1 NOTE ON HEALTH RISKS ASSOCIATED WITH WASTEWATER REUSE

1.1 Order of Health Risk

Shuval (1990) suggests a descending order of risk from intestinal nematodes through bacterial infections to viral infections. The table suggests the following classification of health risks associated with the use of untreated excreta and wastewater in agriculture and aquaculture (from Shuval, 1990 Blum and Feachem (1985) and Blumenthal et al (1989).

Class of pathogen		Likelihood that use of untreated excreta or wastewater will increase frequency of infection or disease
1.	Intestinal nematodes (ascaris, trichuris and hookworm	High (1)
2.	Bacterial infections: bacterial diarrhoeas and typhoid	Lower
3.	Viral infections – viral diarrhoeas, hepatitis A	Least
4.	Trematode and cestode infections – schistosomiasis, clonorchiasis, taeniasis	From high to nil, depending upon excreta use practices and local circumstances

Note (1) Intestinal nematode infections generally have symptoms that are more chronic than acute.

1.2 Options for Health Protection

Blumenthal et al (1989) suggest four options for health protection. These are:

1.2.1 Waste treatment

Full treatment prevents pathogens from even reaching the fields or fishponds in which food is grown. Where treatment is adequate and reliable it reduces the risk to both workers and consumers to negligible levels. Full treatment will normally require a long retention period if it is to successfully remove all pathogens. Some treatment technologies will remove nematodes but not bacteria. Blumenthal et al refer to these technologies as partial treatment. The key here is that treatment must provide a barrier to nematode infections – 8-10 days retention will normally be required). Conventional secondary treatment does not guarantee sufficient helminth egg removal and a reduced level of risk remains for both workers and consumers.

1.2.2 Restriction of the crops grown

Crop restriction can protect consumers but not workers. Crops that can be safely consumed after irrigation with sewage include cereal crops, fodder crops, pasture and trees, including fruit trees. In some cases, vegetables grown well above the ground may also be irrigated in this way.

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1.2.3 Choice of methods used for application of the wastes to the crops; and]

Both workers and consumers can be protected by appropriate application measures. Normally, this will involve the application of the waste directly to the roots of the crop. This might be achieved by localised drip or bubbler irrigation. However, drip irrigation will normally require at least preliminary treatment to remove settleable solids before irrigation. It would appear that in practice sewage is applied to crops in a fairly crude way and there will normally be a need for changes in practices and probably in assumptions before farmers can be persuaded to change the way in which they reuse sewage.

1.2.4 Control of human exposure to wastes.

Human exposure control measures (wearing protective clothing, improved hygiene and cooking food before eating) are possible but are rarely effective on their own.

1.2.5 Combined Approaches

It is possible to combine these approaches. Partial treatment using waste stabilisation ponds (or equivalent) and crop restriction can provide full protection for both workers and consumers, provided that the treatment provides a barrier to nematode infections.

- Conventional treatment to secondary level plus crop restriction may leave some workers at risk, particularly from nematode infections.

- Partial waste treatment plus human exposure control for workers and consumers may provide full protection for workers (assuming that the exposure control can he applied as planned) but a low level of risk to consumers may remain.

- Where there is no possibility of treating wastes, a combination of crop restriction and human exposure control could considerably reduce the risk to workers and provide full protection to consumers.

Based on the above, the authors suggest that three regimes are available to render reused wastes safe for both agricultural workers and consumers. These are:

- Use of appropriate application measures.
- Partial treatment using waste stabilisation ponds combined with crop restriction.
- Full treatment.

1.2.6 Incremental Approach to Health Risk

Other options can reduce health risks and may be used within an incremental approach to reducing health risks. The authors suggest that there are situations in which economic and technical factors may preclude the adoption of full treatment. (Lack of space may be another important constraint on the implementation of full treatment, given the fact that full treatment appears to require at least 25 days retention.

It would theoretically be possible to enforce a regime combining crop restrictions with either human exposure control or partial waste treatment. In practice, either of these approaches will only be possible where there is good institutional capacity to enforce the approach and this would appear to greatly reduce its practical significance.

1.3 Health Risks summary from Various Sources

- In a study in Mexico, irrigation with untreated or partially treated wastewater was directly responsible for 80% of all *Ascaris* infections and 30% of diarrhoeal disease in farm workers and their families (Cifuentes *et al*. 2000).

- A storage period of 6 - 12 months is required in a tropical, year-round warm climate to render the faecal sludges of dry or pour-flush latrines safe for handling and agricultural use (Feachem *et al*. 1983; Peasey 2000; Strauss 1985; WHO 1996). Such pit contents will satisfy the WHO guideline equivalent of 3 - 8 nematode eggs/g of dry matter.

- Protozoal cysts are poor survivors in any environment. A likely maximum in sewage or polluted water would not exceed that shown in Table 1 for *Entamoeba histolytica*. Helminth eggs vary from the very fragile to the very persistent. One of the most persistent is the *Ascaris* egg which may survive for a year or more. The major concern for this helminth is that the soil is its intermediate host prior to reinfecting humans.
  http://www.fao.org/docrep/W5367E/w5367e04.htm below

1.4 Shuval model of order of Risks

The Shuval model shows that helminth diseases, if they are endemic, will be very effectively transmitted by irrigation with raw wastewater. On the other hand, the enteric virus diseases should be the least effectively transmitted by irrigation with raw wastewater. The bacterial and protozoan diseases rank between these two extremes. Shuval *et al*. (1986b) ranked the pathogens in the following descending order of risk:

1. High: **Helminths** (the intestinal nematodes - *Ascaris, Trichuris*, hookworm and *Taenia*)

2. Lower: **Bacterial infections** (i.e. cholera, typhoid and shigellosis) and **Protozoan infections** (i.e. ameobiasis, giardiasis).

3. Least: **Viral infections** (viral gastroenteritis and infectious hepatitis)

Risks in selecting crops to be grown

Shuval *et al*. (1986a) defined three levels of risk in selecting a crop to be grown. They are presented here in increasing order of public health risk:

1. Low(est) risk to consumer but field worker protection still needed

- Crops not for human consumption (for example cotton, sisal).
- Crops normally processed by heat or drying before human consumption (grains, oilseeds, sugar beet).

- Vegetables and fruit grown exclusively for canning or other processing that effectively destroys pathogens.
- Fodder crops and other animal feed crops that are sun-dried and harvested before consumption by animals.
- Landscape irrigation in fenced areas without public access (nurseries, forests, green belts).

2. Increased risk to consumer and handler

- Pasture, green fodder crops.
- Crops for human consumption that do not come into direct contact with wastewater, on condition that none must be picked off the ground and that spray irrigation must not be used (tree crops, vineyards, etc.).
- Crops for human consumption normally eaten only after cooking (potatoes, eggplant, beetroot).
- Crops for human consumption, the peel of which is not eaten (melons, citrus fruits, bananas, nuts, groundnuts).
- Any crop not identified as high-risk if sprinkler irrigation is used.

3. Highest risk to consumer, field worker and handler

- Any crops eaten uncooked and grown in close contact with wastewater effluent (fresh vegetables such as lettuce or carrots, or spray-irrigated fruit).
- Landscape irrigation with public access (parks, lawns, golf courses).
- Another path of infection is from direct contact with the crop or soil in the area where wastewater was used. This path is directly related to the level of protection needed for field workers. The only feasible means of dealing with the worker safety problem is prevention. The following are a few of many low and high risk situations:

1.5 Overview

Extensive epidemiological evidence has been accumulated since the initial 1973 WHO Guidelines (Feachem *et al*., 1983; Blum and Feachem, 1985; Rose, 1986; Shuval *et al*., 1986a). This evidence was reviewed at international meetings in Engelberg (IRCWD, 1985) and Adelboden (Mara and Cairncross, 1989). The consensus of health experts is that the actual risk associated with irrigation with treated wastewater is much lower than previously estimated particularly with respect to bacterial pathogens. On the other hand, they raised the level of concern for parasitic diseases which they felt were the main risk for individual and overall public health associated with the use of insufficiently treated wastewater in agriculture.http://www.fao.org/docrep/W5367E/w5367e05.htm below

1.6 Qualitative comparison of Wastewater treatment systems

TABLE 7: Qualitative comparison of various wastewater treatment systems

	Criteria	Package plant	Activated sludge plant	Extended aeration activated sludge	Biological filter	Oxidation ditch	Aerated lagoon	Waste stabilization pond system
Plant performance	BOD removal	F	F	F	F	G	G	G
	FC removal	P	P	F	P	F	G	G
	SS removal	F	G	G	G	G	F	F
	Helminth removal	P	F	P	P	F	F	G
	Virus removal	P	F	P	P	F	G	G

Key: FC = Faecal coliform; SS = Suspended solids: G = Good: F =Fair: P = Poor
Source: Arthur (1983).

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