Food and Agriculture
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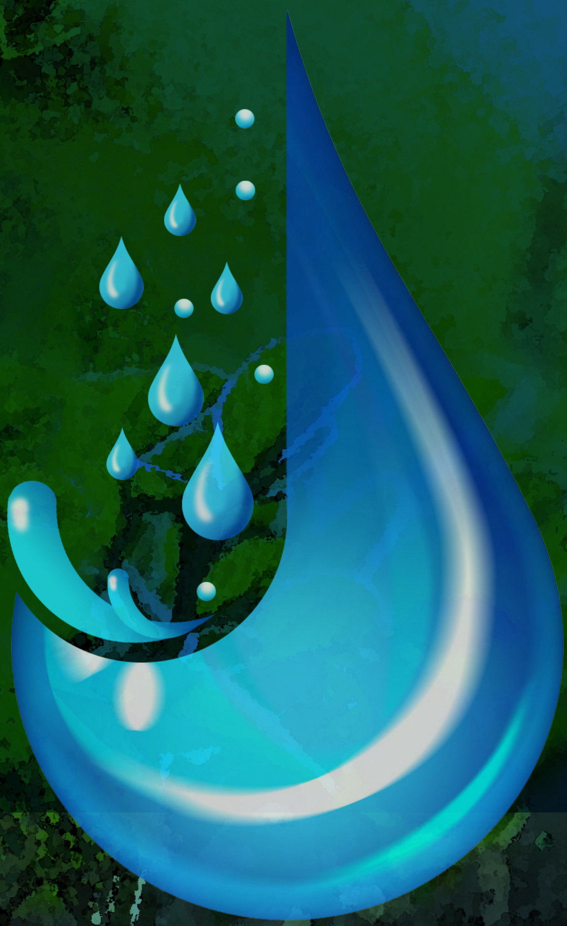
Management Institute

WATER QUALITY IN AGRICULTURE: **Risks and risk mitigation**



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Chapter

1 Introduction

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Water supports important ecosystem services, functions as a non-substitutable input to crop and animal production, and is essential for sustaining economic growth, health and resilience of a country. However, water is also a finite resource and is becoming increasingly scarce in many parts of the world with more countries facing water stress due to climate change. Water pollution from domestic, industrial, and/or agricultural sources can severely affect the availability of the resource for various uses, as well as human and environmental health. Agriculture, as the largest single user of freshwater resources, is also a significant source of chemical and organic pollution to surface water and groundwater resources, causing human illnesses, loss of biodiversity, contamination of marine ecosystems from land-based activities, closure of drinking water sources due to nutrients and toxic algal blooms, and global contamination by persistent organic pesticides.

The 2030 Agenda for Sustainable Development acknowledges the significance of water quality[1], and policy makers have identified water reuse as key to a more sustainable future. This is particularly important for many low- and middle-income countries where wastewater treatment is not keeping pace with urbanization.

Growing urbanization is increasing the demand for water and producing more wastewater. Different sectors such as agriculture, industry and households will face stronger competition for scarce water resources. Achieving sustainable urban development, including food and water security, requires sustainable production and consumption patterns by incorporating water valuation into integrated water resources management and transforming food systems. Globally, about 330 km^3 of urban wastewater, 660 km^3 of industrial wastewater (including cooling water) and an estimated 1260 km^3 of agricultural drainage effluent are annually discharged untreated into the environment (Mateo-Sagasta, Zadeh & Turral, 2018), affecting about 29 million hectares of irrigated farm land (Thebo *et al.*, 2017). In contrast, treated wastewater is reused on only about 1 million hectares of irrigated land worldwide (Drechsel, Qadir & Galibourg, 2022). Besides irrigated crop production, animal husbandry and aquaculture production are also greatly affected by poor water quality, and are significant contributors to water pollution as well (Ongley, 1996; Mateo-Sagasta, Zadeh & Turral, 2018). 'Point' and 'non-point' sources of pollution arise from human activities where the pollutants either have a single point of entry into receiving watercourses or diffuse (multiple) sources where the pollutants are more difficult to trace, measure and control (Ongley, 1996). Salinization is an example of diffuse pollution affecting presently over 20% of the total global irrigated area (Singh, 2021) which prompted the FAO guidelines **Water Quality for Agriculture** (Ayers & Westcot, 1976, 1985). Increasing global attention to domestic wastewater and health was addressed in the FAO benchmark publication titled **Wastewater Treatment and Use in Agriculture** (Pescod, 1992), which presented a guide to the use of treated effluent for irrigation and aquaculture, and drew on the 1989 WHO Guidelines for Safe Wastewater Use in Agriculture (WHO, 1989).

During the subsequent 30 years, the challenge of water quality has grown significantly (Ongley, 1996; UNEP, 2016; WWAP, 2017; Mateo-Sagasta, Zadeh & Turral, 2018; FAO 2021), accelerated by increasing

[1] "Water quality" refers to the physical, chemical, biological and organoleptic (taste-related) properties of water (United Nations, 1997).

water scarcity, urbanization, and climate change. Attention to alternative or nonconventional water sources, including wastewater and desalinized water (UN-Water, 2020; Qadir *et al.*, 2022), resulted in a flurry of new research on water pollution, risk assessments, and water quality management for water conservation or resource recovery in the context of the water–food–energy–ecosystem nexus. Updated water reuse guidelines and fit-for-purpose treatment (e.g., WHO, FAO & UNEP, 2006; USEPA, 2012; FAO & AWC, 2023) to bring water from a particular source to the quality needed for the intended use are increasingly regarded as the most efficient water management approaches. These approaches have been successful as part of integrated water resources management strategies that address multiple sectoral needs and objectives (Qadir *et al.*, 2022). Wastewater treatment remains the safest precondition for reusing the increasing volume of urban water discharge, be it for agriculture, forestry or greening urban and peri-urban areas, in support of a transition from a linear to a more circular economy in the rural-urban interface (Koo-Oshima, 2023). Additionally, aquaculture-agriculture hybrid systems can use brackish and reclaimed water efficiently for fish farming, irrigation, cooling, and non-potable domestic purposes[2]. Finally, residuals from treatment can be conveyed to larger, centralized treatment facilities where energy and nutrients (e.g., phosphorus) can be recovered. In summary, various motivations, benefits, and actions for wastewater reuse should be considered, such as those given below, depending on the geography and local water quality regulations:

- Increasing water security and building resilience to climate change resilience while reducing the dependence on long-distance water transfers or imports.
- Addressing groundwater depletion and related impacts such as land subsidence and saltwater intrusion through targeted groundwater recharge.
- Protecting downstream users, aquatic ecosystems and environmental flows through prevention and control of pollution and promoting safe water reuse.
- Augmenting water supply for irrigated agriculture and food security while freeing up high-quality water for urban use (Drechsel, Qadir & Baumann, 2022).
- Responding to changing economics of the cost of water, energy, and other factors for long-term economic and environmental sustainability (Winpenny *et al.*, 2010).

Promoting a circular economy within the Water–Food–Energy–Ecosystem Nexus approach (Koo-Oshima & Gillet, 2022) is important for addressing climate change, loss of biodiversity, environmental degradation, water scarcity and pollution from any sector and source, impacting the lives and prosperity of countless people every day, and threatening the vital needs of future generations.[3]

Based on this context, in 2020, FAO, in partnership with the International Water Management Institute (IWMI), began production of a review of current water quality guidelines to update the previous FAO guidelines from 1976 (revised in 1985) and 1992 in view of salinity, wastewater use, and other water pollution challenges. The result is the here presented one-volume guidance for evaluating the suitability of water for crop irrigation, livestock, and fish production, as well as environmental protection.

This publication, **Water Quality in Agriculture: Risks and Risk Mitigation,** emphasizes technical solutions and good agricultural practices, including risk mitigation measures suitable for the contexts of differently resourced institutions working in rural as well as urban and peri-urban

[2] FAO Nonconventional water symposium: https://www.fao.org/land-water/events/ncwsymposium19/en/

[3] https://dushanbewaterprocess.org/wp-content/uploads/2022/06/2022-final-declaration-final-draft-0608-en-final-1.pdf

settings in low- and middle-income countries. With a focus on sustainability of the overall land use system, the guidelines also cover possible downstream impacts of farm-level decisions. As each country has a range of site-specific conditions related to climate, soil and water quality, crop type and variety, as well as management options, subnational adjustments to the presented guidelines are recommended.

Water Quality in Agriculture: Risks and Risk Mitigation, is intended for use by national and subnational governmental authorities, farm and project managers, extension officers, consultants and engineers to evaluate water quality data, and identify potential problems and solutions related to water quality. The presented guidelines will also be of value to the scientific research community and university students.

The chapters in this publication address the following topics:

Chapter 2 describes the linkages between water quality and achieving the United Nations Sustainable Development Goals, and the need for water quality monitoring. **Chapter 3** provides an overview of existing water quality guidelines and standards across the world, including those reliant on technological advances and stringent water quality monitoring, and others based on health-based targets, as recommended by WHO. **Chapter 4** is dedicated to pathogenic threats,[4] in particular from domestic wastewater, while the elaborated **Chapter 5** targets chemical risks with significant emphasis on salinity (see also FAO & AWC, 2023). The interlinkages between water quality and aquaculture and water quality and livestock production are described in **Chapters 6** and **7**, respectively. The importance of water quality for a healthy environment and ecology is explored in **Chapter 8**, and further extended to watersheds and river basin scales in **Chapter 9**, looking at the approaches used to analyze, monitor, and manage water quality, and possible downstream impacts in their larger geographical context. Finally, **Chapter 10** provides an overview of the most common and/or significant barriers and drivers of relevance for the adoption of water reuse guidelines and best practices within a given regulatory and institutional context with special attention to low- and middle-income countries.

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[4] For guidance on anti-microbial resistance, see FAO (2020).

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