Journal of Water & Health

IWA PUBLISHING

Journal of Water and Health Vol 21 No 10, 1448 doi: 10.2166/wh.2023.101

Implementation of a national regulatory framework for drinking water safety plans in Uruguay

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ABSTRACT

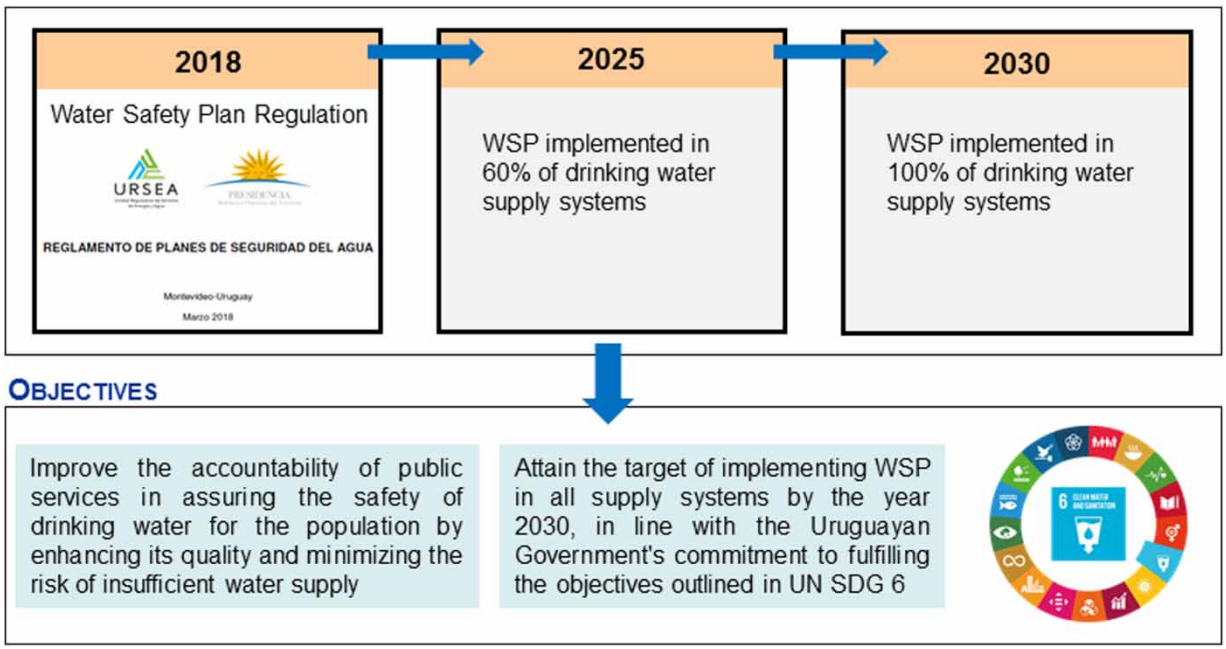
The establishment of national strategic frameworks for systematic scaling-up of water safety plans (WSPs) implementation needs to overcome major constraints: lack of legislation and policies, and the need for appropriate monitoring tools. In 2018, the Uruguayan regulator for energy and water services promulgated a regulation intended to ensure an ambitious and pragmatic strategy that supports and promotes WSP implementation and auditing at a national scale. The goal is to have all drinking water supply systems with their WSP implemented by 2030. For this, a demanding schedule was recommended considering the size of the drinking water supplies: (i) large systems serving more than 2,000 inhabitants and (ii) small and very small systems serving fewer than 2,000 inhabitants. A mandatory verification through internal and external audits was also established. This work describes the legal and regulatory framework as well as the challenges and opportunities that open up for the generalization of WSP implementation in Uruguay. Despite the impact of COVID-19 on working conditions for water suppliers, as for the year 2022, WSPs have been successfully implemented in 94 water systems serving more than 2.4 million people. Results of successful implementation and auditing processes are presented and discussed covering methods and outcomes.

Key words: auditing, drinking water quality, regulation, risk management, water safety plan

HIGHLIGHTS

- Mandatory regulation plays a pivotal role in the nationwide adoption of WSP.
- WSP implementation contributes to achieving targets of SDG 6.
- Regulation provides Uruguayan managerial and operational mechanisms for effective supply of safe drinking water.
- Auditing has proven to be an essential component for ensuring the effective operation of WSP.
- WSP implementation and auditing in Uruguay are currently at an advanced stage.

GRAPHICAL ABSTRACT



INTRODUCTION

The right to safe and clean drinking water as a human right that is essential for the full enjoyment of life and all human rights was first recognized by the United Nations General Assembly in 2010 reflecting awareness of the importance of water to the health, dignity and social well-being of billions of people around the world (UN 2010).

Water is at the heart of the 2030 Agenda for Sustainable Development, adopted by the United Nations Summit for Sustainable Development in 2015. This agreement established a strategic vision with well-defined milestones in 17 Sustainable Development Goals (SDGs) with the aim of achieving significant social and environmental progress in various areas of human activity (UN 2015). SDG 6 sets out the principle of ensuring availability and sustainable management of water and sanitation for all by 2030. However, it will not be achieved for a long time in a great number of developing countries at the current rates of progress where rapid and often unplanned urbanization has put a strain on drinking water supply and sanitation systems. Despite the progress made, in 2020 an estimated 2 billion and 3.6 billion people still lack safely managed drinking water and decent sanitation services, respectively. Also, an estimated 2.3 billion people do not have access to handwashing facilities with soap and 494 million people still practice open defecation. In 2020, 74% of the global population had access to safely managed drinking water services, up from 70% in 2015, with urban coverage increasing from 85 to 86% and rural coverage increasing from 53 to 60%. At the current rates of progress, the world will only reach 81% coverage by 2030, leaving 1.6 billion people without safely managed drinking water services. Achieving universal access will require a fourfold increase in the current rates of progress. Least developed countries have the furthest to go and many more countries are facing challenges in extending services to rural areas and to poor and vulnerable populations who are most at risk of being left behind (WHO & UNICEF 2021).

One of the biggest challenges facing countries is related to the demand for clean water that is increasing with rapid population growth, urbanization and increasing water needs of agriculture, industry and energy sectors. Furthermore, the contamination of water sources and the impacts of climate change have contributed to an accelerating scarcity of freshwater resources that is leading to a global water crisis. Recognizing the importance and the need to counteract these trends and urging all countries to implement policies in line with the objectives of the SDGs, the UN General Assembly launched the Water Action Decade (2018–2028) to mobilize action that will help transform the water management worldwide (UN 2016). In this context, efficient water governance is essential for safely managed drinking water systems. Clean and safe drinking water is of paramount importance for the protection of human health and public water supply systems must have their

main objective to provide drinking water that meets the required standards in terms of quality, quantity, hydraulic pressure and continuity of service (Hrudey & Hrudey 2004; Vieira 2018).

A 'framework for safe drinking water' was first established in 2004 by the World Health Organization (WHO) providing a preventive management approach comprising three key components: (i) health-based targets based on an evaluation of health risks established by a competent health authority; (ii) a comprehensive risk assessment and risk management approach that encompasses all steps in the water supply chain from catchment to consumer, called a water safety plan (WSP) and (iii) a system of independent surveillance that verifies that drinking water safety is guaranteed by implementation of a WSP (WHO 2017a). Since then, there has been a progressive acceptance that water safety planning is the most effective means of consistently ensuring the safety of a drinking water supply leading to a rapid dissemination of this concept at the global level which has contributed to promoting 'safely managed' water supplies to address the SDG 6. The effective implementation of WSP worldwide was greatly boosted by the availability of guidance and training materials (Vieira & Morais 2005; Bartram *et al.* 2009). Also, an online platform dedicated to the development and implementation of WSP was jointly launched by the WHO and the International Water Association (IWA), the Water Safety Portal (https://wsportal.org), with the aim of promoting active interaction between governments, professionals and implementers (WHO & IWA 2023).

From 2004 onwards, there has been rapid development and implementation of WSP at different scales (utility-level and country-level) and in varied geographies in both developed and developing countries. Numerous publications are available describing international experience on drinking water risk assessment and risk management interventions (Vieira 2007; Gunnarsdottir *et al.* 2012a; Perrier *et al.* 2014; Amjad *et al.* 2016; Kanyesigye *et al.* 2019; van den Berg *et al.* 2019; Li *et al.* 2020). Comprehensive review studies documented a continuing increase in experiences at a regional scale, evidencing a growing will and effort from water quality regulators and public health authorities to achieve SDG indicator 6.1.1 of 'safely managed drinking water' (Rinehold *et al.* 2017; WHO 2017b; Baum & Bartram 2018; Ferrero *et al.* 2019).

Despite the limited experience available in evaluating the benefits of implementing the WSP, a number of studies have documented positive outcomes achieved both for public health and for the systematic preventive risk management in drinking water supply systems. Research results carried out following the implementation of WSP in Iceland (Gunnarsdottir *et al.* 2012b) have shown a decrease in clinical cases of diarrhea. Similar studies carried out in France and Spain (Setty *et al.* 2017) and in the Asia-Pacific region (Kumpel *et al.* 2018) suggest that the implementation of WSP is potentially effective in reducing the risk of gastrointestinal diseases. In addition, the risk assessment and risk management approach can provide substantial organizational improvements at the water utility level, such as standardization of operational procedures, water quality improvement, hazard identification and risk management in routine and exceptional situations.

Drinking water quality control in small supplies is typically characterized by lower compliance rates with legal standards, so the implementation of WSP would have obvious benefits to these systems. However, due to the lack of technical and financial resources, small water suppliers in remote and rural areas have often serious difficulties in integrating risk-based approaches. A key to success with improving water safety in small water supplies is training and institutional support, which should receive special attention in national policies (Gunnarsdottir *et al.* 2020). In countries where regulations are in place, independent auditing is an integral part of the WSP approach that plays an important role in understanding whether WSP teams are consistently following the practical implementation and progress of the WSP, as well as identifying areas for improvement and verifying that the documentation is accurate and up to date (Ferrero *et al.* 2019).

Regulations, institutional arrangements and resources (human, technical and financial) are key factors in creating an enabling environment for effective WSP implementation at a national scale (Baum & Bartram 2018). At the international level, documents of WHO and IWA provide a methodology for WSP development and implementation worldwide by adopting common terminology and promoting similarly aligned national and state guidelines and regulations that require systematic risk management (Bartram *et al.* 2009; WHO & IWA 2010). In the European Union, the Drinking Water Directive 2020/2184 requires all member states to promulgate a complete risk-based approach to water safety, covering the whole supply chain from the catchment area, abstraction, treatment, storage and distribution to the point of compliance in line with the WSP principles. For water suppliers providing between 10 and 100 m^3/day as an average or serving between 50 and 500 people, Member States should be able to exempt those water suppliers from carrying out a risk assessment of the supply system, provided that regular monitoring in accordance with this Directive is carried out (EC 2020).

The establishment of national strategic frameworks for systematic scaling-up of WSP implementation needs to overcome major constraints: lack of legislation and policies, and the need for appropriate monitoring tools. In 2018, the Uruguayan regulator for energy and water services promulgated a regulation intended to ensure an ambitious and pragmatic strategy

that supports and promotes the WSP implementation and auditing in all drinking water supply systems by 2030, considering the interim target for the implementation of WSP in 60% of water systems, serving more than 2.9 million people by 2025 (URSEA 2018).

The purpose of this work is to describe the institutional arrangements and specific conditions of a national regulatory framework for scaling-up WSP implementation in Uruguay, highlighting the relevance of auditing for assessing the progress in drinking water quality control.

METHODS

The implementation of WSP on a national scale in Uruguay is intrinsically related to the specificity of the drinking water services organization and the legal and regulatory framework in force in the country. Pertinent information was analyzed covering the following aspects: technical characteristics of water supplies; legal framework for drinking water quality control and the rationale for structuring a national framework for safe drinking water in Uruguay.

Water supplies in Uruguay

The population of Uruguay totals around 3.4 million people who are served by 570 public water supplies. OSE, Administración de las Obras Sanitarias del Estado (*National Administration of Sanitary Works*), is the national public company responsible for supplying drinking water throughout the country, providing water services in 330 towns and in peri-urban and rural areas. Small water supplies (serving less than 2,000 persons) constitute the large majority of these systems (85%) although they represent only 5% of the total population served (Figure 1).

In Uruguay, 99.4% of the population has an improved water source inside or outside the home (whether the source is from a general drinking water supply network or a protected spring well equipped with pumps). 95% of the population has access to drinking water through supply networks, one of the highest drinking water coverage in the American continent, and an average consumption of 120–150 L/capita/day. The country's challenge for universal access to drinking water lies in the coverage of very small systems (<500 inhabitants). The abstracted water undergoes a treatment process before being distributed to consumers. Water treatment comprises conventional custom-designed plants or package transportable units used when the source is surface water where the unit processes and operations applied are: coagulation-flocculation, sedimentation or flotation, filtration and disinfection. Aguas Corrientes is the most important treatment plant that supplies drinking water to the Montevideo metropolitan area (approximately 1.8 million inhabitants). Groundwater serving small and very small water systems in rural areas usually has chlorine disinfection as the sole treatment. Table 1 gives the type of raw water source and the annual volume of drinking water supplied in each of the regional authorities for the year of 2016.

Legal framework for drinking water quality control in Uruguay

In Uruguayan constitutional terms, it is recognized that: 'surface waters, as well as groundwater constitute a unitary resource, subordinated to the general interest, which is part of the state public domain, as hydraulic public domain' and 'the public sanitation service and the public drinking water supply service will be provided exclusively and directly by state legal persons'.

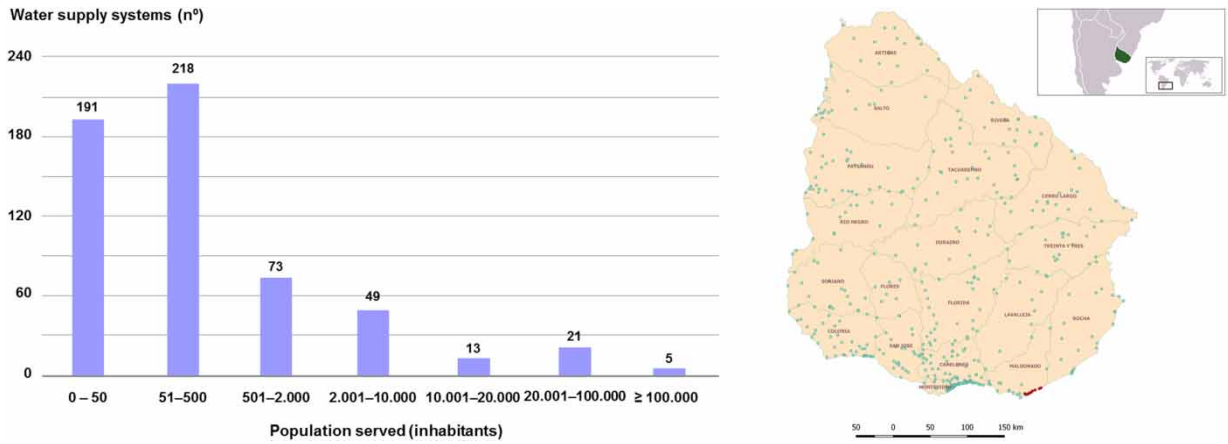


Figure 1 | Size and location of drinking water supply systems in Uruguay.

Table 1 | Origin of drinking water in Uruguay by region (year 2016)

Regional authority	Surface water (10^6 m^3/year)	Surface water (%)	Groundwater (10^6 m^3/year)	Groundwater (%)	Total (10^6 m^3/year)
Center	10.6	70.3	4.5	29.7	15.1
North Coast	25.5	75.8	8.1	24.2	33.6
South Coast	18.3	71.0	7.5	29.0	25.8
Metropolitan	223.3	100.0	0.0	0.0	223.3
Northeast	14.0	58.3	10.0	41.7	24.0
Southeast	10.8	75.0	3.6	25.0	14.4
UGD Maldonado	20.1	100.0	0.0	0.0	20.1
Total country (m^3/year)	322.7		33.7		356.4
Total country (%)	90.5		9.5		100.0

In 2017, the government approved the National Water Plan (PNA) that defines 10 programs and 30 projects and establishes the bases to formulate regional and local plans for water management at the river basin scale. The projects that are developed within one of these programs, 'Water for human use', address (i) the universalization of access to water and sanitation through the implementation of the 'National Plan for Drinking Water, Sanitation and Urban Drainage'; (ii) the development and deepening of public health aspects related to water and (iii) incorporation of water safety plans methodology as a tool promoted by the WHO for risk assessment and risk management related to the quality and quantity of drinking water supplied to the communities (MVOTMA 2017). As of the date of the PNA publication, the following main institutions linked to its implementation can be mentioned:

- The Secretary of State of Environment, Water and Climate Change reports to the Presidency of the Republic and has the specific task of articulating and coordinating with public and private institutions and organizations, the execution of the public policies related to the environment, water and climate change.
- The Ministry of Housing, Territorial Planning and Environment (MVOTMA) has the mission of proposing to the government the National Water Policy and the formulation, execution and supervision of the national environmental, territorial planning and housing policy. These powers are exercised in a decentralized manner through the National Water Directorate (DINAGUA), the National Environment Directorate (DINAMA) and the National Territorial Planning Directorate. DINAGUA is responsible, in general terms, for the administration, use and control of water resources, the promotion and preparation of national, regional and local plans for water resources and their continuous and comprehensive evaluation.
- The Ministry of Public Health has the mission of establishing policies and strategies for compliance with essential public health functions, in order to ensure collective health as a basic human right and a public good that is the responsibility of the State.
- The Regulatory Entity for Energy and Water Services (URSEA) is a decentralized body of the Administration responsible for regulating quality, safety, consumer protection and subsequent inspection of the following activities: '… those referring to the raw water abstraction, treatment and distribution of drinking water through networks on a regular or permanent basis …'
- The National Administration of Sanitary Works (OSE) is a decentralized service subject to the administrative supervision of the government through the MVOTMA. It is responsible for providing the drinking water service for the entire country and the sanitation service throughout the country with the exception of Montevideo.

The quality of water intended for human consumption is regulated by Decree No. 375/011 of November 3, 2011, which adopts the maximum permissible limit values established in Unit 833-2008 Standard for microbiological, biological, physical, inorganic chemical, organic chemical, radioactive and disinfectant parameters and byproducts of disinfection. The sampling frequencies, in accordance with OSE's Internal Drinking Water Quality Standard, are determined for each parameter based on the population supplied. The minimum sampling frequencies refer to the following parameters: (i) microbiological indicators (total and thermotolerant coliforms, *Pseudomonas aeruginosa*, heterotrophic at 35 °C); (ii) biological (plankton); physical (turbidity, color, odor, taste, pH, conductivity); (iii) inorganic chemicals (free residual chlorine, chloramines,

cadmium, arsenic, iron, manganese, copper, aluminum, lead, nitrate, ammonia, chloride, hardness, fluoride, total dissolved solids, sulfate, chromium, mercury, nitrite, sodium, zinc) and (iv) organic chemicals (trihalometanes, haloacetic acids). The sampling points are located in the distribution network, leaving the treatment (water treatment plant or wells) and leaving the storage tanks.

OSE has a network of more than 80 laboratories (central laboratory, regional laboratories and plant laboratories) that perform an average of 50,000 chemical and biological analyses per year. Monitoring of raw water is carried out by DINAMA every 6 months and by OSE monthly in main points of watersheds, intensifying in the season in which cyanobacteria can flourish. URSEA, as the surveillance authority for the regulation and supervision of drinking water supply activities, carries out a program to monitor the quality of drinking water distributed by networks in order to control compliance with current regulations. An average of 270 water supply systems, serving about 3 million people, is annually monitored by the URSEA. The most monitored parameters are: microbiological indicators, arsenic, cadmium, chlorine, chloride, microcystin, nitrate, pH, conductivity, turbidity, hardness, trihalometanes and pesticides.

A national framework for safe drinking water in Uruguay

A coherent, structured and comprehensive national framework for safe drinking water must have the active contribution of policymakers, health and environmental authorities and water stakeholders. Figure 2 depicts a schematic outline for a national framework that should include three main components: (i) *institutional settings*: health authorities and the national regulator may promote the changes needed in legislation and regulation giving support for WSP scaling-up; (ii) *practical implementation*: it is essential that needs and methodologies are defined at a national level, and setting up the system, operational monitoring and self-assessment are established at the water utility level and (iii) *supporting mechanisms*: the approach can be supported by research and education programs, and monitoring of WSP implementation must be done by independent auditing at both national and water utility levels (Vieira 2011).

In the last decade, there have been some specific incidents in Uruguay that have affected the quality of raw water sources, which generated public alarm and prompted emergency actions and responses from OSE and institutional agencies. Among these events are the hydrocarbon spill in Paysandú in 2015, and the odor and taste episodes in Montevideo and the metropolitan area in 2013 and in the Department of Maldonado in 2015. Additionally, climate-related extreme weather events such as droughts and floods have posed serious threats to safe drinking water management from catchment to the consumer.

At the national level, public health and water management agencies are increasingly recognizing shortcomings and limitations of end-product testing methodology, which has contributed to the development of risk assessment and management policies in water quality control. The PNA has placed emphasis on improving the quality of raw water used as a source of water supply and in generating strategies to achieve universal access to safe drinking water and decent sanitation by 2030 in order to achieve the objectives of SDG 6. The PNA also promotes the implementation of water safety plans as an adequate methodology for the surveillance and control of drinking water distribution systems.

Embodying the government's political will and understanding the fundamental role that a mandatory regulation assumes in supporting the WSP scaling-up at a national scale, the URSEA approved the 'Water Safety Plan Regulation', considering the following principles:

- establish a legislative and institutional basis for effective drinking water surveillance that promotes risk assessments and risk management in all water systems throughout the country;

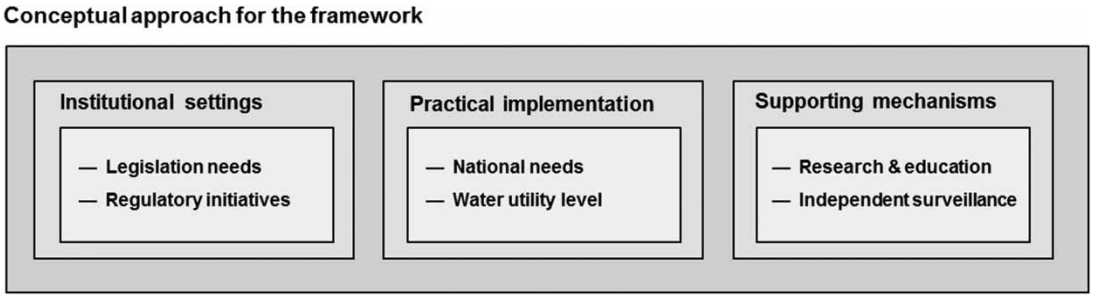


Figure 2 | Main components of a national framework for safe drinking water. *Source*: Vieira (2011).

- ensure the effectiveness of WSPs in small supplies taking into account their specific characteristics;
- ensure that surveillance covers the whole of the drinking water system, from the raw water sources through abstraction, treatment, storage and distribution to consumer;
- establish internal and external audits as appropriate and mandatory surveillance instruments and
- establish a timeline that guarantees achieving the main objective of having all water supply systems with WSP implemented and audited by 2030.

RESULTS AND DISCUSSION

The Water Safety Plan Regulation

The 'Water Safety Plan Regulation' referred to as 'Regulation' provides Uruguayan water suppliers, and public health and regulatory authorities, with the institutional, managerial and operational mechanisms for the effective supply of safe drinking water (URSEA 2018). Its purpose is to establish the requirements and obligations that water utilities must comply with to prepare and implement WSP through a risk assessment and risk management approach, in line with WHO recommendations (Bartram *et al.* 2009). Without going through all the clauses of the Regulation some important aspects are:

- Each water utility must prepare, approve and implement, and make available to the URSEA: (i) a WSP for each system with a population of more than 2,000 inhabitants; (ii) a WSP for systems with a population of less than 2,000 inhabitants, with the necessary variants to adapt it to the characteristics of these systems.
- Each water utility must prepare, approve and implement, for each system, a WSP that must include, as a minimum, the following contents: (i) analysis of the supply system with the assessment of its capacity to supply water in accordance with the sanitary goals; (ii) hazard identification and risk assessment on human health in the supply system chain; (iii) establishment of preventive measures to control the identified risks; (iv) operating procedures and process control to ensure the proper functioning of the measures implemented to keep hazards under control; (v) verification of water quality to prove the effectiveness of the plan in relation to the pre-established goals; (vi) management of incidents and emergencies through rapid and effective corrective actions to deal with situations out of control and (vii) WSP review and improvement whenever it is considered necessary.
- Each water utility must ensure that appropriate auditing and inspection systems are applied to ensure that the WSP is complete, properly implemented and effective, with precise guidelines for good practices and well-established monitoring programs and contributes to the continuous improvement of the whole process. This verification takes three forms: (i) sanitary inspection; (ii) internal audit and (iii) external audit.
- Within the scope of its competence, water utilities must monitor the quality of the raw water that enters the treatment plants or is pumped into the distribution system from wells.
- It is established that by 2030 all drinking water supply systems in Uruguay must have their WSP implemented accordingly with the commitment assumed by the government of Uruguay with respect to the SDG 6 objectives.
- The compliance of the Regulation will be subject to the following schedule: (i) WSPs should be implemented in 60% of the water systems by 2025 and 100% by 2030; (ii) for systems serving a population of more than 2,000 inhabitants, WSPs should be implemented in 25% of the systems by 2020. Within the set of these WSPs, we distinguish those of Montevideo, Paysandú, Laguna del Sauce and Laguna del Cisne, which must be implemented before 2020; (iii) for systems serving a population of less than 2,000 inhabitants, water utilities will submit the general documentation for the WSP suitable for these systems by 2019.

OSE activities in compliance with the Water Safety Plan Regulation

Since 2012, even before the creation of the mandatory Regulation, OSE has taken a proactive approach in the implementation of WSP as pilot projects in some supply systems under its responsibility. Development of supporting programs such as training and regional workshops have proved useful to help water suppliers to understand WSP fundamentals and the benefits of a risk-based management approach for the drinking water supply systems.

After the approval of the Regulation, OSE developed a series of initiatives in order to comply with the requirements established therein. The particular situation of OSE as it is the only company responsible for supplying drinking water throughout

the country and the experience previously acquired allows the integration of coordinated policies and actions, which has facilitated the planning and implementation process of WSP in Uruguay. The main activities were:

- *WSP team structure*: The option for structuring the WSP team reflected the national scale of the OSE, its decentralized production and the existence of a large number of drinking water systems in each regional Department. Working groups were organized on two levels of coordination: (i) between local teams and departmental teams and (ii) between these and the national steering committee.
- *Strategies for updating documents in accordance with the Regulation*: (i) review of the general manual for WSP implementation, the semi-quantitative risk matrix and the management sheets; (ii) preparation of documents for the implementation of WSP in systems of less than 2,000 inhabitants; (iii) adaptation of specific documents and monitoring according to the degree of evolution of each system.
- *Support tools for data collection and analysis*: Tools for operational monitoring and verification data have been developed: (i) water production system (SPA) is the application for recording and storing the results of the operational monitoring of the treatment plant, including controls on raw water, treatment process and treated water; (ii) online measurement (MedLin) is the application to view the metering records of pH, free chlorine and turbidity of the water leaving the treatment plant and (iii) resource management application (AGR) where the operational monitoring records are found (water quality in the distribution network and water levels and flows in wells).
- *Periodic follow-up reports*: A general guide document was developed for the preparation of periodic reports by local teams based on monitoring results, incidents and monthly indicators of water quality and quantity, considering the three components covered by the WSP: source, treatment and distribution.
- *Raw water sampling plan*: In compliance with the Regulation, OSE established a specific program to monitor the quality of surface water entering the treatment plant or groundwater entering the water distribution system. For surface water sources, chemical parameters (*in situ* and in laboratory) and microbiological (in laboratory) are monitored in the abstraction point and in the catchment area. For groundwater sources, the control points include the raw water of the well for the biological parameters, where the frequency is determined in function of the risk analysis.
- *Training program and communication strategies*: OSE has promoted training courses, workshops and face-to-face and virtual meetings convening departmental technical heads, regional managers and technical personnel dealing with aspects related to the methodology and progress of WSP implementation.

Timeline for WSP implementation in Uruguay

In accordance with the Regulation clause 52, OSE prepared and submitted to URSEA a WSP implementation schedule for all drinking water systems. This forecast details the WSP implementation year by year guaranteeing the interim target for the implementation of WSP in 60% of water systems by 2025. Implementation of WSPs on the grand total of 570 water systems (100%) is expected to be completed by 2030.

During 2018 and 2019, WSPs were implemented in 18 water systems. However, two years after the approval of the Regulation, a state of national sanitary emergency in light of the COVID-19 pandemic was declared by the government of Uruguay. This anomalous situation that lasted 2 years between 2020 and 2022 had a great impact on working conditions within the OSE and consequently on the pace of WSP implementation. As of 2022, WSP had been implemented in 94 water supply systems. Figure 3 shows the actual evolution of WSP implementation from 2018 to 2022, where it can be seen that the number of inhabitants supplied by water systems with WSP have exceeded 2.4 million.

WSP auditing in Uruguay

Audit is a formal verification procedure with the objective of a final control on the overall WSP effectiveness, covering the entire drinking water supply chain and guaranteeing the reliability of the continuous supply of water compatible with the safety objectives for the consumers. The Regulation establishes attributions and responsibilities for the enforcement of sanitary inspection, internal audit and external audit activities (URSEA 2018):

- Water suppliers must carry out sanitary inspections and internal audits to confirm whether the WSP meets the requirements of its application and to ensure that water quality and risks are controlled. Systems serving more than 20,000 inhabitants will have at least one complete internal audit on an annual basis. Systems with less than 20,000 inhabitants will have at least one sanitary inspection and one simplified internal audit, on an annual basis (clause 29).

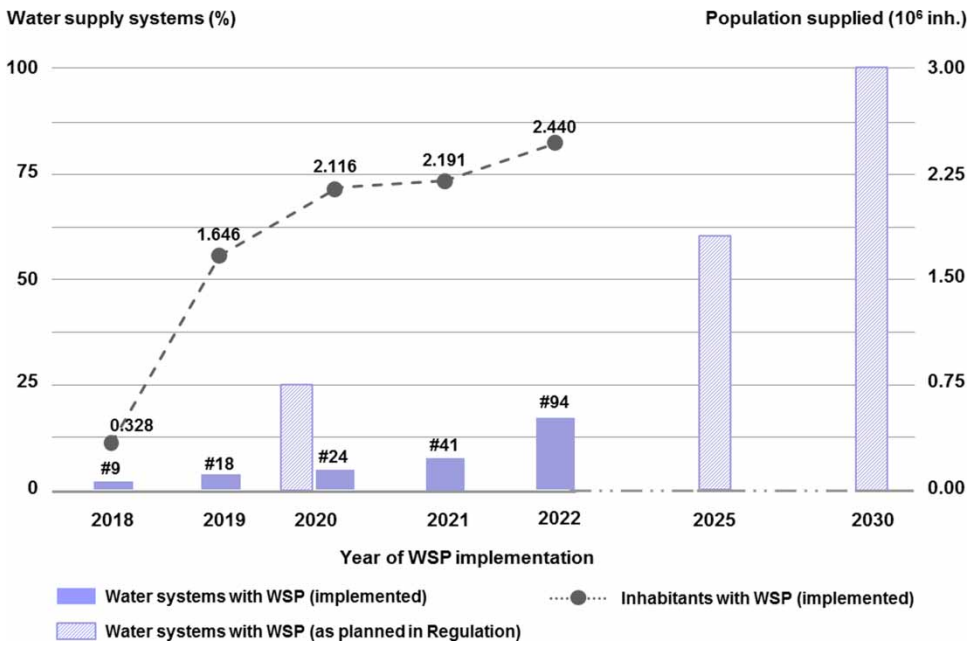


Figure 3 | Planned and implemented cumulative number of water systems and population served with WSP in Uruguay.

- URSEA, as a regulatory entity, will carry out WSP external audits, independent of the water suppliers. URSEA may also carry out sampling and analysis to verify if the water supply is safe and complies with standards based on quality, safety, health and other regulatory requirements (clause 30).

Auditors in charge are expected to assess water suppliers compliance with all the key requirements related to the preventive risk management approach for the drinking water supply system, including:

- emergency management procedures;
- water quality control in raw water intakes;
- water sampling programs;
- critical control points and critical parameters limits;
- risk associated with distribution systems and
- periodic review of the WSP, after significant changes.

The schedule for carrying out the audits was also conditioned during the confinement period due to the COVID-19 pandemic. As for 2022, three external audits were carried out to the drinking water systems of the cities of Dolores, Paysandú and Laguna del Cisne. The external audit included the review of the available documentation and records, including internal audits, meetings with the human resources involved in the WSP and field visits to the water supply systems. It is conducted in person and extends over a period of 2 days. As the implementation of the WSP progresses, internal and external audits will continue on a regular basis, as provided for in the Regulation. Although the sample of external audits carried out is of a reduced size, some generic findings related to the implementation of WSPs can be highlighted:

- *WSP team*. The audits were carried out with the participation of local and departmental teams although there was some difficulty in identifying the WSP team leader. There is evidence of great mastery of the WSP documentation at the drinking water management level. However, there is a perceived need for greater involvement of local teams in WSP documents consulting and preparation.
- *System description*. The water supply chain is described with abundant and sufficient information. However, information on the catchment basin is insufficient, namely with regard to aspects of hydrology, geology, land use and sources of pollution. A greater description of monitoring is also recommended, relating qualitative data (statistics of monitored parameters and non-compliance with regulations).

- *Risk assessment*. Identification of hazards and hazardous events as well as scoring and rating of the risks are recorded in detail in the semi-quantitative risk matrix. Although these tasks involve some subjectivity, the WSP teams demonstrate a great sensitivity and competence to deal with them.
- *Control measures and improvement plans*. It is suggested that control measures include a systematic way to achieve compliance such as calibration plans, maintenance, spare parts stocks, cleaning and compliance monitoring and registration. Although improvement plans have been included in the WSP documents, there is no evidence of follow-up for these actions.
- *Contingency plans*. Relevance is given to the preparation of contingency plans to deal with the occurrence of exceptional events such as floods, drought, electricity supply failure, hydrocarbon spills and algal blooms. It is suggested to include protocols and communication strategies in the contingency plans and the installation of gauging stations is recommended to predict levels and flows of surface water sources in climate change scenarios.
- *Supporting programs*. The implementation of permanent training programs for operators is documented. However, outsourced personnel do not have access to them.
- *Consumer satisfaction*. To assess consumer satisfaction, only complaints sorted by typology are documented and considered, with no indication of the measures taken to resolve them. The development of a structured procedure to deepen the methodology for evaluating consumer satisfaction is suggested.
- *Revision of the WSP*. Documentation of WSPs establishes an annual review, in conjunction with the review of the quality management system. However, it is reported that it has not been carried out with this frequency. No evidence was found of a defined procedure to carry out the reviews or their dissemination after approval.
- *Staff commitment*. The management and implementation of actions related to the external audit findings are coordinated and reported to URSEA by the local WSP team through the departmental technical headquarters in coordination with the regional directorate. Of particular note is the commitment of all staff to providing a safe drinking water supply service and their interest in continuous improvement.

CONCLUSIONS

Clean water is essential for human health. Limitations of end-product testing methodology for water quality were recognized by public health agencies when disease outbreaks and malfunctioning and disruption of water supply systems have occurred. A complete risk-based approach to drinking water safety, covering the entire supply chain from catchment to consumer, was first established in 2004 by WHO, launching the WSP concept. Since then, there has been progressive acceptance and rapid dissemination of this concept around the world, which has contributed to the promotion of universal access to safe drinking water. Major water policy drivers such as the European Union have recognized that preventive safety planning and a risk-based approach, including for small communities, are principles on which legislation on the production and distribution of drinking water should be based.

Available research shows that the mandatory requirement for WSP has proven to be a key institutional instrument for scaling-up risk-based approaches at a national level. The 'National Water Plan' and the 'Water Safety Plan Regulation' are the two documents that form the backbone of a national framework for safe drinking water in Uruguay integrating health-based targets, water safety plans and independent surveillance, as advocated by WHO.

OSE, as the only entity responsible for providing the drinking water service in the country, has an organizational structure whose administrative, technical, laboratorial and financial capacity allows for the coordinated management of policies at the national level. On the other hand, its previous experience with pilot projects and support programs such as training proved to be key factors for the implementation of WSP at the pace and under the conditions established in the Regulation. The regulator URSEA, by assuming the independent surveillance process of WSP, including responsibility for external audits, is a major player at a national level in the enforcement of the monitoring and benchmarking program as defined in the Regulation.

Internal audit by OSE and external audit by the URSEA are integral parts of the process of verifying the effectiveness of the WSP and constitute a crucial step in ensuring that the WSP is working properly and the drinking water meets the defined requirements. Audit findings revealed several shortcomings in the successful implementation of WSPs. In this context, further improvements were identified in areas of: (i) collection of quantitative and qualitative data in the catchment area on available water resources and pollution to protect raw water sources in climate change scenarios; (ii) involvement of the local teams in

the preparation of WSP documents; (iii) systematization of the periodic review of WSP; (iv) methods and indicators to assess WSP outcomes and impacts and (v) methodology for evaluating consumer satisfaction. It should be noted that the commitment and proactivity of all staff in the implementation of the WSP shows that they are key players in providing a safe drinking water supply service.

This study describes the systematic and organic approach for implementing WSPs, including the timeline to achieve the target of 100% implementation in large, small and very small water supply systems throughout the country by 2030. Despite the negative impact of the COVID-19 pandemic on compliance with the schedule established by the Regulation, it can be concluded that WSP implementation and auditing are well in progress in Uruguay. Lessons learned can also serve to highlight the measurable improvement of public health and thus increase consumer confidence in the quality of the served drinking water.

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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First received 29 April 2023; accepted in revised form 7 September 2023. Available online 20 September 2023