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INTRODUCTION

This volume of the *Guidelines for the safe use of wastewater, excreta and greywater* describes the present state of knowledge regarding possible health impacts of wastewater use in agriculture. This chapter describes the objectives and general considerations related to the Guidelines and their target audience. It also provides some definitions and presents an overview of what World Health Organization (WHO) water-related guidelines are and how they relate to wastewater use in agriculture. Driving forces that impact wastewater use in agriculture are also described.

1.1 Objectives and general considerations

The primary objective of these Guidelines is to maximize the public health benefits of wastewater use in agriculture. To achieve this objective, strategies are needed, in the context of wastewater use, to minimize the transmission of infectious agents and the exposure to toxic chemicals for farmers and their families, for local communities and for product consumers. This can be achieved by minimizing human exposure to pathogens and toxic chemicals in the wastewater. Other objectives include, for example, managing the use of wastewater to maximize crop production and minimize environmental impacts. For these aspects, the reader is referred to publications by the Food and Agriculture Organization of the United Nations (FAO) (e.g. Ayers & Westcot, 1985; Pescod, 1992; Ongley, 1996; Westcot, 1997a, 1997b; Allen et al., 1998; Tanji & Kielen, 2002; see also Annex 1) and the United Nations Environment Programme's Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (http://www.gpa.unep.org/).

The Guidelines are based on the development and use of health-based targets. Health-based targets establish a goal of attaining a certain level of health protection in an exposed population. This level of health can then be achieved by using a combination of management approaches (e.g. crop restriction, application techniques, human exposure control) and water quality targets to arrive at the specified health outcome. Achieving the health-based targets requires monitoring and system assessment, defining institutional and supervisory responsibilities, system documentation and independent confirmation that the system is working. Thus, the guidelines consist of both good practice advice and water quality specifications and may include:

- a level of management;
- a concentration of a constituent that does not represent a significant risk to the health of members of important user groups;
- a condition under which such transmissions or exposures are unlikely to occur; or
- a combination of the last two.

The Guidelines provide an integrated preventive management framework (see Box 1.1 and discussion on the Stockholm Framework in chapter 2) for safety applied from the point of waste generation to consumption of products grown with the wastewater. They describe reasonable minimum requirements of good practice to protect the health of the people using wastewater or consuming products grown with it, and they derive health-based targets and explain their adaptation. Neither the minimum good practices nor the health-based targets are mandatory limits. In order to define such limits, it is necessary to consider the Guidelines in the context of national environmental, social, economic and cultural conditions (WHO, 2004a).

Box 1.1 What are the Guidelines?

The WHO Guidelines are an integrated preventive management framework for maximizing the public health benefits of wastewater use in agriculture. The Guidelines are built around a health component and an implementation component. Health protection is dependent on both elements.

Health component:

- defines a level of health protection that is expressed as a health-based target for each hazard;
- identifies health protection measures that, used collectively, can achieve the specified health-based target.

Implementation component:

- establishes monitoring and system assessment procedures;
- defines institutional and supervisory responsibilities;
- requires system documentation;
- requires confirmation by independent surveillance.

The approach followed in these Guidelines is intended to support the establishment of national standards and regulations that can be readily implemented and enforced and are protective of public health. Each country should review its needs and capacities in developing a regulatory framework. Successful implementation of the Guidelines will require a broad-based policy framework that includes positive and negative incentives to alter behaviour and monitor and improve situations. Intersectoral coordination and cooperation at national and local levels and the development of suitable skills and expertise will facilitate implementation of the Guidelines.

In many situations, it will not be possible to fully implement the Guidelines at once. The Guidelines set target values designed in such a way as to allow progressive implementation. They are to be achieved over time in an orderly manner, depending on the current reality and the existing resources of each individual country or region. The greatest threats to health should be given the highest priority and addressed first. Over time, it should be possible to adjust risk management strategies to strive for the continual improvement of public health.

Ultimately, the judgement of safety — or what is a tolerable level of risk in particular circumstances — is a matter in which society as a whole has a role to play. The final judgement as to whether the benefit from using any of the guidelines and health-based targets as national or local standards justifies the cost is for each country to decide, in the context of national public health, environmental and socioeconomic realities and international trade regulations.

1.2 Target audience, definitions and scope

The revised *Guidelines for the safe use of wastewater, excreta and greywater* will be useful to all those concerned with issues relating to the safe use of wastewater, excreta and greywater, public health and water and waste management. The target audience may include environmental and public health scientists, educators, researchers, engineers, policy-makers and those responsible for developing standards and regulations.

This volume of the Guidelines addresses the use of wastewater in agriculture. These Guidelines focus on wastewater consisting of domestic sewage that does not contain industrial effluents at levels that could pose threats to the functioning of the sewerage system, treatment plant, public health or the environment. The ability to use wastewater with significant concentrations of industrial chemicals in agriculture should be determined on a case-by-case basis. Sludge derived from the treatment of municipal or industrial wastewater is not included in the scope of this document. Definitions of common terms used in this volume are presented in the glossary in Annex 4.

The public health aspects and the health-based targets for wastewater-irrigated agriculture are applicable to cases where wastewater is used indirectly (i.e. discharged into surface water, which is then abstracted and used for agriculture). In many areas, surface waters such as rivers used for irrigation may be highly contaminated, with properties similar to those of diluted wastewater.

1.3 Driving forces behind increasing wastewater use

Wastewater is being increasingly used for the irrigation of agricultural crops in both developing and industrialized countries. The principal forces driving the increasing use of wastewater are:

- increasing water scarcity and stress, and degradation of freshwater resources resulting from improper disposal of wastewater;
- population increase and related increased demand for food and fibre;
- a growing recognition of the resource value of wastewater and the nutrients it contains;
- the Millennium Development Goals (MDGs), especially the goals for ensuring environmental sustainability and eliminating poverty and hunger.

1.3.1 Increasing water scarcity and stress

Fresh water is already scarce in many parts of the world, and population growth in water-scarce regions will further increase its value. In 1995, 31 countries were classified as water-scarce or water-stressed, and it is estimated that 48 and 54 countries will fall into these categories by 2025 and 2050, respectively. These numbers do not include people living in arid regions of large countries where there is enough water but it is poorly distributed — e.g. China, India and the United States of America (China is predicted to reach water scarcity by 2050 and India by 2025) (Hinrichsen, Robey & Upadhyay, 1998). Growing competition between agriculture and urban areas for high-quality freshwater supplies, particularly in arid, semi-arid and densely populated regions, will increase the pressure on this resource.

1.3.2 Increasing population

Within the next 50 years, it is estimated that more than 40% of the world's population will live in countries facing water stress or water scarcity (Figure 1.1). Most population growth is expected to occur in urban and periurban areas in developing countries (United Nations Population Division, 2002). For example, most of the 19 cities predicted to grow the most rapidly during 2000–2015 (with populations expected to more than double in this period) are in chronically water-short regions of developing countries (United Nations Population Division, 2002).

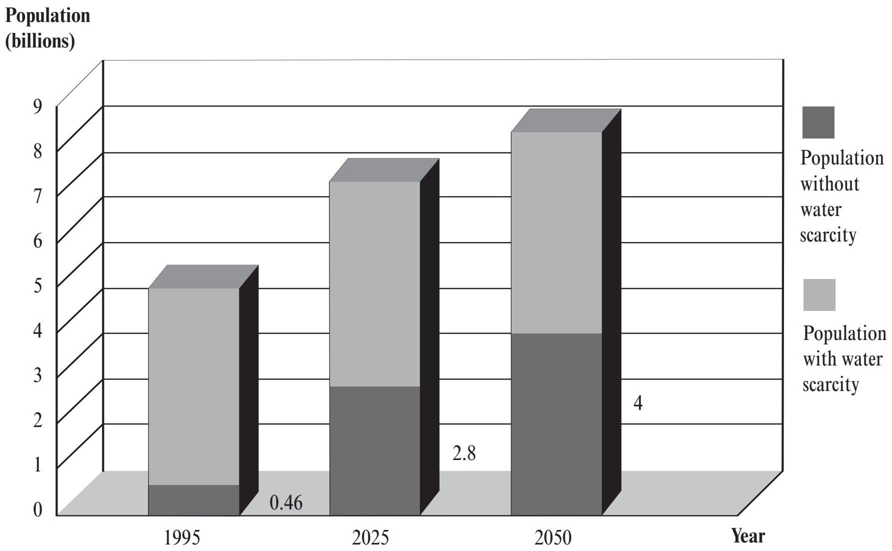

Figure 1.1
Population living in water-scarce and water-stressed countries, 1995–2050
(Hinrichsen, Robey & Upadhyay, 1998; United Nations Population Division, 2000)

As populations grow and become more urban, water use and consequent wastewater generation increase. For example, water usage in North America increased by approximately 800% during 1900–1995, and global water use in 2000 was estimated to be nearly three times what it was in 1950 (Shiklomanov, 1998). Annual household water consumption ranges from approximately 1 m^3 per person in the rural tropics without piped water supplies to >200 m^3 per person in urban areas in the United States of America (Gleick, 2000).

The growth of urban populations, especially in developing countries, will influence the production, treatment and use of wastewater in several ways:

- Higher population densities in urban and periurban areas will generate more waste (much of which will be discharged into the environment with little or no treatment).
- Urban populations consume more water than rural populations, which also increases the amount of wastewater produced.
- Sewerage systems become dominant in urban areas, because on-site waste disposal is not always feasible in many densely populated areas.
- Urban agriculture (with wastewater as a common water source) will play a more important role in supplying food to cities.
- Municipal wastewater will become the sole water source for many farmers in water-stressed areas close to cities.

1.3.3 Wastewater as a resource

Agriculture is the single largest user of fresh water in the world, accounting for nearly 70% (>90% in some countries) of all extractions of fresh water worldwide (Gleick, 2000; FAO, 2002). As fresh water becomes increasingly scarce due to population growth, urbanization and climate change, the use of wastewater in agriculture will increase even more.

At least 10% of the world's population is thought to consume foods produced by irrigation with wastewater (Smit & Nasr, 1992). The water and nutrient value of wastewater are important resources for farmers in both industrialized and developing countries. For example, in California, USA, approximately 67% of wastewater is reclaimed and used for crop or landscape irrigation (California State Water Resources Control Board, 2003), and in Israel the figure is approximately 75% (Arlosoroff, 2002). Wastewater is approximately 99% water. Where households are connected to piped water supplies, wastewater is generated at a rate of 35–200 litres per person per day (12–70 m^3 per person per year), depending on the water supply service level, climate and water availability (Helmer & Hespanhol, 1997). In a semi-arid area, a city of one million people would produce enough wastewater to irrigate approximately 1500–3500 ha.

The use of wastewater for crop irrigation reduces the use of artificial fertilizers and is thus an important form of nutrient recycling. At an irrigation rate of 1.5 m/year (i.e 1.5 m^3 of irrigation water per m^2 of field area per year), a typical requirement in a semi-arid climate, treated municipal wastewater can supply 225 kg of nitrogen and 45 kg of phosphorus per hectare per year. Thus, supplementary fertilization needs can be reduced (or even eliminated) for some crops, with a consequent increase in farmers' income. Additionally, using the nutrients available in wastewater reduces the environmental impacts associated with the mining (phosphorus) and production of artificial fertilizers.

1.3.4 The Millennium Development Goals

The United Nations General Assembly adopted the MDGs on 8 September 2000 (United Nations General Assembly, 2000). The MDGs most relevant to the agricultural use of wastewater are Goals 1 and 7.

Goal 1: Eliminate extreme poverty and hunger

Wastewater irrigation can contribute to the achievement of this MDG, as more food crops can be produced, allowing farmers' incomes to rise. Irrigation with wastewater is potentially very profitable for farmers. For example, in some areas in Pakistan, farmers willingly pay higher fees (US$ 350–940 per year) for access to wastewater compared with access to fresh water (US$ 170 per year), since it allows them to harvest three crops per year instead of one. Despite the higher fees, farmers with access to wastewater earn US$ 300 more per year than farmers using fresh water (Ensink, Simmons & van der Hoek, 2004). In the Guanajuato River basin in Mexico, 140 ha of land are irrigated with wastewater, which provides local farmers with nutrients estimated to be worth US$ 135 per hectare per year. For poor farmers, this is a substantial amount of money, which would otherwise have been used to purchase chemical fertilizers or resulted in lower yields (Future Harvest, 2001).

Irrigation with wastewater produces higher crop yields than irrigation with fresh water, even when artificial fertilizers are used. For example, in Nagpur, India, irrigation with waste stabilization pond effluents yielded 28, 8, 47, 30 and 42% more wheat, moong beans (type of lentils), rice, potato and cotton, respectively, than irrigation with fresh water supplemented with fertilizer containing nitrogen, phosphorus and potassium (Shende et al., 1985). In Dakar, Senegal, farmers who used only wastewater for irrigation had higher yields for most vegetable crops than farmers who used piped water and chemical fertilizers. Moreover, using wastewater resulted in a shorter crop production time for some crops (e.g. lettuce), and thus farmers who used wastewater could produce nine lettuce crops per year compared with six for farmers who used groundwater (Faruqui, Niang & Redwood, 2004).

Higher yields of food crops mean improved food availability. The economics of supply and demand indicate that the more food there is, the lower its price; thus, more people (especially poor people) can buy more food and be at least less hungry. Currently, poor households spend a larger proportion (50–80%) of their income on food and water compared with non-poor households (Lipton, 1983; World Food Programme, 1995). For example, based on household surveys in India, Buechler & Devi (2003) found that per capita expenditure on food averaged 30, 44 and 66% in urban, periurban and rural areas, respectively. Without access to resources such as wastewater, many poor families would not be able to meet their nutritional needs or would have to spend more money on food and less on other health-promoting activities, such as primary health care or education. It is therefore important to use a risk–benefit approach when developing guidelines for wastewater and excreta use in agriculture. This approach is followed in chapter 4 of these Guidelines.

Goal 7: Ensure environmental sustainability

Wastewater irrigation contributes to environmental sustainability by using the nutrients and water in wastewaters beneficially for increased crop production. Consequently, the quantity of untreated wastewater discharged into the aquatic environment will be reduced. It would otherwise lead to the degradation of water quality and act as a vehicle for disease transmission to users of polluted waters. The recognition of wastewater as an integral and reliable component of a nation's water resources (see section 1.3.3) and its equitable distribution as a preferred water for irrigation are essential for the efficient allocation and use of freshwater resources, especially in water-short and water-scarce areas.

Wastewater can also be used to protect groundwater for irrigation uses. When the water in coastal aquifers is pumped out at excessive rates, salt water from the ocean or sea flows into the aquifer, replacing the extracted fresh water. Treated wastewater can act as a barrier to saline intrusion when it is pumped into the aquifer, thus preventing the water from becoming brackish and preserving its value for food production. Aquifer recharge with treated wastewater is becoming more common in many coastal areas where aquifers are depleted through overextraction (Mills et al., 1998; National Research Council, 1998).

1.4 Organization of this Guidelines document

The structure of this volume is illustrated in Figure 1.2. Chapter 2 provides an overview of the Stockholm Framework. Chapter 3 provides the epidemiological, microbial and risk assessment bases for the Guidelines, which are formally developed in chapter 4 as health-based targets. Chapter 5 reviews the health protection measures that can be used to achieve the health-based targets. Chapter 6 reviews monitoring requirements. Chapter 7 presents the sociocultural and public perception aspects that need to be considered in wastewater use in agriculture. Chapter 8 describes environmental aspects of wastewater use in agriculture. Chapter 9 presents information on economic and financial aspects that need to be considered. Chapter 10 discusses policy aspects, and Chapter 11 reviews planning and implementation issues. Annex 1 briefly discusses good agricultural practice in relation to wastewater irrigation, and Annex 2 presents a summary of studies concerning the impact of heavy metals on the environment associated with wastewater irrigation. Health impact assessment with regard to wastewater use in agriculture is discussed in Annex 3.

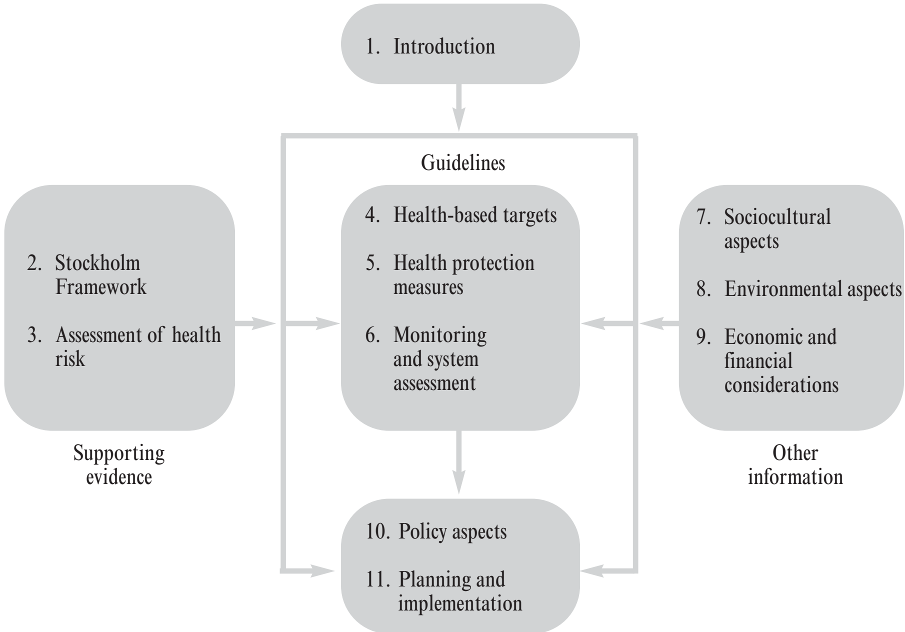

Figure 1.2
Structure of Volume 2 of the *Guidelines for the safe use of wastewater, excreta and greywater*

Annex 4 is a glossary of terms used in the *Guidelines for the safe use of wastewater, excreta and greywater*.