MANAGING THE
QUALITY OF WATER

SATI
South African Table Grape Industry

SATI
SOUTH AFRICAN TABLE GRAPE INDUSTRY

MANAGING THE QUALITY OF WATER USED IN TABLE GRAPE PRODUCTION & PACKING

Risk Identification and Best Practice: Proactive Management and Prevention of Microbial Contamination for Food Safety and Employee Health

INTRODUCTION

As in other Table Grape production regions around the world, South African Table Grape producers utilise rivers as an important source of water for irrigation and other uses for production.[1] Different pressures (Including; population growth, expanding of informal settlements and ineffective sewage management) can result in river systems becoming contaminated with various pathogens, exposing downstream users, including irrigated agriculture, to various risks.[1]

CONTAMINATED WATER USED IN AGRICULTURAL PRODUCTION POSES RISKS AT FARM LEVEL IN TWO MAIN WAYS;

1. The Food Safety of the products produced and processed on the farm that may be exposed to contaminated water.
2. Risks to the Health of Employees on the farm who may be exposed to contaminated water.

THIS DOCUMENT IS BROKEN INTO THREE SECTIONS;

A. General considerations for Water Risk Monitoring and Management (applicable to both Food Safety and Employee Health)

B. Food Safety considerations related to contaminated water.

C. Employee Health considerations related to contaminated water.

Parts "B" and "C" set out the potential "pathways" through which contaminated water can potentially pose a risk, provides a Risk Rating with specific consideration of Table Grape production in South Africa, and summarises the relevant key Good Management Practices associated with mitigating/eliminating potential risks for each risk pathway. A reference is also provided to any relevant Standards and their Control Points and any other relevant resources that are addressing specific risk pathways.

How is this document structured in sections B and C?

Reference:
Document reference number for sections A, B and C to guide navigation through the document.

Risk Rating:
A rating of the risk specifically for Table Grape Production in South Africa in light of growing conditions, current operating practices, standards programs implemented etc.

GMP Resources:
References and links to the applicable resources containing details behind the good management practices, including standards and their relevant control points as well as other resources such as research papers.

REFERENCE	RISK PATHWAY	RISK RATING	GOOD MANAGEMENT PRACTICE	GMP RESOURCES
B.1	Irrigating with contaminated water.[13]	LOW This risk is largely dependent on the method of water application and degree of water contact with the harvestable portion of the crop.[2]	B.1.1 Use of irrigation methods that do not result in water in direct contact with the fruit. Precision irrigation that is well managed prevents the risk of contaminated water directly wetting the grapes.[13, 14, 5]	2. G GAP (FV4.1, ANNEX FV5) 13. SA Water Quality Guidelines Vol 4 14. Research Paper

Risk Pathway:
The identified potential processes in horticultural operations that may lead to exposure to risk. Any additional explanations of each risk pathway are provided in italicised text.

Good Management Practice:
A summary of the Good Management Practices (GMP's) relevant to each Risk Pathway that are recommended for effective management/ mitigation of the associated potential risks.

A. General considerations for water risk monitoring and management

REFERENCE	MANAGEMENT FOCUS AREA	GOOD MANAGEMENT PRACTICE	GMP RESOURCES
A.1	Water quality risk assessment	A.1.1 It is important to carry out an annual risk assessment to identify and document; [2,9,11] • all water sources used by the farm, • the contamination potential per source, • the intended purpose of the water used, • the method used to apply the water, • the timing of water applications with corresponding growth stage and characteristics of the crop, • the periods of the year of greatest Food Safety and/or Employee Health risk.	2. G GAP (CB5, FV4) 9. SIZA Enviro (S1) 11. BRC Std (4.5)
A.2	Water quality monitoring plan	A.2.1 Following the risk assessment, a water management plan should define specific activities to be implemented in operations, including; • specifying the sampling points and frequency of sampling, • the timing of sampling to coincide with high risk periods as identified in the risk assessment,[2, 9] • the laboratories and the testing parameters to be used. A.2.2 Water samples need to be tested at a SANAS accredited laboratory.[9] A.2.3 In order to test the extent of contamination, it is impractical to test for the presence of all potential pathogen strains and "indicator organisms" are used to test for the overall contamination levels – their levels in water indicating probable presence of other disease-causing organisms . The coliform bacteria group and more specifically Escherichia coli (E. coli) is used as the primary indicator to indicate the levels of faecal pollution of water.[1, 2, 11] The World Health Organisation (WHO) recommends a maximum of 1000 E. coli organisms in 100ml of irrigation water.[1, 2, 3, 11] E. Coli should not be present in drinking water.[1, 2]	2. G GAP (FV4) 9. SIZA Enviro 11. BRC Std (4.5) 3. Research Paper

REFERENCE	MANAGEMENT FOCUS AREA	GOOD MANAGEMENT PRACTICE	GMP RESOURCES
A.3	Reducing pollution of water sources	A.3.1 Where possible the farm should endeavour to reduce (or be part of collective effort to reduce) up-stream pollution risks. This requires that; • the farm develops a catchment perspective, which includes defining (and mapping) the catchment systems that serve as the main water sources for the farm, identifies the main upstream sources of pollution (for example industries with waste water, informal settlements etc.) and the other key stakeholders in the catchment (the businesses, farms, communities and municipalities who share the catchment and who have a shared dependence on its water resources) • the farm identifies any forums or platforms that are in a position to take or support collective action to reduce or eliminate pollution sources (such as local Municipalities, Water Users Associations, Farmers Associations etc.), and • the farm exploits opportunities for collaboration with other stakeholders and forums or platforms to facilitate and support necessary change/improvement where possible.[6] *Additional notes:* *Farms need to be understood as members of a complex and connected system containing multiple water-users, where the actions of individual water-users unavoidably impact the whole catchment and the other users within it (and/ or those dependent upon it).* *The National Water Act (NWA) Act 36 of 1998 has divided South Africa into Water Management Areas (WMAs). The responsibility and authority for water resource management ultimately falls under the Department of Water and Sanitation (DWS). Within the WMAs the responsibility rests with Catchment Management Agencies (CMAs) and, at a local level, Water User Associations (WUAs).*	6. SAI Platform (Water Stewardship Guide) 17. SAI Platform (Water Stewardship Report) 18. SAI Platform (Principles & Practices) 19. DWA Chapter 1 20. DWA Chapter 3 21. DWA (Strategic Overview of the Water Sector) 22. OECD (Sustainable Management of Water Resources) 23. WWF Water Report

REFERENCE	MANAGEMENT FOCUS AREA	GOOD MANAGEMENT PRACTICE	GMP RESOURCES
A.4	Treatment of water	A.4.1 Water treatment aims to remove solids, organic matter and nutrients from the water, using methods that may be physical, chemical or biological. Contaminated water should be treated before it can be used for irrigation. The selection of a treatment system and the level of treatment is dependent on the extent of contamination, the required water quality and the practicality of the treatment system. The options that can be considered for implementation are set out below. Treatment systems are categorised by nature into two treatment system types; conventional and natural biological, and further categorised into stages, based on the level of treatment. CONVENTIONAL WASTEWATER TREATMENT SYSTEMS[18] Conventional treatment stages include preliminary, primary, secondary and tertiary/advanced treatment and disinfection. **Preliminary treatment** aims to remove coarse solids in preparation for subsequent treatment units. Preliminary treatment options typically include coarse screening or grit removal processes, and in some cases comminution processes to reduce particle size. **Primary treatment** aims to remove settleable organic and inorganic solids and removal of floating material or scum, this may be considered a sufficient stage of water treatment for irrigation of vineyards.[18] Primary treatment methods typically include processes of sedimentation to remove settleable solids, and skimming to remove floating scum. Structures such as holding dams can be used to allow for sedimentation. **Secondary treatment** aims to remove any residual organics and suspended solids after primary treatment. Secondary treatment typically involves aerobic treatment processes; the use of aerobic microorganisms to metabolise residual organics with the supply of oxygen. Aerobic treatment processes primarily differ by the way oxygen is supplied and the metabolism rate of the microorganisms; the processes include the activated sludge process, the trickling filters process or the process of rotating biological contractors. Following aerobic treatment, sedimentation is necessary to separate the microorganisms from the treated water. **Tertiary/advanced treatment** aims to remove specific constituents such as additional suspended solids that have not yet been removed by the preceding treatment methods. Depending on the constituent to be removed, advanced treatment methods are sometimes combined with primary or secondary treatment methods, for example the addition of chemicals to primary sedimentation processes may be necessary. **Disinfection** may be necessary to remove pathogens following the last treatment step. Effectiveness of disinfectants is dependent on pH, contact time, organic content and water temperature. Disinfection processes typically include the addition of disinfectant chemicals such as chlorine solution, less common methods include ultra-violet irradiation or ozone treatment.	18. FAO (3. Wastewater Treatment) 12. WHO (Guidelines for safe use of wastewater) 8. Research Paper 7. Research Paper

REFERENCE	MANAGEMENT FOCUS AREA	GOOD MANAGEMENT PRACTICE	GMP RESOURCES
A.4	Treatment of water	NATURAL BIOLOGICAL TREATMENT SYSTEMS[18] • Natural biological treatment systems include wastewater stabilisation pond systems and macrophyte pond systems. **Wastewater stabilisation pond systems** are designed to give different forms of treatment up to 3 stages; Primary anaerobic ponds are used to reduce biological oxygen demand (BOD). Effluent from primary treatment requires some degree of aerobic treatment before use, secondary facultative ponds are used for aerobic treatment. The aerobic treatment process differs from the conventional process in that the oxygen for the process is provided by microalgae in the ponds, rather than from an external supply of oxygen. Following primary and secondary treatment, if further pathogen reduction or BOD reduction is necessary, then maturation ponds are introduced for tertiary treatment. The longer the retention time in the stabilisation ponds, the more effective the removal of pathogens. **Macrophyte[18] pond systems** incorporate floating, submerged or emergent aquatic plants to remove inorganic nutrients i.e. N and P as well as heavy metals. Natural floating wetlands on cover rafts can be used to clean water in preparation for irrigation.[8] Natural floating wetlands comprise of emergent vascular plants that grow on mats made up of material such as roots, peat and other debris. Natural Floating Wetlands with extensive root systems are effective in removing BOD, nutrients and algae from the water. Subsequent harvesting of the plant biomass removes the stored contaminants from the system. *It is important to note that treatment methods may be effective in improving water quality but can have various negative environmental and ecological impacts that need to be considered and appropriately managed.	18. FAO (3. Wastewater Treatment) 12. WHO (Guidelines for safe use of wastewater) 8. Research Paper 7. Research Paper

B.Food safety considerations

REFERENCE	RISK PATHWAY	RISK RATING	GOOD MANAGEMENT PRACTICE	GMP RESOURCES
B.1	Irrigating with contaminated water.[13] *Consuming raw produce that has been directly exposed to contaminated water may cause diseases such as gastroenteritis, salmonellosis, dysentery, cholera and typhoid fever*[13]	**LOW** This risk is largely dependent on the method of water application and degree of water contact with the harvestable portion of the crop.[2] There is widespread use of microjet and drip irrigation in the table grape industry in South Africa which means limited/no exposure of the fruit directly to irrigation water. Pathogens that enter the stomata on the leaf surface tend to localise in the leaf tissue,[14] a high risk for leafy greens as the harvestable portion contains the stomata[3, 4] but a limited risk to fruit crops such as Table Grapes. The risk of pathogen's ability to attach, colonise and survive on the surfaces of different fruits is largely dependent on the type of fruit.[4] Grapes tend to have a smooth external waxy layer, which enables them to resist the attachment and internalisation of the pathogen.[4]	B.1.1 Use of irrigation methods that do not result in water in direct contact with the fruit. Precision irrigation that is well managed prevents the risk of contaminated water directly wetting the grapes.[13, 14, 5] ***Additional notes:*** *The presence of any E. Coli can lead to disease, so the target E. Coli count for raw vegetables and fruits should be 0 per gram.*[14] *Moist environments are favourable to E. Coli and therefore it is important to manage/handle produce such that any damage to the fruit surface is minimised/prevented. Any injury to the grape surface exposes a moist environment favourable for E. Coli growth.*[14]	2. G GAP (FV4.1, ANNEX FV5) 13. SA Water Quality Guidelines Vol 4 14. Research Paper 5. Research Paper 4. Research Article

REFERENCE	RISK PATHWAY	RISK RATING	GOOD MANAGEMENT PRACTICE	GMP RESOURCES
B.2	Application of agrochemicals with contaminated water.[5] *The application of agrochemicals such as fungicides and insecticides using contaminated water as a diluent poses a risk dependent on the application technique. Spraying techniques have a high chance of contact with the harvestable portion of the crop.*[5]	MED While fruit may be directly exposed to contaminated water, the risk is dependent on the extent of product contact on application as well as the application time before harvest minimising the survival of any pathogens on the grapes. The pre-harvest interval - the time between last application and harvest - should allow sufficient time for the natural die-off of E. Coli [2,13] but spraying close to harvest time may increase contamination risks. See comments above regarding E. Coli on leaf and fruit surfaces	B.2.1 Ensure enough time between final applications and harvest to maximise and ensure an effective decline in pathogen populations that may be present in the water.[2, 13] ***Additional notes:*** *The persistent survival of pathogens is largely dependent on the type of pathogen and the environmental conditions.*[13, 14] *Environmental factors that contribute to the die-off of pathogens include Time, Temperature, Moisture, UV radiation, pH, organic & inorganic compounds and competing organisms.*[14, 12] *It has been found that E. Coli can survive in water for up to 84 days at 25°C, given sufficient nutrient levels.*[14] *Studies have shown the E. Coli can persist on plants after irrigation spray for up to 27 days.*[5] *Application of agrochemicals close to harvest time should be avoided.*[5]	2. G GAP (FV4.1, ANNEX FV5) 13. SA Water Quality Guidelines 14. Research Paper 5. Research Paper 12. WHO (Guidelines for safe use of wastewater)

REFERENCE	RISK PATHWAY	RISK RATING	GOOD MANAGEMENT PRACTICE	GMP RESOURCE
B.3	Harvest shears and crates that are not clean or are cleaned with contaminated water. *Contaminated harvesting equipment exposes a direct mode of contact of E. Coli with the consumable product.*	LOW The existing mandatory good agricultural practice standards that are implemented on table grape farms include specific control points on maintaining and cleaning harvesting equipment.	**B.3.1** Equipment is clean and well maintained.[2] ***Additional notes:*** *Product residue should not be left on equipment beyond a day to avoid cross-contamination of the grapes from the equipment.*[2]	2. G GAP (FV5.2, ANNEX FV)
			B.3.2 Harvest equipment should only be used for their intended use.[2] ***Additional notes:*** *Using equipment as recommended by the manufacturer and keeping good control over the circulation of equipment is important*[2] *to avoid exposure of equipment to contamination sources.*	2. G GAP (FV5.2, ANNEX FV)
B.4	The packhouse is not cleaned or is cleaned with contaminated water. *An unclean packhouse poses a risk to product contamination through product handling or surface contamination*	LOW The existing standards that are largely implemented include hygienic postharvest handling practices.	**B.4.1** Water used for handwashing or cleaning in the packhouse must be potable.[11]	11. BRC Std (4.5)
			B.4.2 All facilities used for handling product must be cleaned and maintained.[11]	2. G GAP (FV5.4) 11. BRC Std (4.11)
			B.4.3 Ensure packaging materials are kept in clean condition.[2]	2. G GAP (FV5.4)
			B.4.4 Employees are effectively trained in all hygiene and product handling procedures and practices.[2] ***Additional notes:*** *Collaboration and cooperation with employees through training creates the basis for a "food-safety culture" in the business.*	2. G GAP (FV5.1)
B.5	Exposure of grapes to contaminated water in the packhouse.	LOW Table grape packhouses do not use water as a conveyor (static tables and/or conveyor belts are used) and table grapes are not washed post-harvest.	-	

C. Employee health considerations

REFERENCE	RISK PATHWAY	RISK RATING	GOOD MANAGEMENT PRACTICE	GMP RESOURCES
C.1	Drinking of contaminated water. *Consumption of contaminated water poses a risk of employees contracting diseases such as gastroenteritis, salmonellosis, dysentery, cholera and typhoid fever.*[10]	MED The existing legislation and mandatory standards that the table grape producers have to comply with insist on the accessibility to potable drinking water with no tolerance for contamination.[2] This is rated as a Medium risk as employees may, even when potable water is available to them, inadvertently expose themselves to risk by drinking/ using water from a contaminated source (for example, by being unaware of contaminated water sources, not being able to clearly distinguish between potable and unpotable water, not knowing what the risks of consuming contaminated water are, etc.)	C.1.1 Potable drinking water must be accessible to all employees. A portable water station may be necessary to provide employees access to potable water at all times as they work through different areas of the farm. ***Additional notes:*** *The inaccessibility of employees to potable drinking water may lead to the drinking of contaminated water that may be more accessible.*	2. G GAP (AF4.5) 10. SIZA Social (S7.5)
			C.1.2 Training in appropriate health and safety procedures including the identification, access to and use of potable water. ***Additional notes:*** *Collaboration and cooperation with employees through training creates the basis for a "health and safety culture" in the business.* *Training should include how to clearly distinguish between water sources (unpotable versus potable), how and where to access potable water and the risks of consuming contaminated water*	2. G GAP (AF4.1) 10. SIZA Social (S7.2)

REFERENCE	RISK PATHWAY	RISK RATING	GOOD MANAGEMENT PRACTICE	GMP RESOURCES
C.2	Washing hands with contaminated water. *Working with unclean hands greatly increases the chance of spread of pathogens to self, others and the harvestable product.* *Risk of hand to mouth and ingestion.*[15]	MED The existing legislation and mandatory standards that the table grape producers have to comply with insist on the accessibility to potable drinking water for hand washing. This is rated as a Medium risk as employees may, even when potable water is available to them, inadvertently expose themselves to risk by using water from a contaminated source (for example, by being unaware of contaminated water sources, not being able to clearly distinguish between potable and unpotable water, not knowing what the risks of using contaminated water are, etc.)	C.2.1 Water used for hand washing must be at the microbial standard of drinking water.[2] ***Additional notes:*** *Hand washing hygiene addresses both employee health risks as well as the risk of contamination between employees and the fruit both in-field and in the packhouse.*	2. G GAP (FV5.2)
			C.2.2 Handwashing facilities need to be accessible to employees in the field.[2] ***Additional notes:*** *The inaccessibility of employees to potable handwashing facilities raises the risk of employees washing their hands with contaminated river water that may be more accessible.*	2. G GAP (AF4.5, FV5.2) 15. Research Paper

REFERENCE	RISK PATHWAY	RISK RATING	GOOD MANAGEMENT PRACTICE	GMP RESOURCE
C.3	In-field handling and harvest operations with contaminated vines or grapes. *Contracting E. Coli from the field poses a risk of contact and in turn the risk of hand to mouth contamination.*[15]	LOW Existing mandatory standards that the table grape producers have to comply with require employees to wear personal protective equipment (PPE), reducing the risk of contamination contact from in-field work. With the adoption of precision irrigation methods such as drip irrigation, the irrigation is relatively localised and immediately absorbed through the soil surface, minimising the chance of contact with employees.	C.3.1 It is important that employees are trained in hygiene and product handling to avoid cross-contamination.[2] ***Additional notes:*** *As mentioned in C.2.2 above, handwashing facilities must be accessible to all employees in the field.* C.3.2 Protective clothing must be available and utilised by employees according to the relevant farm operations and label requirements.[2,10] C.3.3 Protective clothing needs to be maintained and kept clean according to the extent of use and contamination.[2]	2. G GAP (AF3, AF4, FV5, ANNEX FV) 10. SIZA Social (S7) 11. BRC Std (7.4) 12. WHO (Guidelines for safe use of wastewater) 15. Research Paper
C.4	Contact with contaminated wetted soil by working in field barefoot or barehand. *Risk of hand to mouth ingestion of pathogens.*[15]			
C.5	Employees working within the range of spraying operations that may be spraying with contaminated water can have direct contact with contaminated water.[5]	MED Existing mandatory standards that the table grape producers have to comply with require employees to wear PPE and for the careful control of spraying operations, minimising the risk of contact from spraying operations.		

REFERENCE	RISK PATHWAY	RISK RATING	GOOD MANAGEMENT PRACTICE	GMP RESOURCE
C.6	In-field equipment including harvest shears used may be contaminated. *Handling contaminated equipment exposes a direct mode of contact to worker and in turn a hand to mouth risk of contamination.*[15]	LOW Existing mandatory standards that the Table Grape producers have to comply with highlight the importance of keeping harvest equipment clean and well maintained.	C.6.1 Equipment used by employees needs to be cleaned and well maintained.[2]	2. G GAP (FV 5.2, ANNEX FV) 15. Research Paper

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