7. IRRIGATION WATER QUALITY AND WASTEWATER RE-USE

Large-scale irrigation projects can bring prosperity to an area but less desirable changes can also occur as a result of increased intensity of land and water use. One important change in the hydrological regime is that of an alteration or degradation in quality that takes place as water is used and re-used within the hydrological basin. In addition, wastewater generated by agricultural and urban sources can degrade water quality and must be considered when developing a river basin management plan.

Agricultural subsurface drainage water presents the single greatest threat to water quality. The need for drainage is often quoted as a mechanism to eliminate the hazards from waterlogging and salinity in irrigated land. A drainage scheme can be implemented for engineering or economic reasons, but in either case the drainage water created by the scheme will contain a high concentration of salts. Careful consideration must be given to its disposal so that the water supplies downstream are not polluted.

The disposal of highly saline drainage water into river courses may need to be controlled in order to meet certain minimum standards of water quality for irrigated agriculture in downstream areas. Changes in downstream agricultural practices may be necessary to adapt to the inferior water quality, or alternative schemes may need to be implemented where the drainage or other wastewater is isolated form the main water supply. Due to the high cost of transporting wastewater to a disposal site (ocean, salt-sink or river discharge), the maximum number of uses of that water should be made before discharge. At that time, disposal must be in such a way that the river-basin water quality is protected and agricultural development is not jeopardized. All waste-water should be used and re-used until no longer fit for use.

Of equal importance when protecting the quality of water supplies that are to be used as a source of irrigation water is the utilization of effluent water from domestic sources or from an agricultural processing activity. Re-using wastewater can remove a potential cause of ground or surface water pollution and, at the same time, release higher quality water for other uses. Rising demands for good quality water for domestic and industrial uses in countries with highly developed economies have already created the necessity to re-use wastewater. Many developing countries are now facing a similar situation, especially in arid and semi-arid regions where limited water availability is already a severe constraint on development.

Agriculture is the major user of water and can accept lower quality water than domestic and industrial users. It is therefore inevitable that there will be a growing tendency to look toward irrigated agriculture for solutions to the overall effluent disposal problem. Because wastewater contains impurities, careful consideration must be given to the possible long-term effects on soils and plants from salinity, sodicity, nutrients and trace elements that occur normally manageable if associated problems with these impurities are understood and allowances made for them.

The guidelines presented in Table 1 and crop salinity tolerance values in Table 4 are sufficient to make reliable estimates of soil and crop responses to the use of wastewater where the primary limitation is the chemical constituent, such as the total dissolved salts, relative sodium content and toxic ions. On the other hand, municipal wastewater and some agro-industrial effluents which may be re-used for irrigation require guidelines to estimate public health hazards. The degree of risk associated with such effluents is related to the microbial characteristics.

Table 31 EXISTING STANDARDS GOVERNING THE USE OF RENOVATED WATER IN AGRICULTURE

	California	Israel	South Africa	FR Germany
Orchards and vineyards	Primary[1] effluent; no spray irrigation; no use of dropped fruit	Secondary[2] effluent	Tertiary[3] effluent, heavily chlorinated where possible. No spray irrigation	No spray irrigation in the vicinity
Fodder fibre crops and seed crops	Primary effluent; surface or spray irrigation	Secondary effluent, but irrigation of seed crops for producing edible vegetables not permitted	Tertiary effluent	Pretreatment with screening and settling tanks. For spray irrigation, biological treatment and chlorination
Crops for human consumption that will be processed to kill pathogens	For surface irrigation, primary effluent. For spray irrigation, disinfected secondary effluent (no more than 23 coliform organisms per 100 ml)	Vegetables for human consumption not to be irrigated with renovated wastewater unless it has been properly disinfected (1000 coliform organisms per 100 ml in 80% of samples)	Tertiary effluent	Irrigation up to 4 weeks before harvesting only
Crops for human consumption in a raw state	For surface irrigation, no more than 2.2 coliform organisms per 100 ml. For spray irrigation, disinfected, filtered wastewater with turbidity of 10 units permitted, providing it has been treated by coagulation	Not to be irrigated with renovated wastewater unless they consist of fruits that are peeled before eating		Potatoes and cereals - irrigation through flowering stage only

Source: WHO (1973).

[1] Primary treatment of wastewater refers to the settling and removal of a portion of the suspended organic and inorganic solids.

[2] Secondary treatment refers to the activated sludge process and biological filtration(trickling filtration). It may also include retention.

[3] Tertiary or Advanced Treatment includes several processes depending on the use of the final product but usually includes clarification, activated carbon treatment, denitrification and ion exchange.

The re-use of sewage effluent for agricultural practices is not an entirely new concept. Law (1968) cites 99 references on the use of sewage as an agricultural water resource. Some countries have developed standards for the use of effluents in terms of the treatment required and bacteriological characteristics, as presented in Table 31. A meeting of experts convened by WHO (1973) concluded that primary treatment would be sufficient to permit re-use for the irrigation of crops that are not for direct human consumption.

Secondary treatment and most probably disinfection and filtration are considered necessary if the effluent is to be used for irrigation of crops for direct human consumption. Table 32 presents the WHO suggested treatment processes to meet the given health criteria for wastewater re-use.

Table 32 TREATMENT PROCESSES SUGGESTED BY THE WORLD HEALTH ORGANIZATION FOR WASTEWATER RE-USE

	IRRIGATION			RECREATION	
	Crops not for direct human consumption	Crops eaten cooked; fish culture	Crops eaten raw	No Contact	Contact
Health criteria (see below for explanation of symbols)	1 + 4	2 + 4 or 3 + 4	3 + 4	2	3 + 5
Primary treatment	X X X	X X X	X X X	X X X	X X X
Secondary treatment		X X X	X X X	X X X	X X X
Sand filtration or equivalent polishing methods		X	X		X X X
Disinfection		X	X X X	X	X X X

Source: WHO (1973).

Health criteria:

1. Freedom from gross solids; significant removal of parasite eggs.
2. As 1, plus significant removal of bacteria.
3. Not more than 100 coliform organisms per 100 ml in 80% of samples.
4. No chemicals that lead to undesirable residues in crops or fish.
5. No chemicals that lead to irrigation of mucous membranes and skin.

In order to meet the given health criteria, processes marked X X X will be essential. In addition, one or more processes marked X X will also be essential, and further processes marked X may sometimes be required.

The criteria recommended under recreation by WHO are equally applicable to irrigators who are likely to have physical contact with the effluent during irrigation.

Effluent irrigation may also lead to microbial contamination of air, soils and plants in the vicinity of the irrigation site. The extent of such contamination depends upon the degree of treatment provided, the prevailing climatic conditions, nature of the crop being irrigated and the design of the irrigation system. Where the terrain and the crop type are suitable, effluents may be applied through ‘ridge and furrow’ systems. These contaminate neither the air nor the upper parts of plants. Subsurface tile or trickle irrigation systems create the fewest hazards of any kind. However, the expense of utilizing such systems on a large scale severely limits their feasibility. An additional problem is the clogging of dripper nozzles and subsurface pipelines due to suspended sediments and microbial growth. Sprinklers create the greatest potential for microbial contamination of the vegetation and air.

When considering the use of effluents for irrigation, their microbial and biochemical properties will have to be evaluated. These values should then be compared with the public health standards, taking into consideration the crop, soil and irrigation system and consumption of the produce, and only when the effluent meets these standards should it be evaluated in terms of chemical criteria such as dissolved salts, relative sodium content and specific toxic ions.

In quantitative terms, the volume of wastewater available for re-use by irrigated agriculture is negligible when compared with the overall volume of water used for irrigation. However, the potential impacts associated with water quality and agricultural re-use of wastewater are so important, economically, environmentally and socially, that the need for sound planning far exceeds the relatively small quantities and areas involved. Several examples of wastewater reuse are given in Section 8.

The following list of references contains research as well as practical information on various aspects of the re-use of effluents for crop production: Eckenfelder (1980); Loehr (1977); National Research Council of Canada (1974); Sopper and Kardos (1973); and Wilson and Beckett (1968).