GUIDELINES FOR THE SAFE USE OF WASTEWATER, EXCRETA AND GREYWATER

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Wastewater use in agriculture

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LIST OF ACRONYMS AND ABBREVIATIONS

ADI	acceptable daily intake
BOD	biochemical oxygen demand
2,4-D	2,4-dichlorophenoxyacetic acid
DALY	disability adjusted life year
DDT	dichlorodiphenyltrichloroethane
EC_{DW}	electrical conductivity of the drainage water
EC_{W}	electrical conductivity of the irrigation water
FAO	Food and Agriculture Organization of the United Nations
HIA	health impact assessment
ID_{50}	median infective dose
LF	leaching fraction
MDG	Millennium Development Goal
NOAEL	no-observed-adverse-effect level
OR	odds ratio
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PPPY	per person per year
QMRA	quantitative microbial risk assessment
SAR	sodium adsorption ratio
SAT	soil aquifer treatment
2,4,5-T	2,4,5-trichlorophenoxyacetic acid
TC	total coliforms
TDI	tolerable daily intake
TDS	total dissolved solids
TN	total nitrogen
TOC	total organic carbon
TSS	total suspended solids
UASB	upflow anaerobic sludge blanket
WHO	World Health Organization
WTO	World Trade Organization

PREFACE

The United Nations General Assembly (2000) adopted the Millennium Development Goals (MDGs) on 8 September 2000. The MDGs that are most directly related to the use of wastewater in agriculture are "Goal 1: Eliminate extreme poverty and hunger" and "Goal 7: Ensure environmental sustainability." The use of wastewater in agriculture can help communities to grow more food and make use of precious water and nutrient resources. However, it should be done safely to maximize public health gains and environmental benefits.

To protect public health and facilitate the rational use of wastewater and excreta in agriculture and aquaculture, in 1973, the World Health Organization (WHO) developed guidelines for wastewater use in agriculture and aquaculture under the title *Reuse of effluents: Methods of wastewater treatment and health safeguards* (WHO, 1973). After a thorough review of epidemiological studies and other information, the guidelines were updated in 1989 as *Health guidelines for the use of wastewater in agriculture and aquaculture* (WHO, 1989). These guidelines have been very influential, and many countries have adopted or adapted them for their wastewater and excreta use practices.

Wastewater use in agriculture is increasingly considered a method combining water and nutrient recycling, increased household food security and improved nutrition for poor households. Interest in wastewater use in agriculture has been driven by water scarcity, lack of availability of nutrients and concerns about health and environmental effects. It was necessary to update the guidelines to take into account recent scientific evidence concerning pathogens, chemicals and other factors, including changes in population characteristics, changes in sanitation practices, better methods for evaluating risk, social/equity issues and sociocultural practices. There was a particular need to conduct a review of both risk assessment and epidemiological data.

In order to better package the guidelines for appropriate audiences, the third edition of the *Guidelines for the safe use of wastewater, excreta and greywater* is presented in four separate volumes: *Volume 1: Policy and regulatory aspects*; *Volume 2: Wastewater use in agriculture*; *Volume 3: Wastewater and excreta use in aquaculture*; and *Volume 4: Excreta and greywater use in agriculture.*

WHO water-related guidelines are based on scientific consensus and best available evidence and are developed through broad participation. The *Guidelines for the safe use of wastewater, excreta and greywater* are designed to protect the health of farmers (and their families), local communities and product consumers. They are meant to be adapted to take into consideration national, sociocultural, economic and environmental factors. Where the Guidelines relate to technical issues — for example, wastewater treatment — technologies that are readily available and achievable (from both technical and economic standpoints) are explicitly noted, but others are not excluded. Overly strict standards may not be sustainable and, paradoxically, may lead to reduced health protection, because they may be viewed as unachievable under local circumstances and, thus, ignored. The Guidelines therefore strive to maximize overall public health benefits and the beneficial use of scarce resources.

Following an expert meeting in Stockholm, Sweden, WHO published *Water quality: Guidelines, standards and health — Assessment of risk and risk management for water-related infectious disease* (Fewtrell & Bartram, 2001). This document presents a harmonized framework for the development of guidelines and standards for water-related microbial hazards. This framework involves the assessment of health risks prior to the setting of health targets, defining basic control approaches and evaluating the impact of these combined approaches on public health status. The framework is flexible and allows countries to take into consideration associated health risks that may result from microbial exposures through drinking-water or contact with recreational or occupational water. It is important that health risks from the use of wastewater in agriculture be put into the context of the overall level of disease within a given population.

This volume of the *Guidelines for the safe use of wastewater, excreta and greywater* provides information on the assessment and management of risks associated with microbial hazards and toxic chemicals. It explains requirements to promote the safe use of wastewater in agriculture, including minimum procedures and specific health-based targets, and how those requirements are intended to be used. This volume also describes the approaches used in deriving the guidelines, including health-based targets, and includes a substantive revision of approaches to ensuring microbial safety.

This edition of the Guidelines supersedes previous editions (1973 and 1989). The Guidelines are recognized as representing the position of the United Nations system on issues of wastewater, excreta and greywater use and health by "UN-Water," the coordinating body of the 24 United Nations agencies and programmes concerned with water issues. This edition of the Guidelines further develops concepts, approaches and information in previous editions and includes additional information on:

- the context of overall waterborne disease burden in a population and how the use of wastewater in agriculture may contribute to that burden;
- the Stockholm Framework for development of water-related guidelines and the setting of health-based targets;
- risk analysis;
- risk management strategies, including quantification of different health protection measures;
- chemicals;
- guideline implementation strategies.

The revised Guidelines 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, including environmental and public health scientists, educators, researchers, engineers, policy-makers and those responsible for developing standards and regulations.

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EXECUTIVE SUMMARY

This volume of the World Health Organization's (WHO) *Guidelines for the safe use of wastewater, excreta and greywater* describes the present state of knowledge regarding the impact of wastewater use in agriculture on the health of product consumers, workers and their families and local communities. Health hazards are identified for each vulnerable group, and appropriate health protection measures to mitigate the risks are discussed.

The primary aim of the Guidelines is to maximize public health protection and the beneficial use of important resources. The purpose of this volume of the Guidelines is to ensure that the use of wastewater in agriculture is made as safe as possible, so that the nutritional and household food security benefits can be shared widely within communities whose livelihood depends on wastewater-irrigated agriculture. Thus, the adverse health impacts of wastewater use in agriculture should be carefully weighed against the benefits to health and the environment associated with these practices. Yet this is not a matter of simple trade-offs. Wherever wastewater use in agriculture contributes significantly to food security and nutritional status, the point is to identify associated hazards, define the risks they represent to vulnerable groups and design measures aimed at reducing these risks.

This volume of the Guidelines is intended to be used as the basis for the development of international and national approaches (including standards and regulations) to managing the health risks from hazards associated with wastewater use in agriculture, as well as providing a framework for national and local decision-making. The information provided is applicable to the intentional use of wastewater in agriculture and is also relevant where faecally contaminated water is used for irrigation unintentionally.

The Guidelines provide an integrated preventive management framework for safety applied from the point of wastewater generation to the consumption of products grown with the wastewater and excreta. They describe reasonable minimum requirements of good practice to protect the health of the people using wastewater or excreta or consuming products grown with wastewater or excreta and provide information that is then used to derive health-based targets. Neither the minimum good practices nor the health-based targets are mandatory limits. The preferred approaches adopted by national or local authorities towards implementation of the Guidelines, including health-based targets, may vary depending on local social, cultural, environmental and economic conditions, as well as knowledge of routes of exposure, the nature and severity of hazards and the effectiveness of health protection measures available.

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, water resources development and wastewater management. The target audience may include public health, agricultural and environmental scientists, agriculture professionals, educators, researchers, engineers, policy-makers and those responsible for developing standards and regulations.

Introduction

Wastewater is increasingly used for agriculture in both developing and industrialized countries, and the principal driving forces 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.

It is estimated that, within the next 50 years, more than 40% of the world's population will live in countries facing water stress or water scarcity (Hinrichsen, Robey & Upadhyay, 1998). Growing competition between the agricultural and urban uses of high-quality freshwater supplies, particularly in arid, semi-arid and densely populated regions, will increase the pressure on this ever scarcer resource.

Most population growth is expected to occur in urban and periurban areas in developing countries (United Nations Population Division, 2002). Population growth increases both the demand for fresh water and the amount of wastes that are discharged into the environment, thus leading to more pollution of clean water sources.

Wastewater is often a reliable year-round source of water, and it contains the nutrients necessary for plant growth. The value of wastewater has long been recognized by farmers worldwide. The use of wastewater in agriculture is a form of nutrient and water recycling, and this often reduces downstream environmental impacts on soil and water resources.

The United Nations General Assembly adopted the MDGs on 8 September 2000 (United Nations General Assembly, 2000). The MDGs most directly related to the use of wastewater in agriculture are "Goal 1: Eliminate extreme poverty and hunger" and "Goal 7: Ensure environmental sustainability." The use of wastewater in agriculture can help communities to grow more food and conserve precious water and nutrient resources.

The Stockholm Framework

The Stockholm Framework is an integrated approach that combines risk assessment and risk management to control water-related diseases. This provides a harmonized framework for the development of health-based guidelines and standards in terms of water- and sanitation-related microbial hazards. The Stockholm Framework involves the assessment of health risks prior to the setting of health-based targets and the development of guideline values, defining basic control approaches and evaluating the impact of these combined approaches on public health. The Stockholm Framework provides the conceptual framework for these Guidelines and other WHO water-related guidelines.

Assessment of health risk

Three types of evaluations are used to assess risk: microbial and chemical laboratory analysis, epidemiological studies and quantitative microbial (and chemical) risk assessment.

Wastewater contains a variety of different pathogens, many of which are capable of survival in the environment (in the wastewater, on the crops or in the soil) long enough to be transmitted to humans. Table 1 presents a summary of the information available from epidemiological studies of infectious disease transmission related to

Table 1. Summary of health risks associated with the use of wastewater for irrigation

Group exposed	Health risks		
	Helminth infections	**Bacterial/virus infections**	**Protozoal infections**
Consumers	Significant risk of *Ascaris* infection for both adults and children with untreated wastewater	Cholera, typhoid and shigellosis outbreaks reported from use of untreated wastewater; seropositive responses for *Helicobacter pylori* (untreated); increase in non-specific diarrhoea when water quality exceeds 10^4 thermotolerant coliforms/100 ml	Evidence of parasitic protozoa found on wastewater-irrigated vegetable surfaces, but no direct evidence of disease transmission
Farm workers and their families	Significant risk of *Ascaris* infection for both adults and children in contact with untreated wastewater; risk remains, especially for children, when wastewater treated to <1 nematode egg per litre; increased risk of hookworm infection in workers	Increased risk of diarrhoeal disease in young children with wastewater contact if water quality exceeds 10^4 thermotolerant coliforms/100 ml; elevated risk of *Salmonella* infection in children exposed to untreated wastewater; elevated seroresponse to norovirus in adults exposed to partially treated wastewater	Risk of *Giardia intestinalis* infection was found insignificant for contact with both untreated and treated wastewater; increased risk of amoebiasis observed with contact with untreated wastewater
Nearby communities	*Ascaris* transmission not studied for sprinkler irrigation, but same as above for flood or furrow irrigation with heavy contact	Sprinkler irrigation with poor water quality (10^6–10^8 TC/100 ml) and high aerosol exposure associated with increased rates of infection; use of partially treated water (10^4–10^5 thermotolerant coliforms/100 ml or less) in sprinkler irrigation not found to be associated with increased viral infection rates	No data on transmission of protozoan infections during sprinkler irrigation with wastewater

TC, total coliforms

wastewater use in agriculture. In places where wastewater is used without adequate treatment, the greatest health risks are usually associated with intestinal helminths.

Table 2 presents a summary of the quantitative microbial risk assessment (QMRA) evidence for transmission of rotavirus infection due to different exposures. The risks for rotavirus transmission were always estimated to be higher than the risks associated with *Campylobacter* or *Cryptosporidium* infections.

Table 2. Summary of QMRA results for rotavirus[a] infection risks for different exposures

Exposure scenario	Water quality[b] (*E. coli*/100 ml wastewater or 100 g soil)	Median infection risks per person per year	Notes
Unrestricted irrigation (crop consumers)			
Lettuce	10^3–10^4	10^{-3}	100 g eaten raw per person every 2 days
			10–15 ml wastewater remaining on crop
Onion	10^3–10^4	5×10^{-2}	100 g eaten raw per person per week for 5 months
			1–5 ml wastewater remaining on crop
Restricted irrigation (farmers or other heavily exposed populations)			
Highly mechanized	10^5	10^{-3}	100 days exposure per year
			1–10 mg soil consumed per exposure
Labour intensive	10^3–10^4	10^{-3}	150–300 days exposure per year
			10–100 mg soil consumed per exposure

[a] Risks estimated for *Campylobacter* and *Cryptosporidium* are lower.
[b] Non-disinfected effluents.

Less evidence is available for health risks from chemicals. The evidence that is available is based on quantitative risk assessment and indicates that the uptake of chemicals by plants is highly dependent on the types of chemicals and the physical and chemical properties of soils.

Health-based targets

Health-based targets define a level of health protection that is relevant to each hazard. A health-based target can be based on a standard metric of disease, such as a DALY (e.g. 10^{-6} DALYs), or it can be based on an appropriate health outcome, such as the prevention of the transmission of vector-borne diseases resulting from exposures to wastewater use in agricultural practices. To achieve a health-based target, health protection measures are developed. Usually a health-based target can be achieved through a combination of health protection measures targeted at different components of the system. Figure 1 illustrates different combinations of health protection measures that can be used to achieve the 10^{-6} DALYs health-based target for excreta-related diseases.

Table 3 describes health-based targets for agriculture. The health-based targets for rotavirus are based on QMRA indicating the $\log_{10}$ pathogen reduction required to achieve 10^{-6} DALY for different exposures. To develop health-based targets for helminth infections, epidemiological evidence was used. This evidence demonstrated that excess helminth infections (for both product consumers and farmers) could not be measured when wastewater quality of ≤1 helminth egg per litre was used for irrigation. This level of health protection could also be met by treatment of wastewater or by a combination of wastewater treatment and washing of produce to protect consumers of raw vegetables; or by wastewater treatment and the use of personal protective equipment (shoes, gloves) to protect workers. When children less than 15 years old are exposed in the fields, either additional wastewater treatment (to achieve a wastewater quality of ≤0.1 helminth egg per litre) or the addition of other health protection measures (e.g. anthelminthic treatment) should be considered.

Table 3. Health-based targets for wastewater use in agriculture

Exposure scenario	Health-based target (DALY per person per year)	Log_{10} pathogen reduction needed[a]	Number of helminth eggs per litre
Unrestricted irrigation	$\leq 10^{-6}$ [a]		
Lettuce		6	≤ 1 [b,c]
Onion		7	≤ 1 [b,c]
Restricted irrigation	$\leq 10^{-6}$ [a]		
Highly mechanized		3	≤ 1 [b,c]
Labour intensive		4	≤ 1 [b,c]
Localized (drip) irrigation	$\leq 10^{-6}$ [a]		
High-growing crops		2	No recommendation[d]
Low-growing crops		4	≤ 1 [c]

[a] Rotavirus reduction. The health-based target can be achieved, for unrestricted and localized irrigation, by a 6–7 log unit pathogen reduction (obtained by a combination of wastewater treatment and other health protection measures); for restricted irrigation, it is achieved by a 2–3 log unit pathogen reduction.

[b] When children under 15 are exposed, additional health protection measures should be used (e.g. treatment to ≤0.1 egg per litre, protective equipment such as gloves or shoes/boots or chemotherapy).

[c] An arithmetic mean should be determined throughout the irrigation season. The mean value of ≤1 egg per litre should be obtained for at least 90% of samples in order to allow for the occasional high-value sample (i.e. with >10 eggs per litre). With some wastewater treatment processes (e.g. waste stabilization ponds), the hydraulic retention time can be used as a surrogate to assure compliance with ≤1 egg per litre.

[d] No crops to be picked up from the soil.

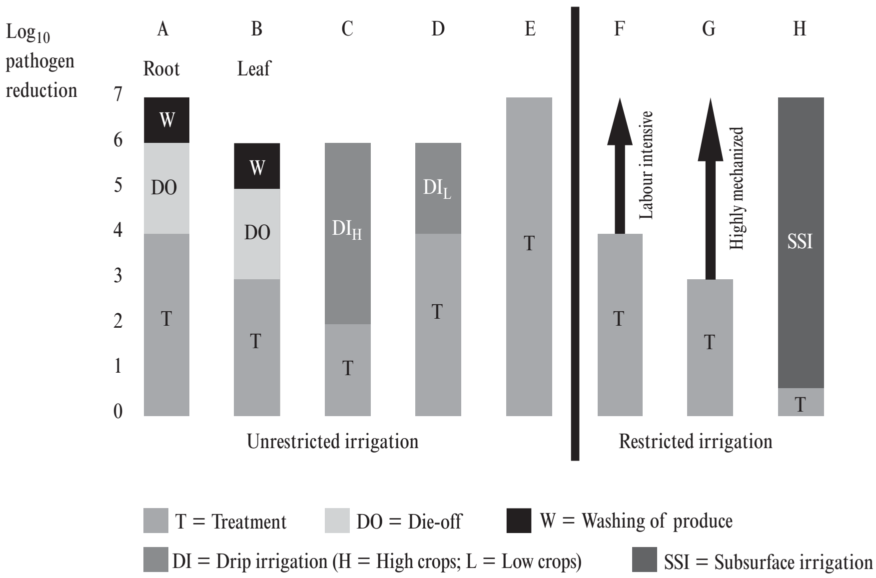

Figure 1

Examples of options for the reduction of viral, bacterial and protozoan pathogens by different combinations of health protection measures that achieve the health-based target of $\leq 10^{-6}$ DALYs per person per year

Table 4. Maximum tolerable soil concentrations of various toxic chemicals based on human health protection

Chemical	Soil concentration (mg/kg)
Element	
Antimony	36
Arsenic	8
Barium[a]	302
Beryllium[a]	0.2
Boron[a]	1.7
Cadmium	4
Fluorine	635
Lead	84
Mercury	7
Molybdenum[a]	0.6
Nickel	107
Selenium	6
Silver	3
Thallium[a]	0.3
Vanadium[a]	47
Organic compound	
Aldrin	0.48
Benzene	0.14
Chlordane	3
Chlorobenzene	211
Chloroform	0.47
2,4-D	0.25
DDT	1.54
Dichlorobenzene	15
Dieldrin	0.17
Dioxins	0.000 12
Heptachlor	0.18
Hexachlorobenzene	1.40
Lindane	12
Methoxychlor	4.27
PCBs	0.89
PAHs (as benzo[*a*]pyrene)	16
Pentachlorophenol	14
Phthalate	13 733
Pyrene	41
Styrene	0.68
2,4,5-T	3.82
Tetrachloroethane	1.25
Tetrachloroethylene	0.54
Toluene	12
Toxaphene	0.0013
Trichloroethane	0.68

[a] The computed numerical limits for these elements are within the ranges that are typical for soils.

Table 4 presents maximum soil concentrations for different chemicals based on health risk assessment. Concentrations of chemicals that impact agricultural productivity are described in Annex 1.

Health protection measures

A variety of health protection measures can be used to reduce health risks to consumers, workers and their families and local communities.

Hazards associated with the consumption of wastewater-irrigated products include excreta-related pathogens and some toxic chemicals. The risk from infectious pathogens is significantly reduced if foods are eaten after thorough cooking. Cooking has little or no impact on the concentrations of toxic chemicals that might be present. The following health protection measures have an impact on product consumers:

- wastewater treatment;
- crop restriction;
- waste application techniques that minimize contamination (e.g. drip irrigation);
- withholding periods to allow pathogen die-off after the last wastewater application;
- hygienic practices at food markets and during food preparation;
- health and hygiene promotion;
- produce washing, disinfection and cooking;
- chemotherapy and immunization.

Wastewater use activities may lead to the exposure of workers and their families to excreta-related diseases (including schistosomiasis), skin irritants and vector-borne diseases (in certain locations). Wastewater treatment is a control measure for excreta-related diseases, skin irritants and schistosomiasis but may not have much impact on vector-borne diseases. Other health protection measures for workers and their families include:

- use of personal protective equipment;
- access to safe drinking-water and sanitation facilities at farms;
- health and hygiene promotion;
- chemotherapy and immunization;
- disease vector and intermediate host control;
- reduced vector contact.

Local communities are at risk from the same hazards as workers, especially if they have access to wastewater-irrigated fields. If they do not have access to safe drinking-water, they may use contaminated irrigation water for drinking or for domestic purposes. Children may also play or swim in the contaminated water. Similarly, if wastewater irrigation activities result in increased vector breeding, then local communities may be affected by vector-borne diseases, even if they do not have direct access to the irrigated fields. To reduce health hazards, the following health protection measures for local communities may be used:

- wastewater treatment;
- restricted access to irrigated fields and hydraulic structures;
- access to safe recreational water, especially for adolescents;
- access to safe drinking-water and sanitation facilities in local communities;
- health and hygiene promotion;

- chemotherapy and immunization;
- disease vector and intermediate host control;
- reduced vector contact.

Monitoring and system assessment

Monitoring has three different purposes: validation, or proving that the system is capable of meeting its design requirements; operational monitoring, which provides information regarding the functioning of individual components of the health protection measures; and verification, which usually takes place at the end of the process to ensure that the system is achieving the specified targets.

The three functions of monitoring are each used for different purposes at different times. Validation is performed at the beginning when a new system is developed or when new processes are added and is used to test or prove that the system is capable of meeting the specified targets. Operational monitoring is used on a routine basis to indicate that processes are working as expected. Monitoring of this type relies on simple measurements that can be read quickly so that decisions can be made in time to remedy a problem. Verification is used to show that the end product (e.g. treated wastewater; crops) meets treatment targets (e.g. microbial quality specifications) and ultimately the health-based targets. Information from verification monitoring is collected periodically and thus would arrive too late to allow managers to make decisions to prevent a hazard break-through. However, verification monitoring can indicate trends over time (e.g. if the efficiency of a specific process was improving or decreasing).

The most effective means of consistently ensuring safety in the agricultural application of wastewater is through the use of a comprehensive risk assessment and risk management approach that encompasses all steps in the process from waste generation to treatment and use of wastewater to product use or consumption. This approach is captured in the Stockholm Framework. Three components of this approach are important for achieving the health-based targets: system assessment, identifying control measures and methods for monitoring them and developing a management plan.

Sociocultural aspects

Human behavioural patterns are a key determining factor in the transmission of excreta-related diseases. The social feasibility of changing certain behavioural patterns in order to introduce wastewater use schemes or to reduce disease transmission in existing schemes needs to be assessed on an individual project basis. Cultural beliefs vary so widely in different parts of the world that it is not possible to assume that any of the practices that have evolved in relation to wastewater use can be readily transferred elsewhere.

Closely associated with cultural beliefs is the public perception of wastewater use. Even when projects are technically well planned and all of the relevant health protection measures have been included, the project can fail if it does not account adequately for public perception.

Environmental aspects

Wastewater is an important source of water and nutrients for many farmers in arid and semi-arid climates. Sometimes it is the only water source available for agriculture. When wastewater use is well managed, it helps to recycle nutrients and water and therefore diminishes the cost of fertilizers or simply makes them accessible to farmers. Where wastewater treatment services are not provided, the use of wastewater in agriculture actually acts as a low-cost treatment method, taking advantage of the soil's capacity to naturally remove contamination. Therefore, the use of wastewater in irrigation helps to reduce downstream health and environmental impacts that would otherwise result if the wastewater were discharged directly into surface water bodies.

Nevertheless, wastewater use poses environmental risks. Possible effects and their relevance depend on each specific situation and how the wastewater is used. In many places, wastewater irrigation has arisen spontaneously and without planning — often the wastewater is untreated. In other situations, the use of wastewater in agriculture is strictly controlled. These practices will lead to different environmental impacts.

The properties of domestic wastewater and industrial wastewater differ. Generally, the use of domestic wastewater for irrigation poses less risk to the environment than the use of industrial wastewater, especially where industries use or produce highly toxic chemicals. Industrial discharges containing toxic chemicals are mixed with domestic wastewater in many countries, creating serious environmental problems and, where the wastewater is used for crop irrigation, endangering the health of the farmers and product consumers. Efforts should be made to reduce or eliminate practices that entail the mixing of domestic and industrial wastewater, particularly where wastewater is used for agriculture.

The use of wastewater in agriculture has the potential for both positive and negative environmental impacts. With careful planning and management, the use of wastewater in agriculture can be beneficial to the environment. Many of the environmental impacts (e.g. salinization of soil, contamination of water resources) can be reduced by good agricultural practices (as described in Annex 1).

Economic and financial considerations

Economic factors are especially important when the viability of a new scheme for the use of wastewater is being appraised, but even an economically worthwhile project can fail without careful financial planning.

Economic analysis and financial considerations are crucial for encouraging the safe use of wastewater. Economic analysis seeks to establish the economic feasibility of a project and enables comparisons between different options. The cost transfers to other sectors (e.g. the health and environmental impacts on downstream communities) also need to be included in a cost analysis. This can be facilitated by the use of multiple objective decision-making processes.

Financial planning looks at how the project is to be paid for. In establishing the financial feasibility of a project, it is important to determine the sources of revenues and clarify who will pay for what. The possibility to profitably sell products grown with wastewater or to sell the treated wastewater also needs analysis.

Policy aspects

The safe management of wastewater in agriculture is facilitated by appropriate policies, legislation, institutional frameworks and regulations at the international, national and local levels. In many countries where wastewater use in agriculture takes place, these frameworks are lacking.

Policy is the set of procedures, rules and allocation mechanisms that provide the basis for programmes and services. Policies set priorities, and associated strategies allocate resources for their implementation. Policies are implemented through four types of instruments: laws and regulations, economic measures, information and education programmes and assignments of rights and responsibilities for providing services.

In developing a national policy framework to facilitate safe wastewater use in agriculture, it is important to define the objectives of the policy, assess the current policy environment and develop a national approach. National approaches for safe wastewater use practices based on the WHO Guidelines will protect public health the most when they are integrated into comprehensive public health programmes that include other sanitary measures, such as health and hygiene promotion and improving access to safe drinking-water and adequate sanitation. Other complementary programmes, such as chemotherapy campaigns, should be accompanied by health promotion/education to change behaviours that would otherwise lead to reinfection (e.g. with intestinal helminths and other pathogens).

National approaches need to be adapted to the local sociocultural, environmental and economic circumstances, but they should be aimed at progressive improvement of public health. Interventions that address the greatest local health threats first should be given the highest priority. As resources and new data become available, additional health protection measures can be introduced.

The use of wastewater in agriculture can have one or more of several objectives. Defining these objectives is important for developing a national policy framework. The right policies can facilitate the safe use of wastewater in agriculture. Current policies often already exist that impact these activities, both negatively and positively. Conducting an assessment of current policies is often helpful for developing a new national policy or for revising existing policies. The assessment should take place at two levels: from the perspective of both a policy-maker and a project manager. Policy-makers will want to assess the national policies, legislation, institutional framework and regulations to ensure that they meet the national wastewater use objectives (e.g. maximize economic returns without endangering public health or the environment). Project coordinators will want to ensure that current and future waste use activities will be able to comply with all relevant national and local laws and regulations.

The main considerations are:

- *Policy:* Are there clear policies on the use of wastewater? Is wastewater use encouraged or discouraged?
- *Legislation:* Is the use of wastewater governed in legislation? What are the rights and responsibilities of different stakeholders? Does a defined jurisdiction exist on the use of wastewater?
- *Institutional framework:* Which ministry/agency, organizations, etc. have the authority to control the use of wastewater at the national level and at the district/community level? Are the responsibilities of different ministries/agencies clear? Is there one lead ministry, or are there multiple ministries/agencies with overlapping jurisdictions? Which ministry/agency is responsible for developing regulations? Which ministry/agency monitors compliance with regulations? Which ministry/agency enforces the regulations?
- *Regulations:* Do regulations exist? Are the current regulations adequate to meet wastewater use objectives (protect public health, prevent environmental damage, meet produce quality standards for domestic and international trade, preserve livelihoods, conserve water and nutrients, etc.)? Are the current regulations being implemented? Is regulatory compliance being enforced?

It is easier to make regulations than to enforce them. In drafting new regulations (or in choosing which existing ones to enforce), it is important to plan for the institutions, staff and resources necessary to ensure that the regulations are followed. It is important to ensure that the regulations are realistic and achievable in the context in which they are to be applied. It will often be advantageous to adopt a gradual approach or to test a new set of regulations by persuading a local administration to pass them as by-laws before they are extended to the rest of the country.

Planning and implementation

Planning and implementation of wastewater irrigation programmes require a comprehensive progressive approach that responds to the greatest health priorities first. Strategies for developing national programmes should include elements on communication to stakeholders, interaction with stakeholders and the collection and use of data.

Additionally, planning for projects at a local level requires an assessment of several important underlying factors. The sustainability of wastewater use in agriculture relies on the assessment and understanding of eight important criteria: health, economic feasibility, social impact and public perception, financial feasibility, environmental impact, market feasibility, institutional feasibility and technical feasibility.