GUIDELINES FOR THE SAFE USE OF WASTEWATER, EXCRETA AND GREYWATER

Volume 3
Wastewater and excreta use in aquaculture

World Health Organization

WHO Library Cataloguing-in-Publication Data

WHO guidelines for the safe use of wastewater, excreta and greywater / World Health Organization.

v. 1. Policy and regulatory aspects – v. 2. Wastewater use in agriculture – v. 3. Wastewater and excreta use in aquaculture – v. 4. Excreta and greywater use in agriculture.

1. Water supply. 2. Water supply - legislation. 3. Agriculture. 4. Aquaculture. 5. Sewage. 6. Wastewater treatment plants. 7. Guidelines. I. World Health Organization. II. Title: Safe use of wastewater, excreta and greywater. III. Title: Policy and regulatory aspects. IV. Title: Wastewater use in agriculture. V. Title: Wastewater and excreta use in aquaculture. VI. Title: Excreta and greywater use in agriculture.

ISBN 92 4 154686 7 (set) (NLM classification: WA 675)
ISBN 92 4 154682 4 (v. 1)
ISBN 92 4 154683 2 (v. 2)
ISBN 92 4 154684 0 (v. 3)
ISBN 92 4 154685 9 (v. 4)

Printed in France.

CONTENTS

LIST OF ACRONYMS AND ABBREVIATIONS

BOD	biochemical oxygen demand
CFU	colony forming unit
CI	confidence interval
DALY	disability adjusted life year
DDT	dichlorodiphenyltrichloroethane
FAO	Food and Agriculture Organization of the United Nations
HACCP	hazard analysis and critical control points
HIA	health impact assessment
MDG	Millennium Development Goal
MPN	most probable number
OR	odds ratio
PCB	polychlorinated biphenyl
PRISM	Project in Agriculture, Rural Industry Science and Medicine (Bangladesh)
QMRA	quantitative microbial risk assessment
TDE	1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethane
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 and excreta in aquaculture are "Goal 1: Eliminate extreme poverty and hunger," as fish raised in waste-fed systems is a main source of protein in many parts of Asia; and "Goal 7: Ensure environmental sustainability." The use of wastewater and excreta in aquaculture 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 and excreta use in aquaculture is increasingly considered a method combining water and nutrient recycling, increased household food security and improved nutrition for poor households. Recent interest in wastewater and excreta use in aquaculture 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 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 aquaculture be put into the context of the overall burden 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 and excreta in aquaculture, 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 — especially with respect to foodborne trematode parasites.

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 and excreta in aquaculture 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 expanded sections on foodborne trematode parasites;
- 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.

ACKNOWLEDGEMENTS

The World Health Organization (WHO) wishes to express its appreciation to all those whose efforts made possible the production of the *Guidelines for the safe use of wastewater, excreta and greywater, Volume 3: Wastewater and excreta use in aquaculture*, in particular Dr Jamie Bartram (Coordinator, Water, Sanitation and Health, WHO, Geneva) and Mr Richard Carr (Technical Officer, Water, Sanitation and Health, WHO, Geneva), who coordinated the development of the Guidelines.

An international group of experts provided material and participated in the development and review of Volume 3 of the *Guidelines for the safe use of wastewater, excreta and greywater*. Many individuals contributed to each chapter, directly and through associated activities. The contributions[1] of the following to the development of these Guidelines are appreciated:

Mohammad Abed Aziz Al-Rasheed, Ministry of Health, Amman, Jordan
Saqer Al Salem, WHO Regional Centre for Environmental Health Activities, Amman, Jordan
John Anderson, New South Wales Department of Public Works & Services, Sydney, Australia
Andreas Angelakis, National Foundation for Agricultural Research, Institute of Iraklio, Iraklio, Greece
Takashi Asano,* University of California at Davis, Davis, California, USA
Nicholas Ashbolt,* University of New South Wales, Sydney, Australia
Lorimer Mark Austin, Council for Scientific and Industrial Research, Pretoria, South Africa
Ali Akbar Azimi, University of Tehran, Tehran, Iran
Javed Aziz, University of Engineering & Technology, Lahore, Pakistan
Akiça Bahri, National Research Institute for Agricultural Engineering, Water, and Forestry, Ariana, Tunisia
Mohamed Bazza, Food and Agriculture Organization of the United Nations, Cairo, Egypt
Ursula Blumenthal,* London School of Hygiene and Tropical Medicine, London, United Kingdom
Jean Bontoux, University of Montpellier, Montpellier, France
Laurent Bontoux, European Commission, Brussels, Belgium
Robert Bos, WHO, Geneva, Switzerland
François Brissaud, University of Montpellier II, Montpellier, France
Stephanie Buechler,* International Water Management Institute, Pantancheru, Andhra Pradesh, India
Paulina Cervantes-Olivier, French Environmental Health Agency, Maisons Alfort, France
Andrew Chang,* University of California at Riverside, Riverside, California, USA
Guéladio Cissé, Swiss Centre for Scientific Research, Abidjan, Côte d'Ivoire
Joseph Cotruvo, J. Cotruvo & Associates, Washington, DC, USA
Brian Crathorne, RWE Thames Water, Reading, United Kingdom
David Cunliffe, Environmental Health Service, Adelaide, Australia

[1] An asterisk (*) indicates the preparation of substantial text inputs.

Anders Dalsgaard,* Royal Veterinary and Agricultural University, Frederiksberg, Denmark
Gayathri Devi,* International Water Management Institute, Pantancheru, Andhra Pradesh, India
Pay Drechsel, International Water Management Institute, Accra, Ghana
Bruce Durham, Veolia Water Systems, Derbyshire, United Kingdom
Peter Edwards,* Asian Institute of Technology, Klong Luang, Thailand
Dirk Engels, WHO, Geneva, Switzerland
Badri Fattel, The Hebrew University Jerusalem, Jerusalem, Israel
John Fawell, independent consultant, Flackwell Heath, United Kingdom
Pinchas Fine, Institute of Soil, Water and Environmental Sciences, Bet-Dagan, Israel
Jay Fleisher, Nova Southeastern University, Fort Lauderdale, Florida, USA
Yanfen Fu, National Centre for Rural Water Supply Technical Guidance, Beijing, People's Republic of China
Yaya Ganou, Ministry of Health, Ouagadougou, Burkina Faso
Alan Godfrey, United Utilities Water, Warrington, United Kingdom
Maria Isabel Gonzalez Gonzalez, National Institute of Hygiene, Epidemiology and Microbiology, Havana, Cuba
Cagatay Guler, Hacettepe University, Ankara, Turkey
Gary Hartz, Director, Indian Health Service, Rockville, Maryland, USA
Paul Heaton, Power and Water Corporation, Darwin, Northern Territory, Australia
Ivanildo Hespanhol, University of Sao Paolo, Sao Paolo, Brazil
Jose Hueb, WHO, Geneva, Switzerland
Petter Jenssen,* University of Life Sciences, Aas, Norway
Blanca Jiménez,* National Autonomous University of Mexico, Mexico City, Mexico
Jean-François Junger, European Commission, Brussels, Belgium
Ioannis K. Kalavrouziotis, University of Ioannina, Agrinio, Greece
Peter Kolsky, World Bank, Washington, DC, USA
Doulaye Koné,* Swiss Federal Institute for Environmental Science and Technology (EAWAG) / Department of Water and Sanitation in Developing Countries (SANDEC), Duebendorf, Switzerland
Sasha Koo-Oshima, Food and Agriculture Organization of the United Nations, Rome, Italy
Alice Sipiyian Lakati, Department of Environmental Health, Nairobi, Kenya
Valentina Lazarova, ONDEO Services, Le Pecq, France
Pascal Magoarou, European Commission, Brussels, Belgium
Duncan Mara,* University of Leeds, Leeds, United Kingdom
Gerardo Mogol, Department of Health, Manila, Philippines
Gerald Moy, WHO, Geneva, Switzerland
Rafael Mujeriego, Technical University of Catalonia, Barcelona, Spain
Constantino Nurizzo, Politecnico di Milano, Milan, Italy
Gideon Oron, Ben-Gurion University of the Negev, Kiryat Sde-Boker, Israel
Mohamed Ouahdi, Ministry of Health and Population, Algiers, Algeria
Albert Page,* University of California at Riverside, Riverside, California, USA
Genxing Pan,* Nanjing Agricultural University, Nanjing, People's Republic of China
Nikolaos Paranychianakis, National Foundation for Agricultural Research, Institute of Iraklio, Iraklio, Greece

Martin Parkes, North China College of Water Conservancy and Hydropower, Zhengzhou, Henan, People's Republic of China
Anne Peasey,* Imperial College (formerly with London School of Hygiene and Tropical Medicine), London, United Kingdom
Susan Petterson,* University of New South Wales, Sydney, Australia
Liqa Raschid-Sally, International Water Management Institute, Accra, Ghana
Kerstin Röske, Institute for Medicine, Microbiology and Hygiene, Dresden, Germany
Lorenzo Savioli, WHO, Geneva, Switzerland
Caroline Schönning, Swedish Institute for Infectious Disease Control, Stockholm, Sweden
Janine Schwartzbrod, University of Nancy, Nancy, France
Louis Schwartzbrod, University of Nancy, Nancy, France
Jørgen Schlundt, WHO, Geneva, Switzerland
Natalia Shapirova, Ministry of Health, Tashkent, Uzbekistan
Hillel Shuval, The Hebrew University of Jerusalem, Jerusalem, Israel
Thor-Axel Stenström,* Swedish Institute for Infectious Disease Control, Stockholm, Sweden
Martin Strauss,* Swiss Federal Institute for Environmental Science and Technology (EAWAG) / Department of Water and Sanitation in Developing Countries (SANDEC), Duebendorf, Switzerland
Ted Thairs, EUREAU Working Group on Wastewater Reuse (former Secretary), Herefordshire, United Kingdom
Terrence Thompson, WHO Regional Office for the Western Pacific, Manila, Philippines
Sarah Tibatemwa, National Water & Sewerage Corporation, Kampala, Uganda
Andrea Tilche, European Commission, Brussels, Belgium
Mwakio P. Tole, Kenyatta University, Nairobi, Kenya
Francisco Torrella, University of Murcia, Murcia, Spain
Hajime Toyofuku, WHO, Geneva, Switzerland
Wim van der Hoek, independent consultant, Landsmeer, The Netherlands
Johan Verink, ICY Waste Water & Energy, Hanover, Germany
Marcos von Sperling, Federal University of Minas Gerais, Belo Horizonte, Brazil
Christine Werner, Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Eschborn, Germany
Steve White, RWE Thames Water, Reading, United Kingdom

Thanks are also due to Marla Sheffer for editing the complete text of the Guidelines, Windy Prohom and Colette Desigaud for their assistance in project administration and Peter Gosling, who acted as the rapporteur for the Final Review Meeting for the Finalization of the Third Edition of the WHO Guidelines for the Safe Use of Wastewater, Excreta and Greywater in Geneva.

The preparation of these Guidelines would not have been possible without the generous support of the United Kingdom Department for International Development, the Swedish International Development Cooperation Agency (Sida), partly through the Stockholm Environment Institute, the Norwegian Ministry of Foreign Affairs, the German Gesellschaft für Technische Zuzammenarbeit GmbH and the Dutch Ministry of Foreign Affairs (DGIS) through WASTE (Advisors on Urban Environment and Development).

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 waste-fed aquaculture on the health of product consumers, workers and their families and local communities. Health hazards are identified for each group at risk, 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 is to ensure that waste-fed aquacultural activities are made as safe as possible so that the nutritional and household food security benefits can be shared widely in affected communities. Thus, the adverse health impacts of waste-fed aquaculture 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 waste-fed aquaculture 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 waste-fed aquaculture, as well as providing a framework for national and local decision-making. The information provided is applicable to intentional waste-fed aquacultural practices but also should be relevant to the unintentional use of faecally contaminated waters for aquaculture.

The Guidelines provide an integrated preventive management framework for safety applied from the point of waste 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 environmental and public health scientists, educators, researchers, engineers, policy-makers and those responsible for developing standards and regulations.

Introduction

A number of forces are both negatively and positively impacting the development of waste-fed aquacultural production. Many of the areas where waste-fed aquaculture has been traditionally practised are shrinking due to urbanization, increasing surface water pollution and the development of high-input aquaculture to produce cash crops. Most of the traditional waste-fed aquacultural production has occurred in parts of Asia. Although intentional waste-fed aquaculture is in decline, the unintentional use of contaminated water in aquaculture may be increasing in some areas.

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. Overall, there are limited data on the health impacts associated with waste-fed aquacultural practices. The evidence suggests that pathogens are often present at significant levels in untreated wastewater and excreta; pathogens can survive long enough in the environment to be transmitted to humans; and waste-fed aquaculture-associated disease transmission can occur.

Foodborne trematode parasites, where they occur, pose significant health risks to consumers of raw or inadequately cooked fish or plants. Priority should be given to implementing control measures against the transmission of foodborne trematode infections, where relevant. Excreta-related pathogens pose health risks to product consumers and people who may have contact with the contaminated water. For product consumers, much of the health risk may be associated with poor fish cleaning practices that lead to cross-contamination between the gut contents and the edible flesh. Thus, improving market hygiene and fish processing/cleaning is an important health protection intervention.

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 the disability adjusted life year or DALY (e.g. 10^{-6} DALY), or it can be based on an appropriate health outcome, such as the prevention of the transmission of foodborne trematode infection associated with waste-fed aquacultural 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 waste-fed aquacultural system. Health-based targets for different waste-fed aquacultural hazards are presented in Table 1.

Table 1. Health-based targets for waste-fed aquaculture

Exposed group	Hazard	Health-based target[a]	Health protection measure
Consumers, workers and local communities	Excreta-related pathogens	10^{-6} DALY	Wastewater treatment
			Excreta treatment
			Health and hygiene promotion
			Chemotherapy and immunization
Consumers	Excreta-related pathogens	10^{-6} DALY	Produce restriction
			Waste application/timing
	Foodborne trematodes	Absence of trematode infections	Depuration
			Food handling and preparation
	Chemicals	Tolerable daily intakes as specified by the Codex Alimentarius Commission	Produce washing/disinfection
			Cooking foods
Workers and local communities	Excreta-related pathogens	10^{-6} DALY	Access control
	Skin irritants	Absence of skin disease	Use of personal protective equipment
			Disease vector control
	Schistosomes	Absence of schistosomiasis	Intermediate host control
	Vector-borne pathogens	Absence of vector-borne disease	Access to safe drinking-water and sanitation at aquacultural facilities and in local communities
			Reduced vector contact (insecticide-treated nets, repellents)

[a]Absence of disease associated with waste-fed aquaculture exposures.

Health protection measures

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

Hazards associated with the consumption of waste-fed aquacultural products include excreta-related pathogens, foodborne trematodes and some toxic chemicals. The risk from infectious diseases 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. Special considerations for managing trematode parasites (including *Schistosoma* spp.) may be required where they are present. The following health protection measures impact product consumers:

- wastewater and excreta treatment;
- produce restriction;
- waste application withholding periods;
- control of trematode intermediate hosts;
- depuration;
- hygienic food handling and preparation;
- post-harvest processing;
- health and hygiene promotion;
- produce washing, disinfection and cooking;
- produce washing, disinfection and cooking;
- chemotherapy and immunization.

Workers and their families may be exposed to excreta-related diseases, skin irritants, schistosomiasis and vector-borne diseases through waste-fed aquacultural activities or contact with the hazards. Wastewater treatment and excreta treatment are control measures for excreta-related diseases, skin irritants and schistosomiasis but may not have much impact on vector-borne diseases. Other health protection measures include:

- use of personal protective equipment;
- access to safe drinking-water and sanitation facilities at aquacultural facilities;
- 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 waste-fed ponds. If they do not have access to safe drinking-water, they may use the contaminated water for drinking or for domestic purposes, such as washing clothes, dishes and themselves. Children may also play or swim in the contaminated water. Similarly, if waste-fed aquacultural activities result in increased vector breeding, then local communities can be affected by vector-borne diseases, even if they do not have access to the waste-fed aquacultural facilities. To reduce health hazards, the following health protection measures may be used:

- wastewater and excreta treatment;
- restricted access to aquacultural facilities;
- access to safe drinking-water and sanitation facilities at aquacultural facilities;
- 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 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/excreta/pond water; fish or plants) meets treatment targets (e.g. microbial reduction targets) 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. whether the efficiency of a specific process is improving or decreasing).

The most effective means of consistently ensuring safety in waste-fed aquaculture is through the use of a comprehensive risk assessment and risk management approach that encompasses all steps in waste-fed aquaculture, from the generation and use of wastewater and excreta to the product consumer. 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, environmental and economic 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 excreta or wastewater use schemes or to reduce disease transmission in existing schemes can be assessed only with a prior understanding of the cultural values attached to practices that appear to be social preferences, yet which facilitate disease transmission. Closely associated with cultural beliefs is the public perception of wastewater and excreta use.

Excreta and wastewater use schemes, if properly planned and managed, can have a positive environmental impact, as well as produce fish and plants. Environmental improvement may be related to:

- avoidance of surface water pollution;
- conservation or more rational use of freshwater resources, especially in arid and semi-arid areas: fresh water for urban demand, wastewater for aquacultural use;
- reduction in risks of flooding in urban areas, as wastewater-fed canals, ponds and lakes act as a "buffer" during heavy rains;
- reduced requirements for artificial fertilizers, with a concomitant reduction in energy expenditure and industrial pollution elsewhere.

The primary negative environmental impacts are often related to contamination of surface waters or groundwaters in proximity to waste-fed aquacultural facilities. Other impacts relate to general aquacultural practices (e.g. the introduction of non-indigenous species or destruction of mangroves) and are not specifically related to waste-fed aquaculture.

Economic factors are especially important when the viability of a new scheme for the use of wastewater and excreta is being appraised, but even an economically worthwhile project can fail without careful financial planning. Economic appraisal considers whether a project is worthwhile, whereas financial planning looks at how projects are to be paid for. Improvements to existing practices must be paid for in some way and therefore also require financial planning.

Policy aspects

The safe management of waste-fed aquacultural practices is facilitated by appropriate policies, legislation, institutional frameworks and regulations at the international, national and local levels. In many countries where waste-fed aquaculture takes place, these frameworks are lacking.

Policy is the set of procedures, rules, decision-making criteria 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 waste-fed aquaculture, it is important to define the objectives of the policy, assess the current policy environment and develop a national approach. National approaches for safe waste-fed aquacultural 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 with foodborne trematodes or intestinal helminths.

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.

Planning and implementation

Planning and implementation of waste-fed aquacultural 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 waste-fed aquaculture 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.