IRCWD NEWS

International Reference Centre for Waste Disposal
WHO Collaboration Centre for Waste Disposal

Ueberlandstrasse 133, CH-8600 Duebendorf/Switzerland

No. 24/25

May 1988

Human Wastes: Health Aspects of their Use in Agriculture and Aquaculture

In view of important developments in the field of human waste use in agriculture and aquaculture in the last few years, IRCWD decided to devote this IRCWD News issue entirely to this subject.

A number of international agencies, in recognising the role of human wastes as an important resource and, at the same time, giving due consideration to health risk minimisation and public health protection, set out several years ago to assess the actual extent and patterns of use practice, to assess the state-of-knowledge regarding health risks and to produce guidelines for decision makers, planners, administrators, and field workers for the safe use of human wastes.

The International Reference Centre for Waste Disposal (IRCWD) and the London School of Hygiene and Tropical Medicine (LSHTM) have, in close collaboration with WHO, reviewed the sociocultural, microbiological and epidemiological aspects of nightsoil use (see IRCWD News No. 23). At the same time, the World Bank and UNDP commissioned a team to assess the existing knowledge regarding health aspects of wastewater use ("Wastewater Irrigation in Developing Countries" by Shuval et al., World Bank, 1986). In July 1985 these reviews were discussed at a meeting in Engelberg, Switzerland. Based on these reviews, tentative guidelines for the microbiological quality of wastewater and excreta were formulated and suggestions were made for further research in this field ("The Engelberg Report" in IRCWD News No. 23, December 1985). In the same year, WHO and UNEP commissioned a consultant to produce "Guidelines for the Safe Use of Wastewater and Excreta in Agriculture and Aquaculture". The document, which is based on the developments made in recent years, both in field practice and through research, will appear in 1988. Its draft version was reviewed in Adelboden, Switzerland, in June 1987 by representatives of WHO/UNEP, World Bank/UNDP, FAO, LSHTM, IDRC, and IRCWD together with persons involved in reuse practices in Latin America, North Africa and Asia. The document is intended to provide information to decision-makers, planners and field workers in government and non-government institutions on potential and actual health risks associated with inadequate use of human waste, and to provide guidance in selecting measures to protect the health of agricultural workers and consumers. An executive summary can be found on page 4 of this IRCWD News issue.

In the light of the progress made in recent years regarding the understanding of epidemiological, technical and institutional aspects of human waste use, WHO decided to revise its official guidelines on the safe use of effluents published in 1973 under WHO Technical Report Series No. 517. A new guideline document was prepared by a working group which met in Geneva in November 1987. This document, which will also be published in due time, is summarised on page 20.

1. Examples of Wastewater and Excreta Use Practices in Agriculture and Aquaculture

By **Martin Strauss,** IRCWD/EAWAG, Duebendorf, Switzerland

Major features of a number of excreta and wastewater use practices have been included as far as available to the author. The list is not exhaustive, however, it presents a range of use practices as regards size of schemes, type of waste used, crops produced, and institutional settings.

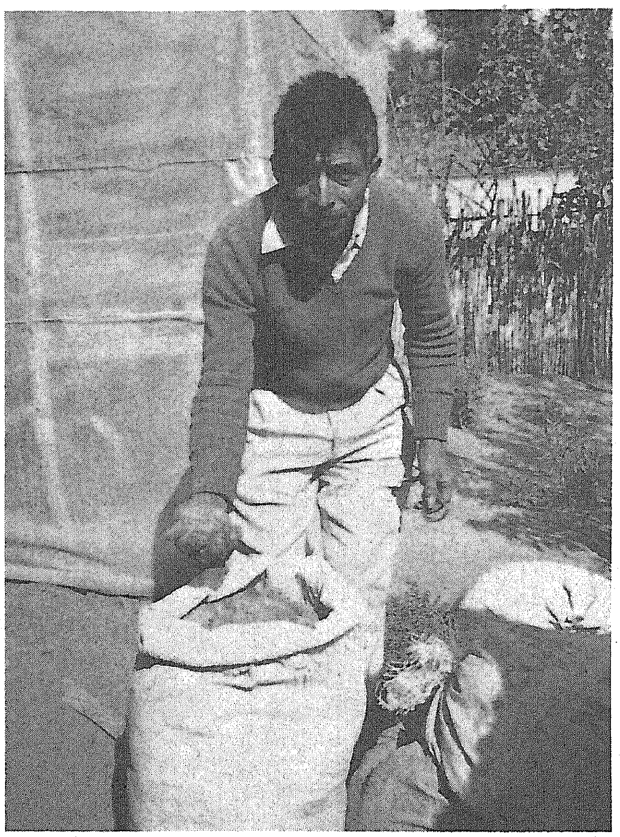
EXAMPLES OF CURRENT WASTEWATER AND EXCRETA USE PRACTICES

Continent/Country	Town or area	Waste used	Crops irrigated/produced	Approx. area irrigated [ha]	Organisational, institutional
THE AMERICAS					
. Argentina	Mendoza (city)	Primary effluent (at times diluted) and dried STP-sludge	Lettuce, onions, tomatoes, artichokes	2000	Provincial government responsible for sewerage, sewage treatment and main irrigation structures; user associations issuing water rights and responsible for secondary irrigation structures; no crop restrictions
. Chile	Santiago (Zanjón de la Aguada)	70 % of city's wastewater (untreated or at times diluted by stormwater runoff)	Lettuce, cabbage, celery, cereals, grapes	6000	Government institutions (Public Works, Health, Irrigation), responsible for planning, implementation, control of sewerage and main sewage distribution; land owners entitled with water rights; users associations responsible for secondary distribution; crop restrictions partly effective
. Peru	(country as a whole)	Wastewater (treated or part. treated or untreated)	Misc. edible and non-edible crops	5-6000	Government (Agriculture, Health) issues permits to use the wastewater
	San Martin de Porras (Lima)	Wastewater (untreated)	Tomatoes, radish, spinach fodder and non-edible crops	1500-2000	Not organised, but occurs due to lack of fresh water
	Ica (Cachiche)	Primary (facult.) pond effluent	Cotton, maize, grapes	400	Crop restrictions effective
. Guatemala	Rural areas	Stored excreta from dry, double-vault latrines	Maize, misc. vegetables		Farming families
. Mexico	Mezquital Valley (State of Hidalgo), Rural Dev. District 063	Wastewater from Mexico City (untreated or diluted or impounded)	Maize, wheat, oats, green tomatoes, chillies, fodder	58'000	Ministry of Agriculture and Water Resources, distributing wastewater, issuing permits to farmers and enforcing crop restrictions
	Mexico City	Secondary effluent	Parks and green belts		Department of the Federal District responsible for sewage collection, treatment and use
. U.S.A., California	Bakersfield	Wastewater: effluent from aerated lagoons	Barley, field corn, cotton, pasture	2000	Regulatory agency: Regional Water Quality Control Boards;
	Irvine	Wastewater: effluent from tertiary treatment plant (includes filtration and chlorination)	Tomatoes, chillies, asparagus, broccoli, cauliflower, sweet corn, citrus orchards	> 5000	Contractual agreements between municipalities and effluent users; health criteria enforced by state health department

EUROPE					
. Federal Republic of Germany	Braunschweig	Wastewater (mixed 90% sec. effluent + 10% raw) & STP-sludge	Cereals, sugar beets, potatoes	2800	Wastewater utilization association embracing the municipality and 440 farmers; cultivation of vegetables and fruits prohibited; irrigation ceases 3 weeks before harvest
. United Kingdom	Greater London	Lagooned, digested STP-sludge	Field and horticultural crops	($3x10^6$ t of sludge/a at 6-10% solids)	Metropolitan Public Health Division (Thames Water Authority) responsible for wastewater and sludge management
NORTHERN AFRICA & WESTERN ASIA					
. Tunisia	Tunis-Soukra	Wastewater (secondary effluent)	Citrus trees	600	Wastewater collection and treatment under responsibility of the national sanitation authority; Ministry of Agriculture responsible for distribution
. Jordan	Zarqa river/ King Talal Dam basin	River water consisting mainly of treated sewage	Trees, industrial crops, vegetables eaten cooked, vegetables eaten raw, depending on crop restriction	500	Various degrees of crop restrictions depending on distance downstream from effluent discharges (quota allocation system handled by Min. of Agriculture; monitoring by Min. of Health)
. Kuwait		Wastewater (tertiary treatment plant effluent)	Fruit trees, fodder crops, maize, wheat, vegetables (raw eaten and eaten cooked); forestry	1000 - 2000 (estimated on basis of installed irrigation pump capacity)	Agricultural use is on enclosed farm complexes (whether state-owned or private is not known)
. Saudi Arabia	Riyadh-Dirab	Wastewater (tertiary treatment plant effluent)	Wheat, fodder crops	2500	Distribution by Min. of Agriculture to individual farmers; flow metering at branch-off to farmer's plot; crop restrictions effective
	Riyadh-Dariyah	- " -	Date palms, lemon trees, fodder crops	800	
SOUTH-EAST ASIA					
. China	(Country as a whole)	Excreta (untreated or stored or co-composted with animal manure and crop residues)	Reportedly, up to 70% of the excreta produced in rural areas and large quantitites of urban nightsoil are used as basic soil conditioner and fertilizer in agriculture. Application is usually by ploughing or harrowing it into the soil prior to planting. Assumingly, use is not restricted to certain crops, and occurs both on the individual farmer's family and on a communal basis		
. India	(Country as a whole)	Wastewater (untreated, diluted; partially treated)	Paddy rice, maize, wheat, sorghum, vegetables, fodder crops	> 70,000	E.g. Kanpur (U.P.): Municipal Corporation and farmers' association responsible for wastewater distribution; fees collected by Corporation's operators
	Calcutta	Wastewater ponds	Fish (Carp species, Tilapia, catfish)	3000	Ponds owned by "landlords", Calcutta Municipality and cooperatives; 4000 fishing families; seasonal fishing work force
. Indonesia	Java Highlands	Excreta fed "domestic" ponds	Fish (Carp and Tilapia) and water vegetables	common	Family-owned ponds (average size: 200 m^2); commercial sale of fish as well as consumption by owner families

2. Guidelines for the Safe Use of Wastewater and Excreta in Agriculture and Aquaculture: Methods for Public Health Protection

Executive summary of a forthcoming WHO/UNEP publication written by **Duncan Mara**,
University of Leeds, Leeds LS2 9JT, England, and **Sandy Cairncross**,
London School of Hygiene and Tropical Medicine, Keppel Street, London WC1E 7HT, England



Photograph 1: Guatemala: The use of double-vault latrines allows the production of about 500 kg of valuable fertilizer/soil conditioner per year by a family of 6–7 persons (Photos 1–5 + 7 by M. Strauss)

2.1 Introduction

Objectives

The overall objective of the Guidelines is to encourage the safe use of wastewater and excreta in agriculture and aquaculture, in such a manner as to protect the health of both the workers involved and the public at large. In the context of the Guidelines "wastewater" refers to domestic sewage and municipal wastewaters which do not contain substantial quantities of industrial effluent. "Excreta" refers not only to nightsoil but also to excreta-derived products such as sludge and septage. Health protection needs will generally require that these wastes be used after some treatment to remove pathogenic organisms. Consideration is also given to other methods of health protection: for example, crop restriction, appropriate waste application techniques and human exposure control.

The Guidelines are addressed primarily to senior professionals in the various sectors relevant to waste reuse. These include planning, public health, sanitary engineering, water resources, and agriculture and fisheries. The guidance given is aimed at the prevention of communicable disease transmission, while optimising resource conservation and recycling. Thus emphasis is directed towards controlling microbiological contamination, rather than the avoidance of health hazards due to chemical pollutants, since these are of only minor importance in the reuse of domestic wastes and are in any case adequately covered in other publications. Similarly, purely agricultural aspects are only considered insofar as they are relevant to health protection.

Recent advances in epidemiology have shown that past standards for hygiene in wastes reuse, which were based solely on potential pathogen survival, are stricter than is necesary to avoid health risks. A meeting of sanitary engineers, epidemiologists and social scientists convened by the World Health Organization, the World Bank and the International Reference Centre for Waste Disposal and held in Engelberg, Switzerland, in 1985, proposed a more realistic approach to the use of treated wastewater and excreta based on the best available epidemiological evidence. The recommendations of the Engelberg Report have formed the basis for the general approach to public health protection adopted in the Guidelines.

Scope

Sections 2.2 and 2.3 of the Guidelines provide an overview of the history and benefits of wastes reuse, together with some examples of existing practices in various parts of the world. An introduction to public health aspects, including the practical implications of recent epidemiological advances, is given in Section 2.4, and sociocultural factors are considered in Section 2.5. Environmental protection and enhancement through wastes reuse are discussed in Section 2.6.

A comprehensive review of the feasible and appropriate control measures for public health protection is given in Section 2.7. The institutional, legal and financial aspects of project planning an implementation are discussed in Section 2.8, having regard to the various steps necessary to ensure that human wastes are used in agriculture and aquaculture to their maximum advantage without endangering public health.

2.2 Human Wastes as a Resource

Human wastes are a widely used resource in many parts of the world and they are used for a variety of purposes (Table 1). The Guidelines concentrate on the following three practices, since these are the most common:

- the use of wastewater in agriculture for crop irrigation;
- the use of excreta, and excreta-derived products such as sewage sludges, septage and compost, in agriculture for soil fertilization and soil structure improvement; and
- the use of wastewater and excreta in aquaculture for fish production and the fertilization of edible aquatic macrophytes.

Wastewater use in agriculture

The irrigation of crops with wastewater became popular in the late nineteenth and early twentieth century with the introduction of the water-carriage system for domestic wastewater disposal. Sewage farms, as they were called, were introduced in Europe as early as 1865, in the Americas in 1871 and in Australia in 1893, but the practice became gradually less popular and almost completely disappeared soon after World War I. However, in the past two decades there has been a notable increase in the use of wastewater for crop irrigation, especially in the arid and seasonally arid areas of both industrialized and developing countries. This has occurred as a result of several factors:

- the increasing scarcity of alternative waters for irrigation, exacerbated by the increasing urban demand for potable water supplies, and the growing recognition by water resource planners of the importance and value of wastewater reuse;
- the high cost of artificial fertilizers and the recognition of the value of the nutrients in wastewater, which significantly increase crop yield;
- the demonstration that health risks and soil damage are minimal if the necessary precautions are taken;
- the high cost of advanced wastewater treatment plants; and
- the sociocultural acceptance of the practice.

Table 1.
Examples of Human Wastes Reuse Practices

	Reuse Practice	Responsible Social Unit	Examples
1.	Soil fertilization with untreated stored nightsoil	Family or community	China, India, Japan, Korea, Taiwan, Thailand
2.	Nightsoil collected and composted for use in agriculture	Community or local authority	China, India
3.	Nightsoil fed to animals	Family	Africa, Melanesia
4.	Use of double-vault latrines	Family	Guatemala, Tanzania, Vietnam
5.	Biogas production	Family or community	China, India, Korea
6.	Fish pond fertilization with treated or untreatet nightsoil	Family or community	China, Indonesia, Korea, Malaysia, Taiwan
7.	Fish farming in stabilization ponds	Family or commercial farmer	India, Israel, Kenya
8.	Aquatic weed production in ponds	Family, community or local authority	S.E. Asia, Vietnam
9.	Agricultural application of wastewater	Local authority or commercial farmer	All continents
10.	Agricultural application of wastewater sludges	Local authority or commercial farmer	England, Kenya, United States
11.	Irrigation with stabilization pond effluents	Local authority or commercial farmer	India, Israel, Peru
12.	Algal production in stabilization ponds	Local authority	Israel, Japan, Mexico

Source: IRCWD Report 04/85

Wastewater is composed of 99.9 percent water and 0.1 percent suspended colloidal and dissolved solids – organic and inorganic compounds, including macronutrients such as nitrogen, phosphorus and potassium as well as essential micronutrients. Industrial effluents may add toxic compounds, but these are not present in any detrimental quantities in normal domestic or municipal wastewaters, and attention needs only to be paid to the boron sensitivity of the crop being irrigated. The application rate of wastewater to crops is calculated in the same way as for irrigation with freshwater, with due regard to evapotranspiration demand, leaching requirements, and salinity and sodicity control.

Excreta use in agriculture

The application of human excreta to the land to fertilise crops is an ancient practice, well-established in many countries of the Far East, where the fertility of the soil has been maintained by excreta fertilization for over four thousand years. It is the only agricultural use option in unsewered areas and, since in developing countries the majority of households are unsewered (and likely, at least in the foreseeable future, to remain so), emphasis should be directed towards the implementation of on-site sanitation systems that readily permit the safe reuse of the stored excreta – for example, alternating twin pit or pour-flush latrines and compost toilets.

Typically some 1.8 litres of excreta (faeces and urine) are produced per person per day, and this comprises about 350 grams of dry solids, including some 90 grams of organic matter and approximately 20 grams of nitrogen together with other nutrients, principally phosphorus and potassium. Excreta treatment is advantageous, not only in destroying the pathogenic microorganisms in the excreta, but also because it converts these nutrients to forms more readily used by crops and stabilizes the organic matter so that it is a better soil conditioner. Excreta and excreta-derived products are generally applied to the land prior to planting at annual rates of 5 – 30 tonnes per ha (these are not high rates: 10 tonnes per ha, for example, is only 1 kilogram per square metre).

Excreta and wastewater use in aquaculture

Aquaculture means "water-farming", just as agriculture means "field-farming", and it refers to the ancient practices of fish culture, notably carp and tilapia, and the growing of certain aquatic crops, such as water spinach, water chestnut, water calthrop, and lotus. The fertilization of aquaculture ponds with human wastes has been practised for thousands of years in the Far East, and today at least two thirds of the world yield of farmed fish is obtained from ponds fertilized with excreta and animal manure; such fish represent the cheapest source of animal protein. China is an important example of waste-based aquaculture: it produces 60 percent of the world's farmed fish in only 27 percent of the world's area of fishponds (2.25 million tonnes per year from 7000 km² of ponds). The mean yield in Chinese fishponds is 3200 kg per ha per year, but in well-managed intensive polyculture ponds the yield can be up to 7000 kg per ha per year.

Fish can also be successfully grown in the maturation ponds of a series of waste stabilization ponds, and annual yields of up to 3000 kg per ha have been obtained. The sale of the harvested fish can be used to pay for the improved operation and maintenance of municipal sewerage systems.

2.3 Examples of Human Waste Reuse

There are many examples of human wastes reuse, and the few described in the Guidelines were chosen as they represent a wide range of locations and sociocultural settings, scales of operation, treatment processes, application techniques, and crops harvested. The Guidelines give examples of human wastes reuse in the following countries:

Wastewater use in agriculture

- Australia
- Federal Republic of Germany
- India
- Mexico
- Tunisia

Excreta use in agriculture

- People's Republic of China
- Guatemala
- India
- United States of America

Wastewater and excreta use in aquaculture

- India
- Indonesia

2.4 Public Health Aspects

Health risks

In developing countries excreta-related diseases are very common, and excreta and wastewater contain correspondingly high concentrations of excreted pathogens – the bacteria, viruses, protozoa, and the helminths (worms) that cause disease in man. There are approximately thirty excreted infections of public health importance, and many of these are of specific importance in excreta and wastewater use schemes. However, the agricultural or aquacultural use of excreta and wastewater can only result in an ***actual*** risk to public health if ***all*** of the following occur:

(a) that ***either*** an effective dose of an excreted pathogen reaches the field or pond, ***or*** the pathogen multiplies in the field or pond to form an infective dose;
(b) that this infective dose reaches a human host;
(c) that this host becomes infected; and
(d) that this infection causes disease or further transmission.

If (d) does not occur, then (a), (b) and (c) can only pose ***potential*** risks to public health.

The sequence of events required for an actual health risk to be posed is summarised in Figure 1, together with the pathogen-host properties and interactions that influence each step in the sequence. If the sequence is broken at any point, then the potential risks cannot combine to constitute an actual risk. This is the rationale behind the various methods of public health protection discussed in Section 2.7.

It is now possible to design and implement schemes for human wastes reuse that do not pose any risk to public health, but this requires an understanding of the epidemiology of the excreted infections in relation to wastes reuse. In this way, adequate standards for the microbiological quality of excreta and wastewaters intended for reuse can be established, in order that public health can be properly protected.

The epidemiological evidence

The actual public health importance of an excreta or wastewater use practice can only be assessed by an epidemiological study to determine whether or not it results in an incidence or prevalence of disease, or intensity of infection, that is measurably in excess of that which occurs in its absence. Such studies are methodologically difficult, and there have been only a few well-designed epidemiological studies on human wastes reuse. Most of the available evidence concerns wastewater irrigation, and there is much less information about excreta use in agriculture and about aquacultural use.

Wastewater irrigation. All the available epidemiological studies on crop irrigation with wastewater have been critically reviewed in a recent World Bank report (Technical Paper No. 51), and the most important conclusions of this study can be summarised as follows:

- crop irrigation with ***untreated*** wastewater causes significant excess infection with intestinal nematodes in both consumers of the irrigated crops and those who work in the irrigated fields; the latter, especially of they work barefoot, are likely to have more intense infections, particularly of hookworms, than those not working in wastewater-irrigated fields;

- crop irrigation with adequately *treated* wastewater does not lead to excess intestinal nematode infection amongst field workers or consumers;
- cholera, and probably also typhoid, can be effectively transmitted by the irrigation of vegetables with untreated wastewater;
- cattle grazing on pasture irrigated with raw wastewater may become infected with beef tapeworm, but there is little evidence for actual risks of human infection;
- there is limited evidence that the health of people living near fields irrigated with raw wastewater may be negatively affected either by direct contact with the soil, or indirectly through contact with farm labourers; in communities with high standards of personal hygiene such negative impacts are usually restricted to an excess incidence of benign gastroenteritis, often of viral aetiology, although there may also be an excess of bacterial infections; and
- sprinkler irrigation with treated wastewater may promote the aerosolized transmission of excreted viruses, but disease transmission is likely to be rare in practice since most people have high levels of immunity to viral diseases endemic in their community.

Excreted Load

↓
. latency
. multiplication
. persistence
. treatment survival

Infective Dose Applied to Land/Water

↓
. persistence
. intermediate host
. type of use practice
. type of human exposure

Infective Dose Reaches Human Host

↓
. human behaviour
. pattern of human immunity

Risks of Infection and Disease

↓
. alternative routes of transmission

Public Health Importance of Excreta and Wastewater Use

Figure 1.
Pathogen-host properties influencing the sequence of events between the presence of a pathogen in excreta or wastewater and measurable human disease attributable to excreta or wastewater use. From: IRCWD Report 05/85.

It is clear from these findings that, when *untreated* wastewater is used to irrigate crops, there are high actual health risks due to intestinal nematodes and bacteria, but little or no risks due to viruses (Table 2). It is also clear that wastewater treatment is a very effective method of safeguarding public health.

Excreta use in agriculture. The epidemiological evidence on the agricultural use of excreta has been extensively reviewed in a recent report published by the International Reference Centre for Waste Disposal (Report No. 05/85). The conclusions of this study are very similar to those of the World Bank study on wastewater irrigation, and can be stated as follows:

- crop fertilization with untreated excreta causes significant excess infection with intestinal nematodes in both consumers and field workers;
- There is evidence that excreta treatment can reduce the transmission of nematode infection;
- the excreta fertilization of rice paddies may lead to excess schistosomiasis infection amongst rice farmers; and
- cattle may become infected with tapeworm, but are unlikely to contract salmonellosis.

Aquaculture use. The IRCWD Report No. 05/85 by Blum and Feachem (1985) also reviewed the epidemiological evidence for disease transmission associated with the aquacultural use of excreta and wastewater. The conclusions of this study are less certain than those concerning wastewater and excreta use in agriculture, due to the limited amount and quality of the available data. There is clear epidemiological evidence for the transmission of certain trematode diseases, principally *Clonorchis* (oriental liver fluke) and *Fasciolopsis* (giant intestinal fluke), but none was found for schistosomiasis (bilharzia) transmission, which is nonetheless a major potential risk to those who work in excreta-fertilized ponds. Nor was any conclusive evidence found for disease transmission by passive transference of the pathogens by fish and aquatic vegetables, but this too remains a potential risk.

Microbiological quality criteria

The epidemiological evidence concerning the use of human wastes in agriculture was reviewed by the group of experts attending the First Project Meeting on the Safe Use of Human Wastes in Agriculture and Aquaculture held in Engelberg, Switzerland, in July 1985, and it was used to formulate what are now known as the Engelberg Guidelines for the microbiological quality of *treated* wastewaters intended for crop irrigation. In summary, these Guidelines recommend that treated wastewaters should contain:

≤ 1 viable intestinal nematode egg per litre (on an arithmetic mean basis), when used for either restricted or unrestricted irrigation; and

≤ 1000 faecal coliform bacteria per 100 millilitres (on a geometric mean basis), when used for unrestricted irrigation.

Unrestricted irrigation refers to the irrigation of trees, fodder an industrial crops, fruit trees and pasture; and restricted irrigation to the irrigation of edible crops, sports fields and public parks.

Table 2.
Relative health risks from use of untreated excreta and wastewater in agriculture and aquaculture

Class of pathogen	Relative amount of excess frequency of infection or disease
1. Intestinal nematodes: *Ascaris* *Trichuris* *Ancylostoma* *Necator*	High
2. Bacterial infections: bacterial diarrhoeas (e.g. cholera, typhoid)	Lower
3. Viral infections: viral diarrhoeas hepatitis A	Least
4. Trematode & cestode infections: schistosomiasis clonorchiasis teaniasis	From high to nil, depending upon the particular excreta use practice and local circumstances

Source: IRCWD News No. 23 (1985), "The Engelberg Report".

These Guidelines are also applicable to excreta use in agriculture if the excreta are applied to the field, for example in the form of liquid nightsoil, while crops are growing.

The intestinal nematode egg guideline value is designed to protect the health of both agricultural fieldworkers and consumers of the irrigated crops, and it represents a high degree of egg removal from the wastewater (over 99 percent). The faecal coliform guideline value is less stringent than earlier recommendations, but it is in accord with modern standards for bathing waters, for example, and is more than adequate to protect the health of consumers. Effluents complying with both guideline values can be simply and reliably produced by treatment in a well-designed series of waste stabilization ponds.

Guidelines for the microbiological quality of treated excreta and wastewater intended for aquacultural use were developed at the Second Project Meeting held in Adelboden, Switzerland, in June 1987. These recommend zero viable trematode eggs per litre or per kilogram (on an arithmetic mean basis), and less than 10,000 faecal coliform bacteria per 100 millilitres or per 100 grams (on a geometric mean basis). Such a stringent trematode guideline is necessary as these pathogens multiply very greatly in their first intermediate aquatic host. The guideline value for faecal coliforms assumes that there is a 90 percent reduction of these bacteria in the pond, so that fish and aquatic vegetables are not exposed to more than 1000 faecal coliforms per 100 millilitres.

2.5 Sociocultural Aspects

Human behavioural patterns are a key determinant factor in the transmission of excreta-related diseases in general, and no less in their transmission through excreta and wastewater use. 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 only be assessed with a prior understanding of the cultural values attached to practices that appear to be social preferences yet which facilitate disease transmission. Cultural beliefs vary so differently in different parts of the world that it is not possible to assume that excreta or wastewater use practices which have evolved in one part can be readily transferred to another. A thorough assessment of the local sociocûltural context is always necessary during the project planning stage (Section 2.8), otherwise the project may be expected – with a high degree of certainty – to fail.

2.6 Environmental Aspects

Excreta and wastewater use schemes, if properly planned and managed, can have a positive environmental impact, as well as providing increased agricultural and aquacultural yields. Environmental improvement accrues as a result of several factors, including:

- avoidance of surface water pollution, which would occur if the wastewater were not used but discharged into rivers or lakes. Major environmental pollution problems such as dissolved oxygen depletion, eutrophication, foaming, and fish kills can be avoided.
- conservation of freshwater resources, or their more rational usage, especially in arid and semi-arid areas: freshwater for urban demand, wastewater for agricultural use.
- reduced requirements for atificial fertilizers, with a concomitant reduction in energy expenditure and industrial pollution elsewhere.
- soil conservation through soil humus build-up and through the prevention of land erosion.
- desertification control and desert reclamation, through the irrigation and fertilization of tree belts.
- improved urban amenity, through the irrigation and fertilization of green spaces for recreation (parks, sports facilities) and visual appeal (flowers, shrubs and trees adjacent to urban roads and highways).

Soil and groundwater pollution are potential disadvantages of the agricultural use of excreta and watewater. However, scientifically sound planning and effective management of the irrigation or fertilization regime can minimise these disadvantages to the level of environmental insignificance.

2.7 Technical Options for Health Protection

Introduction

The available measures for health protection can be grouped under four main headings:

- treatment of the waste;
- crop restriction;
- waste application methods; and
- control of human exposure.

It will often be desirable to apply a combination of several methods. The technical factors affecting each option are discussed below, although the administrative and financial factors, which are discussed in Section 2.8, are equally important.

Wastes Treatment

The degree of removal by a waste treatment process is best expressed in terms of $\log_{10}$ units. To achieve the Engelberg Guideline quality for unrestricted irrigation, a bacterial reduction of at least 4 log units, and a helminth egg removal of 3 log units are required. Helminth removal alone will be sufficient to protect field workers. A lesser degree of removal can be considered if other health protection measures are envisaged, or if the quality will be further improved after treatment. This can occur by dilution in naturally occurring water, by prolonged storage, or by transport over long distances in a river or canal.

Conventional processes (plain sedimentation, activated sludge, biofiltration, aerated lagoons, and oxidation ditches) are not able, unless supplemented by disinfection, to produce an effluent which complies with the Engelberg bacterial guideline for unrestricted irrigation. Moreover, conventional wastewater treatment systems are not generally effective for helminth egg removal.

Waste stabilization ponds are usually the method of wastewater treatment of choice in warm climates wherever land is available at reasonable cost. A series of ponds with a total retention time of about 11 days can be designed to achieve adequate helminth removal, while about twice that time, depending on temperature, would usually be required to reach the bacterial guideline. The high degree of confidence with which pond series can meet the Engelberg Guidelines is only one of the many advantages of pond systems. Others are low-cost and simple operation. The only disadvantage of pond systems is the relatively large area of land that they require.

Disinfection – usually chlorination – of raw sewage has never been achieved in practice with full success. It can be used to reduce the numbers of excreted bacteria in the effluent from a conventional mechanical/biological treatment plant if the plant is operating well. However, it is extremely difficult to maintain a high, uniform and predictable level of disinfecting efficiency. In any case, chlorination will leave most helminth eggs totally unharmed.

Another problem is the cost of chlorine. A more appropriate tertiary treatment option is to add one or more ponds in series to a conventional treatment plant. The addition of polishing ponds is a suitable measure to upgrade an existing wastewater treatment plant.

Excreta storage or treatment. No treatment is required for excreta if they are applied to the land by sub-surface injection, or placed in trenches prior to the start of the growing season. To achieve the guideline for helminthic quality, the excreta to be treated must be stored for a period of at least a year at ambient temperatures. An alternative is the direct treatment of nightsoil and septage in waste stabilization ponds.

Heat treatment of excreta. Two methods of treating excreta at high temperatures may be used to reduce the minimum storage period of twelve months needed to reach the Engelberg standard:

(a) *Batch thermophilic digestion* at 50°C for 13 days;
(b) *Forced aeration composting.*

Composting excreta has several advantages from the agricultural viewpoint.

Crop Restriction

Agriculture. If the Engelberg quality guideline is not fully met, it may still be possible to grow selected crops without risk to the consumer. Crops can be grouped into three broad categories with regard to the degree to which health protection measures are required:

Category A – Protection needed only for field workers. This includes industrial crops such as cotton, sisal, grains, and forestry, as well as food crops for canning.

Category B – Further measures may be needed. This applies to pasture and green fodder crops and also to tree crops and fruit and vegetables which are peeled or cooked before eating.

Category C – Treatment to Engelberg "unrestricted" guidelines is essential. This covers fresh vegetables, spray-irrigated fruit and parks, lawns and golf courses.

Irrigation which is limited to certain crops and conditions, such as Category A, is commonly referred to as restricted irrigation.

Crop restriction is a strategy to provide protection to the consuming public. However, it does not provide protection to farmworkers and their families. Crop restriction is therefore not adequate on its own; it should be complemented by other measures, such as partial waste treatment, controlled application of the wastes, or human exposure control. Partial treatment to the helminthic part of the Engelberg quality guideline would be sufficient to protect field workers in most settings, and cheaper than full treatment.

Crop restriction is feasible and is facilitated in several circumstances, including the following cases:

(i) where a law-abiding society or strong law enforcement exists;

(ii) where a public body controls allocation of the wastes;

(iii) where an irrigation project has strong central management;

(iv) where there is adequate demand for the crops allowed under crop restriction, and where they fetch a reasonable price;

(v) where there is little market pressure in favour of excluded crops (such as those in Category C).

Aquaculture. Health risk minimization through crop restriction is not as straightforward in the case of aquaculture as it is for agricultural use. Most cultured aquatic macrophytes and some fish are sometimes eaten raw so that the agricultural option of not using excreta or wastewater for food crops is often not feasible, especially in small-scale subsistence aquaculture.

Application of Wastewater and Excreta

Wastewater in agriculture. Irrigation water, including treated wastewater, can be applied to the land in the five following general ways:

- by flooding (border irrigation), thus wetting almost all the land surface;
- by furrows, thus wetting only part of the ground surface;
- by sprinklers, in which the soil is wetted in much the same way as rain;
- by subsurface irrigation, in which the surface is wetted little, if any, but the subsoil is saturated; and
- by localized (trickle, drip or bubbler) irrigation, in which water is applied at each individual plant at an adjustable rate.

Flooding involves the least investment, but probably involves the greatest risk to field workers.

If the water is not of Engelberg bacterial quality, but it is desired to use it on crops in Category B, sprinkler irrigation should not be used except for pasture or fodder crops, and border irrigation should not be used for vegetables.

Subsurface or localised irrigation can give the greatest degree of health protection as well as using water more efficiently and often producing higher yields. However, it is expensive, and a high degree of reliable treatment is required, to prevent clogging of the small holes (emitters) through which water is slowly released into the soil. Bubbler irrigation, a technique developed for localised irrigation of tree crops, avoids the need for small emitter apertures to regulate the flow to each tree.

Excreta in agriculture. Untreated or insufficiently treated excreta should only be applied to land by placing it in covered trenches prior to the start of the growing season, or by subsurface injection using specialised equipment. Nightsoil, if treated only to the helminthic quality guideline, may pose a greater risk to fieldworkers than restricted irrigation with wastewater, and which can only be minimized by exposure control measures.

Aquaculture. Keeping fish in clean water for at least 2 to 3 weeks prior to harvest will remove any residual objectionable odours and reduce the degree of contamination with faecal microorganisms. However, such depuration does not guarantee complete removal of pathogens from fish tissues and digestive tracts, unless the contamination is very slight.

Human Exposure Control

Agriculture. Four groups of people can be identified as being at potential risk from the agricultural use of wastewater and excreta. These are:

- agricultural fieldworkers and their families;
- crop handlers;
- consumers (of crops, meat and milk);
- those living near the affected fields.

Agricultural fieldworkers' exposure to hookworm infection can be reduced by the continuous in-field use of appropriate footwear, but this may be more difficult to achieve than it might at first appear.

Immunization is not feasible against helminthic infections, nor against most diarrhoeal diseases, but immunization of highly exposed groups against typhoid and hepatitis A may be worth considering. Additional protection may be provided by the provision of adequate medical facilities to treat diarrhoeal disease, and by regular chemotherapeutic control of intense nematode infections in children and control of anaemia. Chemotherapy and immunization cannot be considered as an adequate strategy, but could be beneficial as a temporary palliative measure.

Risks to consumers can be reduced by thorough cooking and by high standards of hygiene. Food hygiene is a theme to be included in health education campaigns, although their efficiency may often be quite low. Tapeworm transmission can be controlled by meat inspection.

Local residents should be kept fully informed about the location of all fields where human wastes are used, so that they may avoid entering them and also prevent their children from doing so. There is no evidence that those living near wastewater-irrigated fields are at significant risk from sprinkler irrigation schemes. However, sprinklers should not be used within 50–100 m of houses or roads.

Aquaculture. Schistosomiasis is best controlled by treatment and snail control. Regular chemotherapy would be beneficial in endemic areas. Local residents should be informed which ponds are fertilised with wastes. Water supply and sanitation, to reduce the need for contact with pond water, are also important measures for human exposure control.

2.8 Planning and Implementation

Resources Planning

The use of wastewater and excreta touches the responsibilities of several ministries or agencies. The active participation of the Health Ministry and the Ministry of Agriculture is especially necessary. It is usually advantageous to establish an inter-agency committee or possibly a separate parastatal organisation to be responsible for the sector, whose first task is to establish a national plan for wastes reuse, as an integral part of water resources planning. This will normally include plans to improve existing reuse practices, as well as to implement new reuse programmes and projects.

Improvement of Existing Practices

The use of human wastes for crop and fish production already takes place in many countries, often illegally and without official recognition by the health authorities. Simply to ban the practice is not likely to reduce its prevalence or the public health risk involved, but may make it more difficult than ever to supervise and control. A more promising approach is to provide support to improve existing use practices, not only to minimise the health risks, but also to increase productivity.

Some legal controls will usually be required, though it is easier to make regulations than to enforce them. Measures to protect public health are particularly difficult to implement when there are many individual sources or owners of the waste. The measures required to bring the waste under unified control will often amount in practice to setting up a new scheme.

The first stage in any efforts to improve existing practices must be to find out what they are. There is no substitute for a diligent search for the practice in the field combined with tactful informal conversations with farmers, local officials and interested local bodies.

Where current reuse practice contravenes existing regulations, it is important to investigate the reasons why these are not being enforced. The possible reasons for non-enforcement range from inappropriate standards to a lack of resources to enforce them.

Policy options

The following sections consider the feasibility, planning and implementation of the available options. For each type of use, these are discussed under the four headings used in Section 2.7.

(i) Treatment

Wastewater. Treatment is hard to implement when the wastewater in use is from a variety of diffuse sources, such as overflowing septic tanks. One approach may be to take action against those who produce the wastewater, to prevent the environmental pollution it causes. In other cases, the only solution may be to build a sewage system and treatment works.

Excreta. In the same way, treatment of excreta is much more readily implemented where the excreta have been collected or at least treated, by a single body such as a municipality. Individual farmers can be persuaded to treat excreta by local demonstration plots, showing that higher crop yields are obtained. This is a job for the agricultural extension service.

Aquaculture. One treatment option for aquaculture is to connect ponds in series (or to divide a pond into compartments connected in series) and avoid harvesting from the first pond. It may be necessary to establish cooperative arrangements between the owners of the different ponds.

(ii) Crop restriction

The enforcement of crop restrictions on a large number of small farmers can be difficult but not impossible. In some countries, the existing agricultural planning machinery allows a firm control of all crops grown. However, if there is no local experience of crop restrictions their feasibility should first be tested in a trial area. Arrangements are needed for marketing those crops which are permitted, as well as for assisted access to agricultural credit.

(iii) Application

A change in irrigation method so as to reduce health risks is most needed when the current practice is flooding. Farmers may need help with preparing the land to make other methods possible. Arguments which may persuade them to change include the greater efficiency of other irrigation methods and the reduced mosquito nuisance. If the agricultural extension service is not able to promote hygienic application methods, the body controlling the distribution of the wastes may still be able to do so.

(iv) Human exposure control

Measures to reduce exposure to diarrhoeal diseases generally and to promote good case management are well-known components of primary health care. An obvious measure is adequate water supply and sanitation. Care is required to ensure that the wastes do not contaminate nearby sources of drinking water.

Where salaried workers are involved, their employers' responsibility is often set down in existing legislation on occupational health. Hygiene education is also needed for producers, handlers and consumers. Markets may be the best places to advise consumers about the hygienic precautions they should take.

Local residents are best placed to ensure that their health is not put at risk once it has been explained to them what precautions are required. A residents' health committee can be a focus for a health education campaign, as well as monitoring the practice of wastes reuse.

Treatment (chemotherapy) of agricultural workers and their families for intestinal helminth infections is relatively easy to administer in a formal wastewater irrigation scheme, although additional health personnel may be required. Where wastewaser is used on many small farms, the identification and treatment of exposed persons may become quite expensive, so that mass chemotherapy becomes preferable to selective chemotherapy of infected individuals.

New Schemes

Upgrading of existing schemes should generally take priority over the development of new ones. Upgrading may be needed to improve productivity, or to reduce health risks. Attention should be paid not only to the technical improvements required but also to the need for better management of schemes and to their improved operation and maintenance.

A pilot project is particularly necessary in countries with little or no experience of the planned use of excreta or wastewater. The problem of health protection is only one of a number of interconnected questions which are difficult to answer without local experience of the kind a pilot project can give. A pilot project should operate for at least one growing season, and may then be translated into a demonstration project with training facilities for local operators and farmers.

Project planning

In many regards, planning requirements for excreta and wastewater use schemes are similar to those for any other irrigation and fertilization schemes. For each scheme, the planner should seek to maximize benefits to protect health and to minimise costs. An assessment of the benefits requires a forecast not only of crop yields but also of prices. This in turn demands a survey to establish that an adequate market exists for the crops.

For the plan to be useful, it must take the time dimension into account. For irrigation projects, a 20-year planning horizon is often considered. It is advisable to allow for a modest beginning, followed by a phased expansion of the project. Projects using wastewater will be affected by a progressive change, not only in the quantity of wastewater available, but also in its quality.

The organizational pattern of a wastes reuse scheme will largely be determined by the existing land use pattern and institutions. Farmers need security of tenure of the land and of their right to the wastewater, especially if they are to be invest or to change to new crops.

Large schemes need a full-time professional staff to manage them, preferably under a single agency. The issuing and renewal of permits for the use of the resource can be made conditional on the observance of sanitary pratices. It is common to deal with the farmers or pond owners through users' associations, giving them the task of enforcing the regulations which must be complied with for a permit to be renewed.

A joint committee or management board, which may include representatives of these associations, as well as any particularly large users, of the authorities which collect and distribute the wastes, and also of the local health authorities, is another institution which has proved its worth in many schemes.

Various support services to farmers are relevant to health protection, and consideration should be given to them at the planning stage. They include the supply of inputs and farm machinery, agricultural credit, marketing services, primary health care, and training. It is often necessary to commence training programmes prior to the start of the project. Similarly, the likely need for extension services must be estimated, and provision made for them to be available to farmers after implementation.

Legislation

If new projects for the use of wastewater or excreta for agriculture or aquaculture are to be introduced or promoted, legislative action may be needed. Five areas deserve attention:

(i) creation of new institutions or attribution of new powers to existing bodies;

(ii) roles and relationship of national and local government in the sector;

(iii) rights of access to and ownership of wastes, including public regulation of their use;

(iv) land tenure;

(v) public health an agricultural legislation: waste quality standards, crop restrictions, application methods, occupational health, food hygiene, etc.

Economic and Financial Considerations

Economic appraisal considers whether a project is worthwhile, whereas financial planning looks at how projects are to be paid for. Improvements to existing practices also require some financial planning.

Economic appraisal

The economic appraisal of wastewater irrigation schemes must compare them with the alternative – what would be done in the absence of the scheme. The cost of the wastewater includes the cost of any additional treatment required, as well as the cost of conveying it to the field and applying it to the crop. However, it is essential to subtract from this the cost of the alternative arrangements for disposal of the wastewater which would be required if the wastewater use project were not to be implemented.

The economic appraisal of excreta use and aquaculture schemes is less sophisticated, as some of their benefits are more difficult to quantify.

Financial planning

A charge of some sort is normally levied when the waste is distributed to farmers. The level of these charges must be decided at the planning stage. A farmer will pay for wastewater to irrigate his crops only if its cost is less than that of the cheapest alternative water and the value of the nutrients that it contains. In the case of aquaculture and the use of excreta, the price is usually based either on the marginal cost of treatment and conveyance of the wastes, or on the value of their nutrient content, whichever is lower.

It is not always appropriate or feasible to meet the cost of health protection by charging for the use of the wastes. Financial considerations regarding each of the four types of health protection measures are discussed below.

(i) Treatment. The costs of treatment are usually justified on grounds of environmental pollution control. However, the treatment of wastes to a quality adequate for use in agriculture may involve additional costs. Some of these can be met by the sale of the treated wastes. If individual farmers are to be encouraged to treat nightsoil or wastewater, then they may need credit to help them with the capital cost of any construction required.

(ii) Crop restriction. Crop restriction may mean that less need be spent on treatment, but if adequate financial provision is not made for its enforcement, it will not be effective.

(iii) Application. Since preparation of the fields helps farmers avoid other expenditure, the cost can be recovered from them in the same way as other irrigation costs. Since localised irrigation uses less water, farmers may themselves find it worthwhile to change to this method, if the cost of wastewater is high enough.

(iv) Human exposure control. The purchase of protective clothing will normally be at the expense of the workers who wear it or of their employers. The cost of chemotherapy is likely to be borne by the health service.

Monitoring and Evaluation

Health protection measures require regular monitoring to ensure that they continue to function effectively. Institutional arrangements must be made for the information collected to provide feedback to those who implement the health protection measures and enforcement to those who fail to do so. Appropriate aspects for regular monitoring and evaluation include the following:

Implementation of the measures themselves. This can be monitored by simple surveys.

Wastes quality. It may be more fruitful to monitor the functioning of the treatment system than to take frequent samples for analysis. **The Engelberg guideline values are not intended as standards for quality surveillance, but as design goals to be used when planning a treatment system.** The lack of laboratory capacity for monitoring the quality of the wastes is not an adequate reason for not using them.

Crop quality. Microbiological monitoring of crops is the task of the Ministry of Health, as enforcer of public health regulations.

Disease surveillance. This should focus upon farm workers. The minimum on any scheme is a regular stool survey of a sample of workers for intestinal parasites. Where typhoid is endemic, a serological survey can be carried out at the same time.

3. Generalised Model of the Reduction in Health Risk Associated with Different Control Measures for the Use of Human Wastes

By **Ursula J. Blumenthal**, London School of Hygiene and Tropical Medicine, Keppel Street, London WC1E 7HT, U.K.

Measures of Risk and Options for Health Protection

In protecting the health of those exposed to wastes, the focus of attention in the past has often been on the use of waste treatment as the most feasible and fully effective measure for the reduction of health risks. This places most emphasis on microbiological criteria, however, and on the total removal of "potential" risks, and does not fully incorporate the concept of "actual" or "attributable" risk. There is thought to be a ***"potential risk"*** when pathogenic microorganisms are detected in wastewater or on crops, even if no cases of disease due to these microorganisms are detected. This is in contrast to the epidemiologist's concept of risk, which focuses on the chance of an individual developing a given disease over a specified period due to a certain exposure. It is possible that a "potential risk" may not become an "actual risk" due to factors including pathogen die-off, minimum infective dose, human behaviour, and host immunity. In addition, a particular infection may have other routes of transmission in the community, so that some of the disease observed may not be associated with waste use. The most useful evaluation of risk is therefore made using ***"attributable risk"*** or "excess risk", which is a measure of the amount of disease associated with a particular transmission route within a population; in this case, the amount associated with waste reuse. The consequence of this approach is that it is not always necessary to remove all pathogens from wastewater used in agriculture, because they may not represent an actual (attributable) risk to the human population.

There are some situations where full treatment of wastes is not feasible or even desirable, due mainly to economic constraints. It is therefore necessray, as well as possible, to consider ways for the protection of human health other than waste treatment, especially where economic constraints are felt. This approach was taken by the World Health Organization and the United Nations Environment Programme in their Guidelines for the safe use of wastewater and excreta in agriculture and aquaculture, prepared by Mara and Cairncross (1987) and reviewed at Adelboden (see executive summary p. 4). Four options for health protection must be considered. These are:

- waste treatment;
- restriction of the crops grown;
- choice of methods of application of the wastes to the crops; and
- control of human exposure to the wastes.

The points at which these four health protection measures can interrupt the potential transmission routes of excreted pathogens are shown in Fig. 1. While full treatment stops excreted pathogens from even reaching the field or fishpond to which the wastes are applied, crop restriction and human exposure control act later in the pathway, preventing excreted pathogens from reaching the persons concerned, the crop consumers and the agricultural workers.

Some of these health protection measures may not be considered fully efficient in preventing transmission of pathogenic microorganisms, and some do not act on both the consumers and the workers. The purpose of the generalised model (Fig. 2) is therefore to demonstrate that there are ways to combine the various options for health protection to achieve the same reduction in health risks as achieved by full treatment of the wastes. The model is intended to be an aid to thinking and to decision making. It demonstrates that there is a range of options for protecting agricultural workers and the crop-consming public, and allows a flexibility of response to different situations. Each situation can be considered separately, and the most appropriate option chosen for that situation, taking into account economic, cultural and technical factors. Measures for health protection can be "targeted" towards the specific exposed groups in the population, rather than being aimed at protecting unspecified groups, who may or may not actually be exposed.

Description and Use of the Model

The model is made up of 5 concentric bands, each representing steps on the pathway from the waste itself to the human consumer or worker. Pathogen flow is from the wastewater or excreta on the outside towards the workers and consumers in the centre. The thick black circle between the crop band and the worker band therefore represents a barrier beyond which pathogens should not pass if health is to be protected. The level of contamination of the wastewater or excreta, the field or fishpond to which it is applied, and the crop (plant or fish) which is being fertilized, is shown by the type of shading employed; a white area indicates no contamination. In the centre, the level of risk to the agricultural worker and the crop consumer is also shown by the level of shading: a white area in the centre indicates no risk to human health and therefore indicates that the strategy employed leads to the "safe" use of the wastewater or excreta. The model is a simplification of reality, and although it should apply to most situations of reuse of wastewater or excreta in agriculture and aquaculture, there will be some cases where it does not accurately represent the level of risk involved.

From the top sector of the model, it is clear that when no protective measures are used (that is, with the use of raw wastewater or excreta applied directly onto the field or the fishpond) then contamination is present throughout and both agricultural workers and consumers of the crops are at high risk. On the other hand, when ***full treatment*** is given to the waste (regime H), pathogenic microorganisms are removed at the source, no contamination remains, and there is no risk to either workers or consumers. In this case, full treatment is used to describe treatment of wastewater to meet the Engelberg Guideline for unrestricted irrigation in terms of both helminthological ($\leq$ viable nematode egg/l) and bacteriological ($\leq$ 1000 faecal coliforms/100 ml) quality, or treatment of excreta which would make restriction of the crops grown unneccessary.

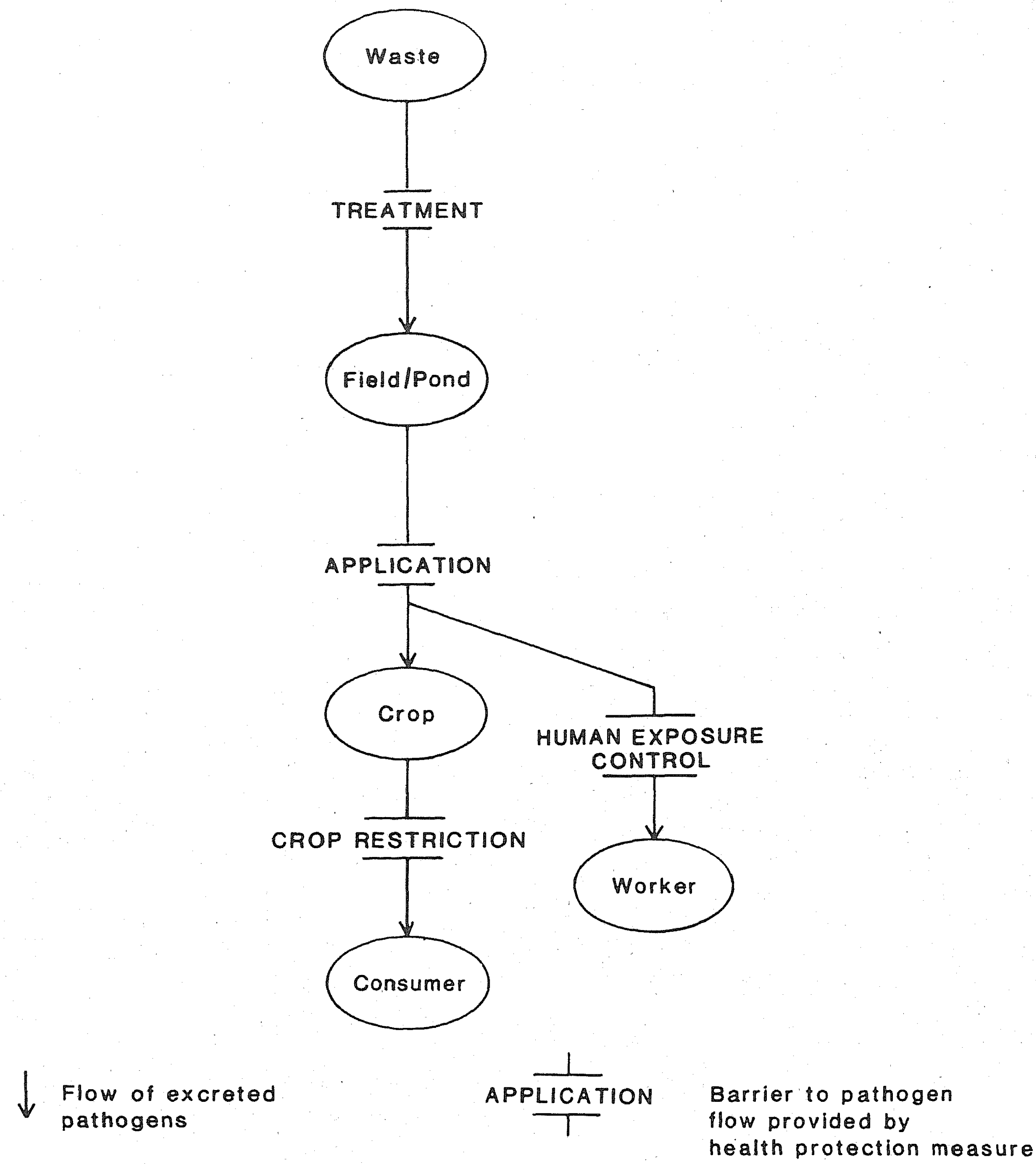


Fig. 1. Flow diagram to show the potential transmission of excreted pathogens and points at which different health protection measures can interrupt the pathogen flow

Wastewater of the required quality could be achieved by several means; firstly, by waste stabilisation ponds of about 25 days' total retention time; secondly, through upgrading existing secondary (mechanical/biological) treatment plants by addition of maturation ponds; and, thirdly, through the use of well-designed and operated tertiary treatment plants including filtration and chlorination. The efficiency of the second and third options is less well-known than that of the first, and more research is needed into pathogen (especially helminth) removal by these methods.

Moving around the model clockwise, and considering the options for health protection singly at first, it is clear that ***crop restriction*** by itself (regime A) is a good measure for the protection of consumers since either consumable crops are not grown, or the crop grown is cooked before consumption. A wide range of crops is allowed unter this regime, including cereal crops, industrial crops, fodder crops, pasture and trees, including fruit trees. Under some circumstances vegetables growing well above the ground (such as chillies, tomatoes and green beans) or vegetables always eaten cooked (such as potatoes) may also be allowed. Although crop restriction protects the health of consumers, it does nothing to protect agricultural workers who remain at high risk since they are still exposed to pathogens in the waste, on the soil and on the crops.

Careful choice of the method and timing of ***application*** of the waste can be very effective (regime B): if it is applied directly to the roots of the crop, then no contamination remains where the workers walk and none reaches the edible part of the crop, so both workers and consumers are safe. In excreta use, this could occur when excreta are applied to the field in covered trenches beforde the start of the growing cycle. In wastewater use this could occur

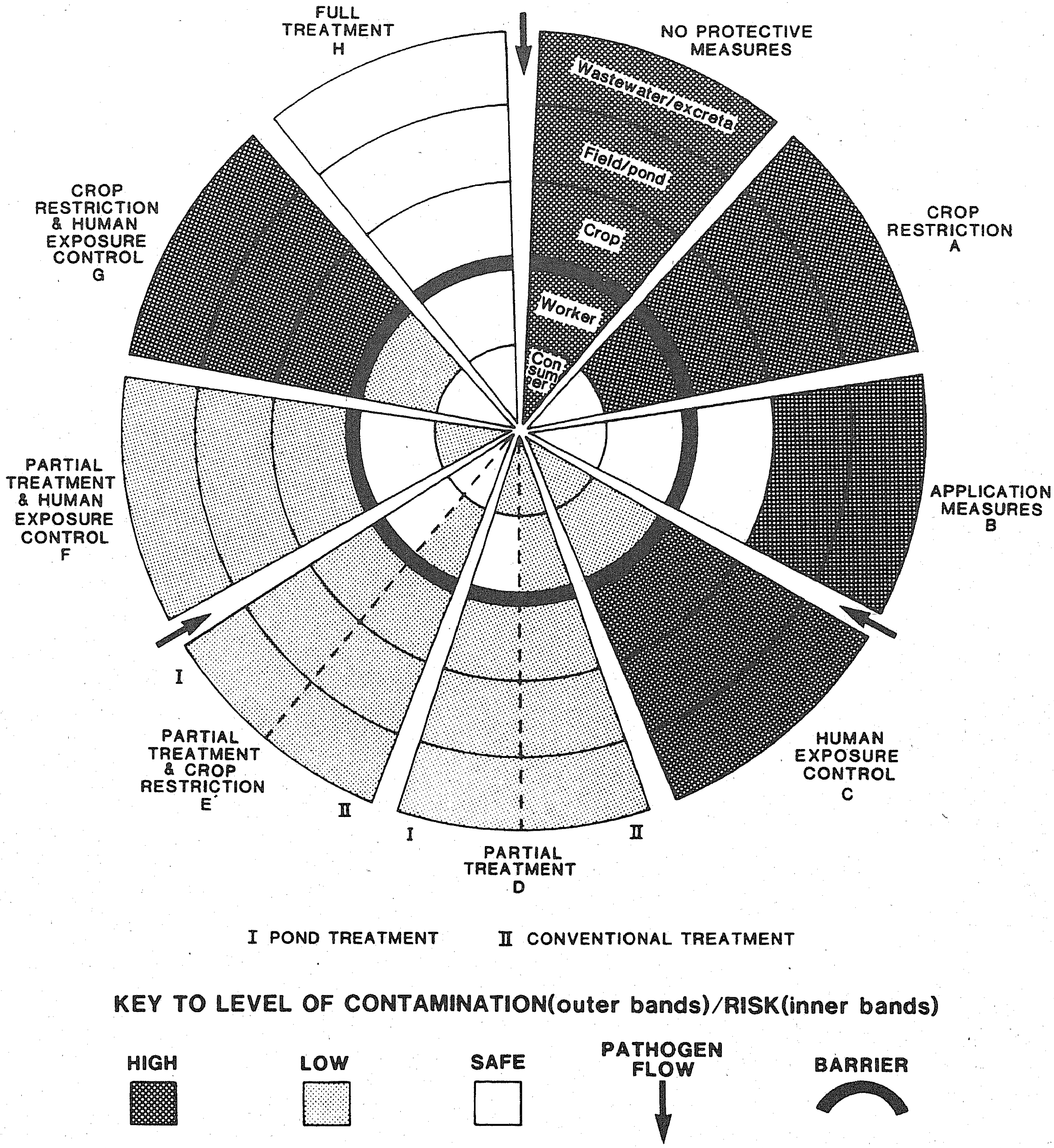


Fig. 2. Generalised model of the effect of different control measures in reducing health risks from waste reuse

through the use of localised drip or bubbler irrigation where row crops (eg. fruit trees) are grown. This method of application has the advantage of using water more efficiently and often producing higher crop yields, as well as giving the greatest degree of health protection. The use of drip irrigation requires substantial treatment of the wastewater to remove the settleable solids before application, even though treatment to provide pathogen removal is not a requirement. A lower grade effluent can be used in bubbler irrigation, a method which has come into use only recently.

Methods of *human exposure control* (regime C) can be used for both workers and consumers. These methods aim to prevent people from coming into direct contact with the pathogens in the wastes, or to stop contact with the pathogens from leading to the manifestation of disease. Measures to protect workers include the wearing of protective clothing (to prevent contact with pathogens), increased levels of hygiene (to remove any pathogens present), and possibly immunisation or chemotherapeutic control of selected infections which could be used as a temporary palliative measure (to prevent infection leading to disease). Measures to protect consumers include increased levels of hygiene and thorough cooking of the food concerned. In practice, such measures are rarely fully effective on their own, and a reduced level of risk to both groups remains.

Partial treatment of wastewater (regime D) causes a reduction in the level of contamination, but the effects of this vary between treatment technologies. Treatment in a waste stabilisation pond system for about 8 – 10 days (regime D_I), or equivalent methods, removes helminth eggs sufficiently to protect the health of agricultural workers and consumers. However, bacteria removal is only sufficient to reduce but not eliminate the risk to consumers of vegetable crops. Conventional secondary treatment, (regime D_{II}), does not guarantee sufficient helminth egg removal and a reduced level of risk remains for both workers and consumers.

Moving further around the model, the effect of combinations of different methods is shown. A combination of *partial wastewater treatment,* using waste stabilisation ponds (or equivalent), and *crop restriction* (regime E_I) provides full protection to both workers and consumers. This is particularly useful in situations where there is demand for the type of crops in the restricted range, but where full treatment of the wastes is not possible. Crop restriction plus conventional treatment to secondary level (regime E_{II}), however, may still leave the workers at some risk, particularly concerning intestinal nematode infections. This emphasises the need to be careful in the choice of treatment technology when the effluent is intended for reuse. *Partial waste treatment* combined with *human exposure control* for both workers and consumers (regime F) would provide full protection for workers, whichever type of treatment technology was employed, since human exposure control would provide an additional barrier. However, it would be difficult to produce sufficient human exposure control in consumers in the absence of crop restriction, and so a low level of risk to consumers may remain. In situations where there is no possibility of treating the wastes, a combination of *crop restriction and human exposure control* (regime G) could be used. In this regime the risk to workers would be considerably reduced, though not eliminated, and the consumers would be fully protected.

Choice of Health Protection Measures

It is easy to see from the model that three regimes are available for rendering waste reuse "safe" to both agricultural workers and the crop consuming public. These are:

1. Localised application of wastes to the crops (regime B).
2. Partial treatment using waste stabilisation ponds, combined with crop restriction (regime E_I).
3. Full treatment (regime H).

Several regimes are available where health risks are much reduced although full "safety" has not been achieved. Measures providing partial protection could be used within an incremental approach to reducing health risks until it is possible to use a regime providing full protection. Full protection of consumers and a reduced (but low) risk to agricultural workers may be acceptable in some situations, for example where the economic and nutritional returns to arming families from the use of wastes are seen to utweigh the low level of risk from infectious diseases.

he choice of the measure or combination of measures to e used would depend on an analysis of important factors ı the local situation. The factors to be considered would include economics, technical factors, sociocultural factors, institutional capaciy, personnel constraints, and also existing patterns of excreta-related diseases. In some situations it may be that economic and technical factors make it unfeasible to adopt the "blanket" approach of full treatment of all wastes to protect all potential workers and consumers. In such a situation, cultural factors (for example, the type of staple food crops),a good institutional capacity and availability of personnel could create good conditions for the enforcement of crop restrictions together with either human exposure control or partial treatment of the wastes. This would be a more "targeted" approach, focusing the resources on protecting the specific exposed populations and not all potentially exposed populations.

Case Studies of the Application of the Model

The following examples show current reuse practices where full treatment of wastes does not occur but where other means of health protection are used. In some cases, full health protection of both workers and consumers is not at present achieved, but the model can be used to aid decision-making on suitable additional measures to adopt.

Mexico: Use of untreated wastewater in agriculture with crop restriction

Part of the wastewater from Mexico City is used in semi-arid areas with low annual rainfall. Food production on a year-round basis is only made possible by the use of wastewater to supplement scarce supplies of fresh water for irrigation. Crop restrictions are rigorously enforced by staff of the Ministry of Agriculture and Water Resources who run the irrigation system, thereby providing protection to consumers. In one district, wastewater is used to irrigate over 80,000 ha of mainly maize, alfalfa, barley, and oats. Prohibited crops include lettuce, cabbage, beetroot, coriander, radish, carrot, spinach, and parsley, and some tomatoes and chillies are permitted, since they grow above the ground. No purposeful treatment is given to the wastewater, although some occurs during its passage through over 60 km of channels, and in one case, further "treatment" occurs in a large storage reservoir. Therefore in some of the areas of reuse, regime (A) applies, involving crop restriction alone, while in other places regime (E) applies, giving partial protection to the health of workers. In some districts, however, it may be necessary to consider the introduction of either partial waste treatment or of human exposure control, to protect the health of the many thousands of agricultural workers involved.

Tunisia: Use of conventionally treated wastewater in agriculture with crop restriction

Wastewater from Tunis is used for irrigation of citrus trees, grown as a cash crop. The largest area is irrigated with wastewater treated in activated sludge plants (with no chlorination). The wastewater is distributed via a system of underground pipes, and the effluent reaches the trees along short furrows coming from wastewater valve outlets located near to groups of citrus trees. The method of application therefore is partially localised. This represents regime E_{II} where partial (conventional) treatment is complemented by crop restriction, but with a further addition of partly localised application of the waste.

This regime should provide good health protection to consumers and may provide good protection to the workers. The system works well in an area where fruit trees are a traditional cash crop, and wastewater is in demand since fresh water has become scarce due to increasing salinity of groundwater resources. In an experimental area, the health authorities are testing a refinement of localised irrigation using drip irrigation (regime B) for health protection of both workers and consumers. In this case, secondary treated effluent undergoes in-line screening in the piped distribution system.

Peru: Use of partially treated pond effluent in agriculture with crop restriction

The coastal zone of Peru is very arid, and without irrigation no agriculture can occur. Use of wastewater for irrigation is popular, and a policy of treating wastewater in waste stabilisation ponds has been developed. Wastewater from the town of Ica is partially treated in a waste stabilisation pond system and used to irrigate principally maize and cotton. The area used to be a wine growing area and later switched to cotton as a cash crop. The ponds only provide partial treatment since the retention time is relatively short. The regime adopted is therefore E_I on the model, providing protection for consumers and probably also for the farm workers. The enforcement of crop restrictions is assisted by two factors: firstly, the desire to grow cotton and maize as cash crops, and secondly, the availability of fresh water (wells) for the growing of vegetables so that farmers are not forced to use wastewater for vegetable growing. In areas of Peru where frsh water is short and where the growing of non-vegetable crops is less traditional, the enforcement of crop restriction is more difficult.

Guatemala: Use of treated excreta in agriculture

The introduction of DAFF (dry alkaline fertilizer producing family) latrines into villages in the volcanic areas of Guatemala has led to the use of the fertilizer in crop production. Most families have only small plots of land of poor quality, which require conditioning and fertilizing for good crop production, so they welcome the fertilizer produced from the double pit DAFF latrines. Investigations in progress will reveal whether the DAFF latrine provides full or partial treatment of the excreta, that is, whether all helminth eggs are rendered non-viable. If the treatment is found to be only partial (regime D_{II}), then it may be necessary to advise farmers to adopt localised application of the fertiliser, some human exposure control (regime F) or some restrictions of the crops grown (regime E) in order to provide full protection to the farmer and the consumer.

India: Use of wastewater in aquaculture

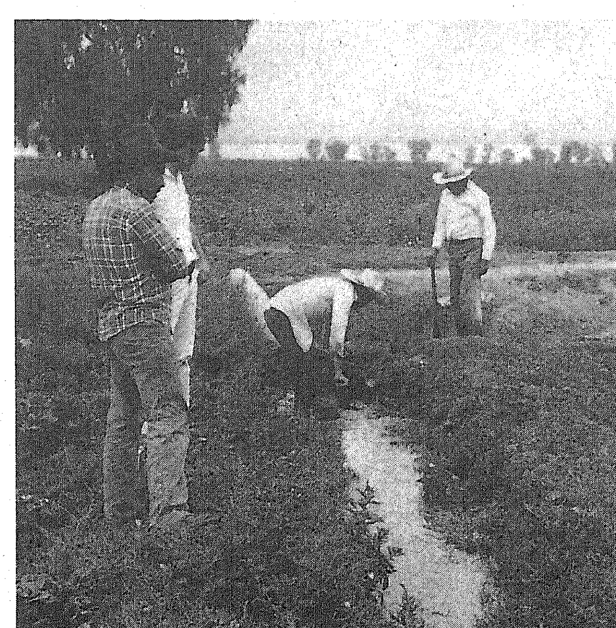
The use of wastewater in aquaculture occurs in the wetlands east of Calcutta. Untreated wastewater is used to fertilize very large fishponds which together cover an area of 4,400 ha, and supply about 10 – 20 per cent of the fish consumed in Greater Calcutta. The ponds appear to act in a similar manner to waste stabilisation ponds and a process of pathogen removal occurs within them. The fishpond worker, who wades into the pond dragging a net through the water to catch the fish, may therefore be exposed to the equivalent of partially treated wastewater. The consumers of the freshwater fish in this area cook the fish thoroughly before consumption. The regime is therefore similar to regime F, partial treatment and human exposure control. The health of the consumer is probably safeguarded, but the extent of protection of the fishpond worker will depend on how much "treatment" has occurred in the pond where contact takes place.

Indonesia: Use of excreta in aquaculture

The use of excreta in small scale fish ponds occurs in West Java. The excreta are diluted in all fishponds and may undergo partial treatment in the larger fish ponds, but possibly not in smaller ponds. Fish are cooked thoroughly before eating. The situation is therefore a cross between regime C and F and it is not certain whether there is a low level of risk to aquaculture workers, though there is probably none to consumers.

These examples of current reuse practice have shown how combinations of different protection measures are being used, and how the model can be used to identify exposed groups who may require further protection. Another implication of the mode, though, merits attention. Where full treatment is given to wastes, both workers and consumers are "safe", and there is no need for further protection measures. However, there are countries which not only require treatment of wastewater to a very high quality but also impose crop restrictions before it can be used in irrigation. In one reuse project in the Middle East, domestic wastewater is treated in high-rate trickling filters, followed by tertiary treatment in a storage pond and chlorination before reuse in irrigation of ceral crops. In another country, effluent from activated sludge plants is treated by rapid sand filtration and chlorination, and ozonation has been added as a further disinfecting step. Such a series of health protection measures provides a very large safety margin, more than is justified by epidemiological evidence, and more than can be afforded by most countries.

In future, those involved in planning or assessing new schemes or current practices of waste reuse should evaluate health risks using the epidemiologists' concept of attributable risk. Health protection measures or combinations of measures should be targeted towards specific exposed groups in the population within their local context.



Photograph 2: Mexico: Chilli field irrigation with sewage from Mexico City

4. Rationale for Engelberg Guidelines

By **Hillel Shuval**, Director, Environmental Health Laboratory, The Hebrew University of Jerusalem, P.O. Box 1172, Jerusalem, Israel

Introduction

A central theme at the meeting of scientists held at Adelboden, Switzerland, in June 1987, was the review of the guidelines for effluent reuse in agriculture proposed by the Engelberg Report (1985). These newly proposed guidelines represent a significant departure from previous concepts and well-established historic guidelines which have dominated the thinking and practice in the field of wastewater reuse in agriculture for over 50 years. Based on the in-depth review carried out at Adelboden, the meeting drafted and approved a statement which provided a clear presentation of the rationale for the Engelberg Guidelines.

Rationale

The very strict microbial standard developed by the California State Health Department and other groups some 50 years ago of 2.2 coliforms/100 ml for effluent irrigation of vegetables and salad crops eaten uncooked were based on a "zero risk" concept. They were partially motivated by the literature on pathogen detection and survival in wastewater and in soil which suggested that the mere presence of pathogens in the environment is evidence of serious public health risk. During that period, many people believed in the "antiseptic" environment as an obtainable public health goal. They tended to perceive all potential health risks as actual risks. They may also have been influenced by the public opposition to earlier mismanaged raw sewage farms near residential areas, which aroused public health fears due to odour and fly nuisances. These standards were not really feasible with normal wastewater treatment technologies even in Western countries, but this was of little concern since the health authorities may well have preferred that unrestricted irrigation of edible vegetable crops not become a widespread practice. It must also be stated that these strict early standards were not based on an analysis of the epidemiological evidence. The Californian standard rapidly spread throughout the world, including to a number of developing countries, as the most commonly accepted guidelines for wastewater reuse since no other credible source of evidence on this subject existed. For some time, many experts have questioned the validity of this early "zero risk" approach as being unreasonably strict and conceptually problematic. The WHO Meeting of Experts on Effluent Reuse (WHO, 1973) recognized that the very strict 2.2 coliforms/100 ml standard lacked an epidemiological basis and indicated the need for a more realistic approach by recommending a coliform guideline of 100/100 ml. A WHO working group reviewing health aspects of the use of sewage sludge in agriculture in Europe (1981) considered as very relevant a statement made at the second European Symposium on Characterization, Treatment and Use of Sewage Sludge (Commission of European Communities, Vienna, 1980): "Economically and practically a no-risk level cannot be obtained, although it may be technologically possible".

The Engelberg meeting of environmental scientists and epidemiologists critically reviewed the massive epidemiological data analysed by The World Bank study (Shuval et. al., 1986) and the IRCWD/WHO study (Blum and Feachem, 1985) on credible quantifiable health effects associated with wastewater and excreta use in agriculture. They unanimously concluded that the health risks of irrigation with **well-treated** wastewater were minimal, and that current bacterial standards were unjustifiably restrictive. However, they did recognize that in many developing countries, the main risks of wastewater irrigation were associated with **helminth diseases** and that safe use of wastewater would require a high degree of helminth removal.

Thus, the Engelberg Guidelines represent a new **stricter approach** concerning the needs to reduce helminth egg levels in effluent to 1 or less per liter. This represents a requirement to achieve very effective helminth removal of some 99.9% by appropriate treatment processes. Stabilization ponds are particularly effective in achieving this goal, however, other technolgies are also available. While the Engelberg Guidelines do not refer specifically to all helminths and protozoans of public health importance such as **schistosoma, amoeba** and **giardia,** it was understood that the strict helminth standard recommended was selected as an indicator for all of the easily settleable pathogens including some of the protozoans. It is implied in the Engelberg Guidelines that equally high removals of all helminths and protozoans will be achieved, some by sedimentation, while others are effectively inactivated by retention for a few weeks in ponds.

On the other hand, the Engelberg Report concurred that a microbial guideline figure of a geometric mean of 1000 faecal coliforms/100 ml for unrestricted crop irrigation was both epidemiologically sound and technologically feasible. They also considered that it was much in line with the actual river water quality used for unrestricted irrigation in Europe and the United States with no known ill effects. A world survey of the microbial levels of rivers (WHO/UNEP, 1987) has shown that the mean faecal coliform concentration in approx. 50% of the rivers is 1000/100 ml or greater. Most of these rivers are used for irrigation. The United States Environmental Protection Agency together with the Academy of Science (1973), recommended a water quality criteria for unrestricted irrigation with surface water of 1000 coliforms/100 ml. This guideline also includes the common situation of rivers carrying varying concentrations of raw or partially treated wastewater, which is essentially a form of indirect wastewater reuse. The group also noted that the European Community countries found levels of 2000 faecal coliforms/100 ml acceptable for bathing water quality (EEC, 1976). It was not considered rational to require a standard for unrestricted irrigation with treated wastewater effluent that was stricter than that considered acceptable for general irrigation and bathing by most of the industrialized countries. However, the fact that an additional 90 – 99% die-off of most pathogens occurs within a few days after the spreading of the effluent on the field, was considered a further safety factor.

The Engelberg group also strongly felt that the irrational application of unjustifiably strict microbial standards for wastewater irrigation had led to an untenable anomalous situation. Standards were often not enforced at all and serious public health problems resulted from totally unregulated illegal irrigation of salad crops with raw wastewater as is in fact widely practised in many developing countries. The new Engelberg approach called for realistic revised guidelines which were stricter for helminth removal but more rational and feasible regarding bacterial levels. It was the combined epidemiological and engineering judgment of the Engelberg group that this new approach would increase public health protection for a greater number of people with goals which were technologically and economically feasible.

For a full analysis of the epidemiological foundations upon which the Engelberg Guidelines are based, the reader is referred to the original reports (Shuval et al., 1986) and (Blum and Feachem, 1985). These recommendations were basically developed to guide design engineers and planners in the choice of treatment technologies and management options (e.g. crop restrictions) that will reliably achieve the proposed quality. Once achieved, there will be no necessity for continuous monitoring of indicator levels. The group concurred that well-designed and operated wastewater treatment facilities, which effectively achieve a high degree of pathogen removal, are the best ways to attain long-term beneficial health protection in wastewater irrigation practice. The Engelberg effluent reuse Guidelines are aimed at achieving this goal in a practical and feasible manner based on the available epidemiological evidence and on research and field experience in wastewater treatment efficacy.

The above analysis developed at Adelboden sums up in a concise manner the thinking that motivated the drafting of the Engelberg recommendations. A further practical aspect of those Guidelines was that they were readily achievable in simple, robust, low-cost stabilization pond systems particularly suitable to the warm climate regions in developing countries. Well-designed stabilization ponds with minimum short-circuiting and providing 20 – 25 days of flow retention in a 4 – 5 multiple pond system have been shown to essentially achieve total removal of helminths. They are normally also capable of removing 99.99 % and more of the coliform bacteria and thereby providing an effluent quality which can meet the Engelberg quality Guidelines. With such a level of treatment, the effluent carries very low concentrations of bacterial and viral pathogens which appear to be epidemiologically insignificant under most conditions.

The current overly strict so-called "no-risk" standards adopted in several countries have at times been an obstacle to wastewater irrigation projects aimed at environmental improvements and agricultural benefits. They are an example of when insisting on the "best" prevents achieving the "good". The new approach, grown out of the World Bank and WHO initiatives in this area and accepted by the meetings of scientists at Engelberg and Adelboden, should provide a very high degree of public health protection. At the same time it will also enable the development of wastewater recycling projects and result in multiple benefits regarding the promotion of agriculture and water conservation coupled with improved water pollution control.

References

Blum, D., and Feachem, R.G. (1985) *Health Aspects of Nightsoil and Sludge Use in Agriculture and Aquaculture: An Epidemiological Perspective.* IRCWD Report No. 05/85, Duebendorf, Switzerland.

CEC – Commission of the European Communities (1981) *Characterization, Treatment and Use of Sewage Sludge,* Proceedings of the Second European Symposium, Vienna, October 21-23.

EEC – European Economic Community (1976) *Council Directive of 8 December 1975 concerning the quality of bathing waters (76/160/EEC),* Official Journal of the European Communities No. L 31/1-4.

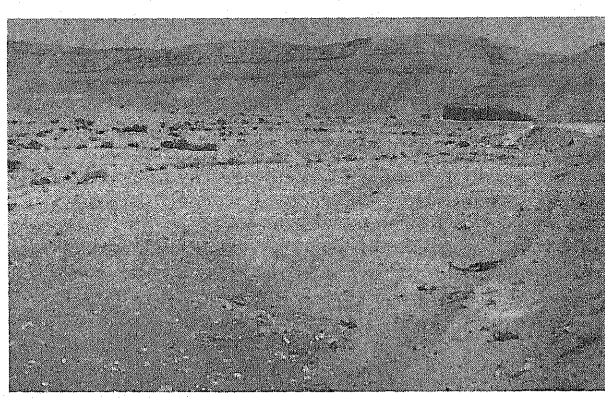
Engelberg Report (1985) *Health Aspects of Wastewater and Excreta Use in Agriculture and Aquaculture, Report of a Review Meeting of Environmental Specialists and Epidemiologists, Engelberg,* Switzerland, July 1-4, 1985, IRCWD, Duebendorf, Switzerland.

EPA-Environmental Protection Agency (1973) *Water Quality Criteria – 1972,* Ecological Research Series – EPA R 3-73-033 USEPA Washington, D.C., USA.

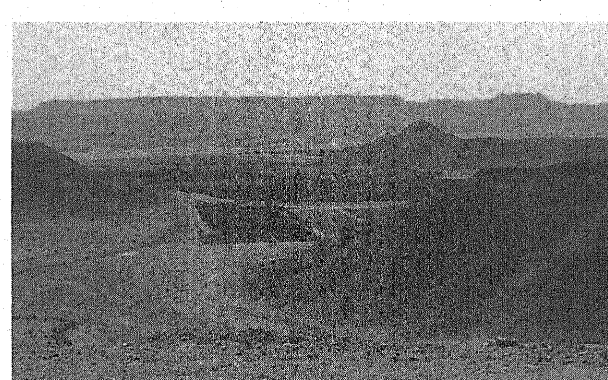
Shuval, H.I., Adin, A., Fattal, B., Rawitz, & Yekutiel, P. (1986) *Wastewater Irrigation in Developing Countries: Health Effects and Technical Solutions,* World Bank Technical Paper Number 51, The World Bank, Washington, D.C., USA, 324 pages.

WHO (1981) *Report of a WHO Working Group on The Risk to Health of Microbes in Sewage Sludge Applied to Land,* EURO Reports and Studies 54, Regional Office for Europe, WHO, Copenhagen, Denmark.

WHO/UNEP (1987) *Global Pollution and Health – Results of Health-Related Environmental Monitoring,* GEMS: Global Environmental Monitoring System, World Health Organization, Div. of Env. Health, 1211 Geneva 27, Switzerland, 22 pages.



Photograph 3: Saudi Arabia: Desert land not receiving any treated wastewater



Photograph 4: Desert land irrigated with tertiary treated wastewater from the city of Riyadh

5. Revision of the 1973 WHO Guidelines: A WHO Scientific Group Proposes Revised Health Guidelines for the Use of Wastewater

By **André Prost**, WHO, Division of Environmental Health, 1211 Geneva 27, Switzerland

A WHO Scientific Group on Health Aspects of Use of Treated Wastewater in Agriculture and Aquaculture met in Geneva from 18 to 23 November 1987. The purpose of the meeting was to update the standards[1] proposed in 1971 by a group of WHO experts in the light of epidemiological findings and of technological changes in wastewater treatment processes during the past 15 years. On the one hand, these existing standards seemed unjustifiably restrictive for bacterial contamination indicators. On the other hand, they did not take into account the variety of pathogens which could be transmitted through wastewater, and therefore public health protection was not safeguarded.

The Group stressed that municipal wastewater is a valuable resource which should be used wherever this is possible with adequate health safeguards. Reuse in agriculture should be the preferred method of disposal because of significant advantages in reducing pollution of the environment as well as in increasing agricultural productivity. Health protection can be achieved by an integrated set of measures which may include wastewater treatment, crop restriction, application techniques, and human exposure control. The optimum combination of measures will depend on local conditions and the specific groups of people to be protected.

The use of raw or partially treated wastewater without sufficient health safeguards has often been tolerated, partly because some standards and regulations have been too strict to be achievable. The Scientific Group recommends feasible measures which can be taken as the first step in an incremental process of upgrading health protection. On the basis of improved epidemiological information and understanding, the Group proposes the following guidelines based on selected indicators:

(a) Raw wastewater should never be used in agriculture, even though exposure of public and workers does not occur. In such cases, primary sedimentation of effluents ist the minimum treatment procedure which is acceptable.

(b) In all cases of reuse where human exposure may occur, wastewater should contain no more than one egg of intestinal nematode per litre (Ascaris, hookworm and Trichuris eggs). The 1971 recommendations did not include any proposal for parasites.

(c) For the irrigation of crops likely to be eaten uncooked, for sportsfields and public parks, the concentration of faecal coliforms in water should be less than 10^3 per 100 ml. No bacterial guideline value is applicable to the irrigation of cereal crops, industrial crops, fodder crops, fruit trees, pasture, and forestry. In this case, it is estimated that treatment requirements for attaining the helminth eggs guideline value will achieve substantial removal of pathogens, sufficient to protect workers and public health. The 1971 Group had recommended a maximum of 10^2 total coliforms per 100 ml for irrigation of all crops used for direct human consumption.

These revised guidelines are in line with the actual river water quality used for irrigation in Europe and the United States with no known ill-effects. For example, the United States Environmental Protection Agency has recommended in 1973 a water quality criteria for irrigation with surface water of 10^3 total coliforms per 100 ml. Also, many countries such as the members of the European Community, find levels of 10^4 total coliforms and 2×10^3 faecal coliforms per 100 ml acceptable for bathing water quality.

The Group did not consider health risks from toxic chemicals, but it stressed the need to monitor the situation when the wastewater contains industrial effluent. It also felt that it did not have enough scientific data available to recommend firm guideline values for wastewater used in aquaculture.

The report describes low-cost technologies available to achieve the microbiological quality indicated, and techniques to monitor parasite eggs in effluents. It strongly points out that effective implementation of health protection measures requires the involvement of several ministries and government agencies.

Photograph 5: Calcutta, India: Partial view of the 40 km² wastewater-fed fishpond scheme

[1] WHO (1973). *Reuse of Effluents: Methods of Wastewater Treatment and Health Safeguards.* WHO Technical Report Series No. 517.

6. Research Activities and Needs in Wastewater and Excreta Use in Agriculture and Aquaculture

By **Ursula J. Blumenthal**, London School of Hygiene and Tropical Medicine, Keppel Street, London WC1E 7HT, U.K.

Current Research

A consideration of research priorities in the field of health aspects of human waste use in agriculture and aquaculture was given in The Engelberg Report, and published in IRCWD News No. 23 in December 1985. The suggested areas of research were epidemiological studies, pathogen survival studies, social aspects, and research on wastewater and excreta treatment. Demonstration projects for the various treatment and reuse technologies were also considered important. Since that time, progress has been made on nearly all fronts. A brief summary of current research reported by participants at the Adelboden meeting is outlined here and grouped into six broad subject areas:

- Waste treatment technology
- Irrigation methods
- Waste quality monitoring
- Microbiological aspects of waste-fed aquaculture
- Epidemiological effects of waste use
- Sociocultural aspects.

The name of the person reporting the research is given in brackets, and further details can be obtained from them.

Waste treatment technology

Research in this field concentrates on investigating treatment technologies that will achieve the proposed quality guidelines for the wastes, and which are low-cost, require little maintenance and are acceptable within the cultural context. In many situations where wastewater is used, a series of waste stabilisation ponds would answer this need. However, in some areas it is not feasible to use a series of waste stabilisation ponds of the currently accepted design, due, for example, to high land costs, adverse topography or scarcity of agricultural land. A possible solution to this would be to use fewer ponds each with a greater depth. Research into the use of deep maturation ponds, carried out in north-east Brazil (D. Mara) indicates that they have the advantage of allowing less evaporation than more shallow ponds, but the disadvantage that removal of nematode eggs and protozoa is less efficient.

An alternative method for saving land involves the use of low-cost treatment of sewage by lime coagulation. Addition of lime causes precipitation, then recarbonation is needed to restore the correct pH. This might be done in a storage pond. Research into these aspects is being undertaken at the Universities of Leeds and Newcastle (D. Mara and M.B. Pescod). At Newcastle, the effect of wastewater treated by lime on soil/plant relationships and the use of lime treatment (to adjust sodium/calcium balance) in areas where a problem of salinity of groundwater exists are also being investigated.

In the field of excreta use in agriculture, the use of dry alkaline fertiliser family (DAFF) latrines for the production of soil conditioner-cum-fertilizer has been occurring in Guatemala for many years, encouraged and supported by CEMAT (Centre for Mesoamerican Studies of Appropriate Technology). In the latrines, the addition of wood ash to the excreta causes the dry and alkaline conditions. The pathogen removal efficiency of this process is being studied by monitoring faecal coliform levels, viruses and helminth eggs (A. Cáceres). Viruses (as measured using ELISA tests) have not been found in the DAFF latrines although they have been detected in contents of normal pit latrines. Preliminary analysis of nematode eggs shows incomplete inactivation in latrines with a storage time of about 6 months. Studies are also being undertaken on alernatives to the use of wood ash. The effect on pathogen die-off of the use of a 1:2:3 mixture of lime/ash/soil is being investigated.

Irrigation methods

Since different methods of application of wastes influence the health risks to populations exposed to the wastes, research into the consequences of different methods is necessary. Research into wastewater irrigation in Portugal has investigated the effect of spray irrigation of fodder crops with effluent from a trickling filter plant (D. Mara). Research on the use of this effluent on lettuce has shown a rapid die-off of indicator bacteria on the crop. Four days after cessation of irrigation, the faecal coliform count on wastewater-irrigated lettuce was found to be less than the count on lettuce bought from the local market. Research on the use of waste stabilisation pond effluent in drip irrigation has shown that the emitters become blocked with algae, but that those algae are soil algae and do not come from the pondwater itself.

Research in Israel at Hebrew University of Jerusalem (H. Shuval) has looked into the type of pretreatment of wastewater that is necessary prior to the use of drip irrigation. Different mesh filters, granular filters and different emitter designs are being tested.

Waste quality monitoring

Research in this field concentrates on finding suitable techniques for measuring the most important microbiological parameters that need monitoring, and on testing the quality of wastes used in the field to see if they achieve the proposed quality standards.

Following the reviews of epidemiological evidence of the health effects of use of wastewater and excreta in agriculture (World Bank, 1985, IRCWD, 1985) it was clear that the highest risk to human health was of infection by the intestinal nematodes. The new nematode egg quality standard was therefore introduced. However, there is no standard method available for the monitoring of nematode eggs in wastewater. An investigation to test and develop suitable simple methods is beginning at Leeds University (D. Mara) and funded by ODA, UK. Development of monitoring techniques for nematode eggs and their field evaluation is also being carried out at the University of Nancy (see **News Flash**).

After nematode infections, the second greatest risk is posed by bacterial infections and these are normally monitored using indicator bacteria rather than specific pathogenic bacteria. The indicator of choice at present is the faecal coliform level, and not total coliform level previously used. However, information on the pathogen removal efficacy of various waste treatment processes in tropical countries remains scarce since in many plants, no microbiological monitoring is done at all. A system of monitoring many treatment plants in different countries using standardised techniques has been proposed by Dept. of Civil Engineering, University of Newcastle upon Tyne (M.B. Pescod), and some collaborating institutions have been identified. It is unfortunate that financing has not yet been found to fund these studies.

Viral infections pose a lower risk than the nematode or bacteria infection, but can be important in some situations. Techniques for the monitoring of rotavirus in waste stabilisation ponds are being tested at Leeds University. Instead of actually monitoring rotavirus, the use of coliphage removal as an indicator for virus removal is being tested at Newcastle University (M. B. Pescod).

Microbiological monitoring of the quality of wastewater coming from Mexico City and being used in irrigation in Rural Development District 063 is being done by the Ministry of Agriculture and Water Resources, with financial support from PAHO (Pan American Health Organization). Initially, monitoring of coliform and faecal coliform levels was started, and this will be supplemented by monitoring for nematode eggs and for viruses. Technical support for virological monitoring will come from University of Arizona, with financial support from the Integrated Resource Recovery Project of the World Bank. New techniques using gene probes will be used, which gives a reduction in costs in comparison with previous techniques (although the cost remains too high for use in routine monitoring at present). Some of the monitoring stations within the irrigation district are around a storage reservoir, and the results will show the effect of detention of the wastewater in the reservoir for different periods at different times of year. The biology of wastewater storage reservoirs has been studied in more detail in Israel by the Hebrew University of Jerusalem where the die-off of pathogens during long-term storage (10 – 12 months) has been monitored (H. Shuval).

In the field of excreta use, research into appropriate monitoring strategies is being undertaken by CEMAT, Guatemala. The use of very simple and inexpensive tests, lik the "shake" test, are being compared with scientific tests. In the shake test, the noise made by a sample of DAFF latrine contents when shaken in a test tube is used to indicate its dryness. This is compared with the results of tests for necessary water content ($\leq 50\%$), pH (≥ 8.5) and volatile solids. The association between these simple and easily testable parameters and pathogen die-off are being investigated.

Monitoring of the DAFF latrine contents also includes quantitative nematode egg analysis and tests for viability of the eggs found. Future work will involve comparison of different quantitative methods for detecting eggs and comparison of a viability test using morphological indicators with a viability test using in vitro cultivation.

Microbiological aspects of waste-fed aquaculture

Health aspects of the use of wastewater and excreta in aquaculture have received less attention from researchers than their use in agriculture. Waste-fed aquaculture systems can be divided into two types: firstly, where untreated excreta or wastewater is added to "natural" pond systems, and secondly where fish are reared in a pond that is part of a wastewater treatment system, a waste stabilisation pond. The first type occurs mostly in China and south-east Asia, and is often a traditional practice, whereas the second type has more often been introduced into an area as an economic venture. Most research that has been reported in the English language is on the second type. Studies on wastewater aquaculture in waste stabilisation ponds in Lima, Peru, have continued for many years. These have been carried out at CEPIS (Pan American Centre for Sanitary Engineering and Environmental Sciences) and supported by UNDP/World Bank/GTZ Integrated Resource Recovery Project. The final results of the research are now available, including detailed microbiological results of water quality (coliform, faecal coliform, parasite, and *Salmonella* counts) and some fish toxicology (C. Bartone). Studies of septage-fed aquaculture are being carried out at Asian Institute of Technology, Bangkok, and a review of sewage-fed aquaculture prepared for Integrated Resource Recovery Project by Peter Edwards.

Large scale sewage-fed aquaculture occurs in ponds in East Calcutta, and microbiological aspects of these pond systems are being studied by Dr D. Ghosh and others at Institute of Wetland Management and Ecological Design (A. Redekopp). Small scale excreta-fed aquaculture occurs in fishponds in West Java, Indonesia, and microbiological aspects of these systems are being studied by Institute of Ecology, Padjadjaran University in Bandung (B. Abisudjak). The extent of waste treatment occurring in the ponds is being tested, using monitoring of indicator bacteria, and certain pathogenic bacteria. It is intended to also monitor the quality of fish grown in the ponds. This is being done in conjunction with an epidemiological study, reported below.

Studies of pathogen uptake by fish from wastewater of different qualities is being carried out in Israel by Hebrew University of Jerusalem (H. Shuval). Microbiological testing of fish after having been subjected to different depuration procedures is being done, to assess the efficacy and feasibility of depuration of fish as a measure for public health protection.

Epidemiological studies of waste reuse in agriculture and aquaculture

Research in this field concentrates on finding the effect on human health of particular waste treatment or waste management strategies. Some studies aim to test the appropriateness of the recommended waste quality guidelines, and others aim to fill in some of the many gaps in our knowledge about the specific health effects of waste reuse in particular cultural settings.

An epidemiological study of waste reuse in kibbutzim in Israel has investigated the effect of exposure of farm workers and nerby population groups to pond effluent applied to non-vegetable crops using spray irrigation (H. Shuval). The detention time for the wastewater in the ponds was about 10 days, and the effluent quality around 10^5 – 10^6 faecal coliforms/100 ml. Comparing cases of disease in exposed groups and control groups, no adverse health effects were detected in the occupational exposure group, and minimal effects were detected in population groups exposed to aerosols. Although the helminthic quality of the wastewater is not known, the results do appear to be consistent with the Engelberg Guideline for restricted irrigation. A serological study of the risks of *Legionella* in irrigation workers, showed there to be no excess risk in irrigation workers exposed to wastewater compared with those using fresh water (H. Shuval).

The London School of Hygiene and Tropical Medicine has been collaborating with IRCWD and the World Health Organization/United Nations Environment Programme project on the health hazards of the reuse of human waste since 1985 to encourage the setting up of a new generation of epidemiological studies. Following visits to many countries, prospects were followed up in Indonesia, Mexico and India (U. Blumenthal). In Indonesia, a study of excreta recycling in aquaculture is being done by Dr Bakir Abisudjak, Padjadjaran University, and funded by World Health Organization (South-East Asia Regional Office). A collaboration was set up and the epidemiological component of the study increased with further funding supplied by the WHO/UNEP project. The study involves a cross-sectional study of both occupational and domestic contact with fishpond water (for washing and bathing, but not for drinking purposes) and its impact on diarrhoeal disease in children as well as adults. This is the first study of its kind, and should help to fill a large gap in the knowledge of the health effects of waste reuse in aquaculture, where nothing is known of its impact on diarrhoeal disease. Measurements of the level of microbiological contamination on the pond water, the fish and other water sources are also being carried out.

In Mexico, links were made with the Ministry of Agriculture and Water Resources and with the Ministry of Health. A protocol was developed for a study of the risks to farm workers and their families of the use of wastewater for the irrigation of a restricted range of crops. Use of untreated water would be compared with use of water stored for several months in a storage reservoir, and its impact on diarrhoeal disease, and on intestinal parasites (nematodes and protozoa) would be tested. The main purpose of the study was to test the Engelberg Guideline for restricted irrigation, and also to test the extent of the morbidity caused by infection with intestinal nematodes in sub-groups of the population exposed to untreated wastewater. Financing for the study was being arranged in collaboration with the International Development Research Centre, Canada. However, the participation of collaborators in Ministry of Health is now in doubt and the project may progress with new project partners.

In India, discussions took place with Dr D. Ghosh at Institute of Wetland Management and Ecological Design, who were already working with IDRC on studies of sewage-fed aquaculture. The development of a protocol for an epidemiological study was initiated, but it is possible that this may only occur after more detailed microbiological studies have been finalised.

Sociocultural studies

In comparison with the other research areas, least progress appears to have been made in the area of socio-cultural studies. However, one study is underway.

In Guatemala, the social acceptance of DAFF latrines has been shown by its use by a small number of families, promoted by CEMAT. Use of the DAFF latrine is now promoted by CARE, and other non-governmental organisations. A study is being conducted by CEMAT (A. Cáceres) to test the success of the larger scale programmes being run by NGOs, and how they can be adapted for running on an even larger scale eventually by governmental organisations. This is being funded by IDRC (A. Redekopp).

Proposed Research Priorities

The list of research priorities given here will concentrate on urgent research needs and will not attempt to be all inclusive. The priorities are grouped into 5 main areas of research:

1 – Treatment of wastewater and excreta for pathogen removal
2 – Waste quality monitoring
3 – Health protection measures other than waste treatment
4 – Sociocultural studies
5 – Epidemiological studies.

Emphasis is placed on research into **methods of achieving health protection** which are in accordance with the new guidelines for wastewater and excreta reuse (Research fields 1, 2 and 3). In addition, emphasis is placed on the setting up of new **epidemiological studies** (Research field 5), to monitor and evaluate the effectiveness of the existing guidelines (which are based on current epidemiological knowledge) in achieving health protection, and to extend our knowledge further.

1 – Treatment of wastewater and excreta for pathogen removal

a. Pathogen removal properties of conventional waste treatment plants:

There is a great need to evaluate the pathogen removal properties of all currently used conventional and advanced waste treatment technologies providing full or partial treatment of wastes, to aid rational decisions about the best type of treatment plant to use in a particular reuse situation. Evaluation should include monitoring for both bacterial removal (using faecal coliform levels as an indicator) and helminth egg removal. Methods of upgrading existing treatment plants to ensure adequate pathogen removal must receive a high priority since in many areas it is not possible to choose to build a new sewage treatment facility.

b. Performance of waste stabilisation ponds:

Research into improving the performance of existing waste stabilisation ponds is needed in some areas. A higher percentage of pathogen removal at each stage could be achieved by the use of baffles, and this needs to be tested. In some areas, ponds at present running in parallel might be altered to run in series, to achieve higher pathogen removal. In other systems, an increase in the number of anaerobic ponds could be used. Research is also needed into the reasons for the failure of some pond systems which are at present non-operational.

c. Land saving options:

Where land is scarce, or land prices high there is an urgent need to develop alternatives which use less land but give similar high pathogen removal to ponds. A good start has been made on this research, but further studies are needed, particularly in countries where ponds are least suitable.

d. Treatment strategies where uncontrolled reuse of wastes occurs:

It is important to do research into ways to provide minimal treatment, particularly to remove helminth eggs, as a first step away from uncontrolled reuse of wastes. For example, research into the optimal design configuration and minimum detention time of anaerobic ponds would be useful in respect of wastewater reuse.

e. Excreta treatment:

Promoting excreta treatment before reuse is in some ways more difficult than wastewater treatment, since excreta are not centrally collected. Research on pathogen removal by twin-pit latrines should receive priority. Where municipal collection is possible, the efficiency of lagoon systems in treating septage and nightsoil should be tested.

2 – *Microbiological monitoring*

Promotion of appropriate microbiological monitoring regimes for hazard detection should be given a priority. Initially the most urgent need is to encourage the monitoring of helminth egg concentrations in the wastewater or excreta, and the monitoring of faecal coliform levels to indicate bacterial contamination. For helminth eggs, the method outlined in WHO/UNEP Guideline document could be used initially, while research into other methods is carried out. There is a need to improve on low-cost, easily reproducible and reliable egg detection methods which have a high degree of sensitivity. Further investigations are also required to improve on methods to determine egg viability which would be suitable for routine application (particularly for sludge or compost use).

3 – *Health protection strategies other than waste treatment*

In the generalised model of the level of risk associated with different control measures, methods other than waste treatment, or in combination with partial waste treatment, are proposed (see article on the model of health protection measures on page 13). There is a great need to do more research into each of these measures, singly and in combinations, to establish in different circumstances their feasibility.

a. Management strategies for crop restriction:

Where crop restriction is known to be working, there is a need to study management strategies within the local cultural context. Such situations should be compared with settings where crop restriction has been attempted and has failed, to try to identify important components of success and failure. Such knowledge can be used to identify other situations where crop restrictions may be usefully applied, and indicate ways to successfully manage the schemes.

b. Localised waste application methods:

Use of localised waste application is a very effective health protection measure. However, at present the localised application of wastewater tends to be possible only with well-treated effluent. Research is needed to find methods that can deliver minimally treated effluents to a variety of crops without clogging delivery devices (especially drip, trickle and bubbler systems).

c. Human exposure control:

Ways to achieve human exposure control have not received as much attention as the other health protection measures. There is a need to investigate seriously what is practical in specific circumstances, for example, what types of human exposure control can be successfully provided to workers in an area with successful crop restriction, but where waste treatment is not feasible. The performance of delivery systems (e.g. health care programmes for hygiene education, etc.) compliance rates and resultant health effects should be assessed. Although, "hardware" components of the range of measures for health protection (like treatment technology) are important, increasingly more attention should be paid to research into "software" components of the system (like management strategies and changing human exposure patterns).

4 – *Sociocultural studies*

a. Sociocultural factors and public health protection measures:

The highest priority for social research into waste reuse should go into identifying and investigating those social and cultural factors which are most important in influencing the success of different public health protection measures. The results would help influence the choice of the best health protection measures to adopt in new situations. This could involve studies of socio-economic factors within current "safe" reuse situations that make the practice culturally acceptable, and similar studies of social factors in current "unsafe" reuse situations to identify impediments to health protection measures. Wherever demonstration projects are being considered, social feasibility studies should be conducted first.

b. Behavioural risk factors affecting transmission:

In support of the health protection measure of human exposure control, studies are needed to investigate the most important behavioural risk factors for transmission, so that appropriate prophylactic behaviours can be encouraged. The investigation of behavioural risk factors should be a part of every epidemiological study of waste reuse.

5 – *Epidemiological studies*

a. Studies to help guide technical policy and test the validity of proposed guidelines

There is still a great need to set up studies to test the validity of the proposed Engelberg Guidelines for wastewater reuse in a variety of different settings, and therefore to guide waste treatment and management policy. Two types of study are most urgently needed. The first is to evaluate if there is a risk of excess intestinal nematode infection to agricultural workers, when they are exposed to effluent with a quality of ≤ 1 nematode egg/litre (the Engelberg Guideline for restricted irrigation). The second type of study needed is to evaluate if there is an excess risk of bacterial (or viral) infections in consumers of raw vegetable crops irrigated with effluent with a quality of ≤ 1000 faecal coliform/100 ml (guideline for unrestricted irrigation).

The first type of study is the most feasible and could be done in a site where sufficient workers use effluent from waste stabilisation ponds (2-cell series), and where control populations are also available. The second type of study is more difficult, since it needs a site where seveal conditions are met; use of effluent from a bigger pond series (4 to 5 cells with around a 25 day retention time) or from a tertiary treatment plant, crops that can be identified at market as being waste-fed, large populations of identifiable consumers and also a large control population.

In addition to studying situations where the guidelines are met, it is also important to do studies where they are not met to see whether contravening the guidelines really causes a health risk. Interesting situations for study include pond systems where the effluent is only a little below the required quality, and the use of effluent from conventional secondary treatment plants. In both situations the possible excess intestinal nematode infection in farm workers should be investigated first.

Similar types of study are needed where **excreta use in agriculture** occurs. However, use of excreta is often on individual small holdings and the excreta does not come from a centralised supply; in this circumstance, use of localised application methods may be more suitable than treatment of excreta, so testing of waste quality standards is not as important as in wastewater use.

For the use of **wastewater or excreta in aquaculture,** present information concerns the risk of trematode infections (e.g. clonorchiasis, schistosomiasis) but there is a need to do epidemiological studies in areas not endemic for these trematode infections, where diarrhoeal disease will often be the disease of greatest interest. A well-controlled study of the impact of waste-fed aquaculture in Africa should also measure the impact on schistosomiasis.

b. Studies to fill gaps in current knowledge

There are several important gaps in the knowledge on the adverse health effects of waste reuse which need to be filled. Firstly, past studies have studied frequency and not severity of infection, and have not attempted to measure excess morbidity or excess mortality from the disease. In the study of excess infection by intestinal nematodes, it is important to study the intensity of infection and not only the prevalence, to give an idea of any excess morbidity attributable to waste reuse. Studies on the more severe infections that may be increased by waste reuse, for example, typhoid fever, should receive high priority. Diarrhoeal disease, particularly in the children of exposed adults should also be studied further since it may be an important cause of mortality as well as morbidity in young children.

Secondly, most past studies have involved farm workers or populations living near to waste reuse sites and more studies on consumers of waste-fed crops are urgently needed. In addition, other vulnerable groups should be investigated, for example, the children of farm workers and not only farm workers themselves. Lastly, the effect of different ways of application of wastes to the crops and the effect of different levels of hygiene in the community should be investigated, since it is not yet clear how health risks may be influenced by general hygienic standards and by the mode of waste application.

c. Refining epidemiological methods

The epidemiological methods used in the measurement of health risks of wastewater and excreta use need developing. By using appropriate study designs, paying attention to obtaining data of high quality and putting time and effort into suitable data analysis, answers should be found to many of these questions within a reasonable time period and at relatively low cost.

However, before epidemiological studies can be done, it is necessary to find epidemiologists to do them. There is an urgent need for personnel involved in agriculture and water resources and concerned about environmental health to seek out and make links with epidemiologists in different institutions. Epidemiologists need to be convinced that this is a subject of great interest and public health importance, and worthy of their attention.

A list of Research Priorities was also given in IRCWD News No. 23, within The Engelberg Report. The reader is referred back to this report, where additional research studies were also mentioned.

Institutions and Projects Supporting Research and Development Activities in the Field

Support for research and development activities in the field of human waste use is provided by several organisations. Current activities of the organisations represented at the Adelboden meeting are described below. Names in brackets refer to the person who reported the activities.

Food and Agriculture Organization (FAO), Land and Water Division, Eastern Mediterranean Region (A. Arar)

FAO is establishing a network in this Region for promoting the treatment and use of wastewater for irrigation. This is being done using research studies and by training methods. Examples of the research being sponsored include research in Cyprus and in Jordan into the performance of pond systems (including deep ponds) and the use of different irrigation methods (for example, drip and sprinkler) taking into account the quality of the effluent necessary for these methods. Promotion of safe use of wastewater in irrigation is also done in workshops such as one recently held in Egypt.

World Bank/United Nations Development Programme (UNDP), Integrated Resource Recovery Project (C. Bartone)

This project promotes the safe and economic use of wastes through sponsoring research, literature reviews, providing technical assistance and setting up demonstration projects. In the field of waste-fed aquaculture, research has recently been finalised in Peru and Thailand, and a literature review prepared (see section on aquaculture). In the field of co-composting, literature reviews and research have been carried out, and demonstration projects are now being set up. In the field of wastewater reuse in agriculture, literature reviews have been done, and some research is being supported. This includes virological monitoring of wastewater from Mexico City, comparison of desert irrigation with other disposal options in Karachi, and in future may include support of an epidemiological study of the effect of wastewater treatment on rates of typhoid in Santiago. Demonstration projects are being set up in Mexico City for solid waste recycling and this may also include a component on the reuse of domestic wastewater.

International Development Research Centre (IDRC), Canada (D. Sharp, A. Redekopp)

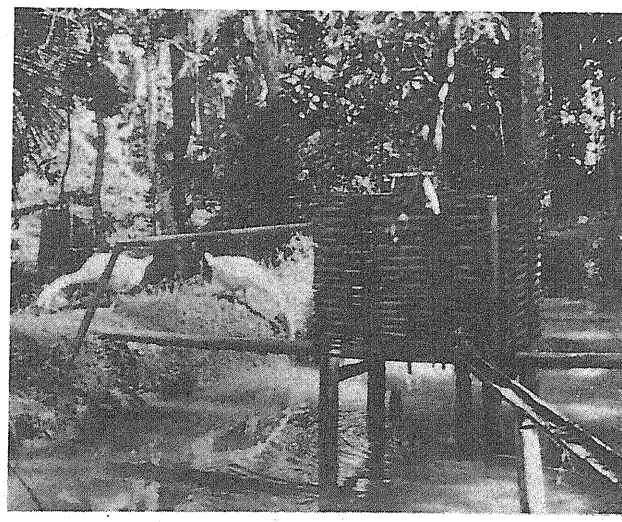
IDRC has a long history of supporting studies of waste reuse. In the past, most have involved monitoring of the microbiological content of different types of waste. Support for microbiological studies continues, for example, funding of a study at CEPIS, Peru, of the relation between pond effluent quality and irrigated vegetable quality, including a comparison with the quality of vegetables from the market. Support is also available for sociocultural and epidemiological studies. The work of CEMAT, Guatemala, on the use and acceptance of DAFF latrines is being supported, and IDRC is collaborating with LSHTM/IRCWD in the development and potential funding of epidemiological studies.

International Reference Centre for Waste Disposal (IRCWD), Switzerland (R. Schertenleib, M. Strauss)

IRCWD began its involvement in waste reuse with the support of literature reviews of pathogen survival, socio-cultural aspects of waste reuse, and on the health effects of use of nightsoil and sludge in agriculture and aquaculture. In the next phase, it has funded the work of LSHTM in the development of epidemiological studies, and has developed a range of case study material through visits to countries where waste reuse occurs. IRCWD is now funding latrine monitoring and pathogen survival studies, for example, a study of the survival of nematode eggs in DAFF latrines by CEMAT. In addition, IRCWD has convened the two major meetings of persons involved in the subject, at Engelberg in 1985 and Adelboden in 1987.

World Health Organization (WHO) (I. Hespanhol, A. Prost)

WHO (Division of Environmental Health, Geneva) initiated the joint project with United Nations Environment Programme (UNEP), on the health hazards of the use of human wastes. WHO/UNEP are collaborating with the London School of Hygiene and Tropical Medicine and IRCWD in promoting new epidemiological studies and in creating a network for information exchange. It has through its Regional Office for South-East Asia (SEARO) also helped fund these new studies, for example, by contributing to the study of excreta use in aquaculture in Indonesia. WHO/UNEP funded the preparation of the "Guidelines for the safe use of wastewater and excreta in agriculture and aquaculture: measures for public health protection" the executive summary of which appears earlier in the publication.



Photograph 6: Java, Indonesia: Traditional fishpond fertilization with overhung latrines (Photo: U.J. Blumenthal)

News Flash

At the Faculty of Pharmacy, University of Nancy, France, extensive investigations on **helminth egg** occurrence in sludge of wastewater treatment plants and on egg removal in waste stabilization ponds have been and are being carried out. In the course of these investigations, the researchers have developed and tested several **analytical methods,** both for egg recovery (quantitative determination) and for the determination of egg viability. Persons interested in obtaining specific information should contact Prof. Schwartzbrod in charge of these investigations.

Prof. (Ms) Janine Schwartzbrod
Professor of Microbiology
Faculty of Pharmacy
5, rue Albert Lebrun
F-54 000 Nancy/France
Tel.: 83 32 29 23 (ext. 260)

News from WHO

Dual-Focus Project – A New Approach to Training

Start-Up Workshop in Amman

By **Neil F. Carefoot & Harald L. Stokkeland**

In November-December 1987, the Dual-Focus Project was initiated by WHO through a four week long workshop utilizing the facilities of the Centre for Educational Development for Health Personnel, University of Jordan, Amman. Budgetary support for the project has been provided by WHO, SIDA and US-AID.

The Dual-Focus Project, which deals with performance problems in water and sanitation programmes, is both a HRD* programme and an organizational development programme at the same time – consequently the name "Dual-Focus". The Dual-Focus approach focusses on both personnel performance and organizational performance simultaneously.

* HRD = Human Resources Development

The workshop itself, lasting one month out of the 18 months of the total project period, laid the foundation for the work to be undertaken "back home"

A number of themes or training components ran parallel throughout the workshop, the most important are:

1) **Problem solving in organizations**

Each participant when nominated had to identify a performance problem with relevance and importance to him and his organization. This then was the focal point of both a considerable part of the workshop activities and the follow-up activities in the real-life on-the-job situations. The number of country projects were reduced from 24 to 6 during the workshop period so that each of the country groups (from Jordan, Pakistan and Tanzania) related to one of the two national problem/project groups.

For the Tanzanian group, the functioning of village health workers in the Kagera Region and the water system operation and maintenance in a district of the Musoma Region were the chosen projects. In the case of Jordan, the unaccounted-for water and the deteriorating water quality of some central urban areas were chosen. The Pakistani projects were Project Management and Water Quality Surveillance.

2) **Effective organizational leadership behaviour and management**

Another important workshop component dealt with the roles of participants as leaders/managers. Using 19 down-to-earth categories of leadership behaviour, the participants identified effective and ineffective leadership behaviours in general and also analyzed their own specific situations.

3) Supporting the workshop climate and thus facilitating learning, and creating a useful awareness of one's own effect on other people in working groups, are the basic justifications for a third component of the workshop, viz., **group leadership/dynamics.** In the Jordan setting, this component was in the shape of "laboratory" exercises. They were of vital importance throughout the workshop, but especially in the beginning when participants do not know one another and the cultural heterogenity creates insecurity.

4) Because training investments are expensive and because human resources development is an important management concern, the participants are also being trained as instructors and facilitators. Consequently, **instructional/presentation skills** is a fourth major component in the Dual-Focus training programme. Giving presentations and getting an immediate feedback from other participants and facilitators, makes this component a time-consuming one. However, this can be justified by the fact that what is most frequently being presented is the analytical work from the Dual-Focus problem solving process. The analysis and plans originated in the workshop will, as mentioned, be the cornerstones of the follow-up work.

The question has been raised: **What makes the Dual-Focus project different from traditional "training"?**

We believe that this special mix of components make our efforts more effective and different. The focus is on both the individual and the organization – the focus is dual: the individual manager in his organizational context with a very

Comparison of Approaches to Solving Performance Problems in Water & Sanitation Organizations

Traditional Training and Studies	Education/Training Considerations	Dual-Focus Approach
Solving performance problems through study and reflection leading to individual formal exam/diploma/certificate	**Objectives**	Solving performance problems through reflection and action leading to growth/change of organization and individual
On individual or on organizational/environmental phenomenon; decided upon by academic consideration	**Focus of Attention**	On individual and organizational/environmental; determined by the needs of the participants' work situations
Predecided upon by content experts	**Curriculum**	Framework provided by facilitators; details filled in jointly by participants and facilitators
"Truths" often imported and imposed from above	**Origin of Knowledge**	"Knowledge" elicited from participants & facilitators in their work contexts
Limited to training period	**Time Frame**	Extended into a long follow-up period
"Here and now" on training campus, most often in classroom	**Location**	Extended into the different job-organizations and work sites of participants
Passive, receiver of information	**Role of Participants**	Active, participative double-role: also "teacher"
"The telling professor" the sole source of knowledge	**Role of Instructors**	"Facilitator", manager of training process double-role: also "student"
Used in repetitive, one-way communication	**Instructor's Expertise**	Used in a dynamic and cooperative way; involved in interchange & follow-up work
Lecture dominated, on "theoretical" topics	**Dominant Learning Method**	Group-work dominated, active participation and contribution on work-related problems

important human resources development mandate – the leader is also a teacher.

Another strikingly different feature from other traditional training is the prolonging and pushing the workshop activities out into the 17-month follow-up time period and out into real-life on-the-job situations. This is achieved by staging interaction between participants and their co-workers both on the subordinate and superior level, as well as between facilitators and dual-focus programme participants.

The answer to our departing question about what makes the Dual-Focus project different from others, could also be given by quoting from the participants' evaluation of the initial workshop.

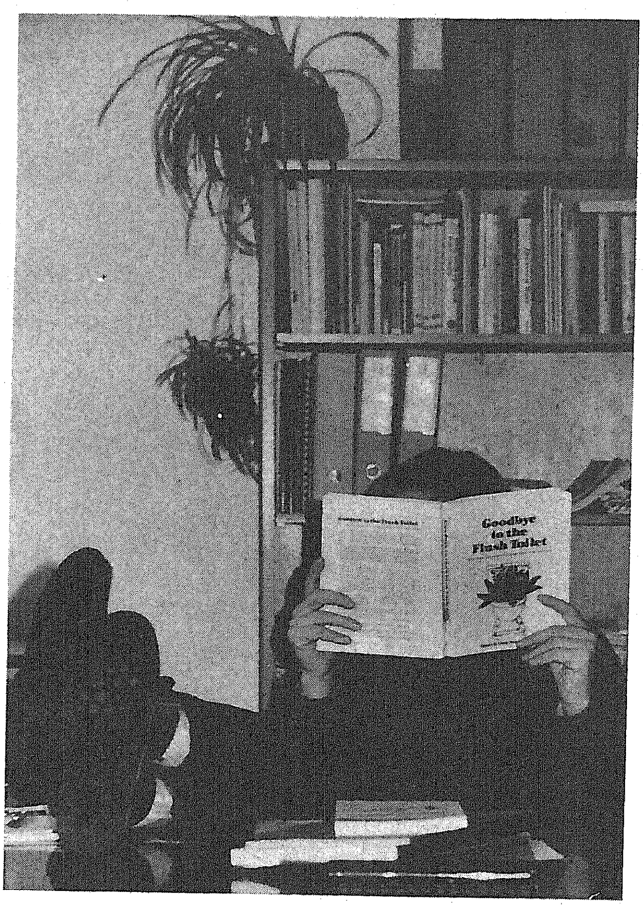
"The participants were not passive but active. The participants were engaged in all activities and group dynamics. The facilitators gave the chance for all participants to play important roles in all sessions held in this workshop".

The differences between "traditional training" and the Dual-Focus approach are summed up in the afore Table. The list represents typical differences between the two approaches. In the Dual-Focus approach we do not claim that we always achieve what we regard as ideal, but we believe that the deliberate shift away from conventional education/training methodologies helps improve the probabilities for success.

Additional information about the Dual-Focus Project can be otained by writing to:

Manager, Community Water Supply and Sanitation, Division of Environmental Health, World Health Organization, 1211 Geneva 27, Switzerland.

New and Almost New Publications



Women as Providers of Health Care by **Helena Pizurki, Alfonso Mejía, Irene Butter, Leslie Ewart,** World Health Organization, Geneva, 1987, 163 pages.

The present publication is the first on the situation of women as providers of health care to be prepared by WHO, and the first in the world to provide a general survey and analysis of this situation and guidance for those entrusted with the development of programmes to deal with it. Drawing upon information gathered at two large WHO-sponsored consultations, the book considers the contribution of women within both the formal health care system and the informal setting of health care to families, neighbours and communities. The objective is to make health planners – and women themselves – more conscious of the importance of women as resources for the solution of health problems while also promoting efforts to enhance, facilitate and recompense the work of women in health development.

This publication is available from WHO, Distribution and Sales Service, 1211 Geneva 27, Switzerland. French and Spanish versions are in preparation. Price per copy: Sfr. 29.– or US $ 17.40. ISBN 92-4-156104-1.

Prevention and Control of Intestinal Parasitic Infections, Report of a WHO Expert Committee, Technical Report Series No. 749. **WHO,** Geneva, 1987, 86 pages.

The book opens with individual profiles for each of the main helminthic and protozoan infections of public health importance. Profiles include information on global prevalence, areas of endemicity, life cycle of the parasite, routes of infection, symptoms, associated morbidity, and conditions favourable to transmission. A second section examines the costs arising from failure to control intestinal parasitic infections. Effects on nutrition, growth and development, on work and productivity, and on medical care costs are considered together with examples of national expenditures on the treatment of selected infections.

The present report includes some of the scientific information reviewed by the WHO Scientific Group on Intestinal Protozoan and Helminthic Infections in 1980. However, in this report a special effort has been made to present practical information on the control of intestinal parasitic infections that can be readily used by those authorities wishing to take action against these major health problems. Additional information covers suitable methods and tools for monitoring and surveillance, data management, diagnosis, and chemotherapy. The book concludes with sections on the planning and implementation of national programmes and on sources of programme support.

Copies are available from WHO, Distribution and Sales Service, 1211 Geneva 27, Switzerland. French and Spanish editions are in preparation. Price per copy: Sfr. 12.– or US $ 7.20. ISBN 92-4-120749-3.

Health Aspects of Nightsoil and Sludge Use in Agriculture and Aquaculture – Part I: Existing Practices and Beliefs in the Utilization of Human Excreta by **Piers Cross, – Part II: Pathogen Survival** by **Martin Strauss.** This is an International Reference Centre for Waste Disposal, IRCWD Report No. 04/85, 1985, 171 pages.

– Part. III: An Epidemiological Perspective by **Deborah Blum and Richard Feachem** is also an IRCWD Report No. 05/85, 1985, 80 pages.

An executive summary of these Reports is contained in IRCWD News No. 23, December 1985.

Copies are obtainable free of charge from International Reference Centre for Waste Disposal, IRCWD/EAWAG, Ueberlandstr. 133, 8600 Duebendorf, Switzerland.

Wastewater Irrigation in Developing Countries – Health Effects and Technical Solutions by **Hillel I. Shuval et al.,** May 1986, 355 pages. This is a World Bank Technical Paper No. 51 of the Integrated Resource Recovery Series, UNDP Project Management Report No. 6.

The principal finding of this study of the negative effects on health of wastewater irrigation and remedial measures for their control is that previous public health positions have been overly conservative and restrictive.

This report summarizes information on practices of wastewater reuse for agriculture in developing and developed countries, and reviews the public health and technological aspects of wastewater irrigation. It evaluates the potential health effects from such reuse, and proposes effective and economic control methods suited in particular to developing countries.

A theorectical model is developed, based on a review of available credible epidemiological studies and reports, to assist in predicting the degree of risk of disease transmission associated with various wastewater reuse practices. The model provides a basis for evaluating control options. The study suggests a guideline for unrestricted wastewater irrigation based on a effluent with less than one nematode egg (Ascaris or Trichuris) per litre and a geometric mean faecal coliform concentration of 1,000/100 ml.

This report is available at a minimal charge from the World Bank, Publications Sales Unit, 1818H Street, N.W., Washington, D.C. 20433, USA. ISBN 0-8213-0763-0

Low-Cost Rural Sanitation – Problems and Solutions by **S. Jeeyaseelan, B.N. Lohani** and reviewed by **T. Viraraghavan,** February 1987, 131 pages. This booklet was published by the Environmental Sanitation Information Center, ENSIC, Bangkok, Thailand.

The manual does not cover complicated issues but provides information in simple terms on how to choose an appropriate sanitation system, with practical examples on how to design, construct and maintain low-cost sanitation systems. Chapters two to six deal with a particular group of individual household sanitation systems, whereas the last chapter is concerned with a communal sanitation system. A comparison is made with regard to economic considerations and the various benefits, advantages and disadvantages pertaining to the available sanitation options.

The figures supplied will also be useful to all those who wish to design and construct such systems on a self-help basis, and to field workers who need practical instructional material for their work.

Orders can be placed with Library, Environmental Sanitation Information Center, ENSIC/AIT, P.O. Box 2754, Bangkok 10501, Thailand. ISBN 97-48-20020-5.

Proceedings – First Seminar and National Workshop on Dry Household Fertilizer Latrines (Primer Seminario – Taller Nacional sobre Letrinas Aboneras Secas Familiares – Memorias), Annex 2, Guatemala, 22-26 June 1987, 144 pages.

This seminar was organized by the Center for Mesoamerican Studies on Appropriate Technology, CEMAT, assisted by DSM, DGSS and MSPAS, Depts. of the Ministry of Health and sponsored by International Development Research Centre, IDRC, Ottawa, Canada. Users and latrine specialists from different regions in Guatemala and members of CEMAT attended the seminar to discuss different aspects related to the construction, maintenance, use and diffusion of dry household fertilizer latrines, as well as the limitations and recommendations concerning their possible diffusion at a national level.

This booklet ist available in Spanish only from CEMAT, 4a Ave. 2-28, Zona 1, P.O. Box 1160, Guatemala City, Guatemala.

Sanitation without Water – Revised and Enlarged Edition by **Uno Winblad** and **Wen Kilama,** illustrated by **Kjell Torstensson,** 1985, 161 pages. This edition was published by M Macmillan with the support of SIDA, Swedish International Development Authority, Stockholm, Sweden.

This edition has been extensively revised and rewritten since it first appeared in 1978. Several new examples and many illustrations have been added. The most significant change, however, is the inclusion of simple pour-flush latrines. A new chapter 4 deals with the selection of the right type of latrine and an appendix has been added describing the design and construction of a soakpit for the disposal of wastewater.

It has been prepared to meet increasing demands for practical information on how to design, build and operate better latrines. The emphasis is on simple measures easily carried out with limited resources.

It is primarily intended for health officers, nurses, medical auxilliairies, and village health workers. It should also be of relevance to other members of the medical professions and to architects, engineers, physical planners, and administrators concerned with appropriate technology.

Requests for copies should be directed to M Macmillan, Higher and Further Education Div., Houndmills, Basingstoke, Hampshire RG21 2XS, U.K. Price per copy £ 8.00 for hard copy or £ 2.50 for paperback. ISBN 0-333-39140-3.

Soil Management: Compost Production and Use in Tropical and Subtropical Environments by **H.W. Dalzell et al.,** 1987, 177 pages. FAO Soils Bulletin No. 56.

This Bulletin explains the basic composting process, suitable organic wastes, practical composting methods, use of the product in a variety of situations, and a consideration of economic and social benefits. It also deals with approaches to practical extension work with farmers on the subject.

It has been written in simple language without detracting from the scientific basis or level of technology involved. Its aim is to reach all those concerned with the maintenance and improvement of soil fertility, especially under tropical and subtropical conditions. It also provides training material on composting for extension workers and teachers and its objective is to promote the use of locally available organic materials to increase soil fertility. It contains material for use in farmer training, and those involved in planning safe waste disposal systems will also find it useful. Schoolteachers in rural areas will be able to base science lessons on it, while officials in local government throughout the tropics should find the manual stimulating.

Thise Bulletin can be purchased locally through FAO sales agents or directly from FAO, Distribution and Sales Section, Via delle Terme di Caracalla, 00100 Rome, Italy. Price per copy approx. US $ 10.–. ISBN 92-5-102553-3.

Community Water Supply: The Handpump Option by **Saul Arlosoroff et al.,** May 1987, 202 pages. This document is a World Bank publication.

This report is the outcome of a five year project carried out jointly by the UNDP and the World Bank, and supported by ten donours active in the sector. It gives a detailed account on the testing and monitoring in 17 countries, involving some 2,700 individual pumps of 70 different models.

This unique data base, along with data from many more community water supply projects, is the basis for the recommendations in this document, which rounds off the first phase of the Project. The report also provides guidelines for the selection of the water supply technology and system that best meet the needs of a given community.

This study, designed as a reference manual for policy makers and professionals, concludes that wells equipped with handpumps are an important water supply option for low-income, rural communities without access to the resources and skills necessary to run more complex water supply systems.

Orders can be placed with the World Bank, Publications Sales Unit, 1818 H Street, N.W., Washington, D.C. 20433, USA. Price per copy US $ 9.95. ISBN 0-8213-0850-5.

The Control of Schistosomiasis, Report of a WHO Expert Committee, WHO Technical Report Series No. 728, **WHO,** Geneva, 1985, 113 pages.

A WHO Expert Committee on the Control of Schistosomiasis met in Geneva from 8-13 November 1984 to discuss measures to control the morbidity due to schistosomiasis.

Health education as part of morbidity control is important in helping the population to modify behaviour to prevent the disease, to understand the meaning of health in contrast to disease, to recognize the symptoms of schistosomiasis, and to use appropriately the available health facilities. Health education should also encourage community involvement in control programmes with a view to social action. The new approach to schistosomiasis control emphasizes collaboration and implementation at the primary health care level in preference to the combined use of different intervention methods.

According to the Committee, the organizational, managerial and operational aspects of control are the major areas where progress can be made in the future.

Copies are available from WHO, Distribution and Sales Service, 1211 Geneva 27, Switzerland. Price per copy Sfr. 10.–. ISBN 92-4-120728-0.

Aquaculture: A Component of Low Cost Sanitation Technology by **Peter Edwards,** April 1985, 45 pages. This is a World Bank Technical Paper No. 36 of the Integrated Resource Recovery Series, GLO/80/004, UNDP Project Management Report No. 3.

This paper discusses all phases of aquaculture throughout the developing world including commercial viability, sanitary and biological considerations, public health, financial/economic, and sociological aspects. The project's objective is to encourage resource recovery as a means of offsetting some of the costs of community sanitation. Current studies are detailed and options are discussed for their potential aplicability to developing countries, considering requirements for capital and labor skills as well as physical needs such as land.

Requests for copies should be addressed to World Bank Publications, P.O. Box 37525, Washington, D.C. 20013, USA. Price per copy approx. US $ 5.–. ISBN 0-8213-0527-1

Guidelines for Planning Community Participation Activities in Water Supply and Sanitation Projects by **Anne Whyte,** 1986, 53 pages, WHO Offset Publication No. 96, WHO, Geneva.

It is now recognized that in water supply and sanitation projects best results are obtained only when the communities participate in the planning and execution of projects and when other sectors contribute simultaneously to the development effort. Such community participation and also intersectoral activities must be planned in great detail, with real, rather than hoped-for, financial and manpower resources committed to them from the outset.

The guidelines for planning presented in this book are simple and readily understandable and draw attention to the "waht, when, where, why, how, and who" questions associated with community participation; the material presented is in the form of check-lists of points to consider. The topics covered include: assessment of a community's potential for participation; setting of programme objectives and priorities: planning for national and regional agency support to communities; planning programme details at the community and project levels; and evaluation of activities.

Although this publication is primarily intended for the planners of water supply and sanitation projects, it may also prove useful to project planners in other development sectors.

These guidelines are available in English from WHO, Distribution and Sales Service, 1211 Geneva 27, Switzerland. Arabic, French and Spanish editions are in preparation. Price per copy Sfr. 10.– oder US $ 6.–. ISBN 92-4-170096-3.

Improving Environmental Health Conditions in Low-Income Settlements – A community-Based Approach to Identifying Needs and Priorities, 1987, 61 pages, WHO Offset Publication No. 100. This publication was prepared under the joint sponsorship of the **UNEP** and **WHO,** Geneva.

This book provides a rationale, a framework and a methodology for tackling the enormous health problems associated with living conditions in urban slums, tenements, shanty-towns, and other low-income settlemetns. The publication advocates an approach that relies upon the community's self-interest to generate change and improve living conditions. The importance of securing support from governments and other local agencies is also considered.

Emphasis is placed on instruments and techniques for data collection that can help define improvements that the community wants, considers affordable and is prepared to work to achieve.

Various survey techniques are described that are inexpensive and do not require any sophisticated knowledge or expertise. Further practical information is provided in annexes offering instructions in the design of questionnaires, sampling, training of interviewers, and the coding and cross-tabulation of data by hand.

Thoroughly practical in content and purpose, this book should be available to and distributed by government ministries, public utility agencies, local authorities, nongovernmental organizations, and international agencies.

Reprints of the English edition of this publication can be requested from WHO, Distribution and Sales Service, 1211 Geneva 27, Switzerland. French and Spanish versions are in preparation. Price per copy Sfr. 12.– or US $ 7.20. ISBN 92-4-170100-5.

Photograph 7: Bogor (Java) Indonesia: Fish production in river cages

Editors:
M. Strauss, S. Peter
"IRCWD NEWS"
Swiss Federal Institute for Water Resources and Water Pollution Control (EAWAG)
Ueberlandstrasse 133, CH-8600 Duebendorf, Switzerland