FACT SHEET

INFORMATION FOR ACTION FROM THE WATER AND SANITATION FOR HEALTH PROJECT

Water Reuse in Developing Countries

Including Guidelines for Wastewater Reuse

As communities around the world reach the limits of their water supplies, wastewater is increasingly being reused to conserve and increase available water resources and to reduce pollution. However, standards and regulations to manage and plan water reuse programs have been lacking.

In 1992, the U.S. Environmental Protection Agency's 1980 Guidelines for Water Reuse *was revised and updated by Camp Dresser & McKee Inc., with funding from E.P.A. and the U.S. Agency for International Development through A.I.D.'s Water and Sanitation for Health (WASH) Project. The primary purpose of the* Guidelines *is to provide information about how to develop effective wastewater reuse programs. They are intended for U.S. utilities and regulatory agencies that are seeking to establish standards or regulations on the reclamation and reuse of wastewater. They also provide useful information for developing countries.*

The Guidelines *address water reclamation for nonpotable urban, industrial, and agricultural use. Also, attention is given to augmentation of potable water supplies by indirect reuse. Although sources of reclaimed water may range from industrial wastewaters to the return flows from agricultural irrigation systems, the* Guidelines *cover only the use of water reclaimed from the effluents generated by domestic wastewater treatment facilities.*

The revised edition of the Guidelines incorporates recent institutional and technical advances in water reuse. In addition, it includes a chapter on water reuse applications in countries outside the United States—mainly in developing countries, particularly the arid and semi-arid countries of North Africa, although the manual is applicable to all countries.

This Fact Sheet provides a summary of the Guidelines, outlining the basic issues for water reuse in developing countries.

The Golden Rule of Wastewater Reuse

Whether wastewater is being reused in industrialized or developing countries, it must be treated. The extent of the treatment depends upon how it will be used. Higher-level uses, such as irrigation of vegetables to be consumed without processing, require a higher level of treatment than lower-level uses, such as pasture irrigation. In urban reuse, where there is a high potential for human exposure to reclaimed water used for landscape irrigation, toilet flushing, and industrial purposes, the water must be adequately disinfected and a chlorine residual must be maintained in the distribution system.

The Basic Rationale for Wastewater Reuse

Many urban residential, commercial, and industrial uses can be satisfied with water of less than potable quality: irrigation of lawns, parks, and roadway borders; air conditioning and industrial cooling towers; industrial processing; toilet and urinal flushing; construction; cleaning and maintenance, including vehicle washing; scenic waters and fountains, and environmental and recreational purposes. Customarily, public water supplies provide water of potable quality to serve all these purposes. When reclaimed water is substituted for potable water formerly used for nonpotable purposes it is as if a "new" source has been discovered, and it becomes possible to maintain the highest quality for public consumption and to extend potable water to an increased population.

While the need for additional water supply has been the impetus for numerous water reuse programs in the United States, many programs have been initiated in response to rigorous and costly requirements for effluent discharge to surface waters. In developing countries the rationale for reuse is generally to increase water supplies, although pollution abatement is a growing concern.

The Current Situation in Developing Countries

A number of conditions that prevail in developing countries have an impact on the potential for reusing wastewater.

- ***Lack of wastewater collection and treatment.*** In developing countries only about 7% of the population is served by wastewater collection *and* treatment facilities. Many cities are unsewered, and the sewers that do exist often discharge untreated wastewater into the nearest drainage channel or water course. Collecting the wastewaters for treatment is a formidable and expensive task, but reuse cannot begin until sewers, interceptors, trunk sewers, and treatment plants are built.

- ***Inadequate treatment of wastewater.*** The major cities of developing countries, including Eastern Europe and the former Soviet Union, generally do have sewers and often wastewater treatment plants, but treatment is seldom sufficient for safe reuse. As these countries rehabilitate their urban infrastructure, there will be significant opportunities to upgrade wastewater treatment plants to reclaim wastewater for urban nonpotable reuse.

- ***Protection of public health.*** High-quality water is generally not available for irrigating high-value market crops near developing country cities. The common practice today is to use raw wastewater for irrigation or to withdraw water from streams that are polluted with raw wastewater. The consequent contamination of food stuffs to be eaten raw maintains a high level of enteric disease. Although wastewater reuse is common in developing countries, the protection of public health has not yet provided an incentive for initiating safe agricultural reuse practices in these countries.

- ***Potential for wastewater reuse.*** Almost all water reuse in developing countries currently is for agricultural purposes; however, meeting a range of urban nonpotable water demands through reuse is a promising option in the growing urban areas of Asia, Africa, Latin America, Europe, the former Soviet Union, and Australia. By 2020, more than half the population of Asia, Africa, and Latin America will be living in cities. With urban growth, water reclamation for nonpotable reuse may be less costly and more feasible than developing new sources of fresh water. Urban reuse has two main advantages over agricultural reuse.

    ✔ *It is partially nonconsumptive.* Urban uses, such as toilet flushing, vehicle washing, stack gas cleaning, and industrial processing are nonconsumptive. The water can be reclaimed again for subsequent reuse, including consumptive use in agriculture or evaporative cooling.

    ✔ *It is more feasible.* Urban markets for reuse are generally closer to the point of origin of the reclaimed water than agricultural markets. Also, the value of water for urban reuse is generally far greater than for agricultural reuse. It can be metered and costs can be recovered. The costs of providing water for domestic urban reuse may be higher than water for some irrigation uses because more treatment is necessary. For market crops, the quality requirements are much the same as for unrestrictive urban use.

- ***The best prospects for wastewater reuse.*** The developing areas of larger, richer, rapidly growing cities with short water supplies, some sewerage, and pressures to control pollution are ideal candidates for wastewater reuse. Sao Paulo, Brazil, is a good example. There the high quality effluent produced by the first module of an activated sludge treatment plant inspired studies of reuse for industry.

Institutional & Financial Aspects of Wastewater Management
Related WASH Reports

Point Source Pollution in the Danube Basin: Vol. 1—Summary: Vol. II—Institutional Studies: Vol. III: Country Technical Reports; Users Manual for the Danube Emissions Management Decision Support System. (FR 374)

Guidelines for Improving Wastewater and Solid Waste Management. (forthcoming)

Andean Regional Workshop on Alternative Approaches to Wastewater Management. (FR 394)

To obtain a copy of these reports or a complete list of WASH reports, contact WASH headquarters.

Table 2: **E.P.A. Comprehensive Guidelines for Wastewater Reuse**

Types of Reuse	Treatment[1]	Reclaimed Water Quality[2]	Reclaimed Water Monitoring	Setback Distances[6]	Comments
Urban Reuse All types of landscape irrigation, also vehicle washing, toilet flushing, use in fire protection systems and commercial air conditioners, and other uses with similar access or exposure to the water	• Secondary • Filtration • Disinfection	• pH = 6 – 9 • ≤10 mg/l BOD • ≤2 NTU • No detectable fecal coli/100 ml[3] • 1 mg/l Cl_2 residual (min.)	• pH—weekly • BOD—weekly • Turbidity—continuous • Coliform—daily • Cl_2 residual—continuous	• 15 m to potable water supply wells	• At controlled-access irrigation sites where design and operational measures significantly reduce the potential of public contact with reclaimed water, a lower level of treatment, e.g., secondary treatment and disinfection to achieve ≤14 fecal coli/100 ml, may be appropriate. • Chemical (coagulant and/or polymer) addition prior to filtration may be necessary to meet water quality recommendations. • The reclaimed water should not contain measurable levels of pathogens.[7] • Reclaimed water should be clear, odorless, and contain no substances that are toxic upon ingestion. • A higher chlorine residual and/or a longer contact time may be necessary to assure that viruses and parasites are inactivated or destroyed. • A chlorine residual of 0.5 mg/l or greater in the distribution system is recommended to reduce odors, slime, and bacterial regrowth.
Restricted Access Area Irrigation Sod farms, silviculture sites, and other areas where public access is prohibited, restricted, or infrequent	• Secondary • Disinfection	• pH = 6 – 9 • ≤30 mg/l BOD • ≤30 mg/l SS • ≤200 fecal coli/100 ml[4] • 1 mg/l Cl_2 residual (min.)	• pH—weekly • BOD—weekly • SS—daily • Coliform—daily • Cl_2 residual—continuous	• 90 m to potable water supply wells • 30 m to areas accessible tp the public (if spray irrigation)	• If spray irrigation, SS less than 30 mg/l may be necessary to avoid clogging of sprinkler heads.
Agricultural Reuse—Food Crops Not Commercially Processed[8] Surface or spray irrigation of any food crop, including crops eaten raw	• Secondary • Filtration • Disinfection	• pH = 6 – 9 • ≤10 mg/l BOD • ≤2 NTU • No detectable fecal coli/100 ml[3] • 1 mg/l Cl_2 residual (min.)	• pH—weekly • BOD—weekly • Turbidity—continuous • Coliform—daily • Cl_2 residual—continuous	• 15 m to potable water supply wells	• Chemical (coagulant and/or polymer) addition prior to filtration may be necessary to meet water quality recommendations. • The reclaimed water should not contain measurable levels of pathogens.[7] • A higher chlorine residual and/or a longer contact time may be necessary to assure that viruses and parasites are inactivated or destroyed. • High nutrient levels may adversely affect some crops during certain growth stages.
Agricultural Reuse—Food Crops Commercially Processed[8]	• Secondary • Disinfection	• pH = 6 – 9 • ≤30 mg/l BOD • ≤30 mg/l SS • ≤200 fecal coli/100 ml[4] • 1 mg/l Cl_2 residual (min.)	• pH—weekly • BOD—weekly • SS—daily • Coliform—daily • Cl_2 residual—continuous	• 90 m to potable water supply wells • 30 m to areas accessible to the public	• If spray irrigation, SS less than 30 mg/l may be necessary to avoid clogging of sprinkler heads. • High nutrient levels may adversely affect some crops during certain growth stages.
Agricultural Reuse—Non-Food Crops Pasture for milking animals; fodder, fiber and seed crops	• Secondary • Disinfection	• pH = 6 – 9 • ≤30 mg/l BOD • ≤30 mg/l SS • ≤200 fecal coli/100ml[4] • 1 mg/l Cl_2 residual (min.)	• pH—weekly • BOD—weekly • SS—daily • Coliform—daily • Cl_2 residual—continuous	• 90 m to potable water supply wells • 30 m to areas accessible to the public (if spray irrigation)	• If spray irrigation, SS less than 30 mg/l may be necessary to avoid clogging sprinkler heads. • High nutrient levels may adversely affect some crops during certain growth periods. • Milking animals should be prohibited from grazing for 15 days after irrigation ceases. A higher level of disinfection, e.g., to achieve ≤14 fecal coli/100 ml, should be provided if this waiting period is not adhered to.

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Types of Reuse	Treatment[1]	Reclaimed Water Quality[2]	Reclaimed Water Monitoring	Setback Distances[6]	Comments
Recreational Impoundments Incidental contact (e.g., fishing and boating) and full body contact with reclaimed water allowed	• Secondary • Filtration • Disinfection	• pH = 6 – 9 • ≤10 mg/l BOD • ≤2 NTU • No detectable fecal coli/100 ml[3] • 1 mg/l Cl_2 residual (min.)	• pH—weekly • BOD—weekly • Turbidity—continuous • Coliform—daily • Cl_2 residual—continuous	• 150 m to potable water supply wells (minimum) if bottom not sealed	• Dechlorination may be necessary to protect aquatic species of flora and fauna. • Reclaimed water should be non-irritating to skin and eyes. • Reclaimed water should be clear, odorless, and contain no substances that are toxic upon ingestion. • Nutrient removal may be necessary to avoid algae growth in impoundments. • Chemical (coagulant and/or polymer) addition prior to filtration may be necessary to meet water quality recommendations. • The reclaimed water should not contain measurable levels of pathogens.[7] • A higher chlorine residual and/or a longer contact time may be necessary to assure that viruses and parasites are inactivated or destroyed. • Fish caught in impoundments can be consumed.
Landscape Impoundments Aesthetic impoundment where public contact with reclaimed water is not allowed	• Secondary • Disinfection	• ≤30 mg/l BOD • ≤30 mg/l SS • ≤200 fecal coli/100 ml[4] • 1 mg/l Cl_2 residual (min.)	• pH—weekly • SS—daily • Coliform—daily • Cl_2 residual—continuous	• 150 m to potable water supply wells (minimum) if bottom not sealed	• Nutrient removal processes may be necessary to avoid algae growth in impoundments. • Dechlorination may be necessary to protect aquatic species of flora and fauna.
Construction Uses Soil compaction, dust control, washing aggregate, making concrete	• Secondary • Disinfection	• ≤30 mg/l BOD • ≤30 mg/l SS • ≤200 fecal coli/100 ml[4] • 1 mg/l Cl_2 residual (min.)	• BOD—weekly • SS—daily • Coliform—daily • Cl_2 residual—continuous		• Worker contact with reclaimed water should be minimized. • A higher level of disinfection, e.g., to achieve ≤14 fecal coli/100 ml, should be provided where frequent worker contact with reclaimed water is likely.
Industrial Reuse Once-through cooling	• Secondary	• pH = 6 – 9 • ≤30 mg/l BOD • ≤30 mg/l SS • ≤200 fecal coli/100ml[4] • 1 mg/l Cl_2 residual (min.)	• pH—daily • BOD—weekly • SS—weekly • Coliform—daily • Cl_2 residual—continuous	• 90 m to areas accessible to the public	• Windblown spray should not reach areas accessible to users or the public.
Recirculating cooling towers	• Secondary • Disinfection (chemical coagulation and filtration may be needed)	• Variable, depends on recirculation ratio		• 90 m to areas accessible to the public. May be reduced if high level of disinfection is provided.	• Windblown spray should not reach areas accessible to the public. • Additional treatment by user is usually provided to prevent scaling, corrosion, biological growths, fouling and foaming.
Other Industrial Uses	← Depends on site specific use →				

Continued . . .

Types of Reuse	Treatment[1]	Reclaimed Water Quality[2]	Reclaimed Water Monitoring	Setback Distances[6]	Comments
Environmental Reuse Wetlands, marshes, wildlife habitat, stream augmentation	• Variable • Secondary and disinfection (min.)	Variable, but not to exceed: • ≤30 mg/l BOD • ≤30 mg/l SS • ≤200 fecal coli/100 ml[4]	• BOD—weekly • SS—daily • Coliform—daily • Cl_2 residual—continuous		• Dechlorination may be necessary to protect aquatic species of flora and fauna. • Possible effects on groundwater should be evaluated. • Receiving water quality requirements may necessitate additional treatment. • The temperature of the reclaiimed water should not adversely affect ecosystem.
Groundwater Recharge By spreading or injection into nonpotable aquifers	• *Site specific and use dependent* • Primary (min.) for spreading • Secondary (min.) for injection	• *Site specific and use dependent*	• *Depends on treatment and use*	• *Site specific*	• *Facility should be designed to ensure that no reclaimed water reaches potable water supply aquifers.* • For injection projects, filtration and disinfection may be needed to prevent clogging.
Indirect Potable Reuse Groundwater recharge by spreading into potable aquifers	• Site specific • Secondary and disinfection (min.) May also need filtration and/or advanced waste-water treatment	• Site specific • Meet drinking water standards after percolation through vadose zone	Includes, but not limited to, the following: • pH—daily • Coliform—daily • Cl_2 residual—continuous • Drinking water standards—quarterly • Other[5]—depends on constituent	• 600 m to extraction wells. May vary depending on treatment provided and site-specific conditions.	• The depth to groundwater (i.e., thickness of the vadose zone) should be at least 2m at the maximum groundwater mounding point. • The reclaimed water should be retained underground for at least 1 year prior to withdrawal. • Recommended treatment is site-specific and depends on factors such as type of soil, percolation rate, thickness of vadose zone, native groundwater quality, and dilution. • Monitoring wells are necessary to detect the influence of the recharge operation on the groundwater. • The reclaimed water should not contain measurable levels of pathogens after percolation through the vadose zone.[7]
Groundwater recharge by injection into potable aquifers	• Secondary • Filtration • Disinfection • Advanced wastewater treatment	Includes, but not limited to, the following: • pH = 6.5–8.5 • ≤2 NTU • No detectable fecal coli/100 ml[3] • 1 mg/l Cl_2 residual (min.) • Meet drinking water standards	Includes, but not limited to, the following: • pH—daily • Turbidity—continuous • Coliform—daily • Cl_2 residual—continuous • Drinking water standards—quarterly • Other[5]—depends on constituent	• 600 m to extraction wells. May vary depending on site-specific conditions.	• The reclaimed water should be retained underground for at least 1 year prior to withdrawal. • Monitoring wells are necessary to detect the influence of the recharge operation on the groundwater. • Recommended quality limits should be met at the point of injection. • The reclaimed water should not contain measurable levels of pathogens at the point of injection.[7] • A higher chlorine residual and/or a longer contact time may be necessary to assure virus inactivation.

Continued . . .

Types of Reuse	Treatment[1]	Reclaimed Water Quality[2]	Reclaimed Water Monitoring	Setback Distances[6]	Comments
Indirect Potable Reuse Augmentation of surface supplies	• Secondary • Filtration • Disinfection • Advanced wastewater treatment	Includes, but not limited to, the following: • pH = 6.5–8.5 • ≤2 NTU • No detectable fecal coli/100 ml[3] • 1 mg/l Cl_2 residual (min.) • Meet drinking water standards	Includes, but not limited to, the following: • pH—daily • Turbidity—continuous • Coliform—daily • Cl_2 residual—continuous • Drinking water standards—quarterly • Other[5]—depends on constituent	• Site specific	• Recommended level of treatment is site-specific and depends on factors such as receiving water quality, time and distance to point of withdrawal, dilution and subsequent treatment prior to distribution for potable uses. • The reclaimed water should not contain measurable levels of pathogens.[7] • A higher chlorine residual and/or a longer contact time may be necessary to assure virus inactivation.

Note: Portions of this table are discussed in detail in the *Guidelines*. Any country interested in using the table to develop standards is advised to obtain a copy of the *Guidelines* for reference. Copies may be obtained on request from WASH headquarters or from Camp Dresser & McKee Inc. in Cambridge, Massachusetts.

For virtually all types of reuse, other recommended levels for trace heavy metals and other parameters may apply. Also, a high standard of treatment reliability is required, because of the potential for harm in the use of improperly treated water. A number of fallible elements combine to make up a water reclamation system. These include the power supply, individual treatment units, mechanical equipment, the maintenance program, and the operating personnel. Design features and backup systems are important in maintaining reclaimed system reliability, similar to drinking water reliability because customers depend upon continuity of supply as well as quality.

Footnotes

1. Types of treatment are as follows: *Primary*—a physical treatment process to remove settleable organic and inorganic solids by sedimentation and floating materials by skimming; *Secondary*—includes activated sludge processes, trickling filters, rotating biological contactors, and stabilization pond systems (secondary treatment should produce effluent in which both the BOD [biochemical oxygen demand] and SS [suspended solids] do not exceed 30 mg/l.); *Filtration*—the passing of wastewater through undisturbed filter media such as sand and/or anthracite; *Disinfection*—the destruction, inactivation, or removal of pathogenic micro-organisms by chemical, physical, or biological means (disinfection may be accomplished by chlorination, ozonation, other chemical disinfectants, UV radiation, and membrane and other processes); *Advanced Wastewater Treatment*—includes chemical clarification, carbon adsorption, reverse osmosis, and other membrane processes, air stripping, ultrafiltration, and ion exchange.
2. Unless otherwise noted, recommended quality limits apply to the reclaimed water at the point of discharge from the treatment facility. Concerning taking measurements of BOD, NTU, fecal coliforms and chlorine residual, please note the following. *BOD* levels are as determined from the 5-day BOD test. *NTU (nephelometric turbidity units)* limits should be met prior to disinfection; the average turbidity should be based on a 24-hour time period; the turbidity should not exceed 5 NTU at any time; if SS is used in lieu of turbidity, the average SS should not exceed 5 mg/l. Unless otherwise noted, recommended *coliform limits* are median values determined from the bacteriological results of the last 7 days for which analyses have been completed. Either the membrane filter or fermentation tube technique may be used. Total *chlorine residual* should be measured after a minimum contact time of 30 minutes.
3. The number of fecal coliform organisms should not exceed 14/100 ml in any sample.
4. The number of fecal coliform organisms should not exceed 800/100 ml in any sample. Some stabilization pond systems may be able to meet this coliform limit without disinfection.
5. Monitoring should include inorganic and organic compounds, or classes of compounds, that are known or suspected to be toxic, carcinogenic, teratogenic, or mutagenic and are not included in the drinking water standards.
6. Setback distances are recommended to protect potable water supply sources from contamination and to protect humans from unreasonable health risks due to exposure to reclaimed water.
7. It is advisable to fully characterize the microbiological quality of the reclaimed water prior to implementation of a reuse program.
8. Commercially processed food crops are those that, prior to sale to the public or others, have undergone chemical or physical processing sufficient to destroy pathogens.

Developing-Country Wastewater Reuse Issues

The technology used in water reuse is little different from conventional water and wastewater treatment technology and is readily available to developing country engineers and government officials. The numerous planning, technical, institutional, legal, and financial and economic issues are, however, site-specific.

Planning Issues

• ***Phased plans for building facilities.*** To develop any reuse program, wastewater treatment facilities need to be built, for all wastewater must be treated to some degree before it can be reused. Because of the high up-front capital costs necessary for building the facilities, planning should include implementation in stages, with each stage contributing a benefit while fitting in with the ultimate plan.

• ***Manpower and financial constraints.*** Designing developing-country wastewater reuse projects calls for greater planning than for similar projects in the industrialized world, due to manpower and financial constraints, specifically:

✔ *Labor intensive designs are to be preferred in developing countries.* While the principles of wastewater reclamation facility design and operation are the same in developing and industrialized countries, implementation of projects differs. Industrialized countries tend to be capital-intensive while developing countries are labor-intensive. In developing countries a facility that can be built and operated with local labor will be more cost effective than one which uses more modern capital- intensive technology. In instances where the task to be performed cannot be readily performed by even low-cost labor, however, mechanization and automation are appropriate in the developing world.

✔ *The difference in availability of qualified engineers, sci ntists, and technicians calls for a different approach to planning.* In developing countries, where qualified staff and support institutions are not readily available, investments in equipment that is reliable and simple, even though the initial costs may be higher, may be advisable.

• ***The advantages of new construction over retrofitting.*** It can be advantageous to take reuse into consideration at the planning stage rather than to retrofit existing systems. For example, reclamation facilities might be located near the potential markets for the wastewater rather than at points of disposal. Retrofitting reclamation facilities is far more costly than installing reclamation facilities with other new infrastructure.

Technical Issues

• ***The need for infrastructure.*** The first technical requirement for water reuse is to build trunk and intercepting sewers to carry water to sites for treatment and/or reclamation. Whereas the principal sources of reclaimed water in the United States are the effluents from municipal wastewater treatment plants, in developing countries the sources are raw wastewaters collected from existing sewer systems. Other sources are the polluted streams that flow through or near cities, being used as natural interceptors.

• ***Cost-saving technologies.*** While the planning and design of sewerage systems is beyond the scope of the *Guidelines*, it is an important consideration. The cost of sewers provided for sanitation in urban areas cannot be charged entirely to water reclamation; however, several possibilities exist for reducing the costs of sewers:

✔ Reducing the minimum slopes to reduce construction and pumping costs.

✔ Increasing the distance between manholes.

✔ Using indigenous materials.

✔ Using computer-aided design to obtain least-cost sewerage system layouts.

Most of these modifications increase maintenance costs, but, with the low costs of labor in developing countries, the greater maintenance costs are offset by the savings in construction. Also required are strong institutions that can provide the necessary personnel for preventive maintenance and other labor-intensive programs of construction and operation.

• ***Water quality standards.*** A critical objective for any reuse program is assurance that health protection is not compromised by the use of reclaimed water. Although other objectives—such as preventing environmental degradation and meeting user requirements—are also important, the major consideration, especially in developing countries, is the safe delivery and use of appropriate quality reclaimed water. Therefore water quality standards must be established.

Public health is protected by reducing concentrations of pathogenic bacteria, protozoa, and enteric viruses in the reclaimed water; controlling chemical constituents in reclaimed water; and limiting human exposure (contact, inhalation, ingestion) to the reclaimed water. Although potable reuse may not be intended, inadvertent ingestion may occur. Reclaimed water for unrestricted nonpotable reuse to which the public at large is exposed must be free of pathogenic microorganisms.

The box on pages 5-6 and the four-page table on the insert provide guidance on setting standards for wastewater reuse. The box summarizes the WHO guidelines for wastewater reuse in agriculture and aquaculture that were prepared partly to meet the need for reuse standards in developing countries.

The table summarizes guidelines for all types of wastewater reuse, not just for agriculture. Suggested treatment processes, reclaimed water quality, monitoring frequency, and setback distances are given for the following reuse categories: unrestricted urban reuse, restricted access area irrigation, irrigation of food crops, irrigation of non-food crops, recreational impoundments, landscape impoundments, construction uses, industrial reuse, environmental reuse, groundwater recharge, and indirect potable reuse.

The table is intended for use mainly by utilities and regulatory agencies in the United States that have not designed their own standards. It is based principally on water reclamation and reuse practice in the United States, but is included here because no other comprehensive guidelines are available. It should provide reasonable guidance but should not be viewed as definitive. Also, it should be noted that A.I.D. does not use the direct application of the guidelines in the table as a strict criterion for funding.

• ***Monitoring water quality.*** A protocol for monitoring the quality of wastewater is required. Deviations in the established standards may be permissible for wastewater discharges to a river; for reclaimed water, particularly in urban reuse, deviations are no more acceptable than they are for drinking water. On-line, real-time monitoring is preferable to sampling and laboratory analysis where the results arrive too late to take corrective action. Although some tests, like fecal coliform counts, take time, a simple and useful measure of reclaimed water quality is turbidity. A sudden increase in turbidity provides a warning that corrective action is required.

• ***Monitoring water quantity.*** Because reclaimed water is a product, the provision of promised quantity, as well as quality, must be assured. For agricultural applications, brief intervals of nondelivery may be tolerable; for most urban applications, a continuous supply is mandatory.

• ***Choice of treatment.*** In developing countries, the choice of treatment—conventional with primary sedimentation, secondary treatment (activated sludge, trickling filtration, rotation biological contactors or something similar), sand filtration, and disinfection, or the use of stabilization ponds—is usually determined by local circumstances.

✔ *If nearby lands are available at a low cost, stabilization ponds may be the most appropriate choice.* The effluent produced will be suitable for agricultural irrigation, and the WHO guidelines indicate the effluent may be acceptable for market crops, recognizing that fruit and vegetable products may need disinfecting before use. Filtration and chemical disinfection of pond effluents may not be operationally feasible; the cost may also be prohibitive.

✔ *In larger cities that have sewerage systems, conventional treatment will likely be the treatment of choice.* In such areas, where reclamation and reuse may be promising, sufficient land for ponds may be unavailable, too expensive, or unacceptable to the public as the city expands.

In countries where wastewater is used for irrigation, treatment like these trickling filters at a wastewater treatment facility in Melipilla, Chile, improve the quality of water for reuse.

WHO Guidelines for Wastewater Reuse in Agriculture and Aquaculture

Guidance in establishing regulations is provided by the World Health Organization. In 1973, WHO recommended health criteria and treatment processes for reuse applications ranging from irrigation of crops not intended for human consumption all the way to potable reuse. These recommendations were reviewed in 1985, and a revised approach to the nature of health risks associated with agriculture and aquaculture was developed (other nonpotable uses were not reviewed). The 1989 WHO publication, *Health Guidelines for the Use of Wastewater in Agriculture and Aquaculture* (Technical Series No. 778), is consistent with the revised approach.

Agricultural Reuse

The 1989 guidelines are based on the conclusion that the main health risks associated with agricultural reuse in developing countries are associated with helminthic diseases and, therefore, a high degree of helminth removal is necessary for the safe use of wastewater for agriculture and aquaculture. The WHO Guidelines for wastewater use in agriculture are summarized in the table below.

WHO Recommended Microbiological Guidelines for Wastewater Use in Agriculture

Category	Reuse Conditions	Exposed Group	Intestinal nematodes[1] (arithmetic mean no. of eggs per liter)[2]	Fecal coliforms (geometric mean no. per 100 ml)[2]	Wastewater treatment expected to achieve the required microbiological quality
A	Irrigation of crops likely to be eaten uncooked, sports fields, public parks	Workers, consumers, public	≤1	≤1,000	A series of stabilization ponds designed to achieve the microbiological quality indicated, or equivalent treatment
B	Irrigation of cerea crops, industrial crops, fodder crops, pasture and trees[3]	Workers	≤1	No standards recommended	Retention in stabilization ponds for 8-10 days or equivalent helminth and fecal coliform removal
C	Localized irrigation of crops in Category B if exposure of workers and the public does not occur	None	Not applicable	Not applicable	Pretreatment as required by the irrigation technology, but not less than primary sedimentation

Note: In specific cases, local epidemiological, sociocultural, and environmental factors should be taken into account, and the guidelines modified accordingly.

Footnotes

1. *Ascaris* and *Trichuris* species and hookworms.
2. During the irrigation period.
3. In the case of fruit trees, irrigation should cease 2 weeks before fruit is picked, and no fruit should be picked off the ground. Sprinkler irrigation should not be used.

Source: WHO, 1989.

Box continued on page 6.

WHO Guidelines Continued

Additional water quality considerations include:

- *Agricultural irrigation near cities.* Where dual urban water systems exist (fresh water for potable purposes in one system and reclaimed water for nonpotable purposes in another) and where water is used for agricultural irrigation near the city, the irrigation water should meet the quality requirements for unrestricted urban reuse.

- *No land available for stabilization ponds.* If the use of stabilization ponds is not feasible and conventional wastewater treatment is used, chlorine disinfection is required for irrigation of market crops.

- *Standards for exports.* If fruits and vegetables are exported, the standards must be those of the target country.

Aquaculture

Concerning aquaculture, a number of infections caused by excreted pathogens are of concern, including invasion of fish muscle by bacteria and high pathogen concentrations in the digestive tract and the intraperitoneal fluid of the fish. Due to the limited available data, the following guidelines are tentative.

- A geometric mean of 1,000 fecal coliforms per 100 ml to insure that bacterial invasion of fish muscle is prevented. The same standard should be maintained for pond water in which aquatic vegetables are grown.

- High standards of hygiene during fish handling and gutting.

- Total absence of viable trematode eggs is recommended as the appropriate helminths quality guideline. This can be readily achieved by stabilization pond treatment.

The WHO guidelines have been and continue to be controversial. Some view them as too stringent; others as not stringent enough. However, in many locations where raw sewage or rivers heavily polluted with raw sewage are used for irrigation, any treatment would be an improvement. If stabilization ponds are feasible and the WHO guidelines can be attained, that would be a major public health advance. If ponds are not feasible, the standards may be approached in stages by providing conventional treatment facilities.

Institutional Issues

• ***Institutional development.*** In some instances, the need for reuse may prompt institutional development. When large investments are to be made in urban sewerage, the government will often assign responsibility for sewerage and wastewater treatment to the water agency instead of creating or strengthening a sewerage agency. An advantage of this approach is that an operating organization with experienced officials is involved in the enterprise. It also offers economies and efficiencies of scale and provides a mechanism for cost recovery.

Examining the relevant institutions and a plan for their modification to permit them to undertake the capital program should be the first order of business.

• ***Lack of funds and agencies for wastewater.*** Developing countries have relatively strong institutions for managing water-supply systems, but agencies for managing wastewater collection, treatment, and disposal are poorly organized and lacking in funds. Water-supply agencies, which can recover some of their costs through user fees for water service, resist being joined with agencies responsible for sewerage since these agencies depend almost entirely on the limited financial resources of local government.

Legal Issues

• ***Vested water rights.*** Traditional practice or customary law in most developing countries, and formal law in many, recognize that a water user acquires vested rights to use a certain amount of water under defined circumstances. If the amount of water available to a current user changes, vested rights may entitle the user to compensation such as monetary payment or a supplemental water supply. Rights in reclaimed water are uncertain; they may be vested in the producer or in riparian downstream owners deprived of the water, who may require compensation.

• ***Regulations.*** Water reuse projects should include development and implementation of regulations to prevent or moderate public health or environmental problems. These regulations include: permit systems for authorizing wastewater discharges; technical controls on wastewater treatment; water quality standards for reclaimed water appropriate for various uses; controls, such as use restrictions, that will reduce human exposure; access controls on reclaimed water systems and controls preventing cross-connections between drinking water and reclaimed water distribution networks; regulations on sludge disposal and facility siting; and mechanisms to enforce these regulations including monitoring requirements, inspection authority, and authority to assess violation penalties.

• ***Legal and procedural issues touched on above.***

- ✔ *An agreed-upon definition of "reclaimed water".*
- ✔ *Specified rights of ownership to reclaimed water.*
- ✔ *A licensing system for use of reclaimed water.*

Economic and Financial Issues

• ***Cost recovery.*** In the United States it is now generally accepted that the user is responsible for meeting the costs of water and sanitation services; however, in developing countries water has often been provided free or at a nominal charge. The economic justification for water reuse is that the costs of developing additional water sources can be offset, but, where such costs are subsidized by governments or external support agencies, they appear low. Unless the real costs of providing water and sewerage are passed through to users, a reclaimed water system will be no more sustainable than a system that does not recover its costs from users.

• ***Integrated approach.*** Because water supply and sewerage costs in water reclamation and reuse should be considered together, all the agencies involved, including external support agencies, should approach water reclamation projects in an integrated way.

• ***Economic rationale.*** The economic rationale for water reuse in developing countries must take into consideration costs savings from new sources that would not be required or that could be postponed. Also, the costs of collection and treatment can be construed as benefits in terms of providing sewerage services that would be necessary in any case.

Continued on page 8.

Continued from page 7.

• ***Cost/benefit calculations.*** Benefits other than cost savings need to be considered more carefully than in developed countries. For example, a wastewater reuse project may free potable water service and accompanying benefits to be extended to people who otherwise would have had to haul water for their households, purchase high priced water, or use contaminated water.

• ***Setting tariffs.*** A reuse program can be the means of introducing a rational pricing structure, based on a rational market price for water. All reclaimed water customers should be metered. The price for fresh or reclaimed wastewater to all customers should reflect the full production cost. The full resource costs of reclaimed water, if conventional sewerage and wastewater treatment are considered separately, should be less than that of fresh water, and this difference should be reflected in tariff structures.

Conclusion

Water reclamation and reuse is a viable option for expanding usable water resources in developing countries. However, it is not sufficient to imitate methods used in industrialized countries; what is done must be adjusted for the specific problems encountered in developing countries. Reuse of untreated wastewater, without regulation by public authorities, is already common practice in urban areas of developing countries where water is scarce. This has resulted in serious health problems.

Implementation of wastewater reuse in most cities in the developing world must begin with provision of basic sanitation services.

Resources

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This fact sheet, prepared by Diane Bendahmane, is based primarily on Chapter 8 of the *Guidelines* by Daniel Okun.

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