CODEX ALIMENTARIUS
INTERNATIONAL FOOD STANDARDS

Food and Agriculture Organization of the United Nations
World Health Organization

E-mail: codex@fao.org - www.codexalimentarius.org

GUIDELINES FOR THE SAFE USE AND REUSE OF WATER IN FOOD PRODUCTION AND PROCESSING

CXG 100-2023

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2024 Revisions

Following decisions taken at the Forty-seventh Session of the Codex Alimentarius Commission in November 2024, Annex III was added.

1. INTRODUCTION

Water has an important role in all stages of the food chain from initial sourcing, storage, treatment, distribution, use in irrigation of food crops and forage for animals, primary production, and food processing through to consumption of the final food. It is used as an ingredient, in direct and indirect contact (e.g. washing, cooling the product, or cleaning of equipment surfaces) with food, food packaging, and for hygiene sanitation in food processing. The important role of water in food production has led to the need to ensure its safety and quality since it can be a carrier for the transmission of diseases, contamination or unwanted sensory attributes.

Water is a dwindling resource worldwide and not all food producers and processors have access to safe water sources, or this access may be limited. Noting that the availability and microbiological quality of water are different in each country, region, context, setting and food establishment, water should always be fit for use for each specific purpose, and it should be managed in a way that the safety of food is ensured, while simultaneously avoiding unnecessary consumption and waste.

Water used along the food production and processing chain can have different microbiological quality requirements, and types of water other than potable water may be suitable for certain purposes, provided that they do not compromise the safety of the final product for the consumer.

Requirements for water safety should therefore be considered in context, considering the purpose of the water use, the potential hazards associated with the water use, and whether there is any subsequent measure to decrease the potential for contamination along the food chain.

A risk-based approach to water sourcing, treatment, handling, storage, and use can help in identifying the hazards associated with the water and its use and determine treatments, if applicable, that water needs to undergo to meet the safety parameters specific to each intended use. This approach can also provide a means to address many of the water access and safety challenges associated with reuse based on the principle of using the right type of water for the intended purpose/need.

Deciding whether water is fit-for-purpose should be based on a hazard analysis that considers risk factors such as those associated with the source water, the end use of the food product (e.g. whether the food is eaten raw – without steps that would mitigate potential hazards introduced by the water source), and management options such as treatment options and their efficacy and the application of multiple barrier processes for risk mitigation.

These guidelines respond to the need for a document outlining a risk-based approach to safe sourcing, use and reuse of water fit-for-purpose, rather than focusing on the use of potable water or water of other quality types (e.g. clean water). Using the risk-based approach outlined in these guidelines will allow for a specific assessment of the fitness of the water for the intended purpose.

Associated annexes provide product-specific guidelines for the sourcing, collection, storage, treatment, handling, distribution, use and reuse of water in both direct and indirect contact with food throughout the food chain. The annexes also provide examples such as decision tree tools (DTTs) that can help to determine if water is fit-for-purpose.

2. OBJECTIVES

These *Guidelines for the safe use and reuse of water in food production and processing* aim to:

- provide guidance for food business operators (FBOs) and competent authorities on the application of a risk-based approach for the use and reuse of water that is fit-for-purpose; and
- provide practical guidance and tools (e.g. DTTs) and risk-based microbiological criteria as examples to help FBOs evaluate risks and potential interventions of water as part of their food hygiene system.

3. PURPOSE AND SCOPE

These guidelines provide a framework of general principles and examples for applying a risk-based approach to determine if the water to be sourced, used, and reused by FBOs involved in production and processing of relevant commodities is fit-for-purpose by addressing microbiological hazards, such as parasites, bacteria, and viruses.

4. USE

The document is intended for use by FBOs (primary producers, packing houses, manufacturers, processors) and competent authorities as appropriate.

These guidelines are complementary to and should be used in conjunction with all relevant Codex texts, including but not limited to: the *General principles of food hygiene* (CXC 1-1969),[1] the *Code of hygienic practice for fresh fruits and vegetables* (CXC 53-2003),[2] the *Code of practice for fish and fishery products* (CXC 52-2003),[3] the *Code of hygienic practice for milk and milk products* (CXC 57-2004),[4] the *Principles and guidelines for the conduct of microbiological risk management (MRM)* (CXG 63-2007),[5] the *Principles and guidelines for the establishment and application of microbiological criteria related to foods* (CXG 21-1997),[6] the *Code of practice on food allergen management for food business operators* (CXC 80-2020),[7] the *Code of hygienic practice for meat* (CXC 58-2005),[8] and the *Principles and guidelines for the conduct of microbiological risk assessment* (CXG 30-1999).[9]

5. GENERAL PRINCIPLES

a) Water, as well as ice and steam made from water, used at any stage of the food chain, should be fit for its intended purpose, as determined by a risk-based approach comprising the evaluation of microbiological, chemical and physical hazards and should not compromise the safety of finished foods for consumers.

b) When reusing, water should be treated or reconditioned, effectively monitored and the treatment should be validated to eliminate or reduce hazards to an acceptable level according to its intended use.

c) In all situations, water sourcing, use and reuse should be part of an FBO´s food hygiene system.

d) When using water as an ingredient in food, it should be potable.

6. DEFINITIONS

For the purposes of this document the following definitions apply:

Clean water: water that does not meet the criteria for potable water but does not compromise the safety of the food in the context of its use.

Potable water: water fit for human consumption.

Recirculated water: water reused in a closed loop for the same processing operation without replenishment.

Reclaimed water: water that was originally a constituent of a food material, which has been removed from the food material by a process step and is intended to be subsequently reused in a food processing operation.

Reconditioning: the treatment of water intended for reuse by means designed to eliminate or reduce microbiological contaminants to an acceptable level according to its intended use.

Recycled water: water which has been obtained from a step in the food production or food processing operation to be reused in the same, prior or a subsequent step of the operation, after reconditioning, when necessary.

Reuse water: water that has been recovered from a processing step within the food operation, including from the food components and/or water that, after reconditioning treatment(s) as necessary, is intended to be reused in the same, prior or a subsequent step of the food processing operation. Types of reuse water can include reclaimed water from food, recycled water from food operations, or recirculated water in a closed loop system.

Wastewater: used water that has been contaminated because of human activities.

Water fit-for-purpose: water that is determined to be safe for an intended purpose through the identification, evaluation, and understanding of potential microbiological hazards and other relevant factors (e.g. history of use, the intended use of the food, etc.), including the application of control measures such as treatment options and their efficacy to ensure effective elimination or mitigation of such hazards.

Water sourcing: the act of identifying and obtaining water for food production from a particular water source (e.g. groundwater, surface water, captured water).

7. WATER FIT-FOR-PURPOSE ASSESSMENT

Assessing if water is fit-for-purpose is required for all sectors and steps in the food chain. Risk principles (i.e. a risk-based approach) should be applied in evaluating if the water is fit-for-purpose during sourcing, collection, storage, treatment, handling, use and reuse.

Conducting such an assessment requires complete knowledge of the water system, the diversity and magnitude of the hazards that may exist, and the capacity of existing processes and infrastructure to address and control risks.

Water fit-for-purpose assessments also require the identification of potential microbiological hazards with the capacity to cause damage to water safety and their sources and should also address safe water sourcing, use or reuse, when developing and implementing the plan. Additional factors to be considered could include water storage and distribution, including the hygienic design and the need for special expertise.

Water use and reuse systems should be subjected to routine, risk-based monitoring and verification of appropriate parameters. The frequency of monitoring and verification can be dictated by different factors such as the source of the water or its prior condition, the efficacy of any treatments, and the intended use and reuse of the water. Relevant routine monitoring data by environmental agencies and public health organizations could be also useful in determining the frequency of monitoring and verification activities.

In the context of safe water sourcing, collection, treatment, handling, storage, use and reuse, water fit-for-purpose assessments can include the following risk-based approaches:

- Descriptive assessment (least comprehensive) – an onsite as well as a document-based evaluation from which a written descriptive assessment is generated. Examples include a sanitary inspection used in evaluating and managing risks from irrigation water and rapid assessment of water safety.
- Semi-quantitative water assessment – the development and use of risk matrices that establish categories of risks from high to low, including consideration of sanitary conditions and their likelihood and estimated frequencies of unacceptable sanitary conditions. These are normally used for planning, prioritization and a rapid assessment of the safety and quality of water sources collection, storage, treatment, and handling.
- Quantitative microbial water assessment (QMWA) (most comprehensive) – a mathematical modelling approach that can be used for estimating risks related to water use with a health outcome target. QMWA helps identify how much of an impact a pathogenic microorganism will have on the health of the population e.g. guiding wastewater use in agriculture.

8. WATER SAFETY MANAGEMENT

Water fit-for-purpose assessments can be used for management decisions in setting target objectives for water sources and treatments for achieving public health outcomes, performance targets (e.g. food safety objectives, performance objectives), acceptable levels of risk and treatment process efficacies as appropriate.

Risks associated with the use of water should be managed with measures implemented within the framework of a structured food hygiene system with monitoring and verification activities in place to ensure that the system is operating as expected.

As part of the food hygiene system, where appropriate, all water systems should be mapped in a process flow diagram and evaluated in the hazard analysis.

Once potential hazards and their sources have been identified, the risks associated with each hazard or hazardous event should be compared so that priorities for risk management can be established and documented. A semi-quantitative matrix might be useful to identify hazards and prioritize control measures for risk management purposes.

Treatment or reconditioning of water intended for fit-for-purpose use and reuse should be based on hazard analysis of the sourced water and, where deemed necessary, treatments should ensure that hazards are eliminated, controlled or reduced to an acceptable level.

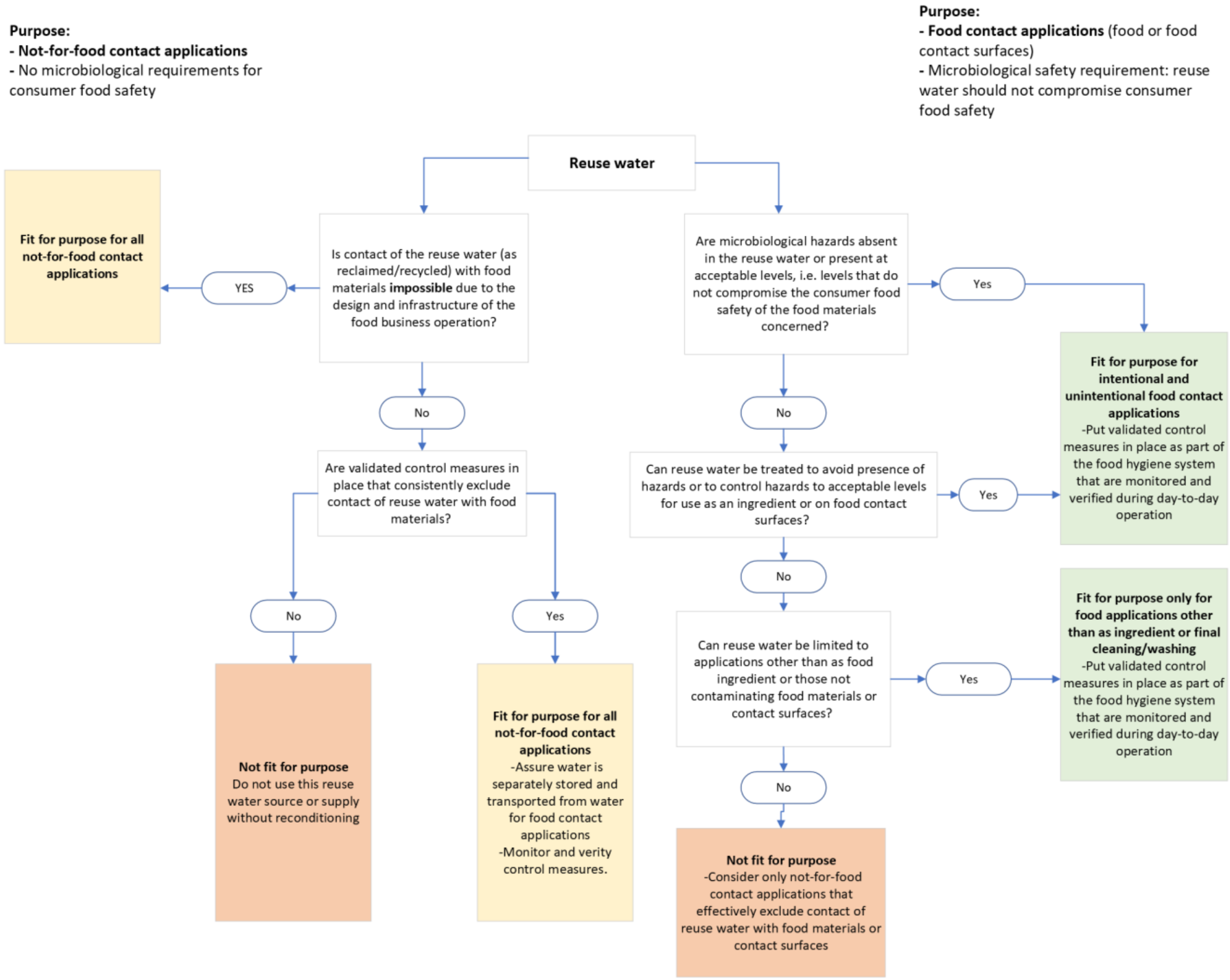
9. DECISION SUPPORT SYSTEMS

Decision support systems (DSS) tools, such as decision trees (DTs) or matrices, are considered to be useful risk management tools to assist stakeholders in making decisions to determine if water is fit-for-purpose and the required quality for use or reuse at a given step in the supply chain.

DSS should allow for the diversity in food production, resulting in different types of risks and risk management steps necessary to ensure the water's fitness for purpose in food production. Examples include the food types involved and their intended use; the food-water interactions; the specific waterborne food safety hazards; and their likelihood and magnitude of transmission to the consumer when present in different foods.

An example of a risk-based DSS tool with further guidance is provided in Figure 1.

Figure 1. *Example of a risk-based DSS framework tool for the purpose of deciding if reused water can be used in either a food-contact application or a not-for-food-contact application for microbiological hazards*



Source: Authors' own elaboration based on Figure 8 from MRA33.

Annex I

FRESH PRODUCE

1. INTRODUCTION

Water can be a source of contamination of all microbiological pathogens associated with the consumption of fresh produce. These pathogens include bacteria such as, but are not limited to, *Salmonella* spp., *Shigella* spp., *Campylobacter* spp., *Listeria monocytogenes* and pathogenic strains of *Escherichia coli* spp., and also viruses such as hepatitis A and norovirus, and parasites such as *Cyclospora* spp., *Giardia* spp. and *Cryptosporidium* spp.

Water is used at all steps in the production chain of fresh produce, from irrigation and other pre-harvest practices, such as fertilization and pesticide application, during harvesting, such as washing in the field, and post-harvest practices, such as cooling, transporting, washing and rinsing, until final washing steps by the consumer. Control measures to prevent water from becoming a source of microbiological contamination of the fresh produce, should be considered at all stages, and an overall management strategy should be developed, taking into account risk factors and control measures applicable at each step.

2. PURPOSE AND SCOPE

The purpose and scope of this annex are to elaborate guidelines for the safe sourcing, use and reuse of water in direct and indirect contact with fresh produce (for primary production and processing) by applying the principle of ‘fit-for-purpose’ using a risk-based approach. The annex recommends good hygiene practices (GHP) and risk-based, sector-specific potential prevention and intervention strategies. It provides examples and/or practical case studies for determining appropriate fit-for-purpose microbiological criteria, (i.e. criteria for bacteria, viruses, parasites), as well as examples of the DSS tools such as DTs to determine the water quality needed for the specific intended purpose in the fresh produce supply chain.

3. USE

This annex is complementary to and should be used in conjunction with the main document, the *General principles of food hygiene* (CXC 1-1969),[1] the *Code of hygienic practice for fresh fruits and vegetables* (CXC 53-2003),[2] the *Principles and guidelines for the conduct of microbiological risk management (MRM)* (CXG 63-2007),[5] the *Principles and guidelines for the establishment and application of microbiological criteria related to foods* (CXG 21-1997),[6] and the *Principles and guidelines for the conduct of microbiological risk assessment* (CXG 30-1999).[9]

4. DEFINITIONS

Biocide: A chemical substance or microorganism intended to destroy, deter, render harmless or exert a controlling effect on any harmful organism by chemical or biological means.

Fresh produce: Any fresh fruit, nuts, mushrooms, herbs and vegetables that are likely to be presented to consumers in a raw form, either unprocessed or physically altered from its original form but remaining in the fresh state (e.g. washed, peeled, cut), and that are generally considered as perishable regardless of it being intact or cut from root/stem at harvest.

5. PRE-HARVEST USE OF WATER

An adequate supply of water of a suitable quality (fit-for-purpose) should be available for use in the various operations in the primary production of fresh produce.

Water has several uses in primary production, e.g. irrigation, application of pesticides and fertilizer, protection against frost/freezing and prevention of sunscald. The quality of water used in primary production is usually very variable. Several parameters may influence the risk of microbiological contamination of fresh produce via water: the source of water, water storage and delivery infrastructures, the type of irrigation system (e.g. drip, furrow, sprinkler/overhead) influencing whether the water has direct contact with the edible portion of the fresh produce, the timing of irrigation in relation to harvesting and exposure of plants to sunlight that can reduce contamination that occurs from water (e.g. microbial die-off). Water used for primary production, including for frost protection and protection against sunscald, which has contact with the edible portion of fresh produce, should not compromise produce safety.

5.1 Water sources

Growers should identify the sources of water used during primary production (e.g. municipality, groundwater including well water, surface water (e.g. open canal, reservoir, river, lake, farm pond), reused irrigation water, rainwater, reconditioned wastewater or discharge water from aquaculture). Apart from municipality (potable) water, examples of water sources that present the lowest risk of contamination (provided these sources and storage and distribution facilities are properly constructed, maintained, monitored and capped, as appropriate) are:

- water in deep wells or boreholes;
- water in shallow wells, provided they are not influenced by surface waters; and
- hygienically collected rainwater.

A number of preventive measures can be implemented to protect a water source if determined to be vulnerable:

- If using more than one water source, ensure all sources are clearly identified to prevent inappropriate use, e.g. provide separate systems for wastewater, potable water supplies, etc.
- Ensure water sources are protected (as much as possible) from contamination by wild and domestic animals, e.g. fencing or netting.
- If storing manure, slurry, composts and other soil amendments, ensure there are no leaks or spillage and they are positioned downhill from the water source, and far enough away to minimize contamination.
- Ensure the catchments and gutters of the water harvesting, distribution and delivery system are regularly cleaned and maintained.
- Ensure that all water storage tanks or water reservoirs are covered, i.e. protected, to prevent contamination.
- If using a private well, ensure it is located away from contamination sources, and constructed appropriately to prevent contamination, e.g. sealed on top.
- Regularly check irrigation systems for damage or leaks and flush lines to remove accumulated organic debris/biofilms. If there has been a period of wet weather, it is recommended to flush the system prior to use.

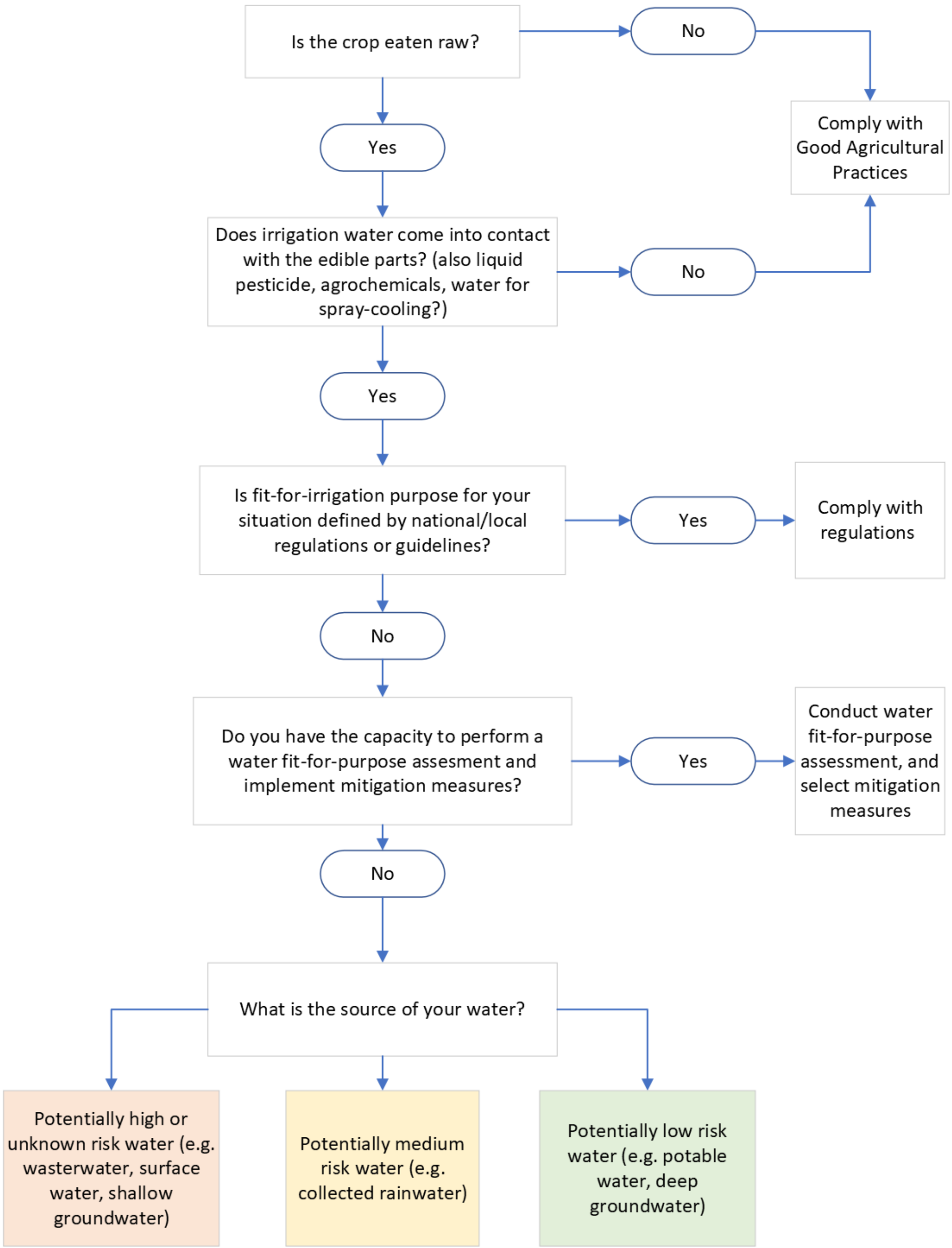
Water sources that pose a higher risk of contamination may need treatment, for example:

- Wastewater: before using wastewater for crop irrigation, an expert should be consulted to assess the relative risk and determine the suitability of the water source. Measures to ensure the safe use may include wastewater treatment, application techniques that minimize contamination, die-off periods before harvesting, produce washing, disinfection and cooking.
- Surface water (e.g. rivers, lakes, canals, lagoons, ponds, reservoirs): when contaminated, options such as application of chemical treatment, sand filtration (combined with other treatment such as application of UV-C), microfiltration or storage in catchments or reservoirs to achieve partial microbiological treatment should be considered. The efficacy of these treatments should be evaluated and monitored.

5.2 Assessing and testing of water

Growers or associated operators should assess the microbiological quality of water, as prescribed by the competent authority, and its suitability for the intended use, and identify corrective actions in case of unacceptable results, to prevent or minimize contamination (e.g. from livestock, wildlife, sewage treatment, human habitation, manure and composting operations or intermittent or temporary environmental contamination, such as heavy rain or flooding). A decision tree on the possible need for a fit-for-purpose assessment on the water is proposed in Figure 1.

Figure 1. *Decision tree on the possible need for a fit-for-purpose assessment on the water*



Source: Authors' own elaboration based on Figure 1 from MRA33.

When water is tested for microbiological hazards, the results should be used by growers and associated operators to inform on the use of water according to the risk associated with the production. The frequency of testing will depend on the water source (i.e. lower for adequately maintained deep wells, higher for surface waters), observed quality based on preceding testing, the risks of environmental contamination, including intermittent or temporary contamination, and factors such as the implementation of another water treatment process by growers.

If water testing is limited to indicator organisms, frequent water tests may be useful to establish the baseline water quality so that subsequent changes in the levels of contamination can be identified. Water testing should be more frequent when establishing the baseline, but the frequency can be lowered once there is a better understanding of the patterns (e.g. seasonality) for microorganisms in the water source. Then, if there are results outside of the range, testing frequency can be increased again at that point.

Growers and associated operators should reassess the potential for microbiological contamination and the need for additional testing if events, environmental conditions (e.g. temperature fluctuations due to change in season, heavy rainfall) or other conditions indicate that water quality may have changed.

When testing, growers may consult, if necessary, the competent authority or experts, or refer to regulations, in order to determine and document the following:

- where to sample (e.g. surface of the water or deeper, close to the edge of surface water or farther back from the bank) and how much to sample;
- which validated test methods should be conducted (e.g. for which pathogens and/or indicator organisms);
- which parameters should be recorded (e.g. temperature of water sample, water source location, weather description and/or time and temperature between sampling and analysis);
- how often tests should be conducted;
- how test results should be analysed and interpreted over time, for example, to calculate the rolling geometric mean; and
- how test results will be used to define corrective actions including use of an alternative source of water.

If the water source is found to have unacceptable levels of indicator organisms or is contaminated with waterborne pathogens, corrective actions should be taken to ensure that the water is suitable for its intended use. Possible corrective actions to prevent contamination of water and fresh produce at primary production may include:

- the installation of fencing to prevent large animal contact;
- improvement of good agricultural practices (GAPs) to prevent contamination from animal waste and fertilizer;
- the proper maintenance of wells;
- the prevention of the stirring of the sediment when drawing water;
- the proper maintenance of distribution and storage systems;
- changing the water application method to avoid direct contact of the water with the edible portion of the crop; and
- maximizing the interval between application of irrigation water and crop harvest, as time-to-harvest intervals will impact the die-off rate of microorganisms which is affected by different weather conditions, produce types and type of bacteria.

Possible corrective action to reduce contamination at primary production may include:

- water filtering by a system that allows capturing particles on which microbiological contaminants may be attached;
- chemical water treatment; and
- the construction of settling or holding ponds or water treatment facilities.

The effectiveness of corrective actions should be verified by regular testing. Where possible, growers should have a contingency plan in place that identifies an alternative source of water.

5.3 Water for irrigation (including greenhouses)

The irrigation system or application method affects the risk of contamination. The timing, the quality of water used, and whether the water has direct contact with the edible portion of the plant should all be considered when selecting the irrigation system or application method to use. Overhead irrigation presents the highest risk of contamination where it wets the edible portion of the crop. The duration of wetting can be several hours, and the physical force of water-droplet impact and the splashing of the soil to the edible part of the product may drive contamination into protected sites on the leaf/produce. If overhead irrigation cannot be avoided, the use of low volume sprays can reduce the risk. Subsurface or drip irrigation that results in no wetting of the plant is the irrigation method with the least risk of contamination, although localized problems may still arise, e.g. when using drip irrigation, care should be taken to avoid creating pools of water on the soil surface or in furrows that may come into contact with the edible portion of the crop.

Water for irrigation should be fit-for-purpose. Special attention should be given to water quality in the following situations:

- irrigation by water-delivery techniques that expose the edible portion of fresh produce directly to water (e.g. sprayers), especially close to harvest time;
- irrigation of fresh produce that have physical characteristics such as leaves and rough surfaces that can trap water; and
- irrigation of fresh produce that will receive little or no post-harvest wash treatments prior to packing, such as field-packed produce.

A number of GAPs for irrigation might be considered:

- establish no-harvest zones if the irrigation source water is known or likely to contain human pathogens, and where failure at connections results in overspray of plants or localized flooding;
- record the crop, date and time of irrigation, water source and any pesticides or fertilizers applied using water;
- maintain and protect the source of the water used/stored and verify its quality;
- where possible, avoid the use of high-risk water sources such as poorly stored rainwater, untreated wastewaters and surface waters from rivers, lakes and ponds;
- growers should focus on the adoption of GAPs to minimize and control the risk of contaminated water and not use testing as the sole method for ensuring control of microbial pathogens in water;
- the type of crop (i.e. ready-to-eat or requiring cooking), timing, irrigation system, soil type and whether the irrigation water has direct contact with the edible portion of the plant should be considered by growers. If contaminated water is in contact with the edible portion of plants, the risk of contamination increases, especially if close to harvesting;
- where possible, avoid water spraying immediately prior to harvest. Water spraying, i.e. misting, immediately prior to harvest, presents an increased microbiological risk. If the soil is heavy and non-free draining, contaminated water can accumulate on the soil surface, increasing the risk of crop contamination;
- minimize soil splashing from irrigation by choosing a system that delivers small water droplets. For low-growing crops, it may not be possible to minimize water contact in this way. The risk of contamination increases if large irrigation droplets are used, or heavy rain occurs. It should also be noted that if the soil has been contaminated by irrigation water, soil splash can transfer contamination to crops;
- inspect the complete irrigation system under the farmer's control at the beginning of each growing season and repair the system or apply corrective measures if necessary; and
- properly store organic fertilizers and manure in areas away from water sources, with no possibility of being washed away by runoff.

Those responsible for the water-distribution system, where appropriate, should regularly carry out an evaluation to determine if a contamination source exists and can be eliminated. Water testing records should be kept.

5.4 Water for fertilizers, pest control and other agricultural chemicals

Water used for the application of water-soluble fertilizers, pesticides and other agricultural chemicals that come in direct contact with products should be of the same quality as water used for direct contact irrigation and should not compromise produce safety, especially if they are applied directly on edible portions of the fresh produce close to harvest. Human pathogens can survive and multiply in many agrichemicals, including pesticides.

5.5 Hydroponic water

Microbiological risks of water used in growing fruits and vegetables hydroponically may differ from the microbiological risks of water used to irrigate fruits and vegetables in soil because the nutrient solution used may enhance the survival or growth of pathogens. It is especially critical in hydroponic operations to maintain the water quality to reduce the risk of contamination and survival/growth of pathogens.

The following should be taken into consideration:

- Water used in hydroponic culture should be changed frequently or, if recycled, treated to minimize microbiological contamination.
- Water-delivery systems should be maintained and cleaned, as appropriate, to prevent microbiological contamination of water.
- In the case of a combination of aquaculture and hydroponics (i.e. aquaponics), effluent from fish tanks should be treated to minimize microbiological contamination.

5.6 Water for other agricultural uses

Clean water should be used for other agricultural purposes, such as dust abatement and the maintenance of roads, yards and parking lots, in areas where fresh produce is grown. This includes water used to minimize dust on dirt roads within or near primary production sites. This provision may not be necessary when water used for this purpose cannot reach the fruits and vegetables (e.g. in the cases of tall fruit trees, live tree fences or indoor cultivation).

5.7 Water for indoor storage and distribution facilities

Where appropriate, an adequate supply of clean water with appropriate facilities for its storage and distribution should be available in indoor primary production facilities. Non-potable water should have a separate storage and distribution system.

Non-potable water systems should be identified (for example with labels or colour codes) and should not connect with or allow reflux into potable water systems. The following should be undertaken regarding water for indoor storage and distribution facilities:

- avoid contaminating water supplies by exposure to agricultural inputs that may contain microbial hazards;
- clean and disinfect water storage facilities on a regular basis; and
- control the quality of the water supply.

6. HARVEST AND POST-HARVEST USE OF WATER

6.1 General

Water used during harvesting and post-harvest practices includes any water that contacts fresh produce during or after harvest including water used for rinsing, washing, transporting or fluming, cooling, waxing or icing. The microbiological quality of post-harvest water is critical because microbial die-off on the fresh produce before consumption is minimal, in particular in case of ready-to-eat produce.

Water-quality management varies throughout the operations. Packers should follow GHPs to prevent or minimize the potential for the introduction or spread of pathogens in processing water. The quality of water used should depend on the stage of the operation: for example, clean water could be used for initial washing stages, whereas water used for final rinses should be of potable quality.

Clean, or preferably potable water, should be used when water is applied under pressure or vacuum during washing, as these processes may damage the structure of and force pathogens into plant cells.

It is recommended that the quality of the water used in packing establishments be controlled, monitored and recorded by testing for indicator organisms and/or foodborne pathogens. When the results of such (verification) testing are not available right away, or when the frequency of verification testing is low, it is recommended to carry out other complementary operational monitoring such as rapid water-quality testing by testing of turbidity, chlorine residuals or visual observation.

If water is used in pre-washing and washing tanks, additional controls (e.g. changing water whenever necessary and controlling product throughput capacity) should be adopted.

If large quantities of fresh produce are washed in the same volume of water, accumulation of microorganisms occurs which favours cross-contamination between different product batches. Residual concentration of biocides in the process water can be used to maintain the microbiological quality of process water to avoid accumulation of microorganisms in the water tank and reduce cross-contamination in the washing tank.

Post-harvest operations/systems that use water should be designed in such a manner as to minimize places where the product may lodge, or cause dirt buildup.

The use of biocides to maintain the microbiological quality of process water should comply with the requirements established by the competent authority and should be validated for efficacy. Biocides should never replace GHPs but be used in addition to GHPs, and where necessary to minimize post-harvest cross-contamination with biocide levels, monitored, controlled and recorded to ensure the maintenance of effective concentrations. The application of biocides should be followed by rinsing of the fresh produce as necessary to ensure that chemical residues do not exceed levels established by the competent authority, using overhead spray, not by an immersion tank without cross-contamination attention.

Where appropriate, characteristics of post-harvest water that may impact the efficacy of the biocidal treatments (e.g. the pH, turbidity and water hardness) should be controlled, monitored and recorded.

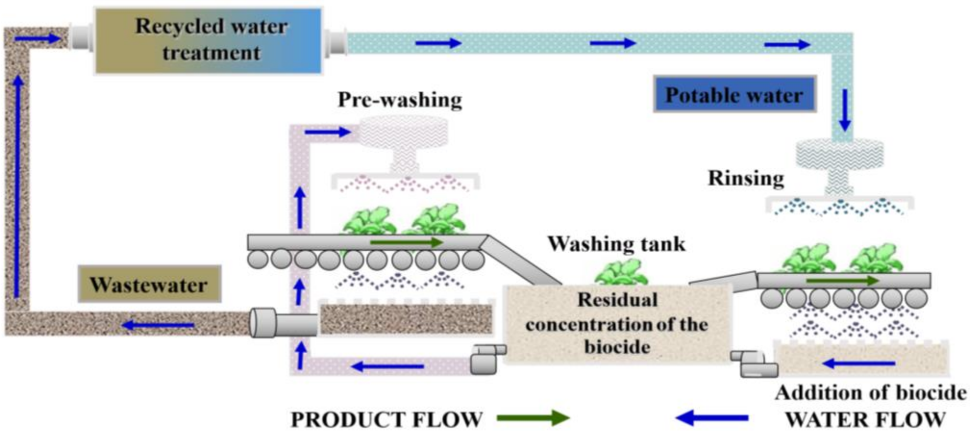
Ice that may come in contact with fresh produce should be made from potable water and produced, handled, transported and stored in such a manner as to protect it from contamination.

Immersion of warm, whole or fresh-cut produce in cool water may induce water into the internal parts of the fresh produce and some fresh produce with high water contents, e.g. apples, celery, melons and tomatoes, are more susceptible to internalization through openings in the peel such as stem-end vascular tissue, stomata or puncture wounds. If the temperature of the wash water is less than the temperature of the produce, the temperature differential can force water into the produce contaminating it on the inside. It is recommended that in these cases, the temperature of the initial wash water is 10 °C higher than the fresh produce, if possible.

6.2 Reuse of water

Water reuse is also possible in the fresh produce industry. As a principle, water reuse should move backwards through the system from clean to less clean steps in the process. Figure 2 shows how water from the rinsing step can be used for the washing tank and how the water in the washing tank can be used as a pre-washing step.

Figure 2. *Example of a potential option for water reuse in the fresh produce industry*



Source: Authors' own elaboration.

The water used in the final rinsing step should be potable water. After rinsing, this water should be treated with a biocide to have a residual concentration of the biocide able to minimize cross-contamination in the washing tank. By doing this, the water in the washing tank will have an "antimicrobial" activity to inactivate any potential pathogens that might be present in the washing tank coming from the produce.

The water from the washing tank can be also used as a pre-washing step. The pre-washing step should remove most of the organic matter and reduce the bacterial load that comes with the produce. This step will help maintain a residual concentration of biocides in the wash water tank, as some biocides are inactivated by organic matter. Reducing the soil and the dust that comes from the field in the pre-washing step will reduce the amount of organic matter and microorganisms introduced into the washing tank, increase the microbial quality of the water in the tank, and help maintain a residual concentration of biocides that are inactivated by organic matter.

The final rinsing step should also minimize the residues of the biocides (e.g. disinfection-by-products) in the fresh produce coming from the washing tank.

In order to have a more sustainable industry, which avoids the use of excessive amounts of water, the water used by the industry can be recycled using reconditioning treatments similar to those that are implemented in wastewater treatment plants to have water of a quality similar to that of potable water.

Recycled water should be treated and maintained in conditions that do not constitute a risk to the safety of fresh produce. The treatment process should be effectively monitored, controlled and recorded. For example, a treatment process that includes primary screening, secondary filtration and a biocidal treatment could be used to maintain the suitability of recycled water.

Recycled water may be used with no further treatment, provided its use does not constitute a risk to the safety of fresh produce (e.g. use of water recovered from the final rinsing for the washing step).

If treating water for use in washing and rinsing, it is recommended to seek professional advice from experts on the safe (re-)use of water in fresh produce before purchasing, installing and using any water treatment system, e.g. water chlorination system.

6.3 Documentation

Documented procedures should be developed for the washing and rinsing of fresh produce, including on:

- the use of vigorous washing to increase the chances of removing contamination if the fresh produce is not subject to bruising;
- the frequency of water replenishment for washing and rinsing considered suitable to minimize risks of fresh produce contamination;
- the monitoring of the water temperature during washing and rinsing, if necessary; and
- the use of a de-watering step, where possible, to remove excess water from the fresh produce, as dry produce is less likely to become re-contaminated; in such case, water should be removed gently to prevent damage to produce.

Develop documented procedures for cleaning and sanitizing of surfaces coming into contact with the fresh produce and used in washing and rinsing of fresh produce which includes:

- All washing and rinsing equipment should be hygienically designed to help ensure adequate cleaning and sanitizing.
- All equipment should be cleaned after use. Mud, soil and fresh produce debris should be removed from equipment, then it should be washed with a detergent and rinsed before a final wash with a chemical disinfectant and, where necessary, a thorough rinse with potable water.
- Ancillary equipment such as knives and blades, and boots and protective clothing should be cleaned and disinfected at the end of each day
- Maximum run time, between cleaning and sanitation cycles, should be determined for each process line.

7. WATER FIT-FOR-PURPOSE ASSESSMENT

The development of a risk-based strategy for water sourcing, use and reuse should take into account:

- identification of water-related microbiological hazards and source of those hazards, relevant for the area of production;
- sources of water available;
- the description of the water supply system (e.g. delivery and storage system);
- uses of water considered such as irrigation, washing (fresh produce, containers and surfaces), storage on ice, etc.;
- type of irrigation, in particular, if the water is in direct contact with the produce;
- type of crop (e.g. leafy greens versus fruit trees);
- physiological characteristics of the fresh produce (such as the peel and whether the produce would be subject to infiltration of water in the produce);
- water treatment and water disinfection techniques available such as heating, microfiltration and treatment with chlorine, chlorine dioxide, chloramine, ozone, UV-C;
- application after use of water (e.g. irrigation cessation, washing, peeling);
- consumers’ habits such as eating raw, cooking, fermenting, etc.; and
- labelling with instructions for the intended use of the food.

If the fresh produce is consumed raw, the source of water should be identified, and the related risk should be assessed in view of determining the level of control measures:

- potentially high or unknown risk if for example untreated wastewater, surface water or shallow groundwater;
- potentially medium risk if, for example, collected rainwater; and
- potentially low risk if treated (waste) water, potable water or deep groundwater.

The matrix in Table 1 is an example that can be used as a simple approach to the potential level of risk posed by the use or reuse of various water sources during pre-harvest stages of fresh produce and their intended use Joint FAO/WHO Expert Meetings on Microbiological Risk Assessment (JEMRA) Report No. 33 (FAO and WHO, 2019).[10]

Table 1. Example to estimate the potential level of risk posed by the use or reuse of various water sources during pre-harvest stages of fresh produce according to their intended use

Intended use of fresh produce	Contact of the water with edible portion?	Water source				
		Wastewater	Surface and groundwater of unknown quality	Groundwater collected from protected wells	Hygienically collected rainwater	Potable water, deep groundwater, or other water, including treated reused water, which complies with the microbiological criteria applicable to potable water
Ready-to-eat	YES	High risk	High risk	Medium risk	Medium risk	Low risk
	NO	High risk	High risk	Low risk	Low risk	Low risk
Cooked	YES	Low risk*	Low risk*	Low risk	Low risk	Low risk
	NO	Low risk*	Low risk*	Low risk	Low risk	Low risk

* Instead of low-risk ranking in the JEMRA Report, No. 33, medium-risk ranking may be considered because the microbial reduction of cooking procedures can be highly variable, depending on the type of produce, the cooking time and temperature applied and the level of contamination of the water. Contact of water with the edible part may also enhance the risk.

Source: Authors' own elaboration based on Figure 2 of MRA33.

When data (e.g. on microbial quality of the water sources, and on relevant health data from exposed populations) and resources allow the conduct of a quantitative or semi-quantitative risk assessment can be considered. This may allow risk mitigation measures to be more cost-effective and tailored to the specific needs.

8. RISK MITIGATION/RISK MANAGEMENT STRATEGIES

8.1 Indicator organism for monitoring hazards in water used in fresh produce production

Indicator organisms should be used as indicators of faecal contamination rather than presence or concentration level of any specific pathogen. The major indicator organisms are *E. coli* and enterococci.

Such faecal indicators can be used as process indicators or to validate the efficacy of water treatments if they respond to treatment processes in a similar manner to pathogens of concern.

It should be taken into account that, in general, faecal indicators reasonably predict the probable presence of faecal pathogens in water, but they cannot precisely predict the concentrations present, with the possible exception of heavily polluted waters. The correlation becomes erratic and biologically improbable as dilution occurs.

Bacteriophages are better indicators of enteric viruses than bacterial faecal indicators, although they cannot be absolutely relied upon as indicators for enteric viruses. A combination of two or more bacteriophages can be considered. Bacteriophages can be used as good process indicators to determine the efficacy of water treatments against enteric viruses.

Protozoa and helminths cysts/eggs survive more easily than bacteria and viruses and there is no suitable indicator of their presence/absence in irrigation water. Specific tests should be performed if the presence of these parasites is suspected.

8.2 Examples for determining water fit-for-purpose sampling frequency and microbiological criteria

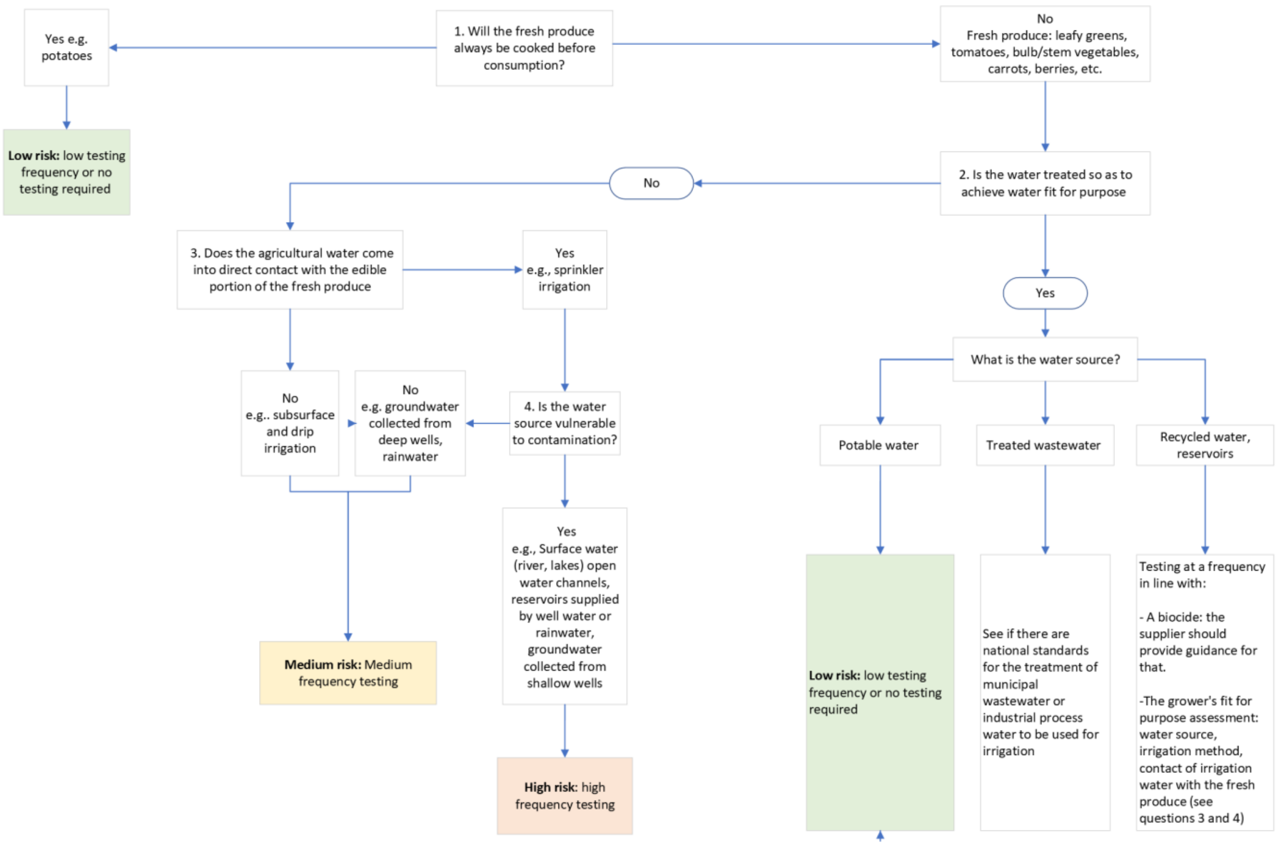
The determination of a fit-for-purpose sampling frequency can contain the following steps:

- identify the activities at the farm in which water is applied;
- identify the sources of water available for the farm;
- evaluate the use of water in relation to the potential contamination to edible parts of the fresh produce;
- check the quality of the water before its use (before the start of the growth season); and
- monitor the quality of water regularly during the growing period.[i]

A risk-based approach can be used for determining testing frequency. For example, the use of potentially high or unknown risk water (see Figure 1 and Table 1) should result in a high frequency of testing, potentially medium-risk water should result in a medium frequency of testing, and potentially low-risk water should result in a low frequency of testing or no testing.

A decision tree approach (for example Figure 3)[ii] could also be used to determine the frequency of testing.

Figure 3. *Example of a decision tree for water testing frequency*



Source: Authors' own elaboration based on European Commission Notice No. 2017/C 163/01.

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[i] Examples of monitoring strategies have been provided in Annex 4 of the JEMRA Report (FAO and WHO. 2021. *Safety and quality of water used with fresh fruits and vegetables*. Microbiological Risk Assessment Series No. 37. Rome. https://doi.org/10.4060/cb7678en).

[ii] Adapted from European Commission Notice No. 2017/C 163/01 Guidance document on addressing microbiological risks in fresh fruit and vegetables at primary production through good hygiene. (https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52017XC0523(03)&from=LV). Accessed by JEMRA as resource for Figure 3 in the 2019 FAO/WHO *Safety and Quality of Water Used in Food Production and Processing* – Meeting report. Microbiological Risk Assessment Series No. 33. Rome.

8.3 Examples of decision support system tools

There is no single DSS tool that applies/fits in all situations. The DTs and examples in Figure 1 and Figure 3, therefore should rather be considered as an approach to evaluate a situation instead of as a tool fixed for all purposes.

Based on Table 1 and Figure 2 of the JEMRA Report No. 33 (FAO and WHO, 2019),[10] a DSS can be developed, using scores to assess the risk or the effectiveness of control measures related to the risk derived from the use of water. The scores below are examples for illustration only. There may be other considerations that could result in a different score.

Scores in the decision tool are:

- Related to the irrigation systems/direct or indirect contact with fresh produce:
  - No direct or indirect contact between irrigation water and produce: 3
  - Drip irrigation: 3
  - Furrow irrigation: 1
  - Overhead irrigation: 0
- Related to the application of mitigation options on water before irrigation:
  - On-farm water treatment ponds with 18+ h sedimentation period; water fetching without disturbing pond sediment: 1
  - Filtering water before irrigation: 1
  - None: 0
- Related to the application of one or more of the following mitigation options at or post-harvesting:
  - Irrigation cessation (3 days): 2
  - Washing with running potable water: 1
  - Washing with running potable water + added biocide: 2
  - Peeling: 2
  - None: 0

The sum of scores is used to determine whether the water is safe to use for its intended purpose. The higher the sum of the scores the lower the associated risk. If the score is too low, the above scores can be used to select additional mitigation options or have an indication to which extent the microbiological quality of the water should be improved.

- When low-risk water (potable water, deep groundwater, other water showing compliance with microbiological criteria of potable water) is used and without the use of fresh manure, excreta or sludge as fertilizer, the risk at primary production can be considered as low.
- When medium-risk water (e.g. collected rainwater or other water showing low microbiological contamination [e.g. *E. coli* 10 CFU/100 ml to 100 CFU/100 ml]) is used, and without the use of fresh manure, excreta or sludge as fertilizer, the risk at primary production can be considered as low, if a score of 4 is reached, by applying the irrigation system or mitigation options in the previous paragraph.
- When high or unknown risk water (wastewater, surface water, shallow groundwater, other water showing high microbiological contamination (e.g. *E. coli* 1000 CFU/100 ml or more)) and without the use of fresh manure, excreta or sludge as fertilizer, the risk at primary production can be considered as low, if a score of 6 and more is reached by applying the irrigation system or mitigation options in the previous paragraph.

An example of a DSS tool[iii] is provided in the appendix, based on the decision tool described in this section.

[iii] Other region/country-specific examples can be found as «Sources for Figure 3» in the 2019 FAO/WHO *Safety and Quality of Water Used in Food Production and Processing* – Meeting report. Microbiological Risk Assessment Series No. 33. Rome.

Appendix 1: Examples of decisions based on support systems tool

The scores below are examples for illustration only. They are based on the DSS described in the last section of the annex on fresh produce. There can be other considerations that would result in a different score.

- Medium-risk water, irrigation water not in contact with the edible portion of the fresh produce (3), no other treatment => total of 3: better to use other source or add mitigation option(s).
- Unknown risk water, irrigation water not in contact with the edible portion of the fresh produce (3), filtering before irrigation (1) and irrigation cessation (2) => total of 6: acceptable.
- Medium-risk water, irrigation water in contact with the edible portion of the fresh produce (0), irrigation cessation (2) + washing with potable water and biocide (2) => total of 4: acceptable.
- Unknown risk water, irrigation water in contact with the edible portion of the fresh produce (0) but filtering before irrigation (1) and irrigation cessation (2) + washing with potable water and biocide (2) + peeling (1) => total of 6: acceptable.
- Medium-risk water, irrigation water in contact with the edible portion of the fresh produce (0) + washing with running potable water and added biocide (2) + peeling (2) => total of 4: acceptable.

Scoring:

- 1–3 unacceptable (use other source or add mitigation options).
- 4–6 acceptable without further mitigation options.

Annex II

(under development)

Annex III

MILK AND MILK PRODUCTS

1. INTRODUCTION

Milk and milk products are an important and often essential source of food in many parts of the world and are a significantly traded food. Water is used for a wide range of activities in dairy operations, and the sector consumes a substantial volume of water for production processes, cleaning and disinfection. Other activities such as chilling and steam production may also have a high demand for water. At primary production, the availability of water fit for drinking for the animals may have a direct impact on animal health, as well as the amount, quality and safety of the milk being produced.

Milk naturally consists of 80 percent to 85 percent of water which may become available for use during certain processes (e.g. concentration and drying of milk products). Reuse of such water, being reclaimed water provides an additional source of water within dairy manufacturing plants. The reuse of reclaimed water from milk and other milk products, and of recycled water in dairy manufacturing plants provides opportunities to significantly reduce the need for water from external sources. It can be an important tool for food business operators (FBOs) to address water scarcity and reduce the stress of water availability in certain parts of the world and/or under certain environmental circumstances.

If water used in the production of milk and milk products is not fit for its intended purpose, it may be a source of microbiological hazards such as *Listeria monocytogenes, Campylobacter* spp.*, Bacillus cereus, Staphylococcus aureus, Salmonella* spp. and Shiga toxin-producing *Escherichia coli*. and protozoa from cross-contamination. The use of non-fit-for-purpose water in dairy operations may also contribute to the distribution and multiplication of such pathogens.

Guidelines on the fit-for-purpose use and reuse of water are essential to ensure the manufacturing of milk and milk products that are safe for consumption.

2. PURPOSE AND SCOPE

This annex provides recommendations for the microbiologically safe use and reuse of water from the dairy farm to the dairy manufacturing/processing plant. It is intended for FBOs and competent authorities, as appropriate, to provide for practical and applicable use and reuse of water in the dairy sector by applying the principle of fit-for-purpose using a risk-based approach. This annex also provides examples of fit-for-purpose use and reuse of water. The scope of the annex strongly focuses on the reuse of water since this provides a significant opportunity to limit the need for external water sources.

3. USE

This annex should be used in conjunction with the general section of these guidelines and the following Codex Alimentarius guidance:

- *Code of hygienic practice for milk and milk products* (CXC 57-2004);[4]
- *General principles of food hygiene* (CXC 1-1969);[1]
- *Principles and guidelines for the conduct of microbiological risk management (MRM*) (CXG 63-2007);[5]
- *Principles and guidelines for the conduct of microbiological risk assessment* (CXG 30-1999);[9]
- *Guidelines for the validation of food safety control measures* (CXG 69-2008);[11]
- *Principles and guidelines for the establishment and application of microbiological criteria related to foods* (CXG 21-1997);[6]
- *Guidelines on the application of general principles of food hygiene to the control of foodborne parasites* (CXG 88-2016);[12] and
- *Guidelines on the application of general principles of food hygiene to the control of viruses in food* (CXG 79-2012).[13]

4. DEFINITIONS

Condensate: water recovered by condensing water vapour, for instance water vapour recovered from the drying of dairy materials/products.

Dairy effluents**:** water from cleaning and disinfection, or other operations involving water, during the manufacture of milk products, including both for-food-contact applications and non-food-contact applications, and which contains identifiable substances.

Permeate**:** the fluid derived from milk or other milk products obtained after removing milk constituents by membrane filtration, microfiltration (MF) ultrafiltration (UF), nanofiltration (NF), reverse osmosis (RO) and/or reverse osmosis and polishing (ROP).

Retentate**:** the product obtained by concentrating milk constituents using membrane filtration (UF/MF/RO/ROP/NF) technology for milk or milk products.

Stagnant water**:** water that occurs as the result of setting, pooling or otherwise accumulating, allowing for the accumulation of organic matter and growth of unwanted microorganisms including yeasts and moulds. Usually found on floors and other areas that do not allow water to drain to floor drains.

5. PRIMARY PRODUCTION AND TRANSPORT FROM THE FARM

An adequate supply of water fit-for-purpose should be available for use in the various operations, including further processing on dairy farms.

Water used as drinking water for animals should be fit-for-purpose and free from feed or faecal material to the extent of possible. Drinking troughs (or other vessels) should be regularly inspected and cleaned when dirty.

Water intended for drinking by animals should be analysed periodically to determine microbiological quality (e.g. based on coliforms, or turbidity/colour limits that can be done at low cost, such as with a Secchi disk modified for relatively shallow water troughs). The frequency of testing should depend on the risk associated with the water source, results from previous testing, applied treatment and intended use of the milk. The risk associated with the water source generally increases from municipality water, deep well water, hygienically collected rainwater, groundwater to surface water.

When washing of the udder is recommended (e.g. when dirty), fit-for-purpose water should be used. In the production of milk for raw milk products, potable water should be used. Attention should be given to proper washing and drying.

Stagnant water near drinking troughs or in milking and storage facilities should be avoided.

Water fit-for-purpose should be available in areas designated for milking of dairy animals and milk storage, as well for use when rinsing, cleaning and disinfecting milking equipment, storage containers, vessels and tanks. It should be available at the dairy manufacturing plants, and elsewhere as required for the cleaning of transport facility equipment and tanks. Rinsing equipment, storage containers, vessels and tanks with water fit-for-purpose, should also be carried out after the use of chemical compounds and biocides for disinfection, when necessary.

New water sources used for rinsing, cleaning and disinfecting the product contact surfaces of milking equipment, tanks, vessels and facilities for milk transport from dairy farms, should be checked visually for clarity and odour as well as tested for microbiological quality where appropriate before first use, and then regularly thereafter in a similar way as in dairy manufacturing plants. Records of analyses should be maintained and should be readily available to competent authorities when requested.

When economically feasible at dairy farms or during transport, reusable water sourcing and reconditioning (as necessary) could add value for the milk production operations seeking to reduce overall consumption of externally sourced water, by collecting, recovering and reconditioning water used for rinsing and cleaning, e.g. the animal housing facility, milk storage area, floors, walls and ceilings and for rinsing, cleaning and disinfecting milking equipment, on-farm milk storage containers, vessels and tanks. When reusing and reconditioning water, the guidance provided below for dairy manufacturing plants should be followed.

As simple examples of reuse, raw milk is heat-treated and concentrated using membrane filtration at the dairy farm, the water from the concentration process may be used as drinking water for animals, cleaning the milking and animal housing facility, as well as milking equipment, provided it is fit-for-purpose. Properly treated sewage water or other water collected from the farm (e.g. from rinsing, cleaning and sanitizing, or from possible production of whey or wash of cheeses at the farm) could be used, for example, to irrigate grazing pastures or to clean the milking and animal housing facility.

6. DAIRY MANUFACTURING PLANT

Within a dairy manufacturing plant, water may be used as an ingredient, for rinsing, cleaning and disinfecting production equipment, for heating and cooling of raw milk, ingredients and finished milk products, as boiler feed water for the production of hot water and steam, and for facility (floors, walls, piping, etc.) cleaning, among other purposes. The availability and volume of fit-for-purpose water required for dairy manufacturing plants, may be limited by geography, climate and competing demands. Also, the dairy industry is continuing to evolve, utilizing facilities with large processing capacities and subsequently, larger water requirements. This large, concentrated demand for water in a small geographical location can stress the availability of water for necessary purposes, such as drinking, irrigation, etc. Water reuse is an important strategy for reducing water consumption from external sources.

6.1 GENERAL RECOMMENDATIONS

Differentiation should be made between water that is used in food or on surfaces that come into contact with food (e.g. ingredient water, water used to rinse, clean, or disinfect food-contact surfaces of processing equipment and transport vehicles), and water that will not come into contact with food, either directly or indirectly (e.g. boiler feed for technical steam, water needed to extinguish fires, or to wash the exterior of vehicles, for cooling towers, to water lawns, to clean exterior surfaces or to flush toilets).

Measures should be taken to avoid or remove stagnant water, condensation or steam from dairy manufacturing plants by the design, operation and maintenance of the plant as quickly and frequently as possible. Ventilation should be adequate to reduce/eliminate steam and condensation accumulation.

Measures should be taken to capture in a sanitary manner, treat and reclaim water from various sources as quickly as possible after its first use or when it originates from milk, whey or other milk products within a dairy manufacturing plant.

As a general recommendation, but subject to adaptation based on testing and evaluation, the following water could be considered as fit-for-purpose:

- potable water and reclaimed water from milk meeting potable water requirements can be used for any purpose in dairy manufacturing, including:
    - as a food ingredient; examples are:
        - low fat dairy spreads;
        - rehydration of dairy powders and other dry ingredients;
        - addition to concentrated dairy products before drying or filtration; and
        - direct steam injection for pasteurization in cheesemaking or fermented milks.
    - to flush dairy materials out of the pipeline at the end of a production run and before the first rinse of the cleaning process; and
    - for any direct or indirect contact with milk products, including for the first rinsing, cleaning, disinfection and final rinsing of food-contact surfaces of processing equipment.
- recycled water from the final rinsing of food-contact surfaces of processing equipment, tanks, vessels, utensils and milking equipment, or from other sources subject to reconditioning:
    - for the first or intermediate rinse during the cleaning and disinfecting of food-contact surfaces of processing equipment, tanks, vessels and utensils (with the possible addition of an acceptable level of biocides);
    - for cleaning non-food-contact surfaces (for example walls, floors); and
    - for food-contact applications or for the final rinse, if the reuse water is subjected to a microbiocidal (e.g. thermal, UV treatment, filtration, chlorination, ozonation), sufficient to reduce microbiological risk to an acceptable level.
- other water may be used for boiler feed purposes, as cooling water/ice or for washing of other surfaces, if not in direct or indirect contact with food.

The dairy plant should have sufficient water supply providing enough water of potable water quality and the water handling systems within the plant should maintain water quality to the point of use. Sampling of water for microbiological testing is relevant upon any suspicion of contamination of the supply water on the premises. It is the responsibility of the FBO to manage any microbiological contamination of the water supply on its premises including informing competent authorities should the food be potentially affected.

Any external supply of non-potable water to the dairy plant e.g. for the production of steam, firefighting and cooling, is acceptable provided that the water handling system is dedicated for these purposes and is clearly marked.

If the FBO has identified contamination in the water supply, it should conduct an investigation and assess whether such contamination was a sporadic occurrence or represents a persistent problem that may require more extensive corrective actions. When a source of contamination is not evident, the FBO should contact competent authorities, to determine whether there is a general contamination of the water supply or whether the contamination originates at the plant and implement appropriate corrective actions to mitigate the cause of the contamination.

Disinfection to reduce microbiological hazards in any water source should never compromise the safety of any milk or milk products.

6.2 WATER INTENDED FOR REUSE

At dairy manufacturing plants, the technology to safely reuse water and dairy effluents to meet fit-for-purpose applications does exist, making this a viable option for dairy manufacturing plants to reduce their externally sourced water consumption (see Annex IV).[i] Attention should be given to address any health risks associated with using reuse water in food production.

The application for which water may be reused is dependent upon its source and how it is collected, stored and treated. Evaluating these elements will establish if the water is fit for the intended purpose. Water that potentially can be sourced for reuse include:

- reclaimed water from milk, dairy ingredients or was part of a milk product (e.g. in milk powder or cheese manufacturing);
- water that has come into a dairy operation in the form of potable water and is recirculated until it is no longer suitable as potable water;
- water that is being recirculated for heating or cooling purposes;
- water that has been used for cleaning processing equipment;
- water that has been used to clean facility floors, walls, ceilings, the outside of piping and processing equipment, etc.; and
- water that is part of a dairy operation's effluent.

Based on the fit-for-purpose assessment, such reuse water can be used for different purposes, subject to appropriate treatment when applicable:

- as an ingredient;
- any direct or indirect contact with milk products and the product contact surfaces of dairy processing or milking equipment;
- the cleaning, disinfection and rinsing of product contact surfaces of processing equipment, tanks, vessels, pipelines, valves, utensils and equipment; water fit-for-purpose for rinsing before cleaning and disinfection (first rinsing) might not be fit-for-purpose for rinsing after cleaning and disinfection;
- cleaning non-product contact surfaces (e.g. walls, floors, etc.);
- boiler water feed; and
- heating or cooling of raw materials, ingredients and finished product.

Further, there might be laws and regulations addressing water reuse established by competent authorities that need to be followed.

A back-up fit-for-purpose water supply such as an external potable water source that can be used in case a reuse water treatment system is not effective or functioning properly should be available.

External technical expertise might be needed for the design of safe water reuse systems in dairy operations.

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[i] Under development.

7. TECHNOLOGIES FOR RECOVERY AND TREATMENT OF WATER

7.1 General recommendations

Membrane filtration, and other technologies of hygienic design, may be applied to reclaimed, recycled or recirculated water (other than potable water) in order to make the water fit-for-purpose. Refer to Annex IV.[ii].

7.2 Specific recommendations for reverse osmosis in the use and reuse of water in dairy production

Reverse osmosis water recovered from permeates, for example whey or water mixtures resulting from equipment and pipeline flushes, typically has very low microbial counts. When the performance efficiency of RO has been subjected to a hazard analysis and validated, and is verified to be consistent, RO water may be used for the following purposes based on a risk assessment or within approximately 24 hours after generation, without additional microbiocidal treatment[iii] for example:

- ingredient in milk products, e.g. reconstitution of dry ingredients and dairy powders, scalding of cheese curds and grains;
- production of ice and steam, including steam for direct injection;
- washing of cheese curd to remove the casein/whey protein and to directly cool cheeses;
- cleaning, disinfection and rinsing in between cleaning steps;
- final cleaning, disinfection and rinsing of product contact surfaces for all processing lines used for heat-treated products;
- cleaning of membrane filtration systems or washing of reusable packaging boxes and product moulds;
- diafiltration, i.e. process applied in combination with another membrane filtration method, where water is added to the membrane filtration retentate to flush out constituents to reduce product viscosity and to make the purification of lactose and minerals more efficient; and
- preparation and dilution of brine used for brining cheese. The microbiological control of reuse water for diluting brine can be done as part of the normal verification process for the microbial quality of the brine.

In dairy production, RO water of which the microbiological quality is uncertain (for example in case of no microbiological testing, when testing indicates poor quality or when the RO system is unvalidated) and that will not be used within approximately 24 hours or based on a fit-for-purpose assessment, should be subjected to an effective microbiocidal treatment.

7.3 Specific recommendations for the recovery of reclaimed water from milk by condensation of vapours evaporated during concentration of milk and milk products

Due to the presence of organic material (different sources of milk products and technologies result in different qualities of organic material in this reclaimed water) which may support the growth of microorganisms, treatment of such condensate (e.g. by UV treatment, thermal treatment, microbiocidal treatment, biological filters, MF, UF, NF or RO filtration) may be required before this condensate water is reused for some applications, such as a food ingredient or for food-contact application. Untreated condensate water may be directly used for non-food-contact applications.

Reuse water from dairy processing operations may contain microorganisms that can form biofilms on stainless steel surfaces, as well as pathogenic bacteria. It is therefore important that reuse water has an appropriate disinfection treatment when required, that achieves the guideline values for the verification of microbial quality appropriate to the intended use. Chemical disinfection of water will inevitably generate disinfection residues. The optimal choice of disinfectant will vary between different dairy manufacturing sites, depending upon their individual milk product range and method of recovering water for reuse, which will affect the organic loading.

8. WATER FIT-FOR-PURPOSE ASSESSMENT

Refer to Section 7 of the general section and Annex IV[iv] of these guidelines.

[ii] Under development.

[iii] Recommendation from MRA40.

[iv] Under development.

9. WATER SAFETY MANAGEMENT

Refer to Section 8 of the general section and Annex IV[v] of these guidelines.

10. EXAMPLES OF FIT-FOR-PURPOSE WATER APPLICATIONS IN DAIRY PLANTS[vi]

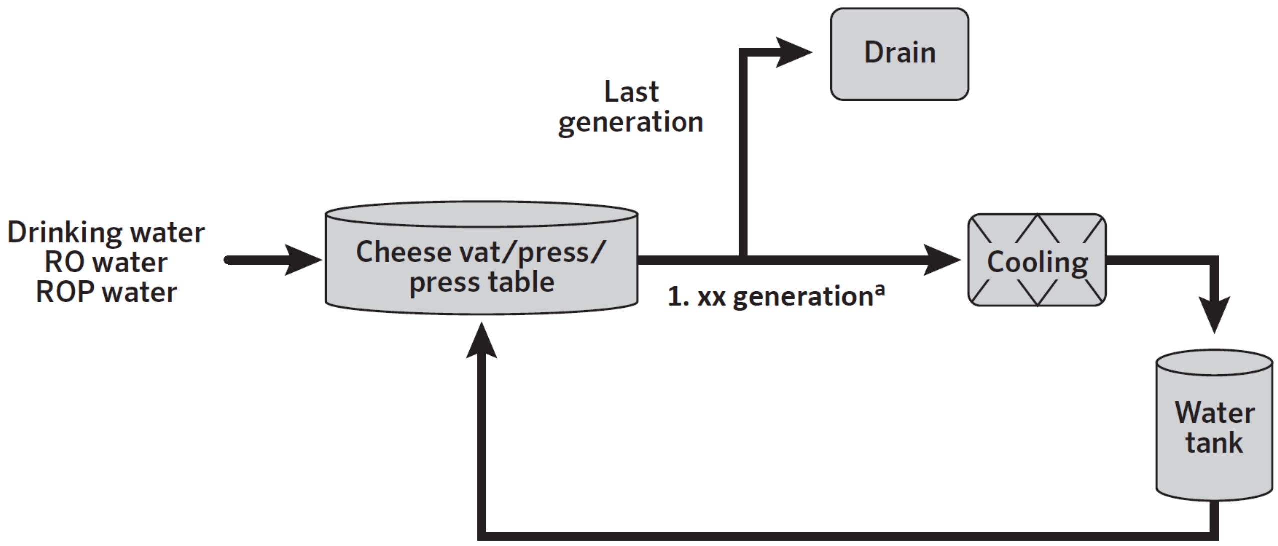
The examples below are for illustrative use only. Any reuse scenario should be based on a proper hazard analysis before implementation.

10.1 Example of reuse of potable water by recirculation or recycling

After introducing potable water in a closed system, the water is recycled for a specific number of times. The number of acceptable cycles is based on the assessment of maximum levels of predefined parameters (e.g. microbiological criteria). The recycled water is then disposed of from the system or is treated with a microbiocidal treatment (e.g. heat, UV or chemical disinfectants) when the number of acceptable cycles has been reached.

As an example, during cheese production, reclaimed water is used for the following cooling step and then recycled in a closed system as illustrated in Figure 1. It is derived from a detailed example that can be found in case study 2 of Annex 4 of MRA40.[14]

Figure 1. *Scheme shows the recirculation of water used for cooling cheeses*



[a] In this scenario, multiple runs of recirculation may apply. Recirculating externally sourced water for a new reuse will produce a second generation of water and recirculation of the second generation would create the third generation, etc. (xx generation), When the number of recirculations has reached its maximum (based on microbial testing), then the water is to be discarded as waste (last generation).

Source: Reproduced with permission from Heggum, C. 2020. Dairy Sector Guide - Recommendations of the Danish Agriculture & Food Council on implementation of food safety management systems in Danish dairy plants.

In case of recycling, the same principle should be applied, but before the water is reused, a reconditioning/treatment step should be applied as necessary.

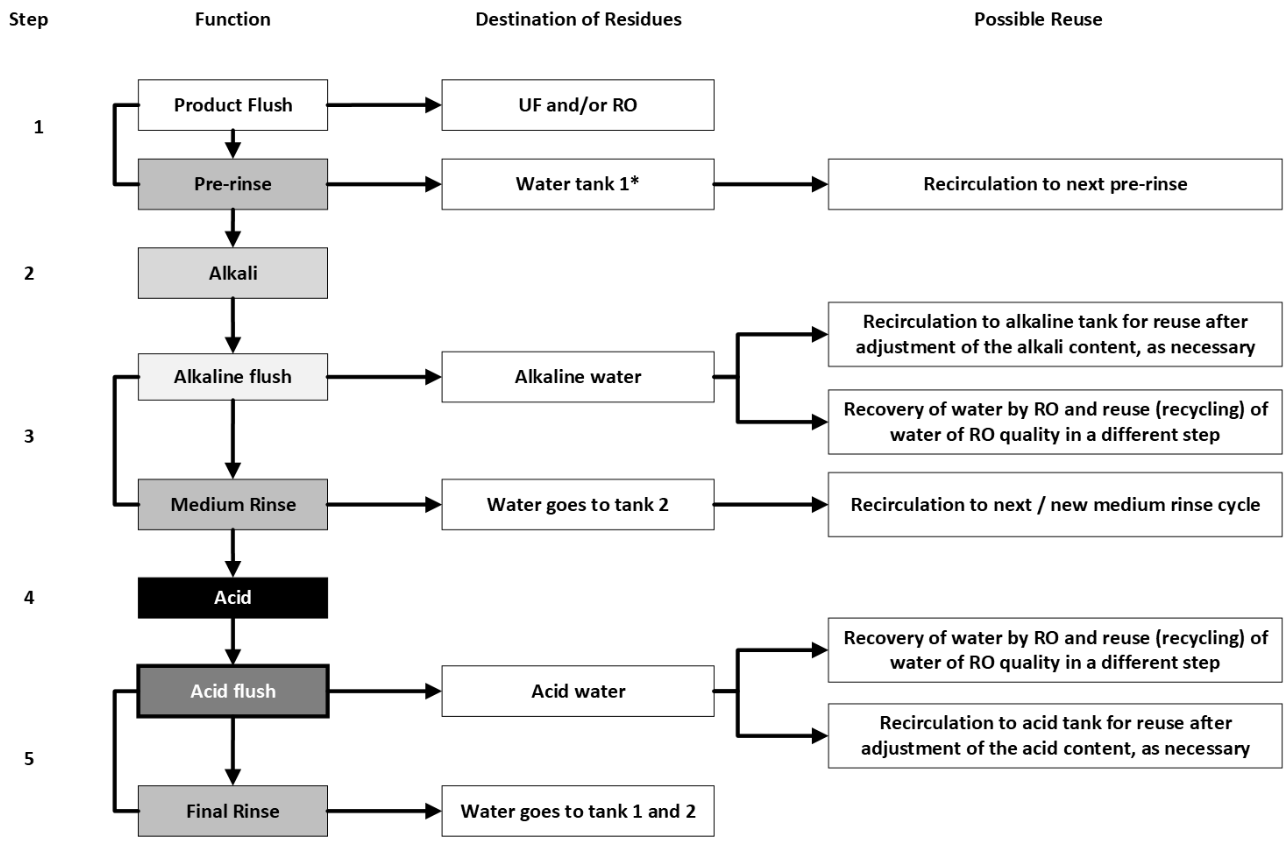
10.2 Example of recovery and reuse of water from cleaning-in-place systems

Cleaning-in-place (CIP) systems are used in dairy manufacturing plants to remove product residues from food-contact surfaces and to remove or reduce biofilm formation. A CIP system consists of a number of consecutive rinsing, cleaning and disinfection steps using fit-for-purpose water at minimum designated temperatures, flow rates, pressures and concentration of chemicals in which the fit-for-purpose water needs to comply with different microbiological, physical and/or chemical parameters. On certain occasions, water used within a step can be recycled for the same step or an earlier step, e.g. potable water needed for the final rinsing step can

[v] Under development.
[vi] Figures in this section were copied from MRA40.

be recycled for earlier rinsing. This is illustrated in Figure 2, which is derived from a detailed example of the use of a CIP system that can be found in case study 3 of Annex 4 of MRA40.[14]

Figure 2. *Sketch for reuse of water streams in a 5-step CIP system, including recovery of RO water from CIP fluids. Illustrates the flow of water streams and the associated options for recirculation or recycling the water from CIP fluids at different steps using UF, RO, ROP*



* When flushing of non-pasteurized product, the water should be pasteurized before reuse. Alternatively it is led to the drain.

Source: Adapted from Heggum, C. 2020. Dairy Sector Guide – Recommendations of the Danish Agriculture and Food Council on implementation of food safety management systems in Danish dairy plants.

10.3 Example of recovery and reuse of water from food production/processing (reclaimed water)

Water present in milk or milk products can be recovered during processing (reclaimed water) and reused. Reclaimed water can be obtained from different processes which will determine its microbiological safety and its need for reconditioning. Examples are condensate from evaporation processes, casein wash water, milk whey and other permeates with additional treatments and milk product rinse water.

This condensate from evaporation processes contains organic materials and chemical compounds such as milk solids and lactic acid, but it is generally very pure. Therefore, it can be used directly or treated in a RO or ROP systems for reuse if it meets fit-for-purpose water criteria as a food ingredient or for cleaning and disinfection of food-contact material.

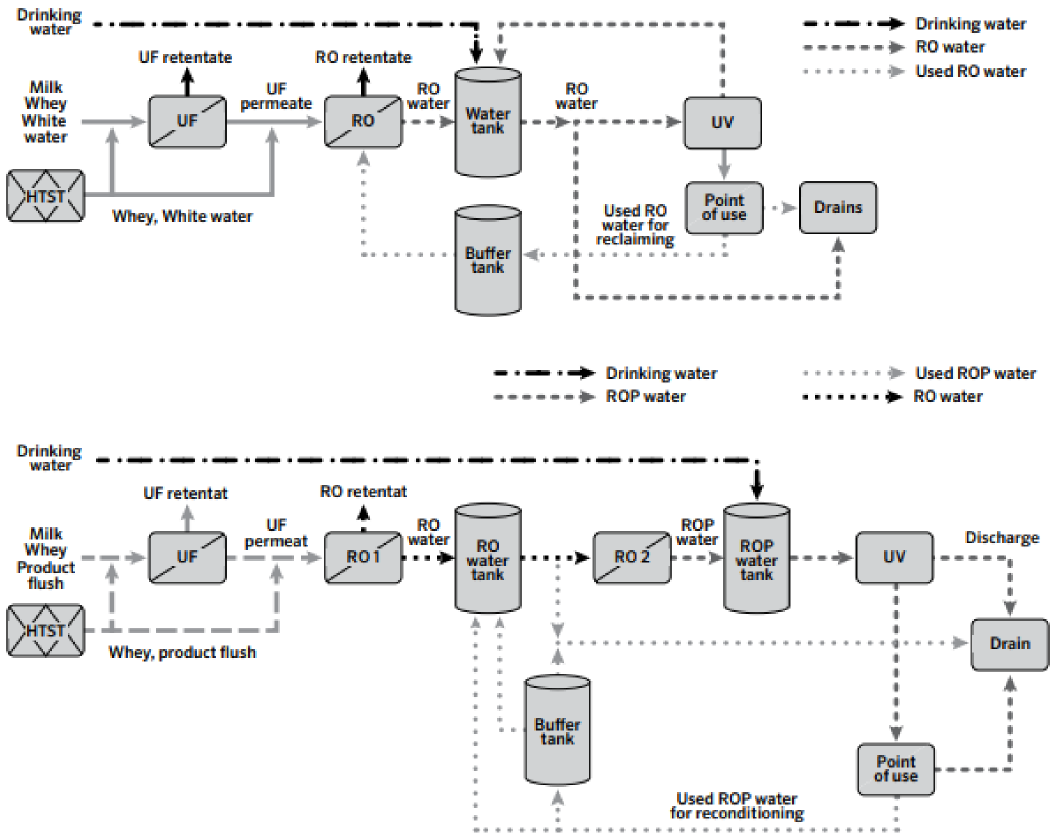
Casein wash water, whey permeate, lactose permeate, milk permeate and some other types of permeates are a good source of reuse water but may support microbiological growth due to the presence of small amounts of milk solids such as milk proteins or lactose. Reusing water conditions should therefore be carefully assessed, monitored and verified. Treatment/purification steps such as NF, RO and UF should be considered.

Milk product rinse water could be water recovered from the initial rinsing of pipes or tanks for milk and consists of a mixture of water and milk, milk-based food materials and deposits. Depending on the place of rinsing (e.g. equipment before or after pasteurization of the milk) and the presence/absence of biofilms, microbiological contamination might vary. Treatment of recovered and stored rinse water to inhibit microbiological growth may need to be considered.

There should be sufficient documentation to identify the source and treatment (if any) of the reuse water (initial lot production) and subsequent use (which subsequent lots were exposed to this reuse water) in case a food safety investigation is needed.

Figure 3 provides an example of the recycling of water from whey using RO or ROP. It was derived from a detailed example that can be found in case study 4 of Annex 4, of MRA40.[14]

Figure 3. *Examples of two scenarios involving recycling of reusable water sources through RO/ROP and UV treatment(s). Top: describes the recovery of reclaimed water from milk, whey and product flushes using RO followed by UV treatment. Bottom: shows how the RO water is further purified by another RO process (a polisher), followed by UV treatment*



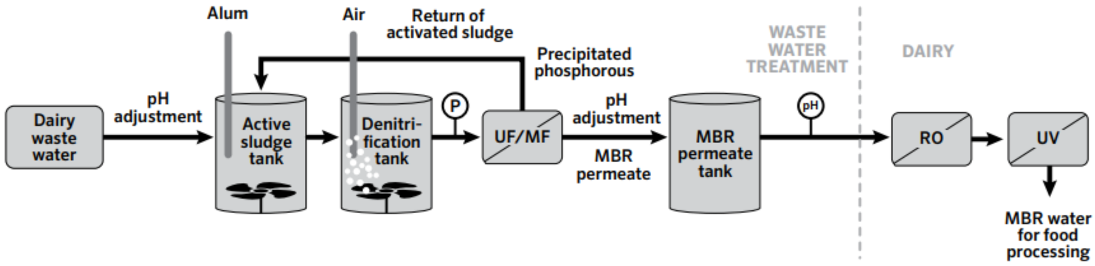
Source: Reproduced with permission from **Heggum, C.** 2020. Dairy Sector Guide - Recommendations of the Danish Agriculture & Food Council on implementation of food safety management systems in Danish dairy plants.

10.4 Example of recovery and reuse of dairy effluents

Effluents from dairy manufacturing plants such as dairy processing wastewater or sewage (wastewater from showers, bathrooms, toilets, wash stations etc.) that contain agents pathogenic to human, may be captured, treated and reused for certain applications when subjected to appropriate treatment and fit-for-purpose assessment and management measures are in place. These effluents may not only contain milk constituents supporting microbiological growth, but other hazardous substances.

Such wastewater should be collected and handled in a manner that prevents cross-contamination of the reuse water, and meets local, regional or national government requirements. Figure 4 provides an example of the recovery of water from dairy effluents using a membrane bioreactor (MBR) and RO. It was derived from a detailed example that is provided in case study 5 of Annex 4 to MRA40.[14]

Figure 4. *Example of the recovery of water from dairy effluents using MBR and RO*



Source: Reproduced with permission from **Heggum, C.** 2020. Dairy Sector Guide - Recommendations of the Danish Agriculture & Food Council on implementation of food safety management systems in Danish dairy plants.

10.5 Example of water recovery and reuse from non-food manufacturing operations

Water originating from external sources such as private wells may vary in chemical, microbiological and physical content and may contain unidentified components. If the manufacturing facility has its own wells, the water may or may not be potable. This will need to be determined through a collection of data that includes microbiological sampling and testing as well as organoleptic evaluation (odour and appearance). Assessment of the pH, turbidity, nitrate level and hardness of such water may be helpful. This will need to be determined through an appropriate evaluation. If the well water has come in contact with surface water, it will most likely have microbial contamination but can still be used if properly treated or for any qualifying fit-for-purpose use. A fit-for-purpose assessment and management measures are needed to identify likely hazards and controls to minimize or eliminate them. Treatment of the water, if needed, should be captured in the hazard analysis critical control points (HACCP) plan.

Case study 1 in Annex 4 to MRA40[14] illustrates the use of water from local wells at or near the dairy manufacturing plant.

Annex IV

(under development)

NOTES

[1] FAO and WHO. 1969. *General principles of food hygiene.* Codex Alimentarius Code of Practice, No. CXC 1-1969. Codex Alimentarius Commission. Rome.

[2] FAO and WHO. 2003. *Code of hygienic practice for fresh fruits and vegetables.* Codex Alimentarius Code of Practice, No. CXC 53-2003. Codex Alimentarius Commission. Rome.

[3] FAO and WHO. 2003. *Code of practice for fish and fishery products.* Codex Alimentarius Code of Practice, No. CXC 52-2003. Codex Alimentarius Commission. Rome.

[4] FAO and WHO. 2004. *Code of hygienic practice for milk and milk products.* Codex Alimentarius Code of Practice, No. CXC 57-2004. Codex Alimentarius Commission. Rome.

[5] FAO and WHO. 2007. *Principles and guidelines for the conduct of microbiological risk management (MRM).* Codex Alimentarius Guideline, No. CXG 63-2007. Codex Alimentarius Commission. Rome.

[6] FAO and WHO. 1997. *Principles and guidelines for the establishment and application of microbiological criteria related to foods*. Codex Alimentarius Guideline, No. CXG 21-1997. Codex Alimentarius Commission. Rome.

[7] FAO and WHO. 2020. *Code of practice on food allergen management for food business operators.* Codex Alimentarius Code of Practice, No. CXC 80-2020*.* Codex Alimentarius Commission. Rome.

[8] FAO and WHO. 2005. *Code of hygienic practice for meat.* Codex Alimentarius Code of Practice, No. CXC 58-2005. Codex Alimentarius Commission. Rome.

[9] FAO and WHO. 1999. *Principles and guidelines for the conduct of microbiological risk assessment.* Codex Alimentarius Guideline, No. CXG 30-1999. Codex Alimentarius Commission. Rome.

[10] FAO and WHO. 2019. *Safety and Quality of Water Used in Food Production and Processing – Meeting Report.* Microbiological Risk Assessment Series, No. 33. Rome. https://www.fao.org/3/ca6062en/CA6062EN.pdf

[11] FAO and WHO. 2008. *Guidelines for the validation of food safety control measures*. Codex Alimentarius Guideline, No. CXG 69-2008. Codex Alimentarius Commission. Rome.

[12] FAO and WHO. 2016. *Guidelines on the application of general principles of food hygiene to the control of foodborne parasites.* Codex Alimentarius Guideline, No. CXG 88-2016. Codex Alimentarius Commission. Rome.

[13] FAO and WHO. 2012. *Guidelines on the application of general principles of food hygiene to the control of viruses in food*. Codex Alimentarius Guideline, No. CXG 79-2012. Codex Alimentarius Commission. Rome.

[14] FAO and WHO. 2023. Safety and quality of water use and reuse in the production and processing of dairy products – Meeting report. *Microbiological Risk Assessment Series*, No. 40. Rome, FAO. https://doi.org/10.4060/cc4081en