement iWSSP, train others and advise on iWSSPs, which is in line with the requirements for sustainable uptake of WSP (Winkler *et al.* 2017; Schmiege *et al.* 2020). Local staff needed significant support from facilitators to implement iWSSP, for example, by filling in the templates for identifying hazardous events and assessig the risks. External support from facilitators was also recognized by other WSP studies (Rahman & Paul 2013; Sutherland & Payden 2017). The facilitators showed high levels of integrity toward their responsibilities to support iWSSP implementation at the pilot sites. For scaling-up, it is necessary that the national IPH train other local IPH staff to support the uptake of iWSSP as a novel approach that diverges from what is currently performed.

CONCLUSIONS

Under this project, an iWSSP approach was developed to integrate water and sanitation safety planning and piloted in rural areas in Serbia. Although the integrated approach seems to have potential, more information on the impact, benefits and feasibility of this integrated approach should be collected with future studies or applications at pilot sites. Future scaling-up of this integrated approach would be beneficial as more guidance becomes available, especially practical easy-to-use guidance such as tools and templates which can be adapted and updated as needed. Furthermore, key experts play a crucial role in scaling-up iWSSP and therefore sufficient experts (facilitators) should be trained to support local communities with implementation and to train others.

STUDY LIMITATIONS

The main focus of this study was to develop an integrated approach to water and sanitation safety planning. This study did not include assessing the impact on water quality and management practices. In future studies, it would be useful to measure the impact and include auditing implementation, as described for WSP. Although the pilot sites had different setting conditions, the number of pilot sites was too low to make a clear statement on the influence of the setting conditions on the implementation. Close collaboration and regular meetings between the facilitators in the different iWSSP teams resulted in sharing challenges, lessons learned and best practices for all iWSSP steps. In this way, the different settings were able to better deal with possible issues. Therefore, it is not possible to provide information to what extent the setting conditions affect the implementation.

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DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

CONFLICT OF INTEREST

The authors declare there is no conflict.

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