Article

Comparison of implementing water safety plan in different countries: A review

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Received 22 March 2023; Accepted 30 March 2023; Published online 5 April 2023; *Published 1 June 2023*

Abstract
The traditional technique for management potable water quality is not an appropriate preventive approach for protecting public health. The Water Safety Plan (WSP) introduces a systematic plan to ensuring the health and quality of potable water. The aim of present study is to compare the performance of water safety plans in several countries. WSP is implemented in 10 countries, including USA, China, France, Palestine, Indonesia, Syria, Iceland, Italy, Uganda, and Iran. Findings showed that microbial contamination in catchment, discharge waste of humans, birds, animals, and domestic waste in water sources, fluctuations of free residual chorine in point of use, lack of manpower training and financial resources, insufficient documentation system, and old infrastructure were identified as the most important barriers. The major benefits of WSP implementation were control of the risks in the water supply system and decrease of expenditures, increase of satisfaction customers, effective coordination and monitoring, improvement in treatment processes, reduction of water borne diseases, improvement of water quality and safety of potable water, and improvement of public health. The results of the present study can help researchers, policy-makers, health decision-makers, and people improve water quality of drinking water and improve public health.

Keywords potable water; HACCP; risk assessment; water supply; water hazards.

Proceedings of the International Academy of Ecology and Environmental Sciences
ISSN 2220-8860
URL: http://www.iaees.org/publications/journals/piaees/online-version.asp
RSS: http://www.iaees.org/publications/journals/piaees/rss.xml
E-mail: piaees@iaees.org
Editor-in-Chief: WenJun Zhang
Publisher: International Academy of Ecology and Environmental Sciences

1 Introduction

Availability to secure potable water is a fundamental person need and vital to public health (Fadaei et al., 2012; Hasan et al., 2011).

Various risk assessment instruments are presently available and in use like Failure Modes and Effects (Criticality) Analysis (FME(C)A), Critical Control Points (CCP), Hazard Analysis and Critical Control Points (HACCP), Total Quality Management (TQM), Qualitative Microbial Risk Assessment (QMRA), Plan-Do-

Check-Act Water Safety Plan (PDCA-WSP), Technology Enabled Universal Access to Safe Water (TECHNEAU), International Organization for Standardization (ISO) 14001 & 9001, Ecological Risk Assessment & Regional Risk Model, and Catchment Risk Management and Water Safety Plans (WSP)(Dunn et al., 2014).

Failure Modes and Effects (Criticality) Analysis (FME(C)A) is a systematic process to know potential failure forms (causes and effects) according to experience with like techniques. Critical Control Points (CCP) (extensively applied in production industries) is a point, phase or method (i.e. a crucial defeat area) that can be recognized in a system. Hazard Analysis and Critical Control Points (HACCP) (Derived from FMEA) is a preventive risk management system in which a point, step or technique (i.e. a crucial defeat area) can be recognized in a system to which amendatory achievements can be used so that a potential hazard can be prohibited, removed, or decrease to an admissible value. Also contains confirmation actions to ensure that the plan is satisfactory (Dunn et al., 2014).

Total Quality Management (TQM) is a comprehensive, confederated management plan whereby all stock holders of an association contribute in protecting and enhancing techniques, products, services. Also explained as an educative invention that breeds a cooperative environment between sectors within an association to amend overall associational quality. Qualitative Microbial Risk Assessment (QMRA) is a systematic quantitative evaluation technique to proximate the risks of human contact to an order of microorganisms that can cause infectious illness epidemics. Merges dose response data for the infectious factor within formation on the release of exposures. International Organization for Standardization (ISO) 14001 & 9001 is an globally identified family of confirmed standards accepted through self-governing assessment. 14001-Environmental Management is a systematic plan to reduce nugatory outcomes, raise operational performance and recognize expenditure savings, under pinned by ongoing improvement. 9001-Quality Management is a frame work for an association to concentration on client and product commitments, method efficiency and effectiveness in the systems delivery with a key concentration on ongoing improvement and aim measurement. Ecological Risk Assessment & Regional Risk Model is a procedure to appraise the potential harmful outcomes of human actions on the ecological health of an ecosystem at a specific place, a clear statement of the environmental level (species, ecological resource, or region kind) that is to be protected, Qualitative Microbial Risk Assessment (QMRA) is a risk analysis of water supply at a catchment-size. Investigation of a regiment of possible catchment of hazard events, affected by natural or human parameters like wild animals erosion, land use, industry, transport, and recreational actions, technology enabled worldwide access to safe water (TECHNEAU) was conducted in order to confront with current and future problems, water supply chains, this technique will enable consumers to make aware options, suitable to their own conditions and limitation (Dunn et al., 2014). The Plan-Do-Check-Act (PDCA)-WSP approach is suggested, determinated from WSP advices and the fundamentals of PDCA for ongoing execution enhancement (Bereskie et al., 2017). Water Safety Plan (WSP) is the comprehensive risk assessment and management plan to recognize and prioritize potential menaces to water quality, a teach step in a specific system's water supply chain (from catchment to consumer) execution best practices to extenuate threats to potable water, derived from HACCP and the multi-barrier approach and limitations of this method are: first focus is on protecting human well-being; low concentration on integrating financial factors. To decrease the risk of potable water pollution and enhance water safety management from source to tap (Kayser et al., 2019), the Water Safety Plan (WSP) approach to manage potable water supplies, through systematic and proactive risk assessment and risk management, has been collecting step since 2004, when the World Health Organization (WHO) prepared guideline for their development and accomplishment in the Guidelines for Drinking Water Quality (Herschan et al., 2020; WHO. et al., 2004). WSPs were presented in 1994. The primary countries executing WSPs in water treatment companies were Iceland in 1997 and Australia in 1999. Since then, various under-developed and developed countries have performed WSPs in the processing of potable water worldwide (Tsitsifli and Tsoukalas, 2021).

These plans have three major constituents: recognize control measures to decrease or remove hazards; monitoring operational to confidence that obstacles in the water system are functioning successfully and effectively; and extend management plans for system defects or hazardous incidents (Edition, 2011; Fadaei and Sadeghi, 2014).

WSPs normally contain five stages and phases: preparation, system evaluation, monitoring, management and communication, and feedback and enhancement (Kayser et al., 2019). The major stages of this program are summarized in Fig. 1.

This plan was then used in countries such as France, Netherlands, Bangladesh, Spain, China, Cuba, Morocco, USA, Germany, Italy, Sweden, and Iran (Kayser et al., 2019; Shafiei et al., 2017).

In the conventional technique, sampling and analysis of findings is time using and always reports past water quality. Thus, it is not able to identify the incidence of events and hazardous in the water supply system and cannot decrease the following outcomes. This study is a review of WSP studies carried out in several countries. Based on the aforementioned subjects, the main aim of this study is to investigate the benefits and difficulties of the Water Safety Plan in the quality management of potable water in different countries.

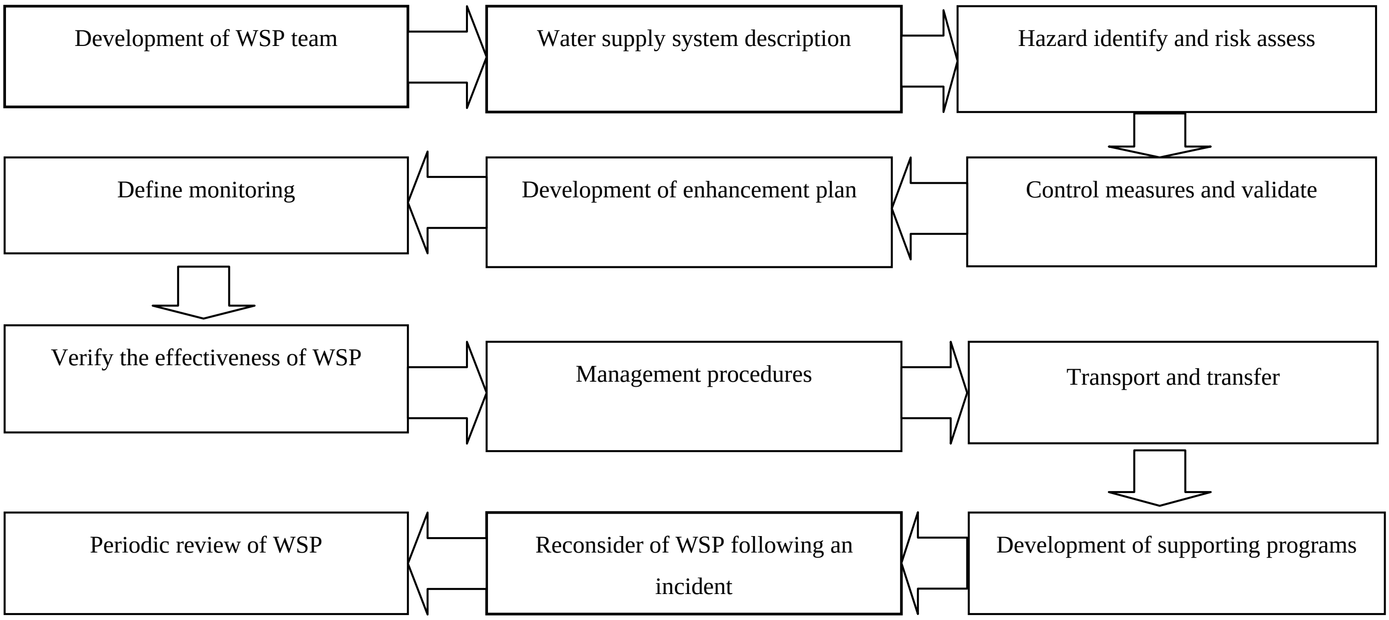

Fig. 1 Methodological steps for developing WSP for water (Bartram, 2009).

2 Methods

The review has mainly classified these methods with the methods. Databases like Google Scholar, Science Direct, and Web of Science are employed to retrieve several papers on the issue. Keywords like “water safety plan”, “risk assessment”, “water quality”, “drinking water”, “water treatment,” “hazard analysis and critical control points”, “risk management”, and “ground water” are added to the methods aforementioned resuming suitable papers. After a whole search and remove papers with no direct relationship with WSP, a total of 53 original articles are primarily contained in the context of the review. This excludes different review articles preparation a perception of various risk assessment. The incidence of hazards and hazardous incidents along the complete water supply system: in the catchments, the water sources, the groundwater systems, the storage reservoirs and intakes, the treatment units, and the distribution networks. Generally, drinking water hazards could be arranged into four major groups: biological, chemical, physical, and radiological. Information on the type of site, type of water systems, country, province/urban/rural, risk management tool, WSP impact evaluation method, hazard and hazardous event, hazard type, risk ranking, benefits, and references were collected. Countries investigated in this study were selected based on information available related to WSP and case study. The most limitation of current study is not available of case study of WSP implementation in all of the countries.

3 Results and Discussion

Water Safety Plan in this study includes water supplying system presented in ten countries. Hazardous detection and water safety risk assessment are carried out on the water coming from catchment, water reservoir, pipe, water treatment, distribution, and plumbing in ten countries.

The main findings are presented in Table 1. Out of 20 articles were studied in this systematic review. These articles were from France (1), Palestine (1), China (2), USA (2), Indonesia (2), Syria (2), Iceland (2), Italy (3), Uganda (2), and Iran (3). Based on the findings obtained in Table 1, out of 20 selected articles, 19 had performed WSP, 1 had implemented risk management, and 1 had executed risk assessment. The stated WSP researches have been implemented on surface and groundwater systems, which contain a total of 20 water supply systems, 10 ground water supply systems, 2 surface water supply systems and 8 both sources (ground and surface waters). More studies have been carried out in urban regions and only five cases are dedicated to rural regions. In a Water Safety Plan, risk refers to all the potential biological, physical, chemical, and radiological hazards that may be related with water supply or quality. In this study, 2, 4, 7, and 7 were water supply with chemical, biological, chemical and microbiological, physical, and chemical risk, respectively. In Table1, risk parameters and risk events are categorized as low and very high risk.

3.1 Italy

Studies have been conducted in 3 areas of the Italy (Mortara, Salento peninsula, and Salento). This approach is going to decrease public well-being risk, ensure a better compliance of water quality factors with regulatory commitments, increase assurance of users and urban authorities, and enhance resource management due to intervention planning. In addition, some new control measures are suggested by the WSP team within this work (Sorlini et al., 2017). In a case study in Italy, findings indicated that the major of hazard and hazardous event include inadequate input water quality, problem of disinfection by UV-lamp, water not appropriate for the intended use, while advantages of WSP plan included monthly bacteriological, chemical, and physical monitoring, installation of UV lamps, and education on good practices for the disinfection (Serio et al., 2021).

3.2 China

The major hazard and hazardous event include disposal of agricultural fertilization and animal defecation around water source, no effective for monitoring methods for disinfectant, no emergency program for staff responsibilities and job, feeble infrastructure and weak external support, lack of adequate motivation and consideration to risk management, and failure of efficient technical guideline.

This plan has capable improvement water quality, satisfaction percentages of certain factors like bacteriological index factors, nitrite nitrogen, free chlorine were efficiently enhanced, comprehensive understanding of the WSP procedures, helpful for emergency management of water services, personnel training, equipment management, increase satisfaction customers, reducing the incidence of water related diseases, and improving well-being (Li et al., 2020; Ye et al., 2015).

3.3 France

The major hazard and hazardous event include lack of the amount of staff time taken for WSP implementation, low free residual chorine. Operational strengths particular to the place under survey were such as: enhance control of production and distribution systems (due to critical control point alarms), increase of awareness, perception, and involvement of personnel; enhance of data entering and traceability of events; increase of consumers satisfaction related to water quality (Setty et al., 2018).

Another study reported that the main advantages from WSP implementation, stated by WSP groups, were improved hazard controls, enhancements in treatment methods, enhanced water safety, and enhanced user and wellbeing official assurance in the water supplier (Kayser et al., 2019).

3.4 Iceland

The major hazard and hazardous event include increase of catchment noncompliance of parameters, problem of disinfection, old infrastructure and failure amendment are problems, information on the condition and water quality of village water supplies is inaccessible. The chemical quality of potable water is commonly good in Iceland with only a few events of inconsistency with regulations, while the strengths of this approach include preparation of education plan for personnel on WSP and change in attitude by the staff, safe protection of the water resource, safe usual external verification and care of WSP (Gunnarsdottir et al., 2017).

3.5 Syria

The major hazard and hazardous event include incidence of diarrheal disease in children, low free chlorine residual in use point potable water, lack of training water officers, while the strengths of this approach include improving water quality and regulation, risk management interventions were prosperous in ensuring free chlorine residual in potable water with installation chlorinators in water supply (Sikder et al., 2018a, b).

3.6 Palestine

The major hazardous events include pipeline leakage, high total dissolved solids, disposal of feces human, livestock, or birds on the ground near of the borehole, inadequate disinfection, fluctuation chlorine, presence of garbage and refuse in water storage reservoir, excessive use of pesticides and fertilizers, growth of the bacteria (biofilm) inside of potable water storage reservoirs, Bacteriological contamination (total coliform bacteria), incidence of acute diarrhea among children under five while the strengths of this approach include attempts and usage of more control measures to decrease the risk of hazardous events (Abuzerr et al., 2020a; Abuzerr et al., 2020b). Another study reported that occurrence of total coliforms, fecal coliforms, and other pathogens like *E. coli*, *streptococcus*, and *pseudomonas* have been found out in the Gaza's water supply chain from source to tap (Abuzerr et al., 2019).

3.7 Indonesia

Researches have been carried out in 2 areas of the Indonesia (Bandarhar, and Semarang). The major hazard and hazardous event include animals execration around water source (bacterial contamination), low free chlorine residual in drinking water, flow meter was submerged, deposit in pipes, cross connection, deficiency in distribution pipe. The result indicated that both, distribution, and final point of use levels have very high risk of pollution, whilst the strengths of this approach include increase of people's awareness of WSP, flushing in distribution system for removing deposits, improving water quality and regulation (Budiyono et al., 2019; Budiyono et al., 2015). The microbiological quality of water supply system in Indonesia (Bandarharjo village) increased 17.5% after execution of WSPs plan. The execution of WSPs plan is able to enhance the quality of potable water and can be replicated (Budiyono et al., 2019).

3. 8 Uganda

Studies have been conducted in 2 areas of the Uganda (Uganda, Kampala). The major hazard and hazardous event include inadequate WSP documentation and implementation, poor water quality and unhygienic conditions, inadequate human resources and staff training, microbial contamination, while the strengths of this approach include WSPs were risk mitigation tool, and cost-effective venture for water suppliers, management requirement, public health accountability, availability of facilities laboratories, enhanced reporting culture and financial availability for WSP (Howard et al., 2005; Kanyesigye et al., 2019; Mudau et al., 2017).

3.9 USA

The most barriers to implement WSP in North Carolina were inadequate staff time, and lack of budgets. Benefits of WSP implementation include increased association of information and communication, decreased operations and maintenance costs, and enhanced risk management (Amjad et al., 2016). Another study in USA showed that WSP implementation causes improvement of water quality, increase of regulatory agreement, improvement of the management of water systems, reduction of waterborne disease, reduction of costs system, and improvement of public health (Baum et al., 2015).

In a study in US by Setty and co-workers demonstrated that again consideration to risk management may be the best practice to help avoid unforeseen pollution and hazardous events, and it can be outcomes on the economy and health (Setty et al., 2019).

3.10 Iran

Studies have been carried out in 3 areas of the Iran (Bukan, Hamadan, Birjind). According to the results of the studies, the most problems include non-perform of WSP in all cities and villages of Iran, release of wastewater and solid waste into the catchment area by village people, lack of awareness of staff and people related to WSP, occurrence of biological pollution and raise in turbidity and chemicals due to reconstruction and restoration of distribution system, occurrence of physical, chemical and biological pollution from direct injection of wells into surface waters, economic challenges and inadequate finance to continue, lack of attention of the policy makers and decision makers to the WSP implementation at the cities and villages, the program feasibility to upgrade the water supply system of cities and villages, ineffectiveness of the conventional plan in cities and villages, increase of consumers satisfaction, decrease of water-borne diseases, increase of people satisfaction, the best approach for ensuring safety in potable water supply, coverage of the WSP from the source to tap, development and execution of WSPs for ground and surface waters resources in the other cities of Iran (Hoshyari et al., 2019; Kishipour et al., 2021; Masroor et al., 2020; Taie et al., 2021).

3.11 Barriers and benefits of WSP implementation in other countries

A study by Mälzer and co-workers indicated that in Germany, the major hazardous event include leakage of oil, fuel, solvents, chlorinated hydrocarbons, lubricants, and pesticides in the water resources and catchment, whilst advantages of WSP perform include enhancing ranked based on the risk of the hazard, improved and communicated within the personnel (Mälzer et al., 2010).

A study by Schmiege and co-workers demonstrated that the execution of the WSP is a road map in Germany, the major benefits include improvement of documentation, identification of limitations within the system or promoted knowledge of tasks (Schmiege et al., 2020).

Other study reported that Vietnam reported the advantages of WSP implementation for 12 years, such as enhancing water quality, raising consumer approval, reducing waterborne illness, and has ensured continued water supply (Lee et al., 2017). A study by van den Berg and colleagues demonstrated that in Netherlands applied combination of risk assessment and risk management plans even before the WSP plan was expanded, the outcomes of these approaches provide information hazards and hazardous events from catchment to consumption (Van Den Berg et al., 2019). Other study in Ethiopia showed that there was inadequate chlorination in the treatment unit. All water samples from both the catchments and consumers were polluted by total coliforms and faecal coliforms (Duressa et al., 2019). A study by Bereskie and co-workers revealed that apply Strengths-Weaknesses-Opportunities-Threats and Plan-Do-Check-Act WSP approaches a safe potable water supply in Canada. This approach prepares an universal option to the present potable water management (Bereskie et al., 2017).

A study in East Africa reported that WSPs have the potential to improve standards and reduce water-quality events and this was the biggest motivating factor, while the major barriers include insufficient laboratory facilities, funds, documentation, control of resource protection, manpower, priority of schematization, and training (Parker and Summerill, 2013). A review study reported that outcomes of WSP program in the short term such as alterations in organizational frame or diurnal methods within a water supply , awareness among water operators and the most barriers include high operator rotation, weak documentation, and a history of ad hoc mends can make the assessment a problem, insufficient of information within a specific water supply, and increase in spending requirements (Kot et al., 2015). Another study reported that WSP was implemented with a considerable decrease of heterotrophic plate counts (HPC) and incidence of diarrhea (Gunnarsdottir et al., 2012). One study reported that there are many problems related with developing and implementing WSP like requirement of practical awareness, governance, and cooperation (Roeger and Tavares, 2018). A study by Roeger and Tavares in Portugal illustrated that execution of WSP has led to efficient preventive methods of risk assessment, increases in consent with water quality legislations, and enhanced wellbeing (Roeger and Tavares, 2018). A study reported that the most benefits to implement WSP in Asia-Pacific Region (i.e. Philippines, Mongolia, Sri Lanka, Bangladesh, Cambodia, Cook Islands, Lao PDR, Nepal, Samoa, Timor-Leste, and Vanuatu) include improvement in infrastructure, operation and management, stakeholder communication and relation, monitoring of consumer satisfaction, and water quality examination (Kumpel et al., 2018). A review reported that the execution condition of HACCP and WSPs in European and non-European nations, recognizing their advantages and obstacles in their favored execution the most important and main advantage resulting from the implementations include enhance the quality and safety of potable water, improvement operational efficiency, increase satisfaction consumers, and reduced costs of system, while the obstacles for the favored execution of HACCP and WSPs are recorded as insufficient maintenance of equipment, the cross-contamination from wastewater treatment plants, the defect personnel skill, and the defect economic resources (Tsitsifli and Tsoukalas, 2021). A study by String and co-workers demonstrated that for the implementation WSPs in Congo, Fiji, Vanuatu, and India, the most important barriers resulting from the implementations include unfinished WSP implementations, lack of documentation microbiological water quality, and no financial and technical resource support (String et al., 2020). A study in six urban areas of Nigeria reported that the most problem include consumption of doubtful water quality, and incidence of water borne diseases (Ezenwaji and Phil-Eze, 2014). A study stated that WSPs mixture art and science, integrating the need for special audience translation, marketing, and support with awareness of technical advances, research techniques, and best practices origin from around the world (Setty and Ferrero, 2021). One study recognized a number of strengths of the WSP, like its naivety and ease of apply. Problems were also recognized, like potential for non-compliances in understanding of risk between controllers, in interpreting queries, and defect pursue achievement (Pond et al., 2020).

Table 1 Most important characteristics of reviewed articles.

Site	Type of water systems	Country	Province/Urban/Rural	Risk management tool	WSP impact evaluation method	Hazard and hazardous event	Hazard types	Risk rating	Benefits	Ref
Reservoir, pipe, distribution, and	Surface water (River)	Indonesia	Rural (Batang Regency)	WSP	Water quality test	Discharge of animal waste and domestic waste in	Biological	Very high	Improvement of chlorination, reservoir draining,	(Subagiyo et al., 2021)

plumbing						water source			and training	
Resource, distribution, and final point of use	Groundwater	Indonesia	Semarang	WSP	Water quality test	Animals execration around water Source, deficiency in distribution pipe	Biological	Low to very high	Regular drainage, disinfection at source system	(Budiyono et al., 2015)
Catchment, household	Ground water (well)	Palestine	Gaza Strip	WSP	Water quality test	High TDS, insufficient of chlorination presence of garbage and refuse in water	Biological, chemical, physical	Low to very high	Attempts and use of measures to decrease the risk of hazard incidents	(Abuzerr et al., 2020b)
Whole Water supply system	Ground water and surface water	US	-	WSP	Water quality test, checklist	High turbidity, microbiological contamination	Biological, chemical, physical	-	Decrease in the incidence of water borne disease	(Baum et al., 2015)
Whole Water supply system	Ground water and surface water	US	North Carolina	WSP	Checklist	inadequate staff time	Biological, chemical, physical	-	Improvement water quality	(Amjad et al., 2016)
Treatment facilities, storage tanks	groundwater and shallow groundwater	France	Southwestern France	WSP	Water quality test	Fluctuation range of free chlorine levels at distribution network	Chemical	-	Decrease in customer complaints, reduced duration of low-chlorine events	(Setty et al., 2018)
Well ,distribution network	groundwater	Iceland	-	WSP	Water quality test	Diarrheal incidence, increase Catchment noncompliance of parameters	Biological	-	Reduction quantity of HPC in water and incidence of diarrhea in society	(Gunnarsdottir et al., 2012)
Water intakes, treatment facilities	Groundwater and surface water	Iceland	-	WSP	Available data- checklist	Problem of disinfection, diarrheal incidence, increase	Biological, chemical	-	Reduction in the incidence of diarrhea and *E. coli*, increased maintenance of the system	(Gunnarsdottir et al., 2015)
Catchment, distribution network	Groundwater	Italy	Mortara	WSP	Available data- checklist	Presence of pollutants like ammonia, manganese, iron and, some when, arsenic	Biological, chemical, physical	Low to very high	Increased the assurance of users and enhanced resource management	(Sorlini et al., 2017)
Catchment	Groundwater(well)	Italy	Southern Italy (Salento peninsula)	Risk Assessment	Available data- checklist	Anthropogenic and natural activities	Biological, chemical	Score: 7-179.2	Improvement of water quality	(De Filippis et al., 2020)

Treatment, Disinfection	Groundwater(well)	Italy	Southern Italy (Salento)	WSP	Water quality test	Accidental contamination, insufficient input water quality	Chemical biological physical	Low to high	Increase quality of water	(Serio et al., 2021)
Water source, Water treatment process	Groundwater	China	Beijing (Rural)	WSP	Water quality test	Animals execration around water source, problems in disinfection	Biological, chemical	Medium to very high	Improvement of water quality, high customer satisfaction	(Ye et al., 2015)
Resource to end user	Groundwater and surface water	China	18 Provinces (Rural and city)	WSP	Water quality test	Failure in the water treatment process	Chemical biological, physical	Low to very high	Improvement microbiological contamination	(Li et al., 2020)
Water resources, and distribution systems	Groundwater (Well)	Iran	Azerbaijan (Bukan)	WSP	Checklist-water quality test	-	Chemical biological physical	Moderate level	Improvement of water quality	(Masroor et al., 2020)
Resource, treatment, distribution, and final point of use	Groundwater (Well)	Iran	Birjand	WSP	Checklist	-	Chemical biological	Moderate level	Increase qualitative management to the WSP	(Eslami et al., 2018)
Resource, treatment, distribution, and final point of use	Groundwater and surface water	Iran	Hamadan	WSP	Water quality test	Discharge wastewater and fertilizer in catchment	Chemical biological physical	Medium to very high	Construction treatment plant, appropriate chlorination	(Hoshyari et al., 2019)
Point of use	Ground water	Syria	Southern Syria	WSP	Water quality test- checklist	Incidence of diarrheal disease in children	Chemical, biological		Improving water quality and regulation	**(**Sikder et al., 2018b)
Point of use	Ground water	Syria	Southern Syria	Risk management	Checklist	Low free chlorine residual in potable water	Chemical	-	Risk management were prosperous in confirming free chlorine residual in end user potable water	(Sikder et al., 2018b)
Point of use	Groundwater and surface water	Uganda	Uganda	WSP	Checklist	Insufficient human resources and staff training	Chemical, biological	-	WSP development and expansion	(Kanyesigye et al., 2019)

Distribution system	Surface water	Uganda	Uganda (Kampala)	WSP	Checklist	Discharge of birds waste enter drinking water, microbial contamination	Biological	Medium to very high	Enhancing water safety management	(Howard et al., 2005)

4 Conclusions

The present article reviews the execution condition of WSPs in several countries, recognizing their strengths and barriers in their prosperous execution.

Potable water supply systems are exposure to many hazards (biological, chemical, physical, radiological) owing to their complication.

The objective of the WSP is to confirm the quality of potable water according to risk management, which corroborates the debarment from pollution of potable water resources, water treatment for reducing or eliminating pollution to attain standards, prevention of water secondary pollution during storage, distribution, and end of user considering the effects of the WSP on the quality of water from source to tap. The execution of this program as the most efficient instrument for confirming safety in the supply of potable water is suggested to water supplier organizations. The most important benefits resulting from WSP implementation is to improve the quality and safety of potable water, while lack of manpower training and financial resources is the most important barriers. In general, indicators of successful implementation of WSP approach include outcome indicators (i.e. policy, operational, financial, institutional, and climate) and impact indicators (i.e. water supply, and health). Future study should concentrate on extracting the causal parameters that improve prosperous application of the WSP program, and on recognizing best practices. Such information can be used to enhance exclusive utilities' of WSP implementation practices and treat world WSP guidance. These results propose a need for further institutionalization of WSPs with enhanced coordination across stakeholders.

Acknowledgements

The author would like to appreciate Shahrekord University of Medical Sciences. The author declares that no funding sources or grants were attributed to this work.

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