ReWater MENA Project

MORE AND SAFER WATER REUSE IN THE MIDDLE EAST AND NORTH AFRICA

Training Handbook
Governance and Reuse Safety Plans

GOVERNANCE & REUSE SATEFY PLANS

IWMI International Water Management Institute · CGIAR · Research Program on Water, Land and Ecosystems · الجمعية العربية لمرافق المياه Arab Countries Water Utilities Association ACWUA · Sweden Sverige

This training material is developed by the Arab Countries Water Utilities Association (ACWUA), in collaboration with the International Water Management Institute (IWMI), under ReWater MENA, a project lead by IWMI and sponsored by Sida. It contains four training modules, covering a range of topics related to reuse of treated wastewater, with a focus on the MENA region.

The main content of the four training modules is provided and reviewed by leading experts in each field as follows:

• **Module 1: Assessing the Economic Feasibility for Integrated Wastewater Reuse (WWR) Projects: From Formulation to Reporting (ECON-WWR):**
Developed by: Dr. M. Ragy Darwish, Economic Expert and TOT.
Reviewed by: Solomie Gebrezgabher, Researcher- Economics, IWMI Ghana Office.
• **Module 2: Governance and Reuse Safety Plans:**
• Developed by: Dr. Maha Halalsheh, Wastewater Treatment Expert.
• Reviewed by: Javier Mateo-Sagasta, Senior Researcher and Coordinator- Water Quality, IWMI Headquarters in Sri Lanka
• **Module 3: Stakeholders' acceptance and gender integration in reuse interventions:**
Developed by: Dr. Noura Abdelwahab, Lead Gender Advisor.
Reviewed by: Everisto Mapedza, Senior Researcher- Social and Institutional Scientist, IWMI Ghana Office
• **Module 4: Water Reuse Technologies:**
Developed by: Dr. Mohammad Duqqa, Wastewater reuse Expert.
Reviewed by: Javier Mateo-Sagasta, Senior Researcher and Coordinator- Water Quality, IWMI Headquarters in Sri Lanka

A general review of the training modules was provided by Dr. Amgad Elmahdi, Head of IWMI MENA Office in Cairo and Eng. Khaldon Khashman, Secretary General, Arab Countries Utilities Association (ACWUA).

The Arabic translation of the training modules was provided by the experts who developed each training module, and was reviewed by Eng. Yasmeen Khashman, the Arab Countries Water Utilities Association (ACWUA) in Jordan, Dr. Mohamed Dawoud, Advisor at Water Resources, Environment Agency in Abu Dhabi and Dr. Nisreen Lahham, the Project Manager of ReWater MENA project at IWMI MENA Office in Cairo.

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Governance and Reuse Sanitation Safety Plans
Learning Objectives and Outcomes

The main objective of this training is to enable the participants to:

- Stimulate policy dialogue between relevant stakeholders in order to optimize governance system related to wastewater reuse.
- Identify the different disciplines needed to prepare sanitation and reuse safety plans (i.e. how to assemble safety plans team).
- Be familiar with key available tools to prepare sanitation and reuse safety plans.
- Prepare a reuse/sanitation safety plan for a defined area.

Module 1: Introduction

The MENA region is facing major challenges due to scarcity of its renewable water resources and increased population growth rate, be it natural or otherwise, and including urbanization and industrial development needs. Coupled with the fragile arid environment and its low resilience in the face of different activities, decision makers are left with major responsibilities to achieve safe and dependable water and food supplies in the future. Fresh water scarcity means greater risks for a community's ability to grow and create jobs (AFED, 2014). On the other hand, the current regional political unrest combined with increased stress on economy exert serious threats to sustainable development. Two governing priority themes, namely water-energy-food nexus, and peace-security-environment were accordingly defined (GEO-6, the West Asia region). However, such priorities should not be examined in isolation from social, economic and institutional priorities, if the scope of the impact of the suggested solutions is called to have long and lasting effects.

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Climate change will also threaten water and food security in the region due to the projected decrease in available fresh water resources for agricultural and food production (Almazroui, 2012). Climate scenarios project changes in the region's temperature, rainfall and sea level, which will have impacts on both availability and use of water resources (Sipkin, 2012). The climate risk index study classified countries in different parts of the world according to their exposure to climate change risks (Abdel Hamid, 2009) and reported that Iraq was the fifth most vulnerable country in the world to decreased water and food availability, extreme temperatures conditions and associated health problems. Recent droughts had aggravated water crisis in Iraq and many studies warn that Tigris and Euphrates might dry up by 2040 (Rowling, 2014). Other countries in the region were rated as highly vulnerable, according to climate change risk index, while Yemen was rated as extremely vulnerable. Climate change impacts will lead not only to a reduction in the quantity of water resources, but also will have an impact on water quality, which is expected to deteriorate by the increased variability and frequency of extreme climatic events (Glass, 2010). It is therefore necessary to prepare for, and respond appropriately to the potential negative impacts of climate change.

On the demand side, a reduced per capita water share was observed in many countries of the region as a main result of the recent increase in the cross-border influx of refugees. The political unrest has arisen in several countries including Iraq, Syria and Yemen, which resulted in a direct impact on water supply and sanitation services. Overexploitation of groundwater resources throughout the MENA region was observed and had resulted in deterioration of water quality, seawater intrusion, depletion and salinization of aquifers, and rising pumping costs. Depletion of non-renewable groundwater has been, moreover, observed with the expansion of agriculture. An increase of about 82% in the region's total blue water withdrawals for agriculture and domestic use was noticed and reached a total of around 153 billion cubic meters per year in 2012. In almost all countries, the agricultural sector is by far the biggest consumer of water resources (Abuzeid, 2014) leaving little amounts for domestic and industrial sectors. All aforementioned challenges at regional level called for urgent responses in order to reduce the gap between water supply and water demand.

2.1 Integrated water resources management and water reallocation

A main response to water scarcity and climate change makes best use of water resources through 'integrated water resources management'. Integrated water resources management (IWRM) strategies include coordinating land and water resources management, recognizing water quantity and water quality linkages, improving techniques to manage demand and conserve water and learning through adaptive management experiments. In this regard, reallocating water towards domestic and industrial sectors -rather than agricultural- may be a critical and controversial way to adjust to water scarcity and enhance water availability. Although sector water reallocation may not have been announced as policies in many countries, the highest priority given to domestic water use have resulted in water reallocation from the agricultural sector (CEDARE et al., 2014). For instance, Iraq, Jordan and Qatar have witnessed significant sector water reallocation. The trend of reallocating fresh water for domestic use and allocating non-conventional water, such as domestic and agricultural wastewaters to agriculture is likely to be part of future water management in the whole region (Abuzeid, 2014). Potential non-conventional water resources in the region are estimated at 1.27 billion cubic meters of treated wastewater (6%), 16.68 billion cubic meters of agricultural drainage water (79%) and 3.06 billion cubic meters of desalinated water (15%) (CEDARE, 2014). Obviously, wastewater is the "renewable water resource" of the future for agricultural expansion (Abuzeid, 2014).

2.2 Wastewater as a resource

Wastewater is brought to front scene in integrated water resources management mainly due to the fact that it is the only water resource expected to increase in the future. Despite the crucial role of wastewater as a non-conventional water source in agricultural production, many challenges still exist regarding its valorization. Current challenges regarding wastewater valorization in agriculture can be grouped into three main themes. Firstly, challenges related to the demanded increase in wastewater collection and treatment and the associated lack of economically feasible services available particularly for rural areas as shown in Table (1) For instance, the percentage of rural communities served with sewerage network does not exceed 50% in the majority of Middle Eastern Countries. The lack of such services presents a real barrier against the full utilization of produced wastewater. The unaffordable investment costs related to conventional wastewater management systems hindered -in many cases- the expansion of sanitation services. Secondly, challenges related to demanded enabling environment such as limited governmental support, absence of legal framework and related institutional arrangements, poor financial arrangements, limited skills and capacities of actors involved in wastewater valorization for agricultural purposes, and lack of socio-cultural acceptance. Thirdly, the long-lasting paradigm of wastewater management that insists to handle wastewater treatment in silo and regardless of upstream and downstream activities. Conventional sewerage network and large-scale wastewater treatment plants are so far the dominant paradigm relying on end-of-pipe technologies. This paradigm was based on the hypothesis that safe use of wastewater can be achieved when treatment plants are optimally capable of producing pathogens' free effluent, and accordingly would minimize risks associated with irrigation water. However, there are two main drawbacks in such approach; Firstly, only 20% of the globally collected wastewater receives treatment (WWAP, 2017), and hence, raw wastewater is being used without regulatory frame, be it for irrigation or otherwise. Secondly, there is evidence for pathogenic contamination of effluent downstream of WWTPs despite the fact that effluents were properly disinfected (Halalsheh et al., 2018).

Notwithstanding that the conventional paradigm, which relies on conventional wastewater management scheme is no option for scattered communities and rapidly expanded per-urban areas in the region, it should be noted that utilizing fresh water to flush excreta is not the zenith of scientific achievements. This historical practice was re-initiated more than 150 years ago when very little was known about water physics and chemistry and when applied microbiology was not discovered. Minimizing fatal diseases breakouts in the nineteenth century was the main concern, and hence, the practice was to ship wastewater as far as possible away from communities by utilizing the existing Roman sewer networks in major European cities. This paradigm became dominant with time resulting in complete division between citizens-consumers at one-hand and service providers at the other hand. However, the financial burden associated with this paradigm had restricted propagation of service provision, not only at regional level (see Table 1), but also at global level. Apparently, wastewater shipping is not necessarily what would be done today if countries had the chance to start again. Current advances in wastewater sciences coupled with some other factors like limited resources and energy costs would encourage adoption of alternative wastewater management schemes. One alternative is to link sanitation management to cities' economic development (Kone, 2010) through resource conservation and recovery since it deals with waste as a resource that has to be utilized. Obviously, this alternative requires high level of community (the beneficiaries) involvement, technical feasibility, economic feasibility and legal and institutional arrangements.

Table 1. Wastewater collection and treatment in Middle East Countries (Moghaddam et al., 2017)

Country	Wastewater collection systems facilities (%)		Ratio of TWW to collected WW
	Urban	Rural	
Algeria	78-85	65	73
Bahrain	70-77	No available inf.	100
Egypt	68	42	79
Iran	17-20	11	4
Iraq	No available inf.	No available inf.	No available inf.
Jordan	70	50	88
Kuwait	No available inf.	85	87
Lebanon	No available inf.	40	2
Libya	54	54	7
Morocco	70	40	6-8
Palestine	25	23	34-54
Oman	90	81	13
Qatar	No available inf.	80	No available inf.
Saudi Arabia	45	37	75
Syria	96	71	57-67
Tunisia	68	50	79
UAE	91	87	22
Yemen	40	12	62

In any case, and despite the substantial benefits of the suggested alternative, it is still far beyond implementation due to many reasons including the discouraging institutional environment and lack of enforcement. Particularly in small scale management schemes, challenges are manifold and can be summarized as follows:
1. High level of coordination and involvement of many different stakeholders is required for the suggested alternative.
2. Low-tech and small-scale wastewater treatment plants or on-site treatment systems are not as noticeable as large-scale conventional systems, which make the latter more appealing to decision makers.
3. Non-conventional sustainable sanitation alternatives would require lenient regulations as compared to conventional systems in order to allow for sustainable business models. Consequently, different institutional arrangements might be required.
Perhaps one of the main bottlenecks related to wastewater management is the institutional fragmentation, which jeopardizes the design and implementation of effective reuse schemes. The fact that a large number of stakeholders have to be involved may cause an overlap of responsibilities and a

lack of coordination. Particularly, lack of coordination between water and agricultural authorities hindered in most cases the implementation of fit-for-purpose water quality and increased unnecessary burden on water authorities to provide high quality water for agricultural production. Moreover, this fragmentation caused also unjustifiable applied stringent standards for treated wastewater use in agriculture as might be shown in the Jordanian case. This is reflected even clearer when it comes to small scale wastewater treatment systems in which the required very high-quality effluent hindered the establishment of a successful business model to run the wastewater treatment plant and the reuse site.

One of the most important foreseen measures that might address both regulatory and institutional bottlenecks related to wastewater, is the recognition of the WHO 2006 guidelines for the safe use of wastewater in agriculture in which wastewater treatment in not seen in isolation from downstream exploitation. This is particularly true due to the fact that treated wastewater might become contaminated downstream due to the presence of different pollution sources including agricultural drainage, dead animals, runoff, etc. Undoubtedly, other non-point pollution sources might even deteriorate quality of treated wastewater after it receives secondary or tertiary treatment. Contamination of agricultural products was observed due to other agricultural inputs and not due to irrigation water quality (Halalsheh et al., 2018). Consequently, controlling one agricultural input will not be, under any mean, sufficient for controlling agricultural produce quality. In fact, effluent disinfection might be useless when non-composted manure is used in agricultural production, and thus investments used to provide a high-quality irrigation water upstream might be lost basically due to uncontrolled downstream processes. Obtained results confirmed the importance of putting WHO 2006 guidelines (JS 1766/2014 in Jordan) effectual by adopting a clear plan that defines responsibilities of each body regarding measures that have to be taken to ensure that safe use requirements are met. It should be noted that Jordan is the only country which adopted WHO guidelines 2006 at national scale.

In WHO 2006 guidelines, there is a clear shift in wastewater management in which many stakeholders should be involved in determining the risks and risks mitigation strategies associated with each agricultural input, but also agricultural practices. The guidelines addressed WWTP effluent quality in conjunction with agricultural inputs and other practices along the food chain as shown in Figure (1) Since produce might become contaminated during handling and marketing, the proposed WHO approach emphasized the importance of controlling all processes before it arrives at the consumer table. Accordingly, and when appropriate control measures are set and monitored, minimal treated and raw wastewater are not excluded from being safely used in agriculture. Albeit the emphasis on pathogenic contamination, other farming practices have an impact on produce quality and should be furthermore considered. For instance, organochlorine pesticides, known as carcinogenic, were shown to accumulate in soil and enter the food chain (Batarseh and Tarawneh, 2013).

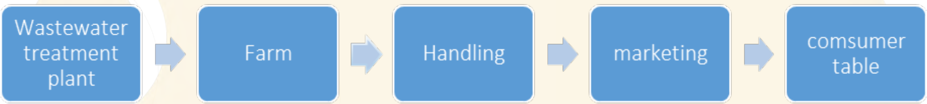

Figure 1: Control measures have to be established along the food chain (WHO, 2006)

As a conclusion, the integral approach proposed by the WHO 2006 guidelines is indeed realistic, however, it cannot be implemented in the absence of detailed management plans that are expected to vary from country to country, as well as within the same country. Of particular interest, and while developing and implementing a plan, emphasis should be given to the role of coordination between different stakeholders. Plans can be established for the whole chain shown in Figure (1), or can be progressively developed according to existing conditions. Moreover, implementation plans shall address acute conditions when wastewater or unprocessed manure is used for agricultural production used for agricultural production (e.g. focus on risk management of microbial hazards); and concurrently shall address additional hazards associated with chemicals (pesticides, pharmaceuticals, and personal care products), which have the risk of producing non-communicable diseases (chronic effects). In any case, the two main objectives of the approach are: firstly, ensuring the public health of human who become in direct contact with the hazard; and secondly ensuring produce safety, hence consumers health safety. To a lesser extent, impact of implementing such approaches on environment may be considered.

Implementation plans, which are named SSPs prioritize risks and utilize limited resources to target highest risk allowing for progressive improvements as presented by the developed manual (WHO SSP manual, 2016). In this context, the following sections aim at describing the steps embedded in sanitation safety planning processes and present the example from Jordan in which a framework for SSP was developed.

3.1 Sanitation Safety Planning (SSP)

SSPs follows almost the same approach used in the development of Water Safety Plans (WSP) as shown in Figure (2) (Davison et al., 2005). However, SSPs are in away more complicated as compared to WSPs and can be best described and presented be the recently WHO developed manual for safe use and disposal of wastewater, greywater and excreta (WHO, 2015). The manual is divided into 6 modules that are described below and comprise: preparatory phase, system description, risk assessment, development and implementation of incremental improvement plan, monitor control measures and performance verification, and lastly development of supporting programs.

Module 1: Preparatory phase

1. Identify SSP priority areas or activities within a certain geographical zone (say catchment area) through a specific steering committee that is formed for the purpose. The steering committee shall comprise stakeholders with combined oversight of sanitation and reuse activities in the selected area. In doing so, the SSP shall focus on issues that pose the greatest health risks and keeping in mind that health risks may vary with time, season or as a result of epidemic. Moreover, selecting priority areas shall consider all wastewater streams with a focus on waste streams with minimal control like wastewaters produced by hospitals, industrial discharges, fecal sludge, or any other activity in which wastewater might be mixed with other wastes like animal waste and agricultural waste. Other factors that might be determinant for priority areas selection include areas with high groundwater vulnerability, vulnerable people, reported sanitation related diseases and areas with informal wastewater use activities.
2. Set the specific objectives of the SSP. The main objective is always the improvement of public health outcomes, while other objectives must be clearly defined. Examples on other objectives might include ensuring that effluent of wastewater treatment plant does not become contaminated with other downstream activities; using bio-solids safely for agricultural production; and improving profitability of agricultural produce by quality assurance system.
3. Define the system boundary and lead organization. The SSP boundary should reflect the specific objectives as defined in point B above. For instance, and for a specific objective of maintaining the quality of produced effluent downstream of treatment plant would necessitate a focus on agricultural activities

in an agricultural downstream area. Consequently, the best lead organization would be the agricultural authorities.

4. Assemble the team. The team shall be selected based on stakeholders' analysis and shall include a mix of health and technical skills so that members are able to define the system, identify hazards and understand how risks can be controlled. After defining stakeholders, the team leader and team members together with their roles shall be defined. Moreover, all required financial resources shall be determined.

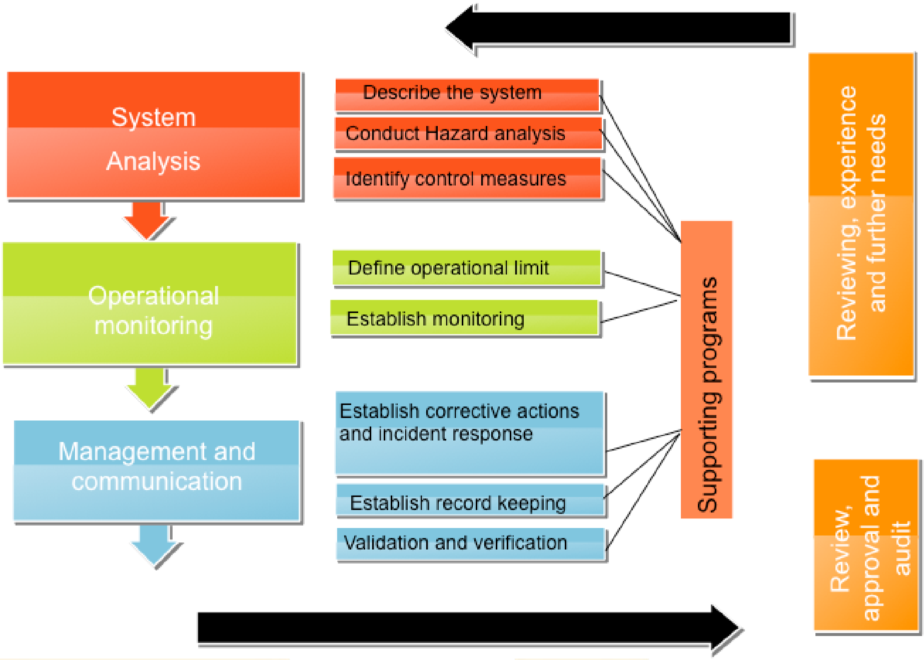

Figure 2: Components of SSPs; Adopted from Halalsheh et al., (2018)

Module 2: System description

System analysis consists of the following sequential steps:

1. **Map the system**, which optimally describes the whole chain within the selected boundaries and can be best represented by flow chart that carefully delineates the system as shown in Figure (3) In case the SSP covers a catchment area, a geographic map might be helpful. Field visits should be conducted as part of the mapping in addition to collecting information on waste streams needed for the SSP.

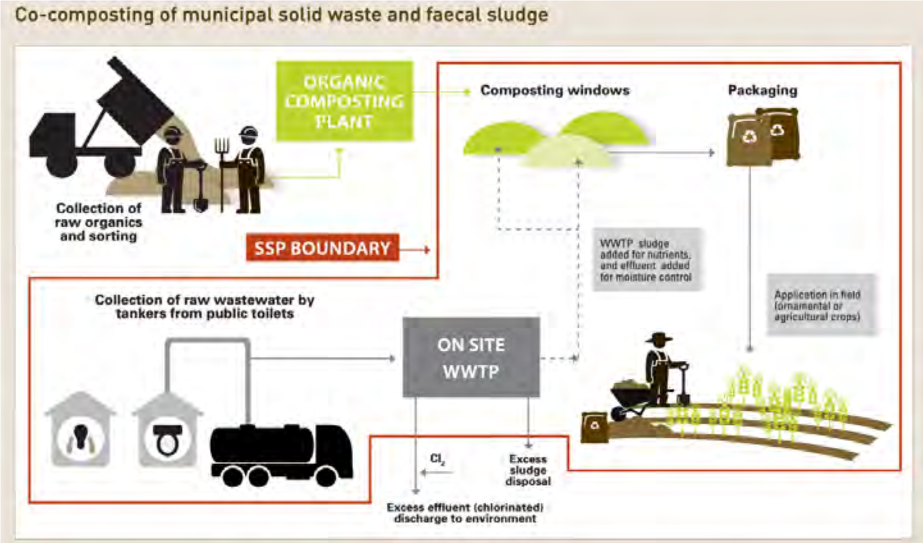

Figure 3: A simplified system mapping (WHO, 2015)

2. **Characterize the waste fraction**. Waste fractions need to be characterized in order to specify the likely associated health hazards. Waste characterization aims to identify all waste streams in the sanitation system within the selected borders. For instance, the term wastewater is broad and describes a mixture of different components like domestic wastewater, excreta, urine, but can also include temporary stormwater overflows or industrial wastewater. It might also include agricultural fertilizers and pesticide runoffs.
3. Identify potential exposure groups. It aims at categorization of people whom might be exposed to a certain hazard. Initial identification and characterization is an integral part of this module and will help in further prioritization for control strategies that will be discussed later in module.
3. An example of exposure group category is shown in Figure (4).

SYMBOL	SHORT NAME	SHORT DESCRIPTION
W	Workers	A person who is responsible for maintaining, cleaning, operating or emptying the sanitation technology.
F	Farmers	A person who is using the products (e.g. untreated, partially or fully treated wastewater, biosolids, faecal sludge).
L	Local community	Anyone who is living near to, or downstream from, the sanitation technology or farm on which the material is used, and may be passively affected.
C	Consumers	Anyone who consumes or uses products (e.g. crops, fish or compost) that are produced using sanitation products.

Figure 4: Exposgroup categories (WHO, 2015)

4. **Gather compliance and contextual information.** It is very important at this stage to collect and summarize all contextual information that would have an impact on the development and implementation of SSP. For instance, enacted quality standards, roles and responsibilities of each authority and stakeholder in order to define how the system will be managed.

5. **Validate the system description.** Once the system map is formed, a validation step is important and might be conducted through field investigations, focus group discussions, interviews, testing programs etc. (WHO, 2015).For instance, evidence of treatment efficiency could be obtained by testing programs and initial process validation data.

Module 3: Identify hazards, assess existing controls, and assess exposure risk
1. **Identify hazards and hazardous events.** All potential hazards and hazardous events are identified in details (biological, chemical, physical, and radiological agents). Hazardous event is the way people are exposed to a hazard in the sanitation system. For instance, farmers are exposed to pathogens (hazard) existing in raw manure during spreading (hazardous event) on agricultural land. Another example is exposure of workers and neighboring community to pathogens in raw wastewater in case of sewers overflow in a rainy season. Hazards identification is an exercise that combines both desk and field work. An example on hazards identification for different waste fractions is shown in Figure (5).

	WASTE COMPONENTS									
	POTENTIAL BIOLOGICAL HAZARDS					POTENTIAL CHEMICAL HAZARDS		POTENTIAL PHYSICAL HAZARDS		
	Viruses	Bacteria	Protozoa	Helminths	Vector-related diseases	Toxic chemicals	Heavy metals	Sharp objects	Inorganic material	Malodours
Liquid waste fractions										
Diluted excreta (human or animal)	□	□	□	□						□
Urine (human or animal)	□	□	□	□						□
Domestic waste water	□	□	□	□	□			□	□	□
Stormwater	□	□	□	□	□	□	□	□		
River water	□	□	□	□	□	□	□			
Industrial wastewater (Note 1)						□	□			
Solid waste fractions										
Faecal sludge	□	□	□	□	□			□	□	□
WWTP sludge	□	□	□	□	□	□	□	□	□	□
Organic domestic waste	□	□			□					
Inorganic domestic waste						□	□	□	□	
Agricultural waste (crop residuals)	□	□	□	□	□			□	□	
Gardening waste					□				□	
Animal manure/slurry	□	□	□	□	□				□	□
Medical waste	□	□	□	□		□	□	□	□	□
Industrial waste						□	□	□	□	□
Slaughter house waste	□	□	□	□	□		□			□
Construction and demolition waste								□	□	

Note 1: The extent of potential hazards associated with industrial wastewater can vary widely. For example, industrial waste hazards may include pathogens and chemicals. See Thompson et al. (2007) to help identify potential chemical contaminants from industries.

Figure 5: Waste fractions and potential health hazards (adopted from WHO, 2015)

2. **Refine exposure groups and exposure routes.** Exposure groups must be described in more details at this stage. Hazardous events might help to identify all groups of people that may become exposed. Key questions that might be used to assist identifying and refining exposure groups and exposure routes are shown in Figure (6) (WHO, 2015). Exposure and transmission routes must also be determined in order to support health risk assessment and consequently identify the required control measures that would minimize exposure to hazards. Common exposure and transmission routes are ingestion after contacting wastewater, dermal contact with fecal sludge, consumption of contaminated agricultural produce, inhalation of aerosols and particles, and vector-borne with flies or mosquitoes. A guidance to common exposure and transmission routes to be considered while developing SSPs is shown in Figure (7) (WHO, 2015).

QUESTION	DESCRIPTION OF QUESTION	EXAMPLE
Exposure group ID	**Give a reference – e.g. W1, C1, L1**	**L1 (Local community group No 1)**
Who are they?	Give a description of who these people are and what they do in relation to exposure. Consideration should be given to vulnerable sub-groups considering age, gender and factors of social exclusion.	ABC village residents and visitors to the stream Female seasonal fruit-picking workers
How many are there?	Give actual numbers, if known, otherwise estimate and give basis of estimate Number of people (individuals) likely to be exposed directly or indirectly.	250 householders (including 90 children) in ABC village
Where are they?	Explain where the exposure occurs within the sanitation system to explain how they might be exposed to hazards.	Recreational use of ABC stream
What they are exposed to?	What contaminant and in what circumstances (e.g. chemical, microbial due to barrier failure, extreme weather etc.).	Microbial contamination when ponds overflow
What is the route of contamination?	Infection route to be considered (e.g. through skin, ingestion of crops, soil or water, intermediate vector).	Dermal contact, ingestion
How often are they exposed to this?	Exposure frequency. Is it every time, daily, weekly or perhaps just once a year? If do not know, have a "guesstimate".	Daily contact during summer months
What dose? See Note	Defines the likely dose of exposure. This depends on the local situation and is sometimes difficult to estimate. The dose will also differ between groups of individuals but an "estimate" is still of value.	Pond water is likely to have: • x *E. coli*/100 ml, and • x Helminth eggs/ litre Assumed inadvertent ingestion is 100 ml

Figure 6: Key questions to assist identifying and refining exposure groups and exposure routes

EXPOSURE AND TRANSMISSION ROUTE	DESCRIPTION
Ingestion after contact with wastewater/ excreta	Transfer of excreta (urine and/or faeces) through direct contact to the mouth from the h ingestion of contaminated soil via contact with hands (e.g. farmers or children).
Ingestion of contaminated groundwater/ surface water	Ingestion of water, drawn from a ground or a surface source, which is contaminated frc unintentional ingestion of recreational waters by swimmers/bathers.
Consumption of contaminated produce (vegetables)	Consumption of plants (e.g. lettuce) that have been grown on land irrigated or fertilized
Dermal contact with excreta and wastewater	Infection where a pathogen (e.g. hookworms) enters through the skin via the feet or oth wastewater, excreta, open defecation, contents of leaking sanitation technologies or dı

Figure 7: Common exposure and transmission routes to consider in SSP

3. **Identify and assess existing control measures.** Control measures are actions or activities that have to be applied to minimize hazards. For instance, at the farm level, terminating irrigation two days before harvesting would result in a significant reduction of pathogens concentration as shown by Halalsheh et al., (2018), and consequently, might be considered as a control measure. For each hazardous event, identify the existing control measures

in place to mitigate the risk of the event. Then determine how effective the existing control measure is at reducing the risk of hazardous event. This might be challenging and needs input of technical studies including WHO (2006) guidelines, which identified log reduction (as a measure of effectiveness) for different control measures. Some examples of control measures can be found in Figure (8) (WHO, 2015). How effective the control measure could be, and how effective the control measure is in practice must be considered when assessing effectiveness of the control measure. The former is usually based on literature and detailed technical assessment and may vary as compared to the actual performance of the control measure.

For illustration, a control measure comprising personal protective equipment is highly dependent on the user behavior. Apparently, validation of control measures shall follow the judgment of the experienced members of the SSP team and shall be reassessed and revisited with time.

TYPE OF CONTROL MEASURE	EXAMPLES
Treatment	• physical settling (e.g. settling tank); • bacterial process (e.g. activated sludge); • adsorption (e.g. in constructed wetlands); • biological inactivation (e.g. composting); • chemical inactivation (e.g. sludge drying (controlled by of pH, temp) and disinfection).
Non-treatment	• crop selection; • irrigation type; • withholding times; • control of intermediate hosts and vectors; • vaccination and preventive chemotherapy.
Non-technical	• use of personal protective equipment; • restricted access to treatment or use sites; • produce disinfection, washing and cooking. Note: Behavioural controls are often in combination with the treatment and non-treatment barriers. Behaviour practices are dependent on individual values and preferences (e.g. fears, phobias, habits), constraints (e.g. cost, time, interest), sense of responsibility, and social-cultural perceptions and practices and can be reinforced with health and hygiene promotion.

Figure 8: Examples for control measures that can be used at some stages of the sanitation chain

4. **Assess and prioritize the exposure risk.** Since hazards analysis will lead to a long list of hazards and hazardous events, a prioritization of such hazards must follow a risk assessment. Different approaches to risk assessment are proposed including descriptive risk assessment which is usually conducted by the SSP team, or semi-quantitative risk assessment using a matrix of likelihood and severity. Other methods including quantitative risk assessment (QMRA) require large number of data and would not be used by most of SSP teams. In the descriptive risk assessment, SSP team classifies hazardous events as high, medium, low or uncertain/unknown depending on the team judgement. Definition of each classification is either specified by the SSP or those given in Figure (9) might be used as presented by WHO (2015). For each selected classification of a hazardous event, it is recommended to record the basis of the decision made in order to act as a reminder on why this particular decision was made at that time. At a later stage and while revisiting the SSP, the team may choose to conduct a semi-quantitative risk assessment.

RISK DESCRIPTOR	NOTES
High priority	It is possible that the event results in injuries, acute and/ or chronic illness or loss of life. Actions need to be taken to minimize the risk.
Medium priority	It is possible that the event results in moderate health effects (e.g. fever, headache, diarrhoea, small injuries) or unease (e.g. noise, malodours). Once the high priority risks are controlled, actions need to be taken to minimize the risk.
Low priority	No health affects anticipated. No action is needed at this time. The risk should be revisited in the future as part of the review process.
Unknown priority	Further data is needed to categorize the risk. Some action should be taken to reduce risk while more data is gathered.

Figure 9: Suggested risk category descriptions for the team-based descriptive risk assessment

Module 4: Develop and implement an incremental improvement plan

1. Consider options to control identified risks. The SSP team shall consider a range of options to control the prioritized hazardous events. The selected control measures are then documented in an improvement plan. The improvement plan can be capital work (expansion of treatment plant, fencing of bio-solids land application site, etc.), operational measure (crop restrictions, allowing irrigation cessation period before harvesting, etc.), behavioral measures (regular medical check-ups, personal protective equipment, etc.), or a combination of the previously mentioned measures. It should be noted that some factors need to be considered during control measures identification including the cost of the suggested measure and its acceptability and monitorability. Noteworthy is that a combination of hazardous events are often most effectively managed through a single control measure in another part of the system. An example of improvement plan options is shown in Figure (10) (WHO, 2015).

Hazard: Helminth eggs

Hazardous event: Exposure to partially treated wastewater in the field by farmers or children (under 15 years) causes helminth infections.

Control measure options and considerations:

1. Wearing shoes or boots can reduce the likelihood of exposure to the hazard. However, because this control measure is often not practical or used by the farmers or children in the field, it cannot be relied upon.
2. Providing some simple wastewater treatment upstream of the irrigation area (e.g. properly sized simple detention pond to reduce the concentration of helminth egg to less than 0.1 egg/litre) can reliably reduce the number of helminth eggs to desirable concentrations (see 2006 WHO Guidelines Vol. 2, 84-86).
3. Regularly providing de-worming medicines to waste handlers (e.g. workers exposed to faecal sludge) can reduce the duration and intensity of infection. In settings where helminth infections are very common, de-worming medicines may also be regularly distributed at community level (e.g. in school children) for reducing prevalence rates.

Figure 10: Improvement plan options for helminth egg control

2. Use selected options to develop an incremental improvement plan. It is necessary to identify the person or agency that is responsible for each proposed action or measure together with the timeframe and estimated financial resources. The template shown in Figure (11) might be used for preparing the incremental improvement plan. The SSP team may select and implement more affordable interim control measures until sufficient fund is secured to apply other measures.

Improvement plan options

Possible control measures for farmers and their families	Comments/discussion	Likely effectiveness of option in reduction of risk of the hazardous event	Reference/validation	Priority for improvement plan
Improved treatment: Full treatment in upgraded Waste Stabilization Ponds to achieve < 1000 *E. Coli*/100 ml and < 1 egg/litre (including maturation pond)	This is an improvement of the existing control measure. Full treatment would be expensive, and seen as unlikely is short to medium term.	High effectiveness (> 4 log reduction).	2006 WHO Guidelines (Vol 2 page 81) and texts on Waste Stabilization Ponds.	Long term.
Partial treatment: Reinstate maturation pond as part of normal process train	This is an improvement of the existing control measure but to a lesser extent than full treatment. No substantial adjustment to existing ponds, just reinstatement of existing maturation pond. Will make substantial reduction to helminth eggs. A further 5 day detention will reduce egg count to 1 / litre. *E. coli* will reduce to 5.8x 10^{3} /100 ml. See Note 1.	High effectiveness for farmer protection. ***E. coli***: Total new log reduction of approx 3.3 (compared with existing of approx. 1.7 log reduction). **Helminth eggs**: will achieve about target of about 1 egg/litre.	Calculation on egg reduction in 2006 WHO Guidelines (Vol 2 page 85) and Waste Stabilization Ponds texts.	Short/medium term.
Crop restriction	Not relevant to farmer protection except when used in conjunction with localized irrigation.	Not applicable for farmer protection, but does provide high protection for consumers of the crops.	2006 WHO Guidelines (Vol 2 page 78).	Not relevant – not proposed for further consideration.
Improved spray irrigation techniques	Use low throw, micro sprinklers, part circle sprinklers.	Low to moderate effectiveness for farmer and local community – approximately, 0.5 log reduction.	2006 WHO Guidelines (Vol 2 page 64 and 77).	Immediate/short term

Figure 11: Example of improvement plan

3. Implement the improvement plan. The SSP team should monitor and report on the implementation status to ensure that the action is taken.

Module 5: Monitor control measures and verify performance

1. Define and implement operational monitoring. Operational monitoring selects monitoring points that can give simple and rapid feedback on the performance of key control measures. Monitoring include simple observations (observations on farm practices, turbidity of wash water at packhouse, etc.). It might also include sampling and testing of irrigation water, applied organic fertilizer, produce quality, etc. Since it will not be practical to monitor all control measures, it is advisable to select the most critical monitoring points based on the control measures of the highest risks. Many aspects need to be identified at this point like monitoring method, monitoring frequency, monitoring agency or individual, a critical limit, and the action that should be taken when the critical limit is exceeded. It is essential to define limits that lead to the safe agricultural use of wastewater and to the safe agricultural use in general. Operational limits don't necessarily mean concentration of hazard as mentioned earlier, but rather a gauge of control measure performance that can explain the objective of monitoring. For instance, setting the maximum allowable water storage time at farm level might be considered as operational limit. On the other hand, monitoring is required to control measures in timely manner and records of all monitoring shall be maintained. A template for operational monitoring is suggested and shown in Figure (12) (WHO, 2015).

OPERATIONAL MONITORING PLAN IN COMPOST PLANT				
Operational monitoring plan for:				
CONTROL MEASURE SHORT DESCRIPTION				
Operational limits (see note)	Operational monitoring of the control measure		Corrective action when the operational limit is exceeded	
	What is monitored?		What action is to be taken?	
	How it is monitored?			
	Where it is monitored?		Who takes the action?	
	Who monitors it?		When it is taken?	
	When it is monitored?		Who needs to be informed of the action?	

Note: If the monitoring is outside this limit(s), the control measure is deemed to be not functioning as intended.

Figure 12: Example on operational monitoring template

2. Verify system performance. Verification monitoring is performed periodically to show whether is working as intended over time. key points along the sanitation chain should be selected and a more complicated monitoring form is conducted (e.g. E. coli, helminth eggs) than operational monitoring. Parameters to be monitored, monitoring frequency, monitoring method, monitoring agency or individual, critical limits, and actions to be taken when the limit is exceeded shall be specified. Verification monitoring can be conducted by the SSP team or by an external authority and usually comprise fewer points for monitoring as compared with operational monitoring. Moreover, it focuses on system end points like microbial quality of agricultural produce, health status of exposed groups, and effluent water quality.

3. Audit the system. Audits ensure that SSP continue to positively impact health outcomes by checking the quality and effectiveness of SSP implementation. It might be performed by internal, regulatory authority or by independent auditors. It should demonstrate that the SSP was properly designed, correctly implemented, and is effective. Auditing frequency should commensurate with the level of confidence required by regulatory authority.

Module 6: Supporting Programs

1. Identify and implement supporting programs and management procedures. Supporting programs comprise all activities that ensure process control such as standard operating procedures (management procedures), hygienic practices, raising awareness among the communities, training, and research. It might also include a program to understand the organization's compliance obligations Accordingly, supporting programs are not directly part of SSP; however, they are extremely important in maintaining the operating environment and ensuring proper control.

Management procedures include instructions on how to operate the system. Additionally, instructions shall include procedures on how to maintain and inspect the system elements. Instructions shall cover both normal and emergency operations. An example on management procedures for a wastewater treatment plant may include: operation and maintenance schedule, schedule and procedure to monitor wastewater quality and statutory requirements, procedures for all treatment aspects (screening, aeration, sedimentation, sludge thickener, sludge drying beds, etc.).

2.Periodically review and update the SSP outputs. The SSP should be systematically reviewed on periodic basis. The review shall include improvements that have been accomplished, any observed changes in operating conditions, and any new evidence of health risks associated with the sanitary system. Moreover, SSP should be reviewed after emergency situation or after major improvements or changes to the system.

Please note that additional document on governance and sanitation safety planning are provided and would support better understanding using a case study from Jordan. Supporting documents will be used during training in order to better illustrate the concept. Moreover, suggested templates for all critical steps of the SSP will be provided during training and will be used during the role play presented at the end of each module.

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