A Review of the Applicability of the South African Guide for the Permissible Utilisation and Disposal of Treated Sewage Effluent in Agriculture and Aquaculture

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Report to the Water Research Commission
on the project:
Assessing Potential Health Risks Related to the Use of Treated Wastewater for Various Agricultural and Aquacultural Activities

by the

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EXECUTIVE SUMMARY

INTRODUCTION

An expanding South African population growth creates a growing demand for recycled water in agriculture. Urban communities in particular perceive treated wastewater effluent as an accessible water and fertiliser source for food production. Optimal use as well as control of recycling of treated wastewater became critical in order to protect public health. When effluents are to be recycled for health-related agricultural and other purposes (excluding recycling for potable purposes and recharge of aquifers), it becomes a function of the Department of Health (DOH), who applies the South African Guide for the Permissible Utilisation and Disposal of Treated Sewage Effluent (1978). This Guide was not reviewed or updated significantly since its inception in 1978. Recent international studies on epidemiological advances, as well as other reviews of international guidelines for the use of wastewater in agriculture and aquaculture, offered the ideal opportunity to assess the current value of the South African Guide and to suggest changes if necessary. This document contains a review of the applicability of the South African Guide to assess whether it still suits its purpose under current and rapidly changing South African circumstances.

PROJECT AIM AND OBJECTIVES

The aim of this project was to evaluate whether the South African Guide for the Permissible Utilisation and Disposal of Treated Sewage Effluent (1978) is still applicable in the current South African situation. Did it still fulfil its original brief of protecting public health during the process of recycling or is it impeding access to an essential renewable resource?

Objectives towards achieving the project aim were:

- To assess the applicability of the Guide to encourage the safe use of treated wastewater in agriculture and aquaculture rather than prohibit.
- To assess whether the Guide criteria are adequate to protect both the consumer public and the health of workers involved with the use of treated wastewater in agriculture.

To achieve the above, the following steps were implemented:

- Current and recent international trends on wastewater recycling and reuse were investigated.
- The South African Guide was compared with selected international guides to identify shortcomings and recommend important changes.
- The proposed changes were tabled and evaluated at a workshop held with specialists in this field.

Recommendations from the workshop proceedings were formulated and presented in this report for future research and development.

INTERNATIONAL TRENDS IN GUIDELINES FOR RECYCLING WASTEWATER

With the emphases on public health risk more than on environmental risk, international guidelines for the recycling of wastewater focus more on the risk posed by health-related microbiological quality of the water. It is evident that in developed countries, guidelines tend to follow a conservative high technology/high cost/low risk (NR) approach, especially towards health sensitive crops. On the other hand, the Health Guidelines for the use of Wastewater in

Agriculture and Aquaculture of the World Health Organisation (1989) encourage the low technology / low cost / controlled risk approach.

These guidelines are currently under review by Blumenthal and co-workers (1999) and are discussed in this document as a basis for the review of the South African Guide (1978). The Specialist Group of the International Water Association on Water Reuse, is developing guidelines in a concept international framework based on matching recycled water quality with applications, thereby balancing risk with affordability.

Further discussions on both the abovementioned concept guidelines were still in progress at the time of drafting this WRC report, but are included in this review since these activities are at the cutting edge of wastewater recycling discussions taking place internationally, as well as in South Africa.

THE APPLICABILITY OF THE SOUTH AFRICAN GUIDE

The South African Guide for the Permissible Utilisation and Disposal of Treated Sewage Effluent (1978) was reviewed against the recent trends in international water recycling discussions and concept guideline developments. International guides and concepts, in which more than 140 relevant national and international guidelines, literature references and research topics were referenced, were used for this review.

The following were the outcomes:

- The South African Guide places excessive emphases on wastewater treatment options.
- The South African Guide does not, like the international guidelines, use non-treatment options such as crop-type regulation and irrigation restriction supported by microbiological threshold criteria to control risks associated with applications of recycled water.
- International microbiological threshold criteria are based on faecal coliform (FC) guideline ≤ 1000 FC / 100 mL recycled water for food crops eaten raw and an intestinal nematode egg guideline <1 per litre recycled water to protect against helminth infections.
- SA criteria of zero (0) detectable FC / 100 mL allowed for irrigation of crops likely to be eaten uncooked are stricter than those of the WHO Health Guidelines (1989) and even, in some respects, those of the US-EPA (1992) Guide.
- Nematode egg or protozoa criteria are not included in the South African Guide, an aspect that needs to be urgently reviewed.
- The South African, as well as international guides, do not contain virus threshold criteria. Recent risk assessments and epidemiological studies have indicated that the faecal coliform guideline of 1000 FC / 100 mL is adequate and no extra viral guideline is necessary.

POLLUTED URBAN DISCHARGES AND AGRICULTURE

South African, as well as international guidelines for the microbiological quality of irrigation water used on a particular crop, do not exist. The quality of water discharged from diffuse sources in urban areas is often comparable to untreated wastewater, yet no regulation or guideline exists for the safe use of these waters in agriculture and aquaculture. A future review of the South African Guide should be extended to investigate and include criteria for the safe unrestricted irrigation of microbiologically polluted water such as untreated urban discharges.

SLUDGE

The South African Guide does not provide for permissible utilisation and disposal of sewage sludge. This should be addressed in the guide to Permissible Utilisation and Disposal of Sewage Sludge (Water Research Commission, 1997).

EFFLUENT USE IN AQUACULTURE

The South African Guide does not provide criteria for recycled water quality intended for use in aquaculture. It seems that no such guidelines exist in South Africa. Aquaculture in South Africa is growing rapidly, adding to the demand for recycled water. Proposed *tentative* effluent guidelines (WHO, 1989) for aquaculture are:

- $\leq 10^3$ faecal coliforms per 100 mL (geometric mean) for fishpond water.
- The absence of viable nematode eggs.

DISCUSSION OF THE ASSESSMENT OUTCOMES

The project steering committee suggested that the report outcomes should be discussed at a technical level in a workshop with knowledgeable persons engaged in the field of wastewater reuse. A workshop was held in Pretoria on January 26; 2000. The theme of the workshop was: *A Revised South African Guide for the reuse of treated wastewater.* The recommendations are presented as follows:

Guideline Philosophy

A new Guide should be developed that at all times reflect its true purpose, which is the protection of public health, while enabling the optimal use of treated effluents.

A new Guide based on needs: A reviewed or new South African Guide should clearly reflect the needs of the components of our society the Guide aims to serve.

A new Guide based on risk: The guidelines would be based on "no excessive risk" (the epidemiological perspective). In the face of lacking epidemiological data in South Africa, a new Guide should be designed in such a way that other technological and scientific information could ensure optimum use of treated effluents as a resource, without compromising public health.

Extent of the new Guide: The Guide should be aimed at recycling wastewater from predominantly domestic environments.

- *Faecally polluted surface waters used for agriculture:* This was referred for intersectoral discussion for possible inclusion in future revisions of the volumes dealing with water quality in Agriculture, which are part of the South African Water Quality Guidelines.
- *Sludges:* Health-related microbiological quality of sludges, generated in wastewater treatment facilities, is to be dealt with in the guide for Permissible Utilisation and Disposal of Sewage Sludge (WRC, 1997).
- *Pollution sources:* The use of water from point and diffuse pollution sources, other than domestic treatment facility discharges, should become a function of catchment management programmes.

Water Quality

The new Guide should focus on the health-related microbiological quality of treated effluents. The use of microbiological indicator organisms is supported.

- *E coli* should be used, as this indicates definite faecal contamination of the effluents.
- Faecal coliforms should also be added to provide a more sensitive indication of faecal contamination. Use of the 1000 FC per 100 mL for unrestricted irrigation should be further investigated and discussed during the development of the new Guide.
- Nematode criteria should be included as recommended by Blumenthal et al. (1999).
- Criteria for other parasites such as *Giardia* spp. can be included in future.
- Virus criteria: inclusion should be intensively investigated and discussed during the development of a new South African Guide. The recommendations of Blumenthal et al. (1999) that a 1000 FC per 100 mL are sufficient public health protection against the possible presence of viruses are provisionally accepted.

Monitoring and compliance

Frequency of monitoring, as well as the level of exceedence (standard deviations etc.) of guideline criteria, appears to be a definite and urgent research need that should be addressed during the development of the new guide.

Physico-chemical criteria

The new Guide should make provision for future inclusion of, but preferably cross-referencing to, physico-chemical criteria.

Treatment Criteria

Treatment systems should remain a main focus of the new Guide. It must be ensured by authorities that systems, including waste stabilisation pond systems, must be properly designed and maintained.

Effluent Classification

Effluents need to be clearly classified as this forms the basis for decision making on water quality criteria, treatment criteria, crop restriction, as well as irrigation type requirements.

Irrigation Types

The new Guide should make provision for modern agricultural practices such as hydroponic crop cultivation. Sub-surface drip irrigation is recommended as the safest form of crop irrigation and should be applied wherever possible. Irrigation should be so managed to minimise human exposure to the water.

Crop Restriction

Crop restriction should be dictated by the quality of the effluent, the treatment system design as well as the irrigation type. Although the current Guide makes provision for this combination of factors, it is too restrictive in this regard and should be reviewed to allow for more optimal use of treated effluent.

Site Management

It is foreseen that urban agriculture would often be practiced in or near densely populated areas. The new Guide should include site management criteria that would ensure protection of public health.

Future Research Needs Identified

- Effluent monitoring frequency, as well as the acceptable level of exceedence of guideline criteria.
- Measuring of acceptable risk in South African communities, posed by irrigation of food crops with recycled wastewater.
- The need to include protozoa and especially nematode criteria in a reviewed Guide.
- Exposure and protection of workers in wastewater irrigation areas.
- Effluents classification to facilitate decision making on water quality criteria, treatment criteria, and crop restriction, as well as irrigation type requirements.
- The impact of recycled wastewater on modern agricultural practices such as hydroponic crop cultivation.
- Microbiological criteria for polluted urban surface run-off used in agriculture and aquaculture.
- Microbiological quality of sewage sludges.

Recommendations

It was beyond the scope of this project to write a new guide. The project steering committee as well as the technical working group expressed the urgency for a new South African Guide. This should be undertaken as an immediate follow-up project.

Conclusion

The aim of this project was achieved. It is evident from the report above that the current South African Guide for the Permissible Utilisation and Disposal of Treated Sewage Effluent (1978) is too prohibitive to encourage the optimum use of a valuable resource such as treated wastewater effluent for agricultural purposes. It is therefore not optimally applicable for the South African circumstances and should be reviewed as a matter of urgency.

Workshop

A revised South African Guide for the reuse of treated waste water, Roodevalley, Pretoria, January 26; 2000.

Paper

Jagals P and Steyn M. *Guidelines for the re-use of treated wastewater: public health protection or denial of essential resources?* International Association for Water Quality, April 1999. Specialist Conference on Waste Stabilisation Ponds, Marrakech Morocco

Poster

Steyn M and Jagals P. *Guidelines for the re-use of treated wastewater: public health protection or prohibiting access to essential resources?* Water Institute of Southern Africa. May, 2000. 6th Biennial Conference, Sun City

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Ms APM Oelofse	Water Research Commission (Chairperson)
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Mr LE van Oudtshoorn	Manager Technical Services, Bloem Water
Dr HJ van der Spuy	Water Research Commission (Committee Secretary)

During the execution of the project, the steering committee requested that the outcomes of the investigation be discussed at a technical level in a workshop with knowledgeable persons engaged in the field of wastewater reuse. This was presented to a technical working group for discussion at a workshop held at Roodevallei, near Pretoria on January 26; 2000.

The constructive contributions of the following persons, who participated in the specialist workshop, are specially noted with appreciation:

Ms APM Oelofse	Water Research Commission
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Chapter 1

INTRODUCTION

Expanding global population growth creates a growing demand for fresh water globally (UNEP, 1991). This has, over the last few decades, led to a growing interest in the agricultural use of recyclable water that has been reclaimed from wastewater treatment processes (Blumenthal et al., 1999).

South Africa is no exception. Increased per capita domestic use of water and demands from industry as well as agriculture, all put pressure on water resources (Department of Water Affairs and Forestry, 1995). Large-scale urbanisation of the South African population sees the unprecedented growth of a need for urban farming, as rural people strive to continue something of their agrigarian tradition, as well as provide for a livelihood amongst the needy. Demands from communities are rapidly increasing in and around urban areas to use treated wastewater since this is perceived as an accessible water and fertiliser source for food production.

It is not only the needy communities that require the use of recyclable water. Substantial water resources are becoming accessible through discharges from wastewater treatment facilities such as waste stabilisation and maturation ponds. These are accessible infrastructures from which recyclable water could be made available to various types of commercial irrigation farming activities in the immediate vicinity of South African urban areas (Griesel and Jagals, 2001; Jagals, 2000).

Large parts of South Africa are semi-arid with erratic rainfall patterns (Midgley et al., 1994), and an annual water deficiency (Snyman and Fouchè, 1991). As a result, optimal use of all waters has become critical (Republic of South Africa, 1997). Extractions for use as well as recycling of water for domestic, agricultural and industrial purposes are therefore strictly regulated to conserve and protect the country's natural water reserve (Republic of South Africa, 1998). Included in this is the control of recycling of treated wastewater.

Regulating treated effluent use is part of conserving the country's natural water reserve as well as protecting the ecological integrity of the reserve. This is a function of the General and Special Standards Regulation R553 of the Extraordinary Government Gazette of 5 April 1962 (as amended) (Republic of South Africa, 1984), and is managed by the Department of Water Affairs and Forestry (DWAF). The aim is to return treated effluent to the natural water environment to recover as much of the volume of water originally extracted while ensuring that this reclaimed water does not harm the natural ecological status of the receiving waters.

Permission for recycling of these waters for other uses before being returned to receiving surface waters is a function of Article 21 of the Water Act - Act No 36:1998 (Republic of South Africa, 1998) and is also managed by the DWAF. Collaboration with the Department of Health nationally as well as at the provincial level is sought when the application for recycling involves activities that may impact on the health of the public.

When effluents are to be recycled for agricultural and other purposes, excluding recycling for potable purposes and recharge of aquifers, it becomes a function of the Department of Health (DOH), who applies the South African Guide for the Permissible Utilisation and Disposal of Treated Sewage Effluent (1978) (Appendix E). While this Guide was meant to protect the health of the public, it was not updated significantly since its inception in 1978. Similar international guidelines are currently or have recently been reviewed to assess their applicability in the face of rapidly changing economic, social and environmental circumstances.

This document contains a review of the applicability of the South African Guide for the Permissible Utilisation and Disposal of Treated Sewage Effluent in Agriculture and Aquaculture (1978) to assess whether it still suits its purpose under current and rapidly changing South African circumstances.

Water recycling requires effective measures to minimise risk to public health and the environment (Anderson, 2001). These measures must be both technically and economically feasible. Countries in the world vary in their levels of wealth, so health and environment protection measures need to be tailored to allow for achieving, especially a health risk, that is acceptable to a community within margins of affordability.

Because of the potential microbiological risk to human health, recycling of treated wastewater in South Africa is historically steered towards irrigation of recreation facilities (sports fields, urban parklands) and non food-related plant production. Only in rare instances are these waters allowed by authorities for use in food-related activities such as fodder production.

Application on health sensitive crops is only allowed if the effluent could be treated to the quality of drinking water – a feat not readily achieved by most treatment facilities. This implies that the application of the South African Guide in the current format can lead to unnecessarily conservative responses from permitting authorities to proposed water recycling projects – especially for urban farming practices in developing communities.

Health risks posed by recycled wastewater include both microbiological risks and chemical risks. Provided industrial discharges are properly controlled, microbiological risks are usually the dominant risk for non-potable applications of recycled water (Anderson, 2001). This is also the case in South Africa where it is evident that threshold criteria in the South African Guide (1978) are aimed at ensuring that pathogenic microorganisms are removed from wastewater that is to be used in agriculture. It appears, however, that the criteria are not comprehensive enough to provide protection against certain microbiological risks such as the risk posed by parasites in recycled wastewater.

Recent advances in epidemiology have shown that past standards for hygiene in wastewater recycling, which were based solely on potential pathogen survival and level of treatment, are stricter than is necessary to avoid health risks. Work done by Shuval et al. (1997) indicates that the levels of treatment required in many instances do not justify the costs in respect of the risk removed. The cost of installing, upgrading and maintaining treatment facilities capable of treating wastewater to high microbiological standards might be so prohibitive, especially in areas with insufficient financial resources, that effluent of an unsuitable microbiological quality may often be produced despite the degree of treatment sophistication the facility might be capable of (Blumenthal et al., 1999).

Microbiological effluent quality criteria as well as classification of wastewater uses, contained in the South African Guide are very comprehensive when compared with other international guidelines. However, the South African Guide provides hardly any discretionary guidance to practitioners and authorities in the environmental and health fields to assess the suitability of recycled wastewater for the production of edible crops. In cases where uncertainty cannot be resolved from the criteria in the South African Guide, health authorities would tend to implement an absolute precautionary principle - thereby preventing the potential sustainable use of a valuable renewable resource to communities (Jagals and Steyn, 1999).

In the light of the recent studies on epidemiological advances, as well as other increasing pressures such as global public demands to use these waters, Blumenthal et al. (1999) recently reviewed the World Health Organisation Health Guidelines for the use of Wastewater in Agriculture and Aquaculture (1989) and suggested an updated concept (Appendix A). The International Water Association (IWA) Specialist Group on Water Reuse are also in the process of developing a framework for discussion on uniform international guidelines (Anderson, 2001) (Appendix B).

This offered the ideal opportunity to assess the applicability of the South African Guide for the Permissible Utilisation and Disposal of Treated Sewage Effluent (1978) in agriculture and aquaculture, and to suggest changes if necessary.

Recovering and use (reuse) of wastewater (recycling) is one of the main options in the search for renewable resources of water in water-scarce regions. Resource recycling also forms the backbone of integrated pollution control internationally as well as in South Africa (Republic of South Africa, 1997).

Nevertheless, criteria, standards and type of wastewater treatment required to reduce health risks related to the reuse of wastewater, should be carefully considered.

PROJECT AIM AND OBJECTIVES

The aim of this project was to evaluate whether the South African Guide for the Permissible Utilisation and Disposal of Treated Sewage Effluent (1978) is still applicable in the current South African situation. Did it still fulfil its original brief of protecting public health during the process of recycling or is it impeding access to an essential renewable resource?
Objectives towards achieving the project aim were:

- To assess the applicability of the Guide to encourage the safe use of treated wastewater in agriculture and aquaculture rather than prohibit.
- To assess whether the Guide criteria are adequate to protect both the consumer public and the health of workers involved with the use of treated wastewater in agriculture.

To achieve the above, the following steps were implemented:

- Current and recent international trends on wastewater recycling and reuse were investigated.
- The South African Guide was compared with selected international guides to identify shortcomings and recommend important changes.
- The proposed changes were tabled and evaluated at a workshop held with specialists in this field.

Recommendations from the workshop proceedings were formulated and presented in this report for future research and development.

Chapter 2

INTERNATIONAL TRENDS IN GUIDELINES FOR RECYCLING WASTEWATER

2.1 INTRODUCTION

Different countries have developed different approaches to protect public health and the environment from both microbiological and chemical risks. Provided industrial discharges are properly controlled, microbiological risks are usually the dominant risk for non-potable applications of recycled water (Anderson, 2001). With the emphases on a public health risk more than an environmental risk, international guidelines for the recycling of wastewater focus more on the health-related microbiological quality of the water (Jagals, 2000).

International guidelines vary in approach towards controlling public health risks posed by recycled water. Two basic approaches can be identified for current as well as developing international wastewater recycle guidelines:

- *No potential risk* (NR). In this approach, no detectable potential risk is accepted to those exposed to the recycled wastewater. The characteristic requirements for guides with a NR approach are specification of the crop to be irrigated (crop restriction), minimum treatment requirements (the quality of water required will be dictated by the combinations of primary, secondary and tertiary treatment processes) as well as specification of explicit and strict quality standards (e.g. 0 faecal coliforms / 100 mL of recycled water).
- *Attributable risk* (AR). The objective for this approach is that while some risk is allowed, there should be no *excess* risk of infection attributable to the circumstances under which water is recycled. Attributable risk takes into account factors that increase the probability of contracting disease as a result of exposure to recycled water. These factors include the epidemiological status of the user population as well as other physical and social factors such as the ratio of susceptible to immune members of the population.

It is evident that in developed countries, guidelines tend to follow a conservative high technology / high cost / low risk (NR) approach, especially towards health sensitive crops. On the other hand, economic realities in developing countries have led to the publication of international guidelines that follow a less prudent approach (WHO, 1989). These guidelines allow for some risk (AR), while proposing a more practicable and affordable approach toward controlling such risk within the economic means of the particular country or community. Such control measures may include low cost technology and non-treatment options, such as irrigation techniques and consumer exposure control, supported by epidemiological information and health and hygiene awareness education.

Since publication of the WHO Health Guidelines in 1989, work done on international water recycling guidelines suggest that there are still these two mainstream approaches with some other more recent developments towards what can be termed a merging of these two main streams.

The US-EPA / USAID Guidelines for agricultural reuse of wastewater (1992) is a good example of guidelines that are intended to achieve a level of no potential risk.

The work done by the group of Blumenthal et al. (1999) is aimed at updating the Health Guidelines for the use of Wastewater in Agriculture and Aquaculture of the World Health Organisation (WHO, 1989), which follow the low technology / low cost / controlled risk path of the attributable risk approach. The WHO approach aims to provide guidance that can be adapted to national conditions and constraints, and allows the introduction of threshold criteria devised from balancing risk and affordability (Anderson, 2001).

Members of an international panel, who participated in the Water Reuse Association's Global Perspectives in Water Reuse seminar in San Francisco in March 1999, developed a concept guideline that was introduced as a discussion document at the Third International Symposium on Wastewater Reclamation, Recycling and Reuse, held in Paris, July 2000 by the International Water Association (IWA) Specialist Group on Water Reuse (Anderson, 2001). Further development of these concept guidelines aims to provide an international framework with national decision-making on matching recycled water quality with applications, thereby balancing risk with affordability. The framework would still provide individual countries with options to apply recycled water anywhere within the spectrum of conservative high technology / high cost / low risk to low technology / low cost / controlled risk activities.

Further discussions on both the abovementioned concept guidelines were still in progress at the time of drafting this WRC report. It was thought appropriate to include discussion of these abovementioned two documents, even at their respective stages of progress into this report, since these were at the cutting edge of wastewater recycling discussions taking place internationally as well as in South Africa.

2.2 NO POTENTIAL RISK - THE CONSERVATIVE TREND IN GUIDELINE DEVELOPMENT

Developed countries tend to adopt conservative high technology/high cost/low risk guidelines or regulations in order to achieve a NR for wastewater recycling. These types of guidelines set strict threshold criteria for the quality of wastewater to be recycled for unrestricted irrigation of health-sensitive crops. The US-EPA / USAID Guide (Appendix D) is a good example of guidelines that are intended for a NR approach towards applications of recycled wastewater. Several other examples of guidelines used in the USA and Australia are included in Appendices D as well as B. These types of guidelines have influenced criteria in guidelines currently used in countries like Israel, Oman and South Africa (Blumenthal et al., 1999).

Because of the strict quality criteria that have to be met, as well as emphases on treatment options, the application of these conservative types of guidelines, in practice, does not always achieve the low risk intended. This is due to the high level of funds, experience and regulatory controls required to operate the kind of sophisticated systems that could produce the effluent quality required (Anderson, 2001), even in developed countries. This means that management of potential risk becomes unaffordable in terms of the actual risk to be avoided.

2.3 NO EXCESS RISK OF INFECTION – MORE AFFORDABLE

The WHO had, in the years before publishing their Health Guidelines for the use of Wastewater in Agriculture and Aquaculture in 1989, not been so supportive of a "no excess risk of infection" approach. In 1973, the WHO published guidelines for the reuse of wastewater effluents. These guidelines focused on treatment methods necessary for health safeguards (WHO, 1973). For example, conventional treatment technologies, supported by chlorination of the final effluent, were considered a suitable option to achieve a bacteriological quality of 100 coliform organisms per 100 mL recyclable water. Such effluent was then regarded to have only a limited health impact when used for unrestricted irrigation of food crops (Blumenthal et al., 1999).

Since then, it had been realised that wastewater treatment options and microbiological water quality is not the only measure available to protect the health of wastewater users (Blumenthal et al., 1999). Non-treatment options such as crop selection and restriction, irrigation techniques and human exposure control were increasingly being considered as equally important health protection measures

In 1985, the World Health Organisation, the World Bank and the International Reference Centre for Waste Disposal convened a meeting of sanitary engineers, epidemiologists and social scientists in Engelberg, Switzerland. This group recommended a more lenient approach to the use of treated wastewater and excreta based on the best available epidemiological evidence at the time, which had by then been comprehensively reviewed by Shuval et al. (1986).

The Engelberg Report recommended a non-treatment approach with more practical microbiological threshold criteria for public health protection during the application of recycled water. This led to the publication of the Health Guidelines for the use of Wastewater in Agriculture and Aquaculture (WHO, 1989) (Appendix C). These guidelines focussed on low technology / low cost / attributable risk conditions for wastewater recycling according to non-treatment options such as crop selection, irrigation techniques and human exposure control.

The microbiological evidence proposed in the WHO Health Guidelines (1989) were based on the criteria of 1000 FC / 100 mL and less than one nematode egg per litre effluent. The bacterial faecal coliform (FC) guideline appears to be a moderate approach compared to the FC criteria in the US-EPA / USAID Guidelines (1992).

Bacterial indicators such as faecal coliforms do not constantly indicate the presence of human viruses and parasites in water resources such as recycled water. Increasing numbers of these pathogens are found in recycled water, which implies that another type of indicator organism group should be used (West, 1991). The WHO Health Guidelines for the use of Wastewater in Agriculture and Aquaculture (1989) includes a viable intestinal nematode egg threshold to serve this purpose. This inclusion adds to the public health protection value of the WHO Health Guidelines (1989).

The WHO recommends the use of "partial" epidemiological evidence (where available) to support health-related microbiological water quality information in user guides such as this for recycled wastewater (Blumenthal et al., 1999; WHO, 1989). This is to allow for local epidemiological, socio-cultural and environmental factors when balancing risk and affordability.

This WHO recommendation to use 'partial' epidemiological studies in developing countries as a basis for adapting the WHO guidelines to local needs (WHO, 1989) was severely criticised. Countries would not use epidemiological studies as the basis for determining local microbiological quality criteria for effluent intended for recycling, as the capacity for doing such study often does not exist, would take a considerable time to complete (Crook, 1998), or epidemiological methods would, as Rose (1986) had pointed out, not be sensitive enough to detect disease transmission.

In areas where epidemiological evidence is lacking, the WHO (1989) proposes using only microbiological evidence based on the criteria of 1000 FC / 100 mL and less than one nematode egg per litre effluent. This too had been criticised - in particular the relaxation of the faecal coliform criteria for unrestricted irrigation to a geometric mean of 1000 per 100 mL. It was said to be too lenient and being conducive to infection risk to human users (Blumenthal et al., 1999).

On the other hand, standards and criteria in several countries have since been based on the WHO Health Guidelines (1989). France and Mexico modified microbiological criteria from the WHO (1989) Health Guidelines to suit local epidemiological and economic circumstances (Bontoux and Coutois, 1998; Peasey et al., 1999). An example of the revised standards introduced by Mexico in 1996 (Peasey et al., 1999) is shown in Appendix D.

2.4 RECENT DEVELOPMENTS – GUIDELINES TO BALANCE AFFORDABILITY WITH RISK

The NR approach to wastewater recycling will always be the best option provided a particular community could afford and manage it. There are countries that can afford this option and many countries that cannot, but would still want the benefits of water recycling. Uncontrolled recycling has high health and environmental costs. Requirements intended to assure a very low risk (NR) might also be too expensive. Balancing risk with affordability therefore depends on the local economy.

The benefits of water recycling are governed by laws of diminishing returns (Anderson, 2001). Removing 99% of the microbiological risk may cost twice as much as removing 90% of the risk. To achieve maximum benefit from investing scarce financial and other resources, it may be more beneficial to achieve 90% removal of risk from water to be recycled to two community-farming projects than to achieve 99% removal of risk for one project.

There is enough epidemiological evidence to believe that the NR approach might be too prudent (Shuval et al., 1997; Blumenthal et al., 1999). The NR approach (e.g. setting a criteria threshold of 0 *E coli* / l00 mL) results in very high additional costs per case of infectious disease averted. On the other hand threshold values of for instance 1000 FC / 100 mL (Shuval et al., 1997), appears to result in no excess risk (controlled or attributable risk) of infection to the population group recycling the water. A controlled risk approach would give the best balance between risk and cost in such circumstances (Anderson, 2001).

Balancing affordability and risk has led to some developing countries adopting the AR approach of low technology / low cost / controlled risk application of recycled water. AR implies that a low level of risk may remain in the use of recycled wastewaters of a lower microbiological quality grade, often below that which is detectable through most epidemiological studies. While AR does not achieve a level of NR, care needs to be taken that no excess risk of infection to a population is caused with the use of any particular quality grade of wastewater that is reclaimed and recycled.

Based on work done by Blumenthal et al. (1999) as well as Shuval et al. (1986; 1997), balancing affordability and risk can be achieved if the required microbiological quality of recycled water used for unrestricted irrigation contains up to a maximum of 1000 faecal coliforms per 100 mL effluent, and less than one nematode egg per litre effluent on average, even in the face of lacking epidemiological and other evidence of local circumstances. At these levels, no excess risk of infection is expected in the user population.

2.4.1 Guidelines to achieve attributable (no excessive) risk

Blumenthal et al. (1999) proposed updated guidelines (Appendix A) to the WHO based on their reviews of epidemiological, microbiological and risk assessment studies done in the past decade. Several other country standards as well as additional issues of concern e.g. the need for virus criteria in wastewater reuse guides were also explored.

Their report included outcomes of epidemiological and microbiological studies done by the London School of Hygiene and Tropical Medicine in collaboration with the Instituto Nacional de la Nutricion in Mexico City. Other members of the group are the Leeds University with colleagues in Laboratorio Nacional de Engenharia Civil, Lisboa, Portugal, and Estacao Experimental de Tratamentos Biologicos de Esgotos Sanitarios, Universidade Federal da Paraiba, Campina Grande, Paraiba, Brasil.

The group proposes guidelines that are not only based on microbiological quality of the recycled water, but also include the use of non-treatment options such as crop selection and restriction, irrigation techniques as well as human exposure control as important health protection measures. Low cost treatment options are recommended for achieving a particular quality level but do not play a decisive role.

If the guidelines are strictly applied, this approach provides a measure of infection risk control in the face of lacking epidemiological and / or risk assessment evidence. By implication, communities who do not have the capacity to conduct epidemiological studies or to assess risks attributable to the particular recycled wastewater application need only go on the guideline conditions and criteria thresholds (Table 2, Appendix A).

2.4.2 Guidelines for fitness of use

The IWA Specialist Group on Water Reuse are developing guidelines (Appendix B) that are based on matching recycled water quality with applications (Anderson, 2001), thereby providing for balancing risk with affordability in a stepwise ladder-climb of continuous improvement.

They propose quality grades for recyclable water that meet health requirements of particular applications (fitness for purpose). In doing so it is possible to define a series of recycled water grades or 'products', which are linked to specific applications.

Fitness for purpose is therefore linked to assessing risk. It is not just the microbiological quality of recycled water but also the method of application, the local health and environmental, as well as local economic circumstances that would have to play a role i.e. these guidelines might be supported by a process of attributable or quantitative risk assessment.

This again implies that a community must have the capacity to do proper risk assessments or to collect meaningful epidemiological information. As evidence of the epidemiological status of the population in these particular areas accumulate or its economy grows, an individual community or country can progress to better risk outcomes by progressive investment over time in upgrading recycled water quality, as lower risk levels become more affordable (Anderson, 2001).

Another important feature of the guidelines proposed by the IWA group is that the origins of the polluted water as well as treatment options are not part of the criteria. It is rather the water quality matched to the application. The choice of technology or treatment option then becomes a function of the water quality required. The concept guidelines therefore allow for approaches over the whole spectrum of applying conservative high technology / high cost / low risk to low technology / low cost / controlled risk.

2.5 CRITERIA FOR VIRUSES AND PARASITES

A remarkable feature of conservative guidelines aimed at "no potential risk" due to the recycling of wastewater is that these generally do not contain the additional conservative measure of parasite limits, something that "less conservative" guidelines such as the Health Guidelines for the use of Wastewater in Agriculture and Aquaculture of the World Health Organisation (WHO, 1989) do contain. Anderson (2001) states that excessive concern about infection from parasites can lead to prohibitively expensive treatment requirements, or costly operating limitations that preclude the use of normal agricultural methods. In the face of lacking epidemiological evidence in many developing countries, the inclusion of a nematode threshold value will be added safeguards against incidences of *Cryptosporidium, Giardia* and *Cyclospora* spp. transmission, all of which are not easily removed by conventional treatment processes (Blumenthal et al., 1999). This emphasises the value of the nematode threshold value

Viral infections, transmitted through treated wastewater recycling in industrialised countries, have been a particularly contentious issue. Inclusion of virus criteria in wastewater reuse guides is presently unresolved (Blumenthal et al., 1999). Virus criteria might be necessary as disinfection processes appear to be relatively inefficient to remove viruses from treated wastewater. Detection of viruses in recyclable water is limited by high analyses costs. Shuval et al. (1997) reported that an appropriate faecal coliform criterion of 1000 FC per 100 mL appears to be an effective threshold value for public health protection.

2.6 SUMMARY

International guidelines generally follow two basic approaches i.e. guidelines for *no potential risk* and for *attributable risk* based on circumstances in the particular area or population. These guidelines would include specification of crops to be irrigated, treatment requirements, effluent quality standards, as well as epidemiological status of the user population. In developed countries, guidelines tend to follow a conservative high technology / high cost / low risk (NR) approach, especially towards health sensitive crops, while in developing countries guidelines follow a more practicable and affordable approach of controlling infection risk with low cost control measures such as irrigation techniques, consumer exposure control and health and hygiene awareness education – measures which are within the economic means of the particular country or community.

Chapter 3

THE APPLICABILITY OF THE SOUTH AFRICAN GUIDE: Comparisons, discussions and recommendations

3.1 INTRODUCTION

The South African Guide for the Permissible Utilisation and Disposal of Treated Sewage Effluent (1978) (Appendix E) was reviewed against the recent trends in international water recycling discussions and concept guideline developments. The following international guides and concepts, in which more than 140 relevant national and international guidelines, literature references and research topics were referenced, provided comprehensive bases for this review:

- Guidelines for the safe use of wastewater and excreta in agriculture and aquaculture (Mara and Cairncross, 1989 for WHO).
- Guidelines for wastewater reuse in agriculture and aquaculture: recommended revisions based on new research evidence (Blumenthal et al., 1999). This proposed new guide is a revision of the 1989 WHO Health Guidelines. It is expected that the WHO will adopt it in the near future (Appendix A).
- Examples for an international guideline based on draft Australian water recycling guidelines (Anderson, 2001) (Appendix B).
- Health Guidelines for Wastewater Reuse in Agriculture and Aquaculture (WHO, 1989) (Appendix C).
- US-EPA/USAID Guidelines for agricultural reuse of wastewater (US-EPA/USAID, 1992) (Appendix D).
- Mexican Standard governing wastewater reuse in agriculture (Peasy et al., 1996) (Appendix D).
- A summary of guides used in the USA (Cooper and Olivieri, 1998) and Australia (Anderson, 2001) (Appendix D).

3.2 THE SOUTH AFRICAN GUIDE AND RECYLED WATER APPLICATION

International guides classify treated effluents based on a combination of *non-treatment* criteria such as purpose of reuse, water quality, irrigation techniques as well as worker and other group exposure to irrigation water. Treatment options are suggested as supplementary (Mara and Cairncross, 1989; WHO, 1989). The Australian example does not classify according to treatment but uses application requirements with quality criteria thresholds and contact restriction (Anderson, 2001). The proposed international guide by Blumenthal et al. (1999) uses reuse conditions (similar to the application requirements of the Australian examples), with quality criteria thresholds, irrigation techniques and the exposed group. Treatment options are suggested as supplementary.

By contrast, wastewater treatment methods serve as the primary benchmark for classification of effluent in the South African Guide (Appendix E). Non-treatment options such as crop types and irrigation restrictions, as well as microbiological effluent quality criteria (based on the numbers of *E coli* per 100 mL instead of faecal coliforms (Sections 3.2.3 and 4.2.1), are used to supplement the various treatment options. The implications of this approach are discussed in the following sections.

3.2.1 Discussion of classification according to treatment

Wastewater classification in the South African Guide (1978) is compared analogously to other international guides in Table 1. The similarity between the South African Guide and the US-EPA / USAID Guidelines (1992) is remarkable.

Table 1: Wastewater classification according to treatment: the South African Guide compared to selected interna

South African Guide (1978)	WHO Health Guidelines (WHO, 1989)	US-EPA/USAID Guideline
Classification Code OD **OXIDATION POND SYSTEM** • designed to be operated free of nuisances • primary pond and approximately 4 secondary ponds • combined retention time of least 45 days • system drains into irrigation reservoir with at least 12 days dry weather capacity • failing the above, each OD system would be considered equivalent to PS. ≤ **1000 *E. coli* / 100 mL**	**Classification Code A** ≤ 1000 faecal coliforms / 100 mL ≤ 1 nematode egg / 1 L **Treatment Options:** **Waste Stabilisation Pond (WSP)** –a series of stabilisation ponds designed to achieve the microbiological quality indicated, or equivalent treatment	**Classification Agricultural R** **Food crops eaten raw** No detectable faecal coli / 100 r **Treatment options:** secondar – filtration – disinfection
Classification Code PS ***PRIMARY AND SECONDARY TREATMENT*** Conventional wastewater treatment. • grid treatment • primary settling • biological treatment e.g. biofiltration or activated sludge process Secondary treatment = settling or clarifying NO MICROBIAL GUIDELINE	Classification Code B **No faecal coliform criterion** ≤ **1 nematode egg / 1 L** **Treatment Options:** **Waste Stabilisation Pond (WSP)** –retention in stabilisation ponds for 8-10 days or equivalent helminth and faecal coliform removal design.	Classification Agricultural Reuse Other food crops ≤ **200 faecal coli / 100 mL** **Treatment options:** secondar – disinfection
Classification Code PST **PRIMARY SECONDARY + TERTIARY TREATMENT** PS + one or more types of tertiary treatment i.e. land treatment, maturation ponds, filtration, disinfection **1000 *E coli* / 100 mL**	Classification Code C *Pre-treatment as required by irrigation technology* **No criteria recommended**	Classification Agricultural Reuse Non-food crops ≤ **200 faecal coli / 100 mL** **Treatment options:** secondar – disinfection
Classification Code STD **PRIMARY SECONDARY + TERTIARY TREATMENT** As PST **0 *E coli* / 100 mL**		Classification Urban Reuse **No detectable faecal coli / 1** **Treatment options:** secondar filtration disinfection
Classification Code SP **STD + ADVANCED TREATMENT** Final effluent compared to drinking water quality **0 *E coli* / 100 mL**		

The South African Guide (1978) as well as the US-EPA / USAID Guidelines (1992), classify water for health-related recycling according to conventional treatment system methods, which is a stricter format of application. While a highly developed country like the USA might be able to afford such a conservative high technology / high cost approach towards achieving low risk, this might not be generally achievable in the South African context.

The South African Guide (1978) clearly favours the use of effluent from more elaborate (conventional) treatment facilities (primary, secondary and tertiary treatment processes within the configuration), especially for purposes of food production and recreation-related applications.
The approach appears to be that conventional systems would ensure effluent of suitable quality to fit the purpose of application. It is the assumption that, if these facilities were operated at their optimum, the quality of the effluent produced would be of the quality required. Optimum conventional treatment often results in high costs especially where strict microbiological standards are required while the risk to be avoided might not be that great. Risk needs to be balanced with affordability.
This is illustrated by the WHO Health Guidelines (1989), which for the sake of balancing risk with affordability classify recyclable effluent according to application (type of reuse) as well as the microbiological quality required for the effluent used. Low technology / low cost treatment methods such as waste stabilisation ponds, are then suggested to achieve the desired results.
The WHO Health Guidelines (1989) proposes waste stabilisation ponds (WSP) as suitable treatment options – especially in developing countries. The advantages of WSP are low cost, simplicity of construction, operation, maintenance and high efficiency, especially with respect to the removal of nematode eggs and faecal bacteria (Mara, 1997; Mara and Pearson, 1998; Blumenthal et al., 1999).
On the other hand, conventional wastewater treatment systems (such as biofilters and activated sludge) can only achieve a 2-log unit reduction of *E coli* and cannot meet the microbiological requirements for agricultural reuse unless supplemented by tertiary treatment processes (Mara and Cairncross, 1989; Mara and Pearson, 1998). It is rare that a well-designed WSP fails to achieve the required result. In instances where existing WSP cannot achieve required effluent qualities, these have probably not been so designed, are overloaded or poorly maintained.
The South African Guide (1978) does not recognise the effectiveness of WSP at a similar level than does the international community. According to the Guide, conventional wastewater treatment without tertiary treatment (Table 1 - PS) produce effluent of the poorest quality, but then classifies WSP with the PS category in terms of water quality potential - again evidence that WSP are not favoured.
A further aspect that needs to be considered in situations where conventional treatment is being planned, is the cost of operation, maintenance and personnel training (all of which are considerably higher than for non-conventional treatment systems such as WSP). This might make future installation of treatment facilities less attractive or even unattainable in a country where financial resources to provide for social upliftment, are under increasing pressure. This would in turn lead to increased installations of WSP in South Africa, an aspect that the South African Guide (1978) does not make appropriate provision for. A revised South African Guide should provide for more liberal use of WSP in future.

3.2.2 Non-treatment options

The primary non-treatment options used in the international guides are crop-type regulation and irrigation restriction (Mara and Cairncross, 1989).
Crop type regulation refers to guidance on the types of crop to be used under particular circumstances – often supplemented by prescriptions for the microbiological quality of the effluent required. *Irrigation restriction* is the practice of irrigating non-food crops with lower quality effluents (Mara and Cairncross, 1989).

International guides tend to use the expressions "reuse type", "reuse conditions" and "application" in the same sense and often concurrent with *crop type regulation* and *irrigation restrictions*. The South African Guide also uses this approach of crop regulation and irrigation restriction, but as the guide focuses on treatment options, the complicated format of such a combination makes these restrictions and regulations difficult to apply.

Table 2 contains a summary of *reuse types* found in the South African Guide compared to similar reuse types, applications, categories and conditions in international guides, ranked in order from the most sensitive use (on crops usually eaten raw) to the use the least likely to cause adverse public health effects.

International guides use *irrigation restrictions* to strengthen crop regulations. For example, the WHO Health Guidelines (1989) (Appendix C), use water categories (A, B and C) as well as microbiological limits but complement these with strict rules of irrigation application. France has used a similar simple approach in the non-compulsory "Sanitary recommendations for the use, after treatment, of municipal wastewaters for the irrigation of crops and landscaped areas", published in 1991 (Bontoux and Coutois, 1998). An example for a category A application in the French guidelines is that the microbiological quality requirement must be complemented by *irrigation regulations* such as:

- Avoid wetting of fruit and vegetables
- For irrigation of golf courses and open landscaped areas, spray irrigation must be performed outside the opening hours for the public.

The South African Guide (1978) also contains *irrigation regulations.* These are interlaced with the classification of the treatment system that produces the effluent, which make them complicated to interpret. These regulations are therefore not summarised in Table 2 but should rather be referred to in Appendix E.

3.2.3 Microbiological effluent quality indicators

The South African Guide deals with the reuse of effluents from systems that predominantly treat domestic wastewater. This is in line with the international emphasis, which is directed towards the control of microbiological contamination, rather than the avoidance of health hazards caused by chemical pollutants, since these are considered of only minor importance in the reuse of domestic wastes (WHO, 1989; Anderson, 2001).

The WHO Guideline for faecal coliforms (FC) (e.g. 1000 FC / 100 mL for food crops eaten raw) was intended to protect against bacterial infections (WHO, 1989). The intestinal nematode egg guideline, introduced in 1989, was intended to protect against helminth infections and also to serve as indicator organisms for all of the large settlable pathogens, including amoebic cysts. The exposed group that each of these criteria was intended to protect, as well as the wastewater treatment expected to achieve the required microbiological criteria, is clearly stated in the WHO Health Guidelines (1989) (Appendix C).

On the other hand, the US-EPA / USAID Guidelines (1992) has recommended the use of much stricter bacterial guidelines for wastewater use in the USA. For irrigation of crops likely to be eaten uncooked, no (0) detectable FC / 100 mL are allowed (compared to $\leq$ 1000 FC / 100 mL for WHO, 1989). For irrigation of commercially processed crops, fodder crops, etc., the guideline is $\leq$200 FC / 100 mL (where only nematode egg criteria are proposed by WHO in 1989).

The microbiological criteria used in the various guides are summarised in Table 3a (faecal coliforms) and Table 3b (nematodes). It is evident that the South African criteria are stricter than those of the WHO and even, in some respects, those of the US-EPA / USAID (1992) Guidelines.

Table 2: Reuse types in the South African Guide compared to similar reuse types and conditions in international guides.

South African Guide (1978) *Irrigation of*	WHO Health Guidelines (1989) *Reuse conditions*	US-EPA/USAID Guidelines (1992) *Reuse type*	Recommended revised microbiological guidelines (1999) *Reuse conditions*	Examples for an international guideline (2001) *Application*
• Vegetables and crops that are eaten raw by humans. • Lawns at swimming pools, children's play parks and crèche's • Sports fields where limited contact is made with the field, e.g. golf-, cricket-, hockey-, soccer fields, et cetera. • School grounds and public parks	**Category A type use** • Irrigation of crops likely to be eaten uncooked • Sports fields, public parks	**Agricultural Reuse** • Any food crop, food crops not commercially processed, including crops eaten raw **Urban Reuse** • All types of landscape irrigation (e.g. golfcourses, parks, cemeteries).	**Category A type use** **Unrestricted irrigation** • **A1** Vegetable and salad crops eaten uncooked, sports fields, public parks • **A2** Fruit trees	**Food crops** • Foods eaten raw including salad vegetables and root crops, RW contacts edible portion • Foods cooked, processed, before eating • Orchards - No RW contact on edible portion. **Urban and residential** • Sporting fields, golf courses, parklands, open space, landscaping, fire protection
• Crops for human use not eaten raw (i.e. fruits, vegetables and sugar cane) • Cultivation of cut-flowers • Fruit trees and vineyards for cultivation of fruit which is eaten raw by humans • Pasture for livestock • Pasture for dairy animals • Crops not for grazing but as dry feed • Crops cultivated only for use as seeds	**Category B type use** • Irrigation of cereal crops • Industrial crops • Fodder crops • Pastures and trees	**Agricultural Reuse** • Food crops commercially processed • Surface irrigation of Orchards and Vineyards	**Category B type use** **Restricted irrigation** • Cereal crops, industrial crops, fodder crops, pasture and trees	**Non food crops** • Silviculture, turf farms • Fodder, fibre and seed crops **Pasture animals and fodder** • Stock water • Pasture and fodder for dairy cattle and pigs • Pasture and fodder for beef cattle, sheep • Dairy wash down water
• Parks - only for embellishment of flower gardens, traffic islands et cetera viz. not recreational areas • Tree plantations • Nursery - Cut-flowers excluded • Any park or sports fields only during development as well as before opening the allowing activities.	**Category C type use** • Localised irrigation of crops in Category B if exposure to workers and the public does not occur		**Category C type use** • Localised irrigation of crops in Category B if exposure of workers and the public does not occur	**Urban and residential** • Residential gardens, car washing, pavement washing, toilet flushing • Sporting fields, golf courses, parklands, open space, landscaping, fire protection
• Mines and industries: ore dressing, dust control, et cetera • Dust control on roads				**Commercial and industrial** • Open systems, minimal aerosols • Road making, soil compaction concrete mixing, dust suppression

The South African Guide (1978) uses *E coli* / 100 mL as prime criterion while international guides use FC / 100 mL. Although the South African Guide erroneously suggests that *E coli* are faecal coliforms, it was evidently the intention of the original composers to conform to the international approach.

In Table 3a the *E coli* criteria used in the South African Guide are tabled analogous to the faecal coliform criteria of the other guides. It had to be done in this manner, since the South African Guide appears to use faecal coliforms in the same context as *E coli* as an indicator of the potential presence of bacterial pathogens in water. This practice is not correct since *E coli* bacteria form but a part of the greater faecal coliform group.

It is only in water heavily polluted with the faeces of humans and other warm blooded animals that the numbers of *E coli* would constitute approximately up to 80% of the numbers of bacteria detectable as faecal coliforms in water samples (Jagals et al., 2000; Jagals 2000). A threshold value of 1000 *E coli* (EC) per 100 mL would therefore constitute a threshold value of 1250 faecal coliforms (FC) per 100 mL, which is of course, more lenient than the WHO guide in some respects.

The use of EC in international guidelines has generally been relegated in favour of FC because of historic complex multi-step analyses methodologies required to detect EC. With recent advances in detection technologies, EC can now reliably be detected in a single-step procedure (Jagals et al., 2000). Since EC is a more reliable indicator of faecal pollution than FC (Jagals, 2000, Grabow, 1996), it is recommended that EC threshold values should be more realistically applied analogous to the values of FC in a future South African Guide.

Standards and criteria in use in many countries e.g. Israel, Oman and also South Africa have been influenced by standards in the USA while other counties have been influenced by the WHO (1989) Health Guidelines and have modified the microbiological criteria to suit local epidemiological and economic circumstances.

The faecal coliform and helminth standards introduced by Mexico in 1996 (Peasey et al., 1999) (Appendix D) were designed to be sufficient to protect groups at the health risk level (according to currently available data) and achievable with the technology and resources available at the time, and in the near future, in Mexico.

The US-EPA / USAID Guidelines (1992) do not specify nematode egg criteria. Nematode egg criteria are also not included in the South African (1978) Guide. Non-inclusion of nematode egg criteria would be reasonable in countries where the endemic status of worm infestations is under control or minimised (Mara and Cairncross, 1989). However, in developing countries (such as South Africa), worm infestations are still at a high level (Blumenthal et al., 1999), and would certainly reflect in treated effluent. It would therefore make sense to include nematode criteria in a future South African Guide.

3.2.3.1 Indicator criteria for viruses in local and international guides

Faecal coliform criteria in most guidelines and standards for wastewater reuse are intended to address risks of enteric infections due to both bacterial and viral pathogens (Blumenthal et al., 1999). There have been discussions concerning the FC criteria's adequacy to protect against the risk of viral infections. This debate started mainly because (Schwartzbrod, 1995):

- Conventional treatment processes (even involving disinfection) are less efficient in removing viruses than removing indicator bacteria, to such an extent that even where the indicator bacteria have been destroyed, viruses can still survive in the treated effluent.
- The minimum infectious dose for enteric viruses is very low (below 50 infectious particles), in comparison with the infectious dose for most enteric bacteria.

Table 3a: Faecal coliform (*E coli*) criteria in the South African Guide compared to selected international guides and standards.					
South African Guide (1978)	**WHO 1989 Health Guidelines**	**US-EPA / USAID 1992 Guideline**	**Mexican Standard (1996)**	**Recommended revised microbiological guidelines (1999)**	**Examples for an international guideline (2001)**
0 *E coli* / 100 mL **Agriculture** Vegetables and crops that are eaten raw by humans- crops for human use not eaten raw (i.e. fruits, vegetables and sugar cane) - Fruit trees and vineyards for cultivation of fruit, which is eaten raw by humans – cut flowers. **Recreation** Lawns at swimming pools, children play parks / crèches, sports fields for limited field contact i.e. golf, cricket, hockey soccer, school grounds & public parks		**NO DETECTABLE FAECAL COLIFORMS (FC)** **For Agricultural Reuse** Food crops not commercially processed. Surface or spray irrigation of any food crop, including crops eaten raw **For Urban Reuse** All types of landscape irrigation e.g. golf courses, parks, cemeteries			
		≤ 200 FC / 100 mL **Agriculture:** Food crops not commercially processed - Surface irrigation of orchards and vineyards – Non-food crops - Pasture for milking animals; fodder, fibre and seed crops			**2.2–200 mL** Spray irrigation of food crops **10 – 1000 / 100 mL** Surface irrigation of food crops **10 – 100 / 100 mL** Parks and playgrounds **0 – 100 / 100 mL** Golf courses and open spaces
≤1000 *E coli* / 100 mL **Agriculture** Pasture for livestock Pasture for dairy animals	**≤1000 FC / 100 mL** **Category A** Irrigation of crops likely to be eaten uncooked, sports fields, public parks		**1000 FC / 100 mL (MPN)** Unrestricted as well as restricted irrigation.	**≤1000 / 100 mL** **Category A – A1** **Unrestricted irrigation of:** Vegetable and salad crops eaten uncooked, sports fields, public parks **Category B – B3** Worker group with children < 15 **Restricted irrigation of:** Cereal, industrial and fodder crops, pastures and trees.	

Table 3a (Continued): Faecal coliform criteria in the South African Guide compared to selected international guides and standards.					
South African Guide (1978)	**WHO 1989 Health Guidelines**	**US-EPA / USAID 1992 Guidelines**	**Mexican Standard (1996)**	**Recommended revised microbiological guidelines (1999)**	**Examples for an international guideline (2001)**
				≤ 100,000 / 100 mL **Category B - B1** Worker group no children <15years **Restricted irrigation of:** Cereal, industrial and fodder crops, pastures and trees.	
APPLICATION OF ANY EFFLUENT QUALITY (management restrictions only e.g. no pool forming etc) **Agriculture** Crops not used for grazing but utilised as dry feed - Crops cultivated for use as seeds Tree plantations - Nursery cut-flowers excluded **Recreation** Any park or sports fields only during development	**NO STANDARD RECOMMENDED** **Only Nematode criterion** **Category B** Irrigation of cereal crops, industrial crops, fodder crops, pasture and trees				
	NO CRITERIA APPLICABLE **Category C** Localised irrigation of crops in **Category B** if exposure to workers and the public does not occur			**NO CRITERIA APPLICABLE** **Category A – A2** Fruit trees if no sprinklers used. **Category B – B2** **Restricted irrigation** Cereal, industrial and fodder crops, pastures and trees if no sprinklers are used. **Category C** Localised irrigation of crops in category B if exposure of workers and the public does not occur.	

Table 3b: Nematode criteria in selected international guides and standards.

South African Guide (1978)	WHO 1989 Health Guidelines	US-EPA / USAID 1992 Guidelines	Mexican Standard (1996)	Recommended revised microbiological guidelines (1999)	Examples for an international guideline (2001)
None		None		**≤0.1 / 1 L** **Category A - A1** **Unrestricted irrigation of:** Vegetables and salad crops eaten uncooked, sports fields, public parks **Category B – B3** Worker group with children < 15 **Restricted irrigation of:** Cereal, industrial and fodder crops, pastures and trees.	None
	≤1 / 1 L **Category A** Irrigation of crops likely to be eaten uncooked, sports fields, public parks **Category B** Irrigation of cereal crops, industrial crops, fodder crops, pasture and trees		**≤ 1 / 1 L** Unrestricted irrigation	**≤1 / 1 L** **Category A – A2** **Unrestricted irrigation of:** Fruit trees **Category B – B1** Worker group no children <15years **Restricted irrigation of:** Cereal, industrial and fodder crops, pastures and trees. **Category B – B2** **Restricted irrigation of:** Cereal, industrial and fodder crops, pastures and trees not using spray or sprinkler irrigation	
			≤ 5 / 1 L Restricted irrigation		
	NO APPLICABLE CRITERIA **Category C** **Not applicable when** Localised irrigation of crops in category B No exposure to workers and public			**NO APPLICABLE CRITERIA** **Category C** **Not applicable when:** Localised irrigation of crops in category B using trickle, drip or bubbler irrigation No exposure of workers and the public	

3.2.3.1 Viruses indicator criteria in local or international guides (continued)

Not enough is known about the viral content of wastewater and the public health effects associated with the use of wastewater and sludge in agriculture (Schwartzbrod, 1995). This makes it difficult to establish norms or make recommendations concerning specific standards for viruses in wastewater.

Risk assessments by Asano et al. (1992) and epidemiological studies (Shuval et al., 1997; 1986) have indicated that tertiary treatment plus disinfection is not needed to protect against viral risks from consumption of effluent-irrigated vegetable crops eaten raw. Furthermore, the faecal coliform guideline of 1000 FC / 100 mL is adequate and no extra viral guideline is necessary in this case (Shuval et al., 1997). Where reuse is for purposes where greater quantities of water are ingested e.g. when swimming in recreational water or through direct contact with wastewater through irrigation or play, there may be a need for a stricter guideline.

The South African Guide (1978) does not provide for virus criteria. It should be discussed, on the evidence above, whether such a guide is needed.

3.2.3.2 Indicator criteria for protozoa in local and international guides

The role wastewater reuse in agriculture plays in the transmission of amoebiasis and giardiasis is not well established. Other routes of transmission, e.g. poor domestic hygiene and contaminated drinking water, are probably more important in developing countries (Blumenthal et al., 1999). Some evidence indicate that there is a small risk of amoebic infection in those in contact with untreated wastewater, but not in those in contact with settled wastewater (Cifuentes, 1995). In total, there is insufficient evidence to support the establishment of a separate guideline for protozoa at present.

It has been assumed that if the helminth egg guideline is met, other 'easily settlable' pathogens such as protozoan cysts will be covered (WHO, 1989). Recent studies have shown that the removal of helminth eggs does not correlate with that of protozoan cysts (Stott et al., 1997). There is increasing concern about the implication of sewage in environmental transmission of emerging protozoan intestinal pathogens such as *Cryptosporidium* and *Giardia spp*.

There is also evidence that conventional wastewater treatment processes do not remove protozoan cysts effectively, with reported efficiencies varying from 26-100% (Bukhari et al., 1997). In addition, the infectious dose can (for *Giardia*) be as low as between 10 and 100 cysts, and (for *Cryptosporidium*) between 30 and 1000 cysts (Cooper and Olivieri, 1998).

The South African Guide (1978) does not contain nematode egg or protozoa criteria. Risks from protozoan parasites may be of more importance in industrialised countries than the risks from helminth infections, which are more important in developing countries (Blumenthal et al., 1999). This can be the driving force to include both in a future South African Guide.

3.2.4 Irrigation techniques

Irrigation techniques are generally included in wastewater reuse guides for two reasons:

- To maximise *crop safety* for consumers by controlling application rates, of potential pathogens that may have survived the treatment processes, to a minimum – especially where effluents are of a lesser quality.
- To reduce *human* (especially worker) *exposure* to irrigation wastewater.

If well managed, irrigation techniques can play a major part in ensuring both of the above without unnecessary strict microbiological effluent quality requirements.

3.2.4.1 Techniques for controlling the safety of crops irrigated by waste water

In general, health risks are greatest when spray / sprinkler irrigation is used, as this distribute contamination over the surface of crops (the opposite occurs with nematode eggs, which tend to be washed off during spray irrigation). Localised irrigation (drip, trickle and bubbler irrigation) can give the greatest degree of health protection by reducing the exposure of most edible crops to wastewater.

Various concurrent control measures can be applied in the irrigation process of ensuring crop safety for consumers. The following are examples, which could, when clearly stated, enhance the microbiological safety of irrigated food crops:

- Cessation of irrigation 1-2 weeks before harvest can allow die-off of bacteria and viruses to such an extent that the quality of irrigated crops improves to levels seen in crops irrigated with fresh water (Vaz da Costas Vargas et al., 1996). However, it is not practical in unregulated circumstances since farmers will e.g. probably not cease irrigation of leafy salad crops 5 days or more before harvest.
- Cessation of irrigation before harvest is more viable with fodder crops, which need not be harvested when fresh, and could enable the use of lower quality effluents (Blumenthal et al., 1999).
- Replacing partially treated wastewater with fresh water for a week or so before harvest, is not a reliable way of improving crop quality since re-contamination of the crops from the soil has been found to occur when, for instance, helminth eggs splash up from the soil onto crops during sprinkler irrigation (Vaz da Costas Vargas et al., 1996).
- Withholding dairy cattle and pigs from pastures and fodder irrigated with recycled water that contained more than 1000 FC per 100 mL (Anderson, 2001).

The South African Guide requires that salad crops should not be irrigated with treated effluent in any way whatsoever if the water is not of drinking water quality. This is unrealistic and not in line with international trends. Other food-related crops may be irrigated in such ways that the water does not touch the consumable part at all, which is a more realistic approach but still does not allow for salad crops to be irrigated with regular quality effluent as the WHO Health Guidelines (1989) do (e.g. effluent containing $\leq$1000 *E coli* per 100 mL). The irrigation technique and further management requirements are not clearly stated in the case of fruit irrigation.

For irrigation of areas used for recreation, the South African Guide (1978) provides for irrigation on the basis of user-contact. This implies that people must not be allowed into the area while being irrigated, with drying-off periods recommended after irrigation before people are allowed into the area. This is in line with provisions in the selected international guides.

3.2.4.2 Worker and other user exposure control during irrigation

The health risks when exposing nearby population groups to aerosols containing bacteria and viruses are, in general, the greatest when spray and sprinkler irrigation is used. This technique should be avoided where possible, and if used, stricter effluent standards should apply or access by people to the area should be restricted. Flood and furrow irrigation exposes field workers to the greatest risk, especially if earth moving is done by hand and without protection. Localised irrigation (drip, trickle and bubbler irrigation) can give the greatest degree of health protection by reducing the exposure of workers to the wastewater (Mara and Cairncross, 1989).

It appears as if the South African Guide (1978) aims only to protect the consumer public, as well as public and players in effluent-irrigated recreational areas, as no considerations are included for treatment- or farm workers. A future South African Guide should provide for the protection of workers in wastewater irrigation areas.

3.3 POLLUTED URBAN DISCHARGES AND AGRICULTURE

The quality of water discharged from diffuse sources in urban areas is often comparable to untreated wastewater, yet no regulation or guideline exists for the safe use of these waters in agriculture and aquaculture (Jagals, 1997). Furthermore, much wastewater in agriculture is indirectly used, that is, treated wastewater is disposed of into rivers and the contaminated river water is used for irrigation downstream from the discharge point.

International guidelines for the microbiological quality of irrigation water used on a particular crop do not exist (Westcot, 1997). The US Environmental Protection Agency (EPA) recommended in 1973 that the acceptable guideline for irrigation with natural surface water, including river water containing wastewater discharges, be set at 1000 FC / 100 mL. Blumenthal et al. (1999) cites Westcot, (1997), who reported that this standard has been adopted in some other countries as an irrigation water quality standard, for example, Chile in 1978. This standard is also consistent with the WHO (1989) Health Guidelines for unrestricted irrigation. The UN-FAO has recently recommended that the WHO (1989) Health Guidelines must be used as interim irrigation water standards, until more epidemiological information is available.

In South Africa, wastewater-contaminated surface waters can be used directly by farmers under licensed extraction, but do not come under the control of public health bodies. In such instances, crop restriction is not effective to control health risks posed by this indirect form of reuse.

A future review of the South African Guide should be extended to investigate and include criteria for the safe unrestricted irrigation of microbiologically polluted water such as untreated urban discharges.

3.4 SEWAGE SLUDGE

The South African Guide does not provide for permissible utilisation and disposal of sewage sludge. This is done in the guide to Permissible Utilisation and Disposal of Sewage Sludge (Water Research Commission, 1997). However, the latter guide does not deal with the health-related microbiological content of these sludges. Sludge from conventional treatment plants or WSP must be treated or disposed of carefully, as pathogens are concentrated there. Helminth eggs can survive and remain viable for nearly 12 months in these sludges (Hespanhol, 1997). In the South African context this issue should preferably be appropriately addressed in the Sludge Guide (WRC, 1997).

3.5 EFFLUENT USE IN AQUACULTURE

The South African Guide (1978) does not provide criteria for recycled water quality intended for use in aquaculture. A South African technical working group had started work on drafting guidelines under the auspices of the South African Bureau of Standards as far back as 1993. Recent enquiries failed to find any progress in this regard. It appears therefore that no such guidelines exist in South Africa.

Aquaculture in South Africa is growing rapidly, adding to the demand for recycled water. The future review of the South African Guide should investigate microbiological criteria for treated effluent use in aquaculture for possible inclusion.

3.5.1 Background and WHO Guidelines (cited from Blumenthal et al., 1999)

The growing South African demand is largely to culture fish in treated effluent. From literature it appears that interest in fish farming in most other areas in the world is based on culturing fish in wastewater-fed fishponds. This is mainly because of the cost-effective recovery of resources invested in wastewater treatment, e.g. through the use of effluent from waste stabilisation ponds, in fishponds.

Following a literature review on the survival of pathogens in and on fish by Strauss (1985), the WHO (1989) proposed *tentative* effluent guidelines for aquaculture:

- A tentative bacterial guideline was set at $\leq 10^3$ faecal coliforms per 100 mL (geometric mean) for fishpond water, which can be achieved by treating the wastewater feed water (effluent) to 10^3-10^4 FC / 100 mL. This was to prevent invasion of fish muscle by pathogens in order to protect consumers against the risk of bacterial infections.
- A helminth quality guideline was set at the absence of viable trematode eggs. This was to prevent the transmission of infections such as schistosomiasis, fasciolopsiasis and clonorchiasis.

3.5.2 Summary of evidence supporting the WHO (1989) tentative guidelines

The main evidence used to support the WHO (1989) Guide, was the level of invasion by pathogens of the muscle of fish, grown in wastewater-fed fishponds of different microbiological water qualities. Strauss (1985) concluded that:

- Invasion of fish muscle by bacteria is very likely to occur when the fish are grown in ponds containing >10^4 / 100 mL and >10^5 / 100 mL faecal coliforms and salmonellae respectively. The potential for muscle invasion increases with the duration of exposure of the fish to the contaminated water.
- Some evidence suggest that there is little accumulation of enteric organisms and pathogens on, or penetration into, edible fish tissue when the faecal coliform concentration in the fishpond water is <10^3 / 100 mL.
- Even at lower contamination levels, high pathogen concentrations may be present in the digestive tract and the intraperitoneal fluid of the fish.
- There were no epidemiological data on the health effects to populations consuming fish cultured in wastewater-fed fishponds.

3.5.3 Recent evidence on health risks

Results from studies (Blumenthal et al., 1991 / 92) showed that recreational and domestic contact with water from excreta-fed fishponds with a mean quality of 4 x 10^4 faecal coliforms / 100 mL causes an excess risk in exposed children under 5 years of age, but not in persons over 5 years of age. Consumption of fish from such ponds is a risk to persons living in areas with no ponds and with less exposure to contamination. In fish farms, or combined WSP/aquaculture systems, the risks from consumption of the fish and contact with the pond water are equivalent to the recreational contact mentioned above.

Related epidemiological studies indicated that exceeding the tentative WHO guideline level by 40 fold is problematic for vulnerable population groups (like young children in this situation), but does not invalidate the tentative guideline, which appears to be around the right level (fishpond water at FC <10^3 / 100 mL).

Many regulatory agencies do not specify microbiological standards for freshly caught fish, but specify standards for processed products, therefore ensuring adequate personal and institutional hygiene during transport, processing, marketing and treatment for conservation of raw, unprocessed products prior to sale (Strauss, 1985).

For the use of wastewater in aquaculture, it seems appropriate for guidelines to specify the:

- Water quality that is acceptable for aquaculture, taking into account the likely microbiological quality of the fish grown in such water.
- Likely health effects to consumers of the fish.
- Likely health effects to workers in contact with the fishpond water.

It is important to note that concentrations of bacteria in the digestive tract is always higher than that in the fish muscle, and there is therefore potential for cross-contamination of fish muscle during gutting and preparation of the fish.

Generally there appears to be sufficient evidence to suggest that the tentative faecal coliform guideline of ≤10^3 FC / 100 mL (WHO, 1989) for the fishpond water is the right order of magnitude, and insufficient data to warrant a reduction of this level to 10^2 FC / 100 mL or a relaxation to 10^4 FC / 100 mL.

The water quality should be monitored weekly if there are likely to be fluctuations in its quality. It would also be useful to consider adding a bacterial criterion for the quality of the wastewater (Standard Plate Count / 100 mL) and for the quality of fish (SPC / g).

Wastewater treatment is not enough. Attention should also be paid to protect aquaculture workers and populations living nearby the ponds from contact with the pond water, and to ensure that high standards of hygiene are maintained during fish handling and gutting. The use of health promotion programmes, by health services units to address such behaviour, needs further consideration.

The implications of guidelines at this level are that wastewater (or excreta / septage) needs to undergo some form of treatment before it can be used in fishponds. If the quality is >1000 FC / 100 mL, the retention time in the fishpond should be increased or a maturation pond could be added to the WSP.

All the trematode eggs settle out in the anaerobic and facultative ponds. Where effluent from conventional secondary treatment plants is used, the quality of the effluent may need to be improved by use of a polishing pond prior to the effluent being discharged into a fishpond.

3.6 Summary

The South African Guide (Appendix E) was reviewed against the recent trends in international water recycling discussions and concept guideline developments and the following comparisons, discussions and recommendations were made:

- International guides classify treated effluents based on a combination of *non-treatment* criteria such as purpose of reuse, water quality, irrigation techniques as well as worker and other group exposure to irrigation water. Treatment options are suggested as supplementary.
- The Australian example does not classify according to treatment. It uses application requirements with quality criteria thresholds and contact restriction instead.
- The proposed international guide by Blumenthal et al. (1999) suggests treatment options as supplementary. This guide uses reuse conditions which is similar to the application requirements of the Australian examples, with quality criteria thresholds, irrigation techniques and the exposed group.
- In the South African Guide, by contrast, wastewater treatment methods serve as the primary benchmark for classification of effluent. Non-treatment options such as crop types and irrigation restrictions, as well as microbiological effluent quality criteria (based on the numbers of *E coli* per 100 mL instead of faecal coliforms (Sections 3.2.3 and 4.2.1), are used to supplement the various treatment options.
- A future review of the South African Guide should be extended to investigate and include criteria for the safe unrestricted irrigation of microbiologically polluted water such as untreated urban discharges.
- The South African Guide does not provide for permissible utilisation and disposal of sewage sludge. This is however addressed in the guide to Permissible Utilisation and Disposal of Sewage Sludge (Water Research Commission, 1997). The latter guide, however, does not deal with the health-related microbiological content of these sludges and should preferably be addressed in the Sludge Guide.
- The future review of the South African Guide should be extended to investigate the microbiological criteria for treated effluent use in aquaculture.

Chapter 4

PROPOSED GUIDELINE DOCUMENT

The findings of the report were discussed at a technical level in a workshop, held in Pretoria on January 26; 2000, with knowledgeable persons engaged in the field of wastewater reuse. The recommendations proposed at the workshop are presented as follows:

4.1 GUIDELINE PHILOSOPHY

A new Guide should at all times reflect its true purpose, which is the protection of public health, while enabling the optimal use of treated effluents.

4.1.1 A Guide based on needs

A reviewed or new South African Guide should clearly reflect the needs of the components of our society the Guide aims to serve. Such a guide must provide a road map for decision making in order to address needs.

4.1.1.1 Community needs

There are definite needs for the use of treated effluents in the development of urban agriculture as well as other non-domestic purposes such as the irrigation of parks and sports fields. The needs include the following:

- Treated effluents are needed as a resource to produce edible consumer products. However, because of the risk involved, information about the quality, limitations and appropriate application of treated effluents, is paramount to protect public health and to gain and maintain wide acceptance of foodstuffs produced with treated effluents.
- Communities, as well as individuals, need information about the process of licensing in order to access and use treated effluents.

4.1.1.2 Environmental health practitioner needs

Officials such as environmental health practitioners that need to evaluate the circumstances related to licensing applications need an unambiguous Guide that would enable decision-making to ensure optimal use of this resource without compromising public health.

4.1.2 A Guide based on risk

The idea of guidelines based on "no excessive risk" (the epidemiological perspective) appears to be the most appropriate option. However, epidemiological data, as well as processes of obtaining such data over the short and even medium term in South Africa, are currently not readily available.

A new Guide should be designed in such a way that this option can be developed in future as the health sector develops capacity to gather data and synthesize appropriate epidemiological as well as risk assessment information. For the short term, the Guide should be so designed that other technological and scientific information could be used to ensure optimum use of treated effluents as a resource without compromising public health.

4.1.3 Extent of the Guide

The Guide should be aimed at recycling wastewater from predominantly domestic environments.

4.1.3.1 Faecally polluted surface waters used for agriculture

It was decided not to include the above issue in the Guide. Nevertheless, it was referred for intersectoral discussion for possible inclusion in future revisions of the volumes dealing with water quality in Agriculture, which are part of the South African Water Quality Guidelines.

4.1.3.2 Sludges

Health-related microbiological quality of sludges, generated in wastewater treatment facilities, is to be dealt with in the guide for Permissible Utilisation and Disposal of Sewage Sludge (WRC, 1997).

4.1.3.3 Pollution sources

The use of water from point and diffuse pollution sources, other than domestic treatment facility discharges, should become a function of catchment management programmes. The Guide should address the issue of applying integrated pollution control in areas where potential exists to use raw sewage in agriculture, as a means to minimise the cost of treating wastewater.

4.2 WATER QUALITY

The Guide should focus on health-related microbiological quality of treated effluents, as this is the most relevant public health issue related to domestic wastewater. The use of microbiological indicator organisms is supported.

4.2.1 Faecal coliform criteria

The use of *E coli* should be continued as this indicates definite faecal contamination of the effluents. Faecal coliforms should also be added, as these will provide a wider, more sensitive indication of faecal contamination. Use of the 1000 FC per 100 mL for unrestricted irrigation should be further investigated and discussed during the development of the new Guide.

4.2.2 Nematode criteria

The new Guide should include nematode criteria as recommended by Blumenthal et al. (1999). The Guide should be so designed that criteria for other parasites such as *Giardia* and *Cryptosporidium* spp. can be included in future, once suitable monitoring techniques become available, especially in areas with limited laboratory facilities.

4.2.3 Virus criteria

The recommendations of Blumenthal et al. (1999) that a 1000 FC per 100 mL are sufficient public health protection against the possible presence of viruses are provisionally accepted. This issue should be intensively investigated and discussed during the development of a new South African Guide.

4.2.4 Monitoring and compliance

Frequency of monitoring, as well as the level of exceedence (standard deviations etc.) of guideline criteria, appears to be a definite and urgent research need that should be addressed during the development of the new guide.

4.2.5 Physico-chemical criteria

The new Guide should make provision for future inclusion of, but preferably cross-referencing to, physico-chemical criteria in areas where site-specific conditions (e.g. presence of heavy metals in effluents in areas receiving heavy industrial effluent with domestic sewage) would require such control. It was felt that the very nature of treated domestic effluents would generally not warrant the inclusion of what could be a very costly and comprehensive set of criteria in the new Guide. It was further reasoned, that in such instances, it would be more effective to require on-site treatment of industrial effluents to remove chemicals prior to release into the sewerage system for final treatment at general wastewater treatment facilities.

4.3 TREATMENT CRITERIA

There was a strong feeling that treatment systems should remain a main focus of the new Guide and not only as options to be followed to achieve desired effluent quality.

Nevertheless, the group recognised the fact that the design capacity of many facilities in South Africa may currently be compromised - especially the components designed to ensure pathogen reduction. An effective system, properly maintained and operated, would generally ensure the desired quality of effluent without the need of constant effluent quality monitoring. This approach would be suitable for any effectively designed system – including waste stabilisation pond systems.

The following should be included in the new Guide to ensure that uncertainty of treatment process design criteria of any particular facility does not stall effective decision-making during licensing of effluent reuse:

- Applications should include proof that the design of the facility concerned is effective to produce effluent of the desired microbiological quality.
- Applications should include submissions on sustained and effective maintenance and operation of an approved facility to ensure continuous effluent of desired quality.

4.4 EFFLUENT CLASSIFICATION

Effluents need to be clearly classified as this forms the basis for decision making on water quality criteria, treatment criteria, crop restriction, as well as irrigation type requirements. The approach followed by Blumenthal et al. (1999) will form a suitable basis to which more effluent classes can be added, to provide for other uses such as aquaculture and non-agricultural activities including irrigation of recreation facilities and dust prevention.

4.5 IRRIGATION TYPES

The new Guide should make provision for modern agricultural practices such as hydroponic crop cultivation. Sub-surface drip irrigation is recommended as the safest form of crop irrigation and should be applied wherever possible. Irrigation should be so managed to minimise human exposure to the water – especially in densely populated areas where human exposure could be incidental and difficult to control.

4.6 CROP RESTRICTION

Crop restriction would be dictated by the quality of the effluent, the treatment system design as well as the irrigation type. Although the current Guide makes provision for this combination of factors, it is too restrictive in this regard and should be reviewed to allow for more optimal use of treated effluent.

4.7 SITE MANAGEMENT

It is foreseen that urban agriculture would often be practiced in or near densely populated areas. The new Guide should include site management criteria that would ensure, as far as possible, that the following practices are managed within the philosophy of protecting public health:

- Human exposure control – Contact with treated effluents by site workers as well as the public at large, should be kept to a minimum. Facilities must be provided for people to cleanse themselves after inevitable or accidental contact with the water.
- Final treatment of produce such as washing with clean water and cessation of irrigation, prior to harvesting, should be clearly described with issues such as crop restriction and irrigation.
- Licence conditions such as crop restrictions, irrigation types and water quality monitoring should be clearly stipulated in the conditions and should be strictly adhered to by responsible persons identified on the various sites.

Chapter 5

RECOMMENDATIONS AND CONCLUSIONS

5.1 RESEARCH NEEDS IDENTIFIED

Research is needed on the following issues before the new reviewed guide could be compiled:

- Frequency of effluent monitoring as well as the acceptable level of exceedence of guideline criteria – this will provide more data for effective risk assessment based on the quality of effluents.
- The acceptable levels of risk in South African communities posed by irrigation of food crops with treated wastewater - this will provide an additional measuring tool for risk assessment based on the quality of effluents.
- The need for - and inclusion of – virus, protozoa and especially nematode criteria in a reviewed Guide.
- Exposure and protection of workers in wastewater irrigation areas – although this had been done internationally, local circumstances and effects appear not to have been well researched.
- Effluents classification to facilitate decision making on water quality criteria, treatment criteria, and crop restriction as well as irrigation type requirements. The approach followed by Blumenthal et al. (1999) could form a suitable interim basis. However, from a South African perspective, more effluent classes could be needed as can already be seen from the current South African Guide.
- The impact that treated wastewater could make on modern agricultural practices such as hydroponic crop cultivation. The findings of these could well influence the drafting of a new guide.
- The inclusion of microbiological criteria for polluted urban surface run-off used in agriculture and aquaculture.
- The microbiological quality of sewage sludges.

5.2 RECOMMENDATIONS

The project steering committee as well as the technical working group expressed the urgency for a new South African Guide. It was beyond the scope of this project to write a new guide. It was envisaged that the review process of this project, as well as recommendations from the expert workshop discussed above, would give direction to the drafting, discussion and finalising of a new Guide. The technical outcomes, discussed in Chapter 4 above, could be converted into criteria to form specific guidelines for the optimal and safe reuse of treated effluents. It is proposed that such guidelines be included in a reviewed or new South African Guide.

The new South African Guide should be a blend of the 1) *no potential risk* approach (no detectable potential risk is accepted to those exposed to the recycled wastewater) for those areas and parts of the population where infection can be expected to be poorly tolerated and the 2) a*ttributable risk* approach where some risk but no *excess* risk of infection is allowed.

This could be a task of considerable proportions and should therefore be undertaken as an immediate follow-up project. The following role players are suggested:

- The Water Research Commission should be the lead agent in ensuring the follow-up.
- The national Department of Health as well as SALGA (South African Local Government Association) should facilitate the participation of environmental health service providers at local authority governance levels.
- The Department of Water Affairs and Forestry should continually be involved in this process as the principal of licensing water use (Article 21 of the National Water Act; Act 36 of 1998).

- A consultant group or syndicate research group should be appointed by the WRC to provide a draft (new) guideline document based on the blend approach suggested above. A *preliminary structure* for the draft is suggested below.
- To provide the detail of the various issues suggested below, the proposed new guide should be discussed with the various authorities mentioned above, as well as other interested and affected parties that may influence the use of treated wastewater. Consultations should be held in at least nine provincial centres throughout the country.

A preliminary structure (scope) for the new Guide, as suggested by Mara and Cairncross (1989), is proposed here:

- An overview of the history and benefits of wastewater reuse, together with some examples of existing practices in various parts of the world, and particularly in South Africa.
- An introduction to public health aspects of wastewater reuse, including the practical implications of recent epidemiological advances.
- Socio-cultural factors.
- Hygiene promotion could possibly be included in a component for health promotion in the new Guide that could be linked to existing health related services.
- Environmental protection and enhancement through treated wastewater reuse should be discussed.
- Comprehensive descriptions of feasible and appropriate control measures for public health protection – this component will essentially contain the criteria core of the new Guide.
- Non-treatment options should be so formulated that assessors of licence applications can use discretion in situations where treatment facilities are marginally compliant. Such discretion, however, should still be considered as part of an integrated approach to health and environmental protection.
- Institutional, legal and possibly financial aspects of project planning, licensing and implementation, indicating various steps necessary to ensure that treated effluents are used to maximum advantage in agriculture and aquaculture without endangering public health.

5.3 CONCLUSION

The aim of this project was achieved. It is evident from the report above that the current South African Guide for the Permissible Utilisation and Disposal of Treated Sewage Effluent (1978) is too prohibitive to encourage the optimum use of a valuable resource such as treated wastewater effluent for agricultural purposes. It is therefore not optimally applicable for the South African circumstances and should be reviewed as a matter of urgency

5.4 PAPER AND POSTER PRESENTATIONS

The following transfer actions were undertaken to expose this research on a wider scale:

- Paper presented: Jagals P and Steyn M. *Guidelines for the re-use of treated wastewater: public health protection or denial of essential resources?* International Association for Water Quality, April 1999. Specialist Conference on Waste Stabilisation Ponds, Marrakech Morocco.
- Poster presentation: Steyn M and Jagals P. *Guidelines for the re-use of treated wastewater: public health protection or prohibiting access to essential resources?* Water Institute of Southern Africa. May, 2000. 6th Biennial Conference, Sun City.

5.5 TECHNOLOGY TRANSFER AND APPLICATION OF THE CURRENT GUIDE

Indirect capacity building is already taking place through interaction of environmental health practitioners, knowledgeable persons involved in urban agriculture, as well as officials who apply the current South African Guide and who had, to date, not realised the intricacies surrounding treated wastewater application and public health.

The contents of the current Guide are difficult to transfer as knowledge or technology to communities, as the original format was aimed to provide guidance to officials involved in the licensing process. This research will greatly assist in the optimum interim application of the Guide in the Free State Province, as the complicate nature of the Guide is now clearly understood and this understanding transferred to officials and community members, who wishes to apply the current Guide.

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APPENDIX A

Guidelines for wastewater reuse in agriculture and aquaculture[a]: recommended revisions based on new research evidence (Blumenthal et al., 1999).

Category	Reuse conditions	Exposed group	Irrigation technique	Intestinal nematodes[b] (arithmetic mean no of eggs per litre[c])	Faecal coliforms (geometric mean no per 100 mL[d])	Wastewater treatment expected to achieve required microbiological quality
A	**Unrestricted irrigation** **A1** Vegetable and salad crops eaten uncooked, sports fields, public parks	Workers, consumers, public	Any	≤ 0.1[1]	≤ 1,000	Well designed series of waste stabilization ponds (WSP), sequential batch-fed wastewater storage and treatment reservoirs (WSTR) or equivalent treatment (e.g. conventional secondary treatment supplemented by either polishing ponds or filtration and disinfection)
	A2 Fruit trees[e]	Workers, consumers	Not spray / sprinkler	≤ 1	Not applicable	Retention in 2-3 WSP in series or WSTR depending on number of eggs in raw wastewater or equivalent treatment (e.g. conventional secondary treatment supplemented if necessary by either polishing ponds or filtration)
B	**Restricted irrigation** Cereal crops, industrial crops, fodder crops, pasture and trees	**B1** Workers (no children <15 years), nearby communities	(a) Spray / sprinkler	≤ 1	≤ 1,000	Retention in WSP series inc. one maturation pond or in sequential WSTR or equivalent treatment (e.g. conventional secondary treatment supplemented by either polishing ponds or filtration)
		B2 As B1	(b) Other	≤ 1	Not applicable	As for category A2
		B3 Workers including children	Any	≤ 0.1[e]	≤ 1,000	As for category A1
C	**Localised irrigation** of crops in Category B if exposure of workers and the public does not occur	None	Trickle, drip or bubbler	Not applicable	Not applicable	Pre-treatment as required by the irrigation technology, but not less than primary sedimentation.

[a] In specific cases, local epidemiological, socio-cultural and environmental factors should be taken into account and the guidelines modified accordingly.

[b] Ascaris and Trichuris species and hookworms.

[c] During the irrigation season (if the wastewater is treated in WSP or WSTR which have been designed to achieve these egg numbers, then routine effluent quality monitoring is not required).

[d] During the irrigation season (faecal coliform counts should preferably be done weekly, but at least monthly).

[e] Irrigation should cease two weeks before fruit is picked and no fruit should be picked off the ground.

[f] ≤ 1 egg per litre if (i) conditions are hot and dry and spray irrigation is used, or (ii) if wastewater treatment is supplemented with anti-helmintic chemotherapy campaigns in areas of wastewater re-use.

APPENDIX B

Linking recycled water applications and grades - examples for an international guideline based on draft Australian water recycling guidelines (Anderson, 2001).

GRADES					APPLICATIONS
Restricted D (1 star) FC<10,000	**Low contact C (2 star) FC<1,000**	**Medium contact B (3star) FC<100**	**High contact A (3'/2 star) FC<10**	**Open access A+ (4 star) FC<l**	
					Surface waters/impoundments
Not allowed	Not allowed	Water quality met post mixing	Allowed	Allowed	Surface water- protected water supply Primary contact recreation
Water quality met post mixing	Allowed	Allowed	Allowed	Allowed	Surface water - secondary water supply Secondary contact recreation
Allowed	Allowed	Allowed	Allowed	Allowed	Surface water - restricted access Ornamental water bodies
					Groundwater
Not allowed	Not allowed	Not allowed	Water quality met post mixing	Allowed	Groundwater potable aquifer Direct injection, retention >12 months
Not allowed	Water quality met post mixing	Allowed	Allowed	Allowed	Groundwater potable aquifer Percolation >3m and retention >12 months
					Non food crops
Allowed Withhold 4hrs	Allowed	Allowed	Allowed	Allowed	Silviculture, turf farms Fodder, fibre and seed crops
					Pasture animals and fodder
Not allowed	Not allowed	Allowed except pigs	Allowed	Allowed	Stock water
Not allowed	Allowed Withhold 5 days	Allowed	Allowed	Allowed	Pasture and fodder for dairy cattle and pigs
Not allowed	Allowed	Allowed	Allowed	Allowed	Pasture and fodder for beef cattle, sheep Dairy wash down water
					Food crops
Not Allowed	Not allowed	Not allowed	Allowed	Allowed	Foods eaten raw including salad vegetables and root crops, RW contacts edible portion
Not allowed	Allowed	Allowed	Allowed	Allowed	Foods cooked, processed, before eating Orchards - No RW contact on edible portion.
					Urban and residential
Not Allowed	Not allowed	Not allowed	Allowed	Allowed	Residential gardens, car washing, pavement washing, toilet flushing
Not allowed	Allowed Withhold 4 hours	Allowed	Allowed	Allowed	Sporting fields, golf courses, parklands, open space, landscaping, fire protection
					Commercial and industrial
Not allowed	Allowed	Allowed	Allowed	Allowed	Open systems, minimal aerosols
Not allowed	Allowed Withhold 4 hours	Allowed	Allowed	Allowed	Road making, soil compaction concrete mixing, dust suppression

APPENDIX C

Health guidelines for the use of Wastewater in Agriculture and Aquaculture (WHO, 1989)

Category	**Reuse conditions**	**Exposed group**	**Intestinal nematode** (arithmetic mean nr. eggs per litre)	**Faecal coliforms** (geometric mean nr. per 100 mL)	**Wastewater treatment expected to achieve the required microbiological guideline**
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 cereal crops, industrial crops, fodder crops, pasture and trees	Workers	≤ 1	No standard recommended	Retention in stabilization ponds for 8-10 days or equivalent helminth and faecal coliform removal
C	Localised irrigation of crops in Category B if exposure to workers and the public does not occur	None	Not applicable	Not applicable	Pre-treatment as required by irrigation technology, but not less than primary sedimentation

APPENDIX D

US-EPA/USAID Guidelines for agricultural reuse of wastewater (adapted from suggested guidelines for water reuse[1]) (US-EPA/USAID, 1992)

Types of Reuse	Treatment	Reclaimed Water Quality	Reclaimed Water Monitoring
Agricultural Reuse - Food crops not commercially processed Surface or spray irrigation of any food crop, including crops eaten raw	Secondary[2] Filtration Disinfection	≤ 10 mg/L BOD No detectable faecal coli/100 mL[3] 1 mg/L Cl_2 residual (min.)	BOD – weekly Coliform - daily Cl_2 residual - continuous
Agricultural Reuse - Food crops commercially processed Surface irrigation of orchards and vineyards	Secondary[2] Disinfection	≤ 30 mg/L BOD ≤ 30 mg/L SS ≤ 200 faecal coli/100 mL[4,5] 1 mg/L Cl2 residual (min.)	BOD - weekly SS - daily Coliform - daily Cl_2 residual - continuous
Agricultural Reuse - Non food crops Pasture for milking animals; fodder, fibre and seed crops	Secondary[2] Disinfection	≤ 30 mg/L BOD ≤ 30 mg/L SS ≤ 200 faecal coli/100 mL[4,5] 1 mg/L Cl_2 residual (min.)	BOD - weekly SS - daily Coliform - daily Cl_2 residual - continuous
Urban Reuse All types of landscape irrigation (e.g. golf courses, parks, cemeteries).	Secondary[2] Filtration Disinfection	≤10 mg/L BOD No detectable faecal coli/100 mL[3] 1 mg/L Cl_2 residual (min.)	BOD - weekly Coliform – daily Cl_2 residual - continuous

Footnotes:

1 These guidelines are based on water reclamation and reuse practices in the U.S., and they are especially directed at states that have not developed their own regulations or guidelines. While the guidelines should be useful in many areas outside the U.S., local conditions may limit the applicability of the guidelines in some countries.

2 Secondary treatment processes include activated sludge processes, trickling filters, rotating biological contractors, and many stabilization pond systems. Secondary treatment should produce effluent in which both the BOD and SS do not exceed 30mg/L.

3 The number of faecal coliform organisms should not exceed 14/100 mL in any sample.

4 The number of faecal coliform organisms should not exceed 800/100 mL in any sample.

5 Some stabilisation pond systems may be able to meet this coliform limit without disinfection.

Examples of microbial quality standards used by various States in USA (Cooper and Olivieri, 1998)

Exposure Route	Total coliforms per 100 mL		Faecal coliforms per 100 mL		Enteric viruses per 40L	
	n[a]	Range of Values	n	Range of Values	n	Range of Values
Spray Irrigation[b]	4	2.0-100	3	2.2-200	1	1e
Surface Irrigation[b]	2	100	9	10-1,000	0	-
Parks and Playgrounds[c]	8	2.2-100	3	10-100	1	125
Golf Courses and Open Space[d]	6	2.2-1,000	5	0-100	0	-

a Number of states involved out of the 13 selected.

b Includes food crop irrigation.

c Includes playgrounds.

d Includes cemeteries.

e Arizona is the only state that has a virus standard.

APPENDIX D (Continued)

Examples of microbial quality requirements suggested for use in Australia (from Anderson, 2001)

Grade	Description	FC/100 mL	Treatment
5 star	Potable		Advanced multi-barrier treatment processes effective against microbiological and chemical pollutants
A. 4 star	Open Access	< 1	Secondary + membrane filtration + disinfection Secondary + coagulation + filtration +disinfection
A. 3 ½ star	High Contact	< 10	Secondary + filtration + disinfection
B. 3 star	Medium Contact	< 100	Secondary + disinfection
C. 2 star	Low Contact	< 1,000	Secondary + disinfection Advanced Primary + filtration + disinfection (Jimenez 1998) Upflow anaerobic sludge blanket + disinfection (El Gohary 1998)
D. 1 star	Restricted	< 10,000	Secondary + maturation ponds Oxidation pond systems

Mexican Standard governing wastewater reuse in agriculture (Peasy et al., 1999)

Irrigation	FC/100 mL (MPN)	Helminth ova/litre
Restricted	1,000m – 2,000d	≤5
Unrestricted	1,000m – 2,000d	≤1

(m=monthly mean, d=daily mean, MPN=most probable number)

APPENDIX E

ref 11/2/5/3

May 30; 1978

GUIDE:

PERMITTED UTILISATION AND DISPOSAL OF TREATED SEWAGE EFFLUENT

<table>
<tr><th colspan="2">CLASSIFICATION OF TREATED EFFLUENTS (SEWAGE TREATMENT WORKS).</th></tr>
<tr>
<td>PS - PRIMARY & SECONDARY TREATMENT (HUMUS TANK EFFLUENT)
Conventional wastewater treatment according to recognised design criteria#. This includes grid treatment and primary settling followed by biological treatment for e.g. biofiltration or activated sludge process. Secondary treatment also includes settling or further clarifying after biological or alternative treatment methods.</td>
<td>OD - OXIDATION POND SYSTEM
Final effluent contains a maximum of 1000 E. coli /100 mL
The pond system should be designed according to a recognised standard# to be operated free of nuisances. The combined retention time of the primary pond and approximately four secondary ponds in the system should generally be at least 45 days. The system should drain into an irrigation reservoir of which the reservoir-capacity is at least 12 days during dry weather.
Except if there is enough space and the dams are built far enough from built-up areas this type of system is not recommended for communities larger than 5 000 people.
Each oxidation pond system, which cannot attain the abovementioned quality, would be considered for the purpose of this guide according to merit to be at the most, equivalent to PS.</td>
</tr>
<tr>
<td>PST -PRIMARY, SECONDARY AND TERTIARY TREATMENT.
Final effluent comply with the general standard*, with a slackening of the E coli count to 1,000 E coli / 100 mL
The above-mentioned system primary and secondary or equivalent treatment should have added on one or more types of tertiary treatment i.e. land treatment, maturation ponds, filtration, chlorination or another type of disinfection etc.</td>
<td rowspan="3">SEPTIC TANK EFFLUENT
(Primary settling and limited biological treatment)
This effluent must undergo further secondary, tertiary or equivalent treatment before it is reused for the purposes indicated in this guide.
For direct use or disposal of this water, only nuisance free land treatment or irrigation of fenced plantations is permitted according to merit.</td>
</tr>
<tr>
<td>STD - PRIMARY SECONDARY AND TERTIARY TREATMENT (compare with PST).
Final effluent comply with the general standard* thus 0 E. coli / 100 mL</td>
</tr>
<tr>
<td>SP - STD ADVANCED TREATMENT
Final effluent comply with at least the special standard* and the quality compare favourably with drinking water quality
Except for the abovementioned primary, secondary and tertiary treatment, this also includes advanced treatment with special physical and chemical treatment or other advanced techniques.</td>
</tr>
</table>

General & special standards: The quality requirements which is determined for treated effluent by the Department of Water Affairs - see regulation R.553 of the Extraordinary Government Gazette of 5 April 1962.

Design criteria: Design criteria taken from “Guidelines for the design of waste water treatment works” from the Institute of “Bestryding van Waterbesoedeling” (IBWB), branch of Southern Africa (March 1974).

Abovementioned classification of the types of treated effluent is followed in the tables below.

GUIDELINES FOR THE USE OF TREATED EFFLUENTS FOR THE USE OF IRRIGATION					
IRRIGATION OF	**PS- PRIMARY AND SECONDARY**	**PST- PRIMARY SECONDARY AND TERTIARY**	**STD- GENERAL STANDARD**	**SP STD – ADVANCED TREATMENT**	**OP- OXIDATION POND SYSTEM**
1 Vegetables and crops that are eaten raw by humans (3. Excluded) Lawns at swimming pools, children's play parks and crèche's	Not permitted	Not permitted	Not permitted	Any type of irrigation permitted	Not permitted
2 Crops for human use not eaten raw (i.e. fruits, vegetables and sugar cane)	Not permitted	Not permitted	Not permitted	Any type of irrigation permitted	Not permitted
Cultivation of cut-flowers (Also see 6)		Proper drainage and drying-off before harvesting is essential.	Any type of irrigation permitted		Proper drainage and drying-off before harvesting is essential
3 Fruit trees and vineyards for cultivation of fruit which is eaten raw by humans (See 2- Fruit not eaten raw)	Not permitted	Flood irrigation permitted Droplet and micro-irrigation permitted according to merit if fruit is not touched by the water Proper drainage and drying-off before harvesting of fruit. Fruit blown off by wind not suitable for human consumption	Any type of irrigation permitted	Any type of irrigation permitted	Flood-, droplet and micro-irrigation permitted according to merit if fruit is not touched by the water Proper drainage and drying-off before harvesting of fruit. Fruit blown off by wind not suitable for human consumption
4 Pasture for livestock: Dairy animals excluded (See 5)	Not permitted	Any type of irrigation permitted but not during grazing Grazing only permitted after proper drainage and drying - no pool forming. Not permitted as drinking water for animals	Any type of irrigation permitted Permitted as drinking water for animals	Any type of irrigation permitted Permitted as drinking water for animals	Any type of irrigation permitted but not during grazing Grazing permitted only after proper drainage and drying - No pool forming Not permitted as drinking water for animals
5 Pasture for dairy animals (Definition of milk see article 1(xv) of the Health act, 1977 (Act 63 of 1977)	Not permitted	Not permitted	Any type of irrigation permitted Permitted as drinking water for animals.	Any type of irrigation permitted Permitted as drinking water for animals.	Not permitted

IRRIGATION OF	PS- PRIMARY AND SECONDARY	PST- PRIMARY SECONDARY AND TERTIARY	STD- GENERAL STANDARD	SP STD – ADVANCED TREATMENT	OP- OXIDATION POND SYSTEM
6 Crops not used for grazing but as dry feed Crops cultivated only for use as seeds Tree plantations Nursery - Cut-flowers excluded (See 2) Any park or sports fields only during development as well as before opening the allowing activities.	Any type of irrigation permitted according to merit No over-irrigation or pool forming No odour nuisance. Must be properly fenced No public permitted No meat-, or dairy animals or any poultry permitted.	Any type of irrigation permitted (also see 4 & 5)	Any type of irrigation permitted	Any type of irrigation permitted	Any type of irrigation permitted according to merit (also see 4 & 5)
7 Parks and sports fields (See 6) Lawns at swimming pools excluded (See 1) 7.1 Parks: only for embellishment of flower gardens, traffic islands et cetera. Viz. Not recreational areas	Only flood irrigation permitted No sprinkler irrigation permitted No public during irrigation	Flood irrigation permitted Sprinkler irrigation permitted according to merit No public during irrigation	Any type of irrigation permitted No public during irrigation	Any type of irrigation permitted	Flood irrigation permitted Sprinkler irrigation permitted according to merit No public during irrigation
7.2 Sports Fields: where limited contact is made with the field, e.g. golf-, cricket-, hockey-, soccer fields, et cetera.	Not permitted	Any type of irrigation permitted No over-irrigation or pool forming No public or players during irrigation Public and/ or players only permitted after proper drainage and drying-off	Any type of irrigation permitted No over-irrigation or pool forming No public or players during irrigation	Any type of irrigation permitted No public or players during irrigation.	Flood irrigation permitted Sprinkler irrigation permitted according to merit No over-irrigation or pool forming No public or players during irrigation Public and/or players permitted after proper drainage and drying-off.
7.3 Sports Fields: Where frequent contact with the field is made i.e. rugby fields, athletic track, etc. School grounds Public parks - special children playgrounds excluded (see 1)	Not permitted	Flood irrigation permitted Sprinkler irrigation permitted according to merit No over-irrigation and no pool forming No public or players during irrigation Public and/or players only permitted after proper drainage and drying-off	Any type of irrigation permitted No over-irrigation and no pool forming No public or players during irrigation Public and/or players only permitted after proper drainage and drying	Any type of irrigation permitted	Only flood irrigation permitted Sprinkler irrigation not permitted No over-irrigation and no pool forming No public or players during irrigation Public and or players only permitted after proper drainage and drying-off

IRRIGATION – GENERAL REMARKS AND PRECAUTIONARY MEASURES	
In order to prevent that the irrigation system becomes a nuisance with time, proof must be given that the type of the soil at ground level, the size of the soil surface and the type of crop concerned is adequate for irrigation with the proposed quantity and quality effluent. The effluent flow-pipe must differ conspicuously from drinking water pipes in colour, type of material and construction. This is to prevent pipes from being accidentally crossed connected. The taps, valves and nozzles of the irrigation system must be so designed that only authorised persons may open it or put into operation. This is to prevent that people accidentally drink the water or wash in it Each water point, where uninformed people could accidentally drink the water, must be provided of distinct legible notices in Afrikaans, English and the applicable black languages, which indicate that the water is potentially dangerous to drink.	The expression "after proper drainage and drying-off", in the table above, implies that the action involved can only be undertaken when there are no pools or effluent droplets visible on the particular irrigation area. All possible precautionary measures must be taken to ensure that the irrigation water does not pollute any water source, above or under the ground, especially where the irrigation water does not comply with the general standard. Over-irrigation must be avoided and the irrigation area must be protected against storm water by suitable contour and protective walls. Sprinkler irrigation is permitted only if no spray is blown to areas where such irrigation is not permitted. The quality of the irrigation effluent, the use of such other area as well as the distance between the area to be irrigated and the other area, must be taken into account before sprinkler irrigation is permitted

GUIDELINES FOR OTHER USES OF TREATED EFFLUENTS					
OTHER USES OF EFFLUENTS	**PS- PRIMARY AND SECONDARY**	**PST- PRIMARY SECONDARY AND TERTIARY**	**STD- GENERAL STANDARD**	**SP STD – ADVANCED TREATMENT**	**OP- OXIDATION POND SYSTEM**
1 Industrial - and diverse uses not mentioned in guide	Only permitted in exceptional cases according to merit	Every event will be assessed according to merit. The emphasis will be placed on the E. coli count. In general the effluent must be free from parasite eggs, pathogens, toxic substances et cetera.			Only Permitted in exceptional cases according to merit
2 Food industries (Also cooling water)	Not Permitted	Not Permitted	Not Permitted	Not Permitted	Not Permitted
3 Mines and industries: ore dressing, dust control, et cetera	Only permitted in exceptional cases according to merit	Permitted according to merit provided that human contact is excluded	Permitted	Permitted	Only Permitted in exceptional cases according to merit
		All taps and water points of the effluent distribution system, must be supplied with distinct legible notices in Afrikaans, English and the applicable black languages which indicate that the water is not appropriate for human consumption			
4 Washing purposes for humans	Not Permitted	Not Permitted	Not Permitted	Permitted according to merit Distinct legible notices must indicate that the water is not appropriate for human consumption or food preparation.	Not Permitted
5 Flush toilets	Not Permitted	Permitted according to merit. In order to prevent the use of effluents for illegal purposes, no other taps may be installed on the effluent flow-pipe system.		Permitted	Not Permitted
6 Dust control on roads	Not Permitted	Over - irrigation and pool forming must be prevented. No surface or ground water may be contaminated. No odour nuisance may occur. Direct human contact with spray must be avoided as far as possible. No effluent may be used directly or indirectly for household purposes. Containers used for the transportation of effluents may only be used for household water after proper cleaning and disinfection.			Not Permitted
GENERAL REMARKS					
It is compulsory that for each of the above mentioned uses, the necessary precautionary measures needed to prevent that treated effluent is used for drinking- or house hold purposes are made. Besides this it is also compulsory that the materials and/or the colour of the effluent flow pipes must be so that accidental cross-connection with drinking water pipes will be prevented. Also see b) under the heading "Irrigation- general remarks and precautionary measures"					

METHODS FOR THE MANAGEMENT AND DISPOSAL OF TREATED EFFLUENTS					
METHODS FOR THE DISPOSAL OF TREATED EFFLUENTS	**PS- PRIMARY AND SECONDARY**	**PST- PRIMARY SECONDARY AND TERTIARY**	**STD- GENERAL STANDARD**	**SP-STD – ADVANCED TREATMENT**	**OP- OXIDATION POND SYSTEM**
1. Disposal in rivers and watercourses (estuaries, dams and lagoons excluded)	Not Permitted	Permitted according to merit and with taking into account local circumstances for e.g. dilution factor in river, rainfall The permissibility of discharging must be determined with taking into account the use of the river water downstream. The discharge point must be determined with taking into account the water abstraction point for domestic purposes downstream. The effluent must contain no harmful substances in health threatening concentrations	Permitted on condition that the effluent contains no harmful substances in health threatening concentrations	Permitted	Not Permitted
2. Discharge in river estuary, dam, lake, lagoon or another water body. (Sea is excluded - see 3)	Not permitted	Permitted according to merit if there is reasonable assurance that the quality and volume is such that it would not pose to be a nuisance or a threat to health The water may not, after mixing with the effluent, be less useable for household or recreational purposes The effluent must contain no harmful substances in health threatening concentrations	Permitted on condition that the effluent contains no harmful substances in health threatening concentrations	Permitted	Not Permitted
3. Discharging at sea	Only Permitted outside wave zone The discharge point must be determined with taking into account the quality and volume of the effluent, the sea currents, the diffusion and dilution of the effluent and the proximity of the present and future bathing areas.		Permitted Discharge in the wave zone must be determined in compliance with the proximity of present and future bathing areas and the effect on the quality of the seawater in such areas.	Permitted	Permitted according to merit as for PS and PST
	No coastal area may be polluted with potential health hazardous substances or any other hazardous substances in effluents The disposal of effluents must not pose any nuisances as well as have any effect on the marine life that could directly or indirectly affect humans negatively				
In most cases the influence of the above mentioned disposals is not readily predictable. It will usually be required that the necessary investigation be carried out to determine such influence with reasonable certainty.					

GENERAL REQUIREMENTS AND PRECAUTIONARY MEASURES	
The wastewater treatment facility must be efficiently operated at all times by adequately qualified personnel and must, as far as is reasonably possible, not be overloaded. The institution or person in control of the treatment facility must ensure that the quality of the final effluent complies with these guidelines at all times. Regular control assessments must be done at least once every three months on representative samples of the final effluent and records must be kept on such findings. The person or institution in control of the treatment facility must see to it that the quality of the final effluent and the use there-of comply with these guidelines. This also implies another person or institution using this effluent. The supply and use of the effluent must be stopped if these guidelines are not complied to.	A person or institution which uses treated wastewater for a purpose described in this guide, but who do not treat such wastewater themselves, must note that only practices permitted by these guideline's are maintained. The use of such water must immediately be stopped if any deviations from these guidelines are suspected. The compliance with these guidelines for the use of treated wastewater effluent, are the individual and collective responsibility of the supplier as well as the user of the final effluent. In the case of a use described as "permitted according to merit", it is necessary that the use and specific methods of use must be thoroughly motivated as well as investigated. In most such cases more stringent supervision and control will be required from the system as well as effluent quality, in order to prevent the nuisances and health hazards.