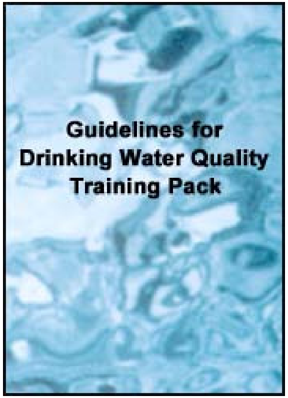


Guidelines for Drinking Water Quality - Training Pack (WHO)

Legislative Frameworks

Session Objectives

- **To highlight the need for a clear and comprehensive legislative framework for the water sector as a means of promoting its effective functioning.**

- **To describe the mechanisms for establishing legislation and outline the basic content of water sector legislation.**

- **To stress the need to view surveillance and quality control of water supply in a broader context and recognise the value of such**

programmes beyond simple compliance monitoring.

- **To emphasise the risks of over-reliance on legalistic approaches to water quality and to promote greater openness regarding water quality information.**

Introduction

A comprehensive and effective legislative framework is essential for the smooth operation of the water sector and for it to meet its goal of providing an adequate water supply. The key principle that should underlie the legislative structure of the drinking-water sector should be to protect and improve public health through the sustainable provision of drinking-water of adequate quality in sufficient quantities to all the population continually at a price which is affordable.

Water sector legislation is likely to be a collection of acts, codes of practice and regulations under a general water law which as a whole govern the functioning of the sector. It is unlikely that a single document would cover all aspects referred to within this paper and indeed this would not be advisable as it would make the legislation unwieldy and difficult to update. Legislation should be flexible and dynamic and respond to developments within the sector rapidly and coherently.

Within the legislative framework which governs the sector, some key areas

must be addressed to provide the sector with the structure it requires to function efficiently and effectively. It is essential that the institutions undertaking different functions within the sector - supply, resource management and surveillance - are clearly identified. For each institution, the roles, responsibility and remit must clearly stated and the type and level of interaction between each body must apparent.

Legislation is a tool to incorporate water policy within the national political-legal framework and should aim to protect both individual and communal water rights issues. Water quality is therefore only one aspect of water legislation which should cover aspects such as quantity of water supplied, access assurances, continuity provisions and limits set on costs charged to consumers. The legislation will empower the surveillance bodies, both financial and health-based, to closely monitor the water supplier to ensure that they met statutory functions which guarantee the supply of wholesome drinking-water.

However, it is also important to keep legislation within perspective and not allow an overly-legalistic approach to be developed towards water quality and supply. For instance, it is clear that surveillance of drinking-water supply has a value independent of legislation or enforcement of compliance. As it should be an activity primarily designed to identify risks, the primary concern should be to influence management decision making to reduce risks to public health.

The lack of provision in the legislation or lack of will to prosecute water suppliers for noncompliance should never be used as a pretext for abandoning surveillance activities. Some authors have suggested that surveillance is pointless without the political will to enforce legislation. Such an approach fails to recognise the wider role of surveillance and the link to improved decision making. It is vital that legislation is seen as a tool which facilitates water supply improvement and not as an end in itself.

Establishing legislation

It is common to find that much of the water legislation in a country has historically been incorporated within other acts and elements of legislation, such as Public Health Acts or Natural Resources Acs. Whilst these may address water, it is limited to specific impacts and fails to provide a comprehensive framework for the sector. It is therefore desirable that all water legislation be brought under an umbrella Water Act which has an array of associated addenda, regulations and codes of practice.

A complicating factor in establishing water legislation will be the current level of water supply coverage and the plans for extending coverage of the total population with access to an adequate water supply. In particular, the legislative framework should take into account that a significant proportion of water supplies may be community managed and operated whilst others may rely on a water supply agency. Furthermore, in many countries there may be a mix of piped water supply with a high level (in-house) of service

and communal point source or shared tap water supplies.

The standards which cover these different types of supply must be carefully considered - for instance to insist on the same standards of supply from a community-managed hand-dug well and a sophisticated treated and piped water supply based on tariff collection is unlikely to be feasible. Furthermore where the community is the water supplier, the implications for legislation are very different from situations where a revenue-generating agency operates a water supply.

It is therefore essential that national water legislation recognises the variation in water supply types and establishes a range of regulations and codes of practice which can be used as a flexible method of promoting water supply quality. In these circumstances, therefore, although the same legislation will cover all water supplies, the standards set for each type of supply will be different.

Key elements of legislation

Policy statement

The legislation must clearly outline the policy principles which underlie the development of comprehensive water laws which govern the sector and also gives clear indications to the long-term goal for the sector. Thus, the principle of equitable access to water sources and supplies for the whole

population and establishment of guiding principles for the levels of service and quality of services provided should be outlined.

The policy statement should also clearly highlight source protection, minimum treatment requirements and water supply monitoring that is expected from the different institutions. The policy statement should also clearly state the different but complementary roles of the supplier and the surveillance agencies. It should be made clear that independent, health-based surveillance is essential and entails the routine monitoring of suppliers performance with respect to nationally and regionally accepted norms of practice.

The policy statement should also clearly state the underlying health related rationale for water supply in the country and the primacy of drinking-water supply in use of water resources. This should also clearly state the need for source protection and distribution maintenance as well as outlining the need for minimum treatment requirements for water supplies of all types.

Institutional roles

The different institutions, their remit and responsibility should be clearly defined within the legislative framework. Failure to provide this will lead to long-term problems within the sector from overlapping responsibilities, duplication of effort, unclear reporting lines and difficulties in enforcement.

By preference, the number of institutions active within the sector should be limited and not allowed to become overly complex. The actual responsibility of suppliers and surveillance agencies must be very precisely defined and the interaction between the two and the process of dialogue, direction and enforcement transparent. It is important that the need for an ongoing and effective inter-agency dialogue and co-operation is essential for the effective functioning of the sector. The legislation should provide the framework for dialogue and cooperation by establishing minimum acceptable procedures in terms of information sharing and action. However, the legislation should also try to encourage greater dialogue than merely the basic minimum.

For further information on the institutional framework of the sector, please refer to the session on Institutional Frameworks and to Volume 3 of the GDWQ.

Service levels

Service levels in this context are taken to mean the parameters such as quantity, continuity and accessibility of the water supply to the user community. These issues are as important was water quality aspects of water sector legislation and must be included within a policy statement or reference within the legislation.

Service levels will have to be addressed at several levels and may therefore be referenced at various points in the legislation. For instance, at a national

level, service should be addressed through the statement of position regarding the basic right of all the inhabitants to have access a water supply of sufficient quality and quantity to meet all their needs. In the first instance this may only be included as the goal of the sector within the legislation, but it should act as the fundamental basis for water sector legislation.

Within the areas supplied by water supply companies, the minimum acceptable and optimal quantities of water to be supplies should be outlined as well as the continuity of supply and the coverage of supply. This is essential if suppliers are to be governed by a framework which allows to function effectively and efficiently.

Where water supplies are community managed, the legislation should provide a framework for the acceptable population using point water supplies or communal facilities and the maximum acceptable distances to water supplies allowable. The latter may not refer to the entire population of a community but, for instance, the 90 or 95 percentile in dispersed communities. This legislation is essential if NGOs and Government agencies are active within community water supply in the country.

Source protection, sanitary norms and minimum treatment requirements

The details of source protection measures expected at different types of water supply and dealing with immediate source surrounds and broader measures should be clearly outlined in standards and regulations. Thus

information regarding sanitary completion of wells, boreholes and springs, land-use control within the immediate vicinity of the water source and within the broader recharge area should be included within the legislation governing water supplies.

The information should include the details of standard designs of point source water supplies and the acceptable sanitary norms to be enacted within the immediate vicinity of the source. This will include aspects such as the grouting of the upper levels boreholes, size and thickness of aprons and headwalls, pump fittings and fencing. For groundwater sources, the legislation should also reference the need the acceptable types of pumps (including make and model), acceptable pumping and lining materials in different conditions and training for operators in community based water supplies.

The need for broader protection measures of sources should also be covered and should include reference to groundwater protection policies and strategies at local and aquifer levels and the principles and broad categorisation of land-use zones surrounding groundwater and surface water sources given.

Minimum treatment requirements should be referenced and the requirements for different water sources clearly outlined. The importance of maintaining a free residual when chlorinating is practised should be emphasised. The need for maintenance of distribution systems should also

be referenced, particularly with regard to maintaining chlorine residuals and the frequency and use of sanitary inspection outlined. Again, training requirements should be outlined.

Liability

The question of liability with respect to water supplies may arise from a variety of scenarios, including an outbreak of water-related illness, insufficient supply or discontinuity of supply. Liability will be an issue when an agency or company provide water to tariff paying consumers. In these circumstances, water supply is acting in part as an economic good and as such, a certain level of service and quality of service should be expected by the consumers. In these circumstances, failure to meet acceptable levels of service or failures in water quality leading to outbreaks of disease should make the water supplier liable for prosecution from either the surveillance agency or consumer groups.

However, whilst the above can be seen as being an fair position with regard to liability, caution must be exercised when pursuing a liability-based approach to enforcement of water supply standards. In all circumstances, the emphasis on liability will tend to make water suppliers both more defensive in accepting blame for water supply failure, thus possibly leading to a reluctance to undertake remedial work that is required as this may be interpreted as an admission of guilt. Furthermore, in the cases of an infectious disease outbreak, it may become more difficult to identify sources

of contamination and routes of disease transmission as water suppliers become reluctant to cooperage fully with investigation teams. In many countries, where liability has been successfully pursued, a net result has actually been the reduction in availability of water supply quality data from suppliers who increasingly will only provide the minimum required.

Issues regarding liability should not arise when community water supplies are dealt with as in these circumstances, the consumers are also the operators and managers of the water supply. No attempt should be made in these circumstances to assign liability on a water supply basis. However, there may be a case of assigning liability to whichever Government agency responsible for extending water supply coverage within the country and where this agency fails to provide support to certain areas for non-justifiable reasons, appropriate action may be followed.

The surveillance agency also clearly has a responsibility to keep the users of water supplies informed about any deterioration in water quality or any events which may compromise health because of water supply problems. Failure to carry out these functions should make this agency liable, although again a common sense approach is required to judge whether failure to inform the public results from justifiable reasons (lack of resources, lack of available information etc.) rather than wilful dereliction of duty.

Liability is a difficult issues in the water sector and the degree to which the rules of liability apply will vary between countries. However, it must be

recognised that whilst liability may be a final solution for achieving action to improve water supplies - whether from an individual supply agency or Government Department responsible for water supply coverage - it is rarely the most effective way of achieving improvements.

Monitoring and surveillance aspects

The legislative framework should clearly outline the responsibility for monitoring and assessment procedures and activities to be undertaken by suppliers and surveillance agencies. The regulations and standards which support legislation should cover the numbers of samples both agency should take routinely, the numbers of samples to be taken for non-routine assessments (for instance during source selection, periodic quality assessment of sources etc.) and the numbers of samples to be taken in the event of suspected failure in water quality.

The analytical range to be covered in routine monitoring, non-routine assessment and in outbreak investigations should also be outlined in the regulations. The definition of the parameters is best left out of the legal instrument itself but should be included as an addendum or similar document which can be easily updated on a regular basis. In addition, the regulations should also clearly reference standard analytical methods acceptable for different circumstances and also the sampling techniques etc. to be employed.

Where community-based water supplies are the norm, there will be no need to establish supplier monitoring requirements, but surveillance agency responsibilities should still be outlined. The legislation covering surveillance of community based supplies should be less demanding than supplier operated supplies unless sufficient resources will be made available to the surveillance agency to conduct routine monitoring activities on a regular basis.

Where community based supplies are widely used, these are likely to involve many small water supplies scattered over a wide geographical area. Thus to expect a similar level of surveillance activity as in piped supplier operated water supplies. Furthermore, this would be likely to divert resources required for funding improvements of water supplies or supporting community based development.

In community based supplies, the surveillance agency should have a requirement to promote and conduct sanitary inspection and critical parameter water quality analysis and have a clear remit to conduct water use and hygiene education. Legislation should emphasise the need for management-linked monitoring aimed at building capacity and not data collection for its own sake.

Reporting requirements and data access

The inter-institutional reporting of monitoring and assessment data and the

public access to water supply quality information should also be clearly highlighted in the legislative framework of the sector. The requirements of suppliers to report water quality data both routinely and in the event of failure must be clearly stated. It must also be clearly stated to whom such reports must go to. The latter is particularly important in water quality failures as there may be other bodies (such as local health boards, national public health agency etc.) which require information in addition to the surveillance agency.

The feedback of information from the surveillance body to suppliers and communities is equally important and the requirements and procedures for doing this need to be at least referenced within the legislative framework, although the detail may be held within appropriate regulations.

Clear guidelines for reporting to the general public and general policies towards public access to water quality data should be outlined within the legislation. It is important that both surveillance agency and water suppliers function in a open and transparent manner which encourages public awareness. The general public, whether using supplier-operated or community-based water supplies, clearly have a right to water supply quality information in an comprehensible format. Thus, data should not presented in a form which is confusing to non-specialist readers as this will foster a belief that suppliers and surveillance agencies are hiding the true situation.

In addition to public access to water quality data, the legislation should outline or reference, issues regarding the access and use of raw data. In some countries, notably the USA, there is a strong belief in the right of access to raw data for the public to view and use. In many other countries, access to raw data is strictly controlled and very few people outside of the supply or surveillance agency can access or use such data and then only in certain ways set down in legislation. There are advantages and disadvantages to both approaches and the route followed is a national decision based, in part, on relevant national legislation on the freedom of information. It is, however, an important area to legislate for as a lack of a strong position may cause unnecessary confusion.

Water quality standards

Whilst it is usually preferable not to include the actual standards within the legal instrument, clear reference should be made to the process of establishing standards and make provision for regular updating of standards by the appropriate bodies. The approach of inclusion of standards within the legal instrument is often adopted as it is felt that this is the most effective way of ensuring that standards have a legal force. The problem with this approach is that it makes the process of standards revision time-consuming and unwieldy. This has implications for countries trying to progressively improve water quality through the use of interim standards and with respect to the increasing large and diverse range of pollutants found in drinking-water which are of health concern.

In less wealthy countries, where trying to achieve WHO Guideline levels of substances may not be feasible for some time and there is a need to progressively improve the water supply situation, an unwieldy legal framework may be counterproductive. As interim standards may be established which are progressively upgraded, the system for establishing these must be flexible. Equally, a rigid legal approach to standards may result in resources being used for inappropriate levels of compliance monitoring, rather than the use of monitoring to improve water supplies.

The increasing range and diversity of pollutants of health concern has implications for all countries, no matter what their level of socio-economic development. There are a great many substances, including many synthetic organics, which are now being found in drinking-water and whose impact on health is not conclusively proved. The acceptable limits for concentrations of these substances in water may change considerably as more information becomes available and therefore the legal instrument establishing these in the national legislation must be responsive to these likely changes.

A mechanism for overcoming these problems is to clearly refer to the process of standard setting, with the Minister responsible named and also clearly stated that this Minister will provide the national legislative body with the standards that their experts deem necessary for safeguarding the well-being of the population. Furthermore, it is important that standards are not set for substances for which no conclusive evidence exists of a risk to health. For these substances, guidelines are more appropriate and a research

programme initiated to quantify the level of risk posed.

Interim standards and exemptions

Within the legislative framework, clear provision should be made for the establishment of interim standards where these will be adopted in the short or medium term. However, if interim standards are to be set, there must be clear rationale established for the need and desirability for interim standards and some indication given for the final standards being aimed for. It is unwise to reference standards as interim unless clear indication is given of the final standard as this will in all likelihood lead to inertia in updating standards and to pressure from suppliers to maintain sub-optimal standards, even when higher standards could be achieved.

An alternative to interim standards is the use of exemptions from meeting certain standards. These may be of particular value when the failure is restricted to certain geographical areas or affect a relatively small proportion of the population.

Within the legislation, the process for establishing exemptions should be clearly outlined and time limits set for the duration of an exemption. The whole purpose of exemptions is to allow for short-term deviations from proscribed water quality limits which are permitted whilst remedial work is carried out on a water supply or source with the aim to meet national standards. Therefore, when an exemption is issued, it should be clearly

linked to a programme of work within a specified time which has clear aims and objectives. There is little point in issuing exemptions which are *de facto* permanent. In these cases it is more effective to establish either an interim national standard, establish a regional or supply type interim standard or establish tiered standards.

Exemptions should clearly relate to specific substances and should indicate the concentration of a particular substance which is being allowed and for what period. It should be clear that when an exemption is granted that this does not imply that the water quality is allowed to deteriorate beyond the stated limit of the exemption or for substances other than those indicated within the exemption. Thus, granting an exemption must not be interpreted as being a licence to provide poor quality water. It is merely a temporary relaxation of particular standards which is clearly linked to remedial action being carried out to meet the specified standard.

It is more effective to prepare a series of interim standards which are relevant to particular water supply types or geographical and which clearly link to a process of water supply improvement to meet microbiological standards within as short a time as is feasible.

The issuing of exemptions on microbiological grounds should be avoided for public health reasons and as this may establish a dangerous precedent on non-compliance with microbiological standards. If it is know that microbiological standards in some types of water supply or in particular

geographical regions cannot be met, it is more sustainable to establish interim or tiered standards rather than an exemption. If, for instance, a standard to set which cannot be met in a small community piped water supply and these are provided with an exemption, this may be seen as a precedent for large supplier-operated water systems to also apply for an exemption.

Conclusion

The legislative framework of the water sector is a vital component in improving and maintaining water supply quality within a country. However, it is only one of several tools which facilitate this and the limitations of legalistic and liability-based approaches to water supply improvements must be recognised.

Legislation should be flexible and comprehensive in its coverage of the water sector and it should be easy to update standards governing the sector. Due consideration should be given to the nature of water supply within the country and the implications this has for legislative framework. However, it is essential that any water laws clearly identify the goals of the water sector and provide it with a framework within which these are achievable.

The institutional framework of the sector should be incorporated within the legislation and the roles, responsibilities, remit and accountability of each institution clearly outlined. Failure to this is likely to result in considerable

overlap, duplication of effort and inefficient implementation of water policies.

Presentation Plan

Section	Key points	OHP
Introduction	• there is a great diversity of approaches to legislation world-wide	
	• a comprehensive and effective legislative framework is essential for sector	
	• legislation should be underpinned by the principle of protecting public health through the provision of drinking-water	
	• legislation is likely include a basic water law supported by a collection of codes, regulations and standards which outline institutional responsibilities, remit of agencies, sampling frequencies, information sharing etc.	
	• key aspects such as institutional responsibility and inter-institutional co-operation are key for the sector performance	
	• legislation incorporates the water policy within the political-legal framework of the country and should guarantee communal and individual water rights	
	• legislation should be kept in perspective and care must be taken not to develop an overly-legalistic approach to monitoring	

	• surveillance has a value independent of compliance monitoring and is an important tool to promote water supply improvement	
	• a lack of legislation or political will to enact legislation should not be used as a pretext for abandoning surveillance activities	
Establishing legislation	• historical legislation often included in other legislation (e.g. public health act)	
	• however, it is desirable to have an umbrella water act which governs the sector	
	• establishing legislation may be complicated by community managed schemes and mixture of supply service level	
	• standard and legislation covering different types of supply should be carefully considered and different conditions set for different types and levels of water supply	
Key elements of legislation	*policy statement*	**1**
	• legislation must clearly outline policy principles underlying the development of water laws - this includes equitable access to water supply and service indicators	
	• source protection, minimum treatment requirements and water supply monitoring should all be highlighted	
	• the need and role of independent, health-based surveillance	

	• the need and role of independent, health-based surveillance should be emphasised	
	institutional roles	
	• the institutions and their responsibilities and remit should be outlined in legislation	
	• the number of institutions active in the sector should be minimised to prevent overlap and duplication of effort	
	service levels	**2**
	• includes: quantity, continuity and accessibility	
	• these should be addressed at national, regional and local levels and the legislation should clearly outline the principle of the right of all the population to have access to an adequate water supply	
	• water suppliers should be required to meet minimum levels of services	
	• community-based approaches should highlight issues such as minimum acceptable distance to the supply and numbers of people per water point	
	source protection, sanitary norms and minimum treatment requirements	**3,4**
	• source protection requirements for all types of sources should	

	• source protection requirements for all types of sources should be included in legislation	
	• standard designs and acceptable sanitary norms around point sources should be clearly outlined in the legislation	
	• the need for broader protection measures should also be covered, including protection zones and land-use control	
	• minimum treatment requirements should be clearly outlined and the importance of maintaining disinfectant residuals emphasised	
	liability	
	• liability may result from a number of scenarios including disease outbreak, temporary interruption of supply or insufficient supply	
	• where a water supplier levy water charges, they will become liable for failure to meet proscribed service levels	
	• however, a liability approach alone will not necessarily lead to water supply improvement and may lead to a reduction in access to information	
	• liability should not be ascribed for community managed water supplies	
	monitoring and surveillance	**5**
	• monitoring and surveillance procedures should be clearly outlined	
	• these should include sampling frequency, numbers of samples	

	• these should include sampling frequency, numbers of samples, sample locations and analytical range for both supply and surveillance agencies	
	• for community-based supplies no supplier requirements need be set, but surveillance agency requirements should be established	
	• for community-based water supplies, greater emphasis should be placed on using monitoring to improve water supplies	
	reporting requirements and data access	
	• inter-institutional reporting and public access to water quality information are key aspects to be addressed by legislation	
	• this should include routine monitoring data, reporting when failures occur and to whom reports should be sent	
	• clear statement of principles concerning public access is required and where possible as much information as possible should be made available	
	water quality standards	**6**
	• don't include actual values of standards in legislation, but do clearly reference mechanism of establishing standards	
	• including values in legal instrument makes updating of legislation difficult and makes legislation unwieldy	
	• important for countries which adopt interim standards to be	

	able to update these progressively	
	• also important as many new pollutants recognised which must be covered by legislation	
	• possibly use an addendum or a regulation to cover actual values of standards	
	interim standards and exemptions	**7**
	• where interim standards used, these should be covered in legislative framework,	
	• make sure some reference is made to desired final standards	
	• also may use exemptions where problems with meeting standards is restricted to defined geographical areas or particular technologies	
	• exemptions should only be granted where a short-term deviation is to be permitted and should be allowed to become permanent	
	• exemptions should relate to specific substances and clearly indicate the substance and the concentration covered by the exemption	
	• exemptions should not be granted for microbiological quality - use interim standards instead	
Conclusion	• legislative framework of the water sector is a vital component	**8**
	• enforcement powers must be included in legislation and	

	enforcement powers must be included in legislation and penalties punitive if they are to be successful	
	• however, it is one of several tools to achieve this and over-reliance on legalistic approaches should be avoided	
	• legislation must be comprehensive but flexible to allow updating as required	
	• the institutional framework of the sector must be covered by legislation	

Major Elements of Drinking-water Legislation

- **Policy Statement**

- **Definition of agencies:**

  - functions
  - responsibilities
  - authority

- **Source protection, sanitary protection and minimum treatment requirements**

- **Service levels**

- **Monitoring surveillance**

- **Water quality standards**

- **Liability and compliance**

- **Interim standards and exemptions**

Service Levels

- **Minimum quantity of water to be supplied**
- **Continuity of water to be supplied**
- **Coverage by supplier within their area of operation**
- **Cost of water supplied**
- **Penalties required for failure to meet minimum service levels**

Source Protection

- **Statement of Principles:**

  - sustainable levels of use
  - precedence for use as drinking water
  - levels of protection required

- **Local scale:**

  - sanitary completion measures
  - abstraction permits

- **Regional scale:**

  - land-use planning
  - catchment protection
  - groundwater protection zones
  - management of water resources

Minimum Treatment Requirements

- **Must emphasis the multiple barrier principle**

- **Emphasise the need for all non-community operated piped water supplies to be chlorinated**

- **Must emphasise the need for adequate record keeping and information sharing**

Monitoring and Surveillance

- **Identify responsible agencies**

- **Identify acceptable monitoring frequency for all agencies**

- **Identify reporting mechanism for water quality data**

- **Identify accepted analytical and quality control procedures**

- **Describe process of compliance monitoring**

Water Quality Standards

- **These should not be recorded in the actual water act**
- **Separate legal instrument should be established to allow easy updating**
- **The basis of standards should be identified**
- **Priority given to microbiological standards**
- **Describe process for establishing and reviewing standards**

Interim Standards, Compliance and Exemptions

- **Interim standards may be required where quality is poor and resources scarce**
- **Better to establish interim standards that have standards which cannot be met**
- **When setting interim standards, set time limits on them and identify final standard**

- **Surveillance should assist in achieving standards**

- **Compliance monitoring sometimes required where there is wilful disregard to meet standards**

- **Exemptions may be granted where problems are limited by space and time**

- **Exemptions should be temporary and never set for microbiological standards**

Enforcement Powers

- **These should be defined in the water legislation establishing the surveillance agency**

- **Legislation should define the protocol or procedures to be followed when enforcement action is undertaken**

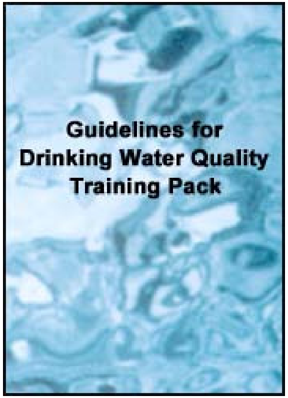
- **Legal penalties must be punitive to be credible and must be achievable in a court of law**

- **The establishment of legal enforcement powers requires that:**

    - legislation exists concerning water quality and pollution control

- the surveillance agency has specialist legal staff to advise on and initiate legal proceedings

Home"" """""> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw



Establishing National Drinking-Water Standards

Session Objectives

- **To describe the need to establish national water quality standards.**
- **To examine the role of the Guidelines as the basis for the development of national standards.**

- **To discuss the factors to be considered when setting national standards.**

- **To identify the process of national standards development.**

- **To identify priorities for national drinking-water quality standards.**

- **To discuss the establishment of national drinking-water quality standards in the context of legal frameworks.**

Introduction

The primary aim of setting national drinking-water standards is the protection of public health and thus the elimination, or reduction to a minimum, of constituents of water that are known to be hazardous to the health of the community. However, standards achieve nothing unless they can be implemented and enforced, and this requires relatively expensive facilities and expertise as well as the appropriate legislative framework.

As reflected in the title, the *Guidelines for Drinking-Water Quality* are intended to be used as a basis for the development of national standards by the appropriate authorities in Member States. It must be emphasised that the recommended guideline values are not mandatory limits. In order to define such limits, it is necessary to consider the guideline values in the context of local or national environmental, social, economic, and cultural

conditions.

The main reason for not promoting the adoption of international standards for drinking-water quality is the necessity of using a risk-benefit approach (qualitative or quantitative) to the establishment of national standards and regulations. This approach should lead to standards and regulations that can be readily implemented and enforced.

The establishment of drinking-water quality standards must follow a very careful process in which the health risk is considered alongside other factors, such as technical and economic feasibility. When establishing national standards, consideration must be given to the practical measures that will need to be taken with respect to finding new sources of water supply, instituting certain types of treatment, and providing for adequate surveillance and enforcement.

National standards will, of necessity be influenced by national priorities and economic factors such as lack of resources for water treatment or unavailability of alternative water supply sources. Such economic factors, conflicting national priorities, and varying local geographical, dietary and industrial conditions may lead to national standards that differ appreciably from the WHO Guideline Values (GV). The final judgement as to whether the benefit from adopting any of WHO recommended GV does or does not justify the risk is for each country to decide. However, considerations of policy and convenience must never be allowed to endanger public health.

The Standards Setting Process

Formulation of standards to protect health usually occurs in two stages, as follows:

(1) The scientific or risk assessment stage

The process for assessment of human health risks associated with exposure to microbial or chemical contaminants is multifaceted and incorporates some of all of the following steps:

- *Hazard identification* - Utilisation of all available data (epidemiological, animal-bioassay, *in vitro,* structure-activity relationship) to determine whether an agent can cause an adverse effect in humans;

- *Dose-response assessment* - Determination of the quantitative relationship between the dose and the incidence of adverse health effects;

- *Exposure assessment* - Estimation of the dose, or level of an agent to which various individuals, or populations are exposed;

- *Risk characterisation* - Estimation of the incidence and severity of the adverse effects that are liable to occur in a

population due to actual or predicted exposure.

At the conclusion of this stage it should be possible to define levels of pollutants that will not result in appreciable health risk in an exposed population.

(2) The political and administrative stage, or risk management stage

This second stage is situated in the socio-political and administrative arena and has to cater for a wide variety of sometimes conflicting interests. Risk management usually includes:

- *Determination of acceptable risk:* to view the problem not as a scientific issue, but rather one of opinion. The judgement of what is an acceptable risk is a matter in which society as a whole has a role to play;

- *Determination of public to be protected:* to consider not only healthy individuals, but also vulnerable population groups;

- *Choice of control technology:* to formulate a strategy and to select appropriate control techniques;

- *Legislation/standards:* to consider existing national legal framework and identify necessary legal strategies;

- *Economics:* to strike a balance between costs and benefits.

The *Guidelines* have dealt with the scientific stage in the hope that such international risk assessment would provide a sound scientific basis for the further development of national standards.

The risk management stage requires knowledge of the technical, social, financial, legal, and institutional implications of the standards to be adopted, and is more appropriately carried out by national or regional authorities. Those who are involved in setting standards know that at this stage compromises will be inevitable.

Priorities for setting drinking-water standards

(a) The first priority is to make sure that water is available to consumers, even if the quality is not entirely satisfactory. If there is a consideration to discontinue use of a contaminated water supply, there must be provisions made for instituting an alternative water supply.

(b) The second priority is to control the microbiological quality of the water supply. The consequences of contamination with pathogenic bacteria, viruses, protozoa and helminths are such that their control must always be of paramount importance.

(c) Toxic chemicals in drinking-water must also be controlled if we are to prevent long-term health effects from exposure to contaminants such as lead, arsenic or certain organic solvents.

(d) Finally, in assessing the quality of drinking-water, the consumer relies principally on the sense organs. Colour, taste, odour and appearance of the water, although not directly related to health, must be acceptable to the consumer. Some countries have elected to issue recommendations, rather than standards, for these aesthetic parameters.

Selection of contaminants for setting standards

There are generally insufficient resources available to deal with all the contaminants that may occur in drinking-water in a country, and it will be necessary to establish priorities. Figure 1 depicts a qualitative prioritisation scheme for setting drinking-water standards. Standards should be set at first for those contaminants that occur frequently and at significant concentrations in drinking-water and that have the greatest health impact. Microbiological contaminants belong to this category.

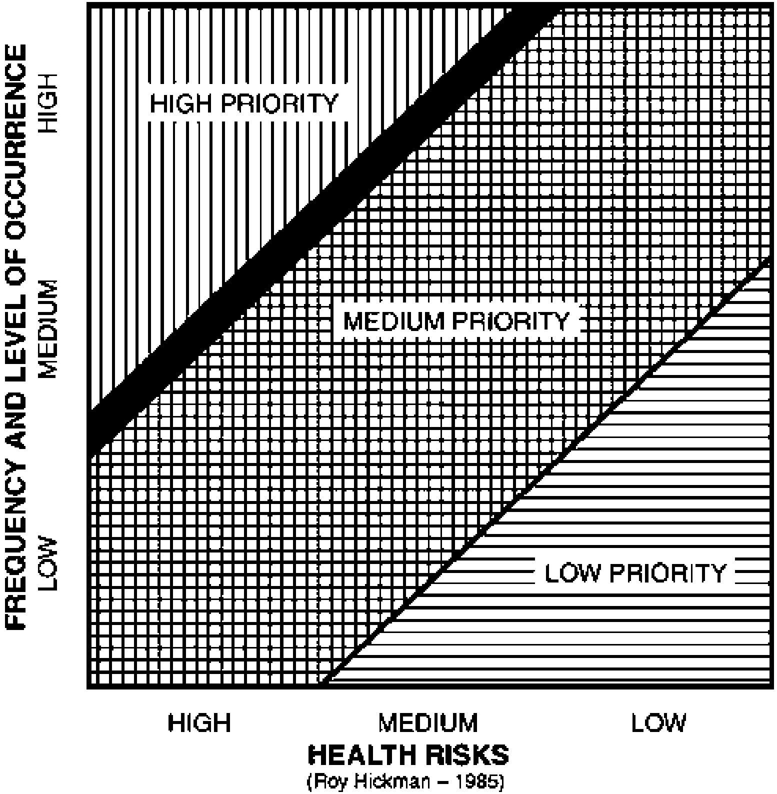


Figure 1: Priorities for setting standards

All chemicals are not of equal concern. Six criteria are usually applied in determining the priority chemical contaminants for which drinking-water

standards should be first established. These are:

- **Severity and frequency of observed or suspected adverse health effects. Of importance are substances that are carcinogenic, and substances which may cause reproductive and developmental effects.**

- **Extent of production and use.**

- **Ubiquity and abundance of the pollutant in water.**

- **Persistence in water. Contaminants that resist environmental degradation and accumulate in humans, or in water, deserve attention.**

- **Exposure from drinking-water relative to other sources such as air or food can be substantial.**

- **Population exposed. Attention should be paid to exposure involving a large proportion of the general population, and to selective exposures of highly vulnerable groups such as pregnant women, new-born children, the infirm or the elderly.**

Legal framework

The format and structure of standards incorporated in legal instruments vary from country to country. However, any regulation will generally contain the

following (WHO, 1987):

> **(a) A statement of the legal instrument, together with a definition of the applicable terms and concepts, specification of the responsible authority, and of the areas and substances to which the instrument will apply.**
>
> **(b) Mention of applicable documents, such as other standards, specification and regulations.**
>
> **(c) A detailed description of the requirements, including limits on pollutants, applicable tests, mandatory control methods, reporting requirements, etc. Where the requirements are to be implemented over a period of time, a timetable will be included.**
>
> **(d) A specific statement of the monitoring, reporting, and inspection systems; and**
>
> **(e) A statement describing applicable penalties for contraventions.**

The authority empowered to enact and enforce regulations varies from country to country. As regards drinking-water standards, the appropriate authority may be the Ministry of Health or the Environment.

Compliance with drinking-water quality standards

Once standards are established, it is essential to monitor drinking-water quality to assess compliance with the specified limits and regulations.

Both the water and health authorities are involved in monitoring, the health authority being responsible for ensuring that the legal requirements are met and compliance with standards is achieved.

Monitoring requirements should be appropriate to the needs of the country. They should not be too complicated and cumbersome as this may, from the onset, discourage their implementation.

Both the water and health authorities should have properly equipped laboratory facilities with trained and properly qualified personnel. The water authority is often required to provide event reports and periodic reports of water quality to health authorities, and sometimes to the public.

The water authority, as producer, and the health authority, as overseer, are both accountable for the quality of water supplies.

Conclusion

In developing national drinking-water standards, it will be necessary to take account of a variety of geographical, socio-economic, dietary, and other conditions affecting potential exposure. This may lead to national standards that differ appreciably from the guideline values.

The number of chemical contaminants for which guideline values are recommended is very large. It is unlikely that all of these chemical contaminants will occur in all water supplies or even in all countries. Care should therefore be taken in selecting substances for which national standards will be developed.

In developing national standards, care should be taken to ensure that scarce resources are not unnecessarily diverted to the development of standards and the monitoring of substances of relatively minor importance. Priorities must be established, and this should be done in direct relation to the potential adverse health effects and magnitude of exposure. For instance, in cases where drinking-water contributes little to the overall exposure, standards and other risk management strategies should be directed to media (e.g. air, food) which are important in contributing to total exposure.

The establishment of standards should take into account the possibilities for implementation in view of the socio-economic constraints facing a country.

In all countries, including the richest, choices must be made. The potential consequences of microbial contamination are such that microbiological standards must take precedence over standards for disinfectants and their by-products.

References

National Research Council (1983). Risk assessment in the Federal Government: Managing the process - National Academy Press. Washington, D.C.

World Health Organization (1987). Setting environmental standards - Guidelines for decision making. Geneva.

Presentation Plan

Section	Key Points	OHP
Introduction	• aim of setting national standards is to protect public health. Standards must be implemented and enforced through legislative framework	**1**
	• the WHO Guidelines are intended to be used as a basis for establishing national standards	
	• it is not considered appropriate to set international standards	
	• national standards must consider national priorities, economic factors, technical feasibility and health risk.	
	• these will vary between Member States	
The standard setting process	• this is done in two stages:	**2**

	1. scientific or risk assessment stage - 4 steps - largely dealt with by the *Guidelines*	
	2. political and administrative stage - 5 factors to be considered - to be carried out by national/regional authorities	
Priorities for setting drinking-water standards	• there are four priorities for standards:	**3,4**
	1. unrestricted availability of water to consumers	
	2. control of microbiological quality of water supply	
	3. control of toxic chemicals	
	4. aesthetic standard of water	
Selection of contaminants for setting standards	• resources are the limiting factor to deal with contaminants, therefore priorities need to be set based on frequency and concentration of occurrence and health risk. Microbiological contaminants are a priority	**5**
	• six criteria have been identified to prioritise chemical contaminants.	
	• when setting standards, need to establish costs of meeting standards, current water quality status and resources	

	available to meet national standards	
Legal framework	• format and structure of standards in legal instruments vary between countries but generally have 5 common components -	**6**
	1. statement of the legal instrument	
	2. mention of applicable documents	
	3. detailed description of the requirements	
	4. statement of the monitoring, reporting and inspection systems	
	5. statement of penalties for contraventions	
Compliance with drinking-water standards	• to ensure compliance with standards the quality of the drinking-water must be monitored by the appropriate bodies	**8**
	• monitoring regime must be appropriate to the country's needs	
	• monitoring requires adequate equipment and trained personnel	
Conclusion	• drinking-water quality standards may vary nationally due to differing conditions and may be appreciably different from guideline values	
	• GVs are recommended for a large number of chemical	

	contaminants and not all are applicable to every country	
	• countries must prioritise substances to develop national standards. These should take into account health risks and magnitude of exposure primarily, as well as resources to ensure implementation	

National Water Standards

- **Aim to protect public health**
- **Must be achievable and enforceable**
- **Should reflect national conditions and priorities**
- **Set for:**

  - quantity of water supplied
  - continuity of supply
  - coverage of the population
  - cost of water

Formulation of Standards

Scientific or Risk Assessment Stage

- **Hazard identification**

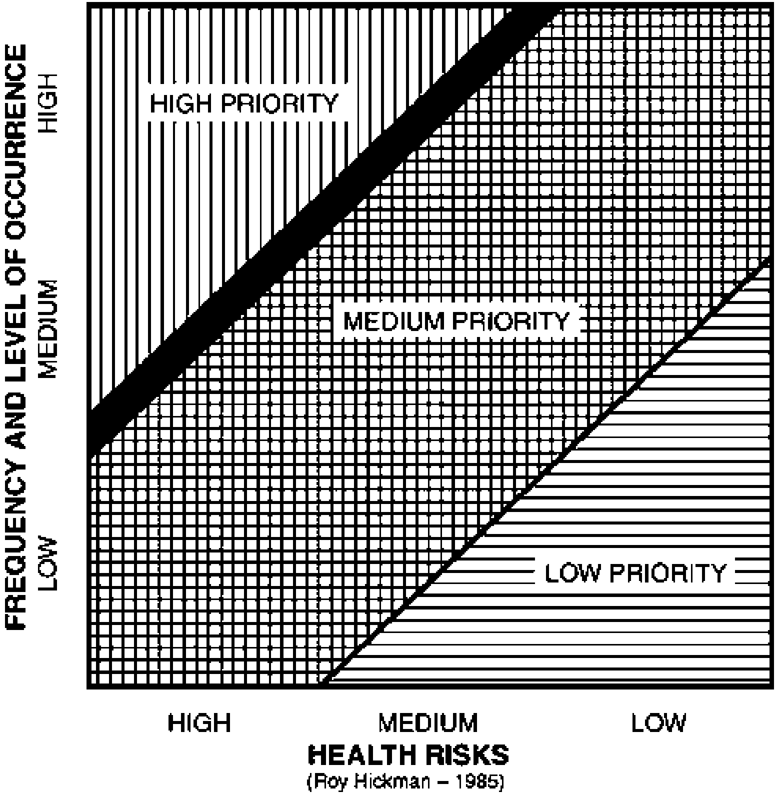
- **Dose-response assessment**
- **Exposure assessment**

Political/Administrative Stage of Risk Management Stage

- **Determination of acceptable risk**
- **Determination of public to be protected**
- **Choice of control technology**
- **Legislation/Standards**
- **Economics**

Four Priorities for Standards

- **Unrestricted availability of water to consumers**
- **Control of microbiological quality of water supply**
- **Control of toxic chemicals**
- **Aesthetic standard of water**



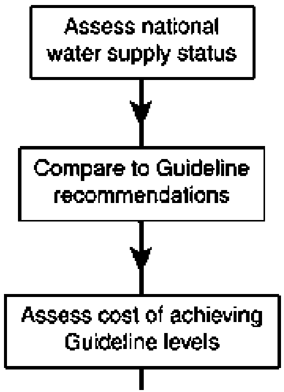
Priorities for Evaluation

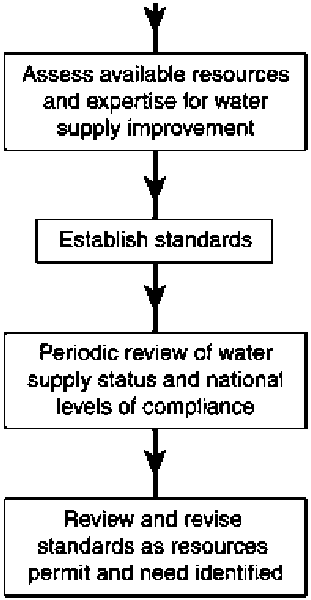
Selection Criteria for Setting Standards

- Severity and frequency of observed or suspected health effects
- Extent of production and use
- Ubiquity and abundance of pollutant in water
- Persistence in water
- Exposure from water relative to other sources
- Population exposed

Framework for Drinking-water Quality Standards

- Statement of legal instrument
- Mention of applicable documents
- Detailed description of requirements
- Statement of monitoring, reporting and inspection systems
- Statement of penalties for contravention





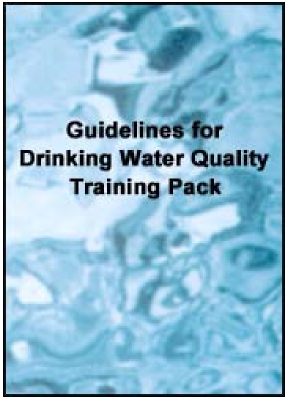
Standard Setting Process

Categories for FaecalColiform Densities

Category	Faecal coliforms/100ml	Health Risk
A	0	No risk
B	1-10	Little risk
C	11-50	Intermediate risk

D	>50	High risk

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw



Preface

Between 1993 and 1997, the World Health Organization (WHO) published the second edition of *Guidelines for Drinking-Water Quality* in three volumes: Volume 1: Recommendations (1993); Volume 2: Health Criteria and Other Supporting Information (1996); and Volume 3: Surveillance and Control of Community Supplies (1997). As with the first edition of the Guidelines, their development was organised and carried out jointly by WHO

headquarters and the WHO Regional Office for Europe.

This pack is intended to provide information for use in the planning and delivery of seminars, workshops and training courses in water quality surveillance, control and improvement, especially where these concern the WHO *Guidelines for Drinking-Water Quality*. The pack contains 23 different sessions, including both presentation and practical exercises.

It is hoped that the availability of this pack will encourage and assist local, national and regional authorities to implement events of this type with or without the assistance of expert institutions or individuals. It is hoped that the pack will facilitate the development of expertise and thereby promote the organisation of further events.

The pack is designed to cover a broad range of water-related topics in order that appropriate elements can be selected in response to local circumstances and priorities. The pack includes sessions addressing the scientific basis of the Guidelines; the establishment of national standards; the ways in which water supplies may be improved; and some broader issues such as human resource development.

Each section of the pack addresses a single session and includes the objectives, a session plan, a background paper and overhead transparencies. The materials are intended to provide a resource person with information to assist in the review of what they might reasonably expect to achieve in a

session, and to plan the structure and layout of the session. The background papers can, where appropriate, be provided to participants. The pack also addresses practical sessions. The materials provided to support these give guidance as to how such sessions could be delivered and the materials required to implement them.

It is unlikely that all sessions would be necessary for a single seminar, workshop or training course. It is therefore important that the overall objectives of an event are defined, taking local priorities into account when selecting which sessions will be of most practical use.

The sessions in the pack can be divided into a number of groups which could be of value when planning its use, defining the target audience and selecting sessions. The groups are described in the table over leaf.

In order to develop a well-balanced seminar, workshop or training course, at least one session would normally be required from each group. Discussion of drinking-water quality and the use of the *Guidelines for Drinking-Water Quality* should, for example, generally be accompanied by sessions considering monitoring and assessment and the means to secure improvements; and, possibly, a practical session illustrating issues of particular local relevance.

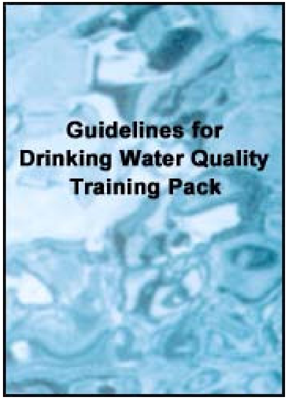
	Group	Session Title
1	Introduction	Water and public health:

		Water and public health; The WHO *Guidelines for Drinking-Water Quality.*
2	The Guidelines	Microbiological aspects; Disinfectants and disinfection by-products; Inorganic and aesthetic parameters; Organic chemicals; Pesticides in drinking-water.
3	Monitoring and assessment	Monitoring and assessment of microbiological activity; Monitoring and assessment of chemical quality; *Guidelines for Drinking-Water Quality* Volume 3.
4	Technical aspects	Source protection; Drinking-water treatment; Disinfection; Water treatment chemicals and construction materials.
5	Organisational aspects	Institutional frameworks; Legislative frameworks; Establishing national drinking-water standards; Human resources; Cost recovery.
6	Practical exercises	Microbiology; Disinfection; Sanitary inspection; Planning.

It is hoped that this pack will be a useful addition for those implementing training courses in water quality. The pack should assist in building capacities to provide and facilitate initial, further and ongoing training for staff of diverse disciplines. Any comments that users of the pack may have on experience with its use and which might assist in its further development would be gratefully received and should be addressed to:

Jamie Bartram
WHO
Water and Sanitation for Health Unit
1211 Geneva 27
Switzerland

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw



- **Disinfectants and Disinfection By-Products**
- **Inorganic Constituents and Aesthetic Parameters**
- **Organic Chemicals**
- **Pesticides in Drinking-Water**
- **Monitoring and Assessment of Microbiological Quality**
- **Monitoring and Assessment of Chemical Quality**
- **Guidelines for Drinking-Water Quality Volume 3**
- **Source Protection**
- **Water Treatment**
- **Disinfection**
- **Water Treatment Chemicals and Construction Materials**
- **Institutional Frameworks**
- **Legislative Frameworks**
- **Establishing National Drinking-Water Standards**
- **Human Resources**
- **Cost Recovery**
- **Microbiology (Practical Exercise)**
- **Disinfection (Practical Exercise)**
- **Sanitary Inspection (Practical Exercise)**

Planning (Practical Exercise)

Human Resources

Session Objectives

- **To describe the human resource requirements of monitoring programmes, whether quality control or surveillance, for all levels of staff.**

- **To highlight the need for a broad approach to human resources development, including career development structures, overall staffing and training.**

- **To emphasise the need for and value of ongoing investment in staff in terms of training, delegation of responsibility and encouragement to join professional bodies and undertake applied research.**

- **To briefly describe some key responsibilities of managerial, analytical, field and data management staff.**

Introduction

Monitoring programmes are reliant on good human resources to make them efficient and effective. The strength of any monitoring programme is

determined by the weakest element and this can often be identified as inadequate human resources. This may result from insufficient numbers of staff, but also from insufficiently trained and motivated staff who feel undervalued and do not perform their duties well. It is therefore essential that human resources development strategies are developed for the surveillance agency and quality control staff within water supply agencies to ensure that they have the capacity and capability to carry out the activities assigned to them.

Human resources development strategies are not merely training programmes, they encompass a wider view of staff development which acknowledges that access to career structures, interaction with peers and ongoing professional development are all of equal value. Furthermore, the human resources development strategy for an institution should also address the need for adequate numbers of staff at different grades and within different wings of the institution and the need to focus recruitment purely on the basis of job requirements. Therefore, all these elements should be covered by the human resources management team in the monitoring agencies.

Staffing requirements

Different countries will have different staffing requirements depending on the stage of development of monitoring programmes, the institutional framework of the water sector and the availability of qualified and trained

personnel. However, appropriately qualified and trained staff will be required both in the surveillance agency and the quality control wing of the water supply agency.

Staff in both agencies will fall into four broad categories: managerial staff; analytical staff; field staff; and, data processors/managers. However, it should be recognised that this classification is very broad and that clearly there will be many instances when individuals play more than one role. For instance, it may be common to find that field staff also undertake analytical work, or that managerial staff or analytical staff undertake a significant amount of information management. Thus the descriptions provided below of key tasks relate to generic needs of the position rather than to the specific tasks undertaken by individuals.

Managerial staff

Managerial staff are responsible for the overall planning, operation and monitoring of the programme. They take responsibility for strategic developments in the programme, reorientation to meet new or changing objectives and for the overall staffing and human resources development of the programme. Managerial staff will certainly include the overall programme or section manager and head of the laboratory/analytical services and possibly other staff such as the head of the information management unit. However, the programme manager and head of analytical services are possibly the two key members of staff and are discussed in

more detail below.

Programme manager

The role of programme managers in both supply agency and surveillance agency will be to co-ordinate activities of the different sections and bear ultimate responsibility for the water quality data produced. Both should bear administrative responsibility for their programmes and the staff within the programme. This will include assessing training requirements in collaboration with other senior staff, defining training programmes, lobbying for resources and establishing staff development strategies. They should both clearly identify research needs within their organisation. As both will take ultimate responsibility for the quality of data their organisations produce, both need to work closely with the quality assurance officer to ensure that the analytical data produced is reliable.

In both agencies, the programme manager should lead the national planning team defining monitoring programmes and should ensure that regional and local level monitoring programmes are consistent with broader national goals. The programme mangers will also be expected to lilies with section heads to ensure that adequate standard operating procedures are prepared and followed through all stages of the monitoring process from sample collection, through analysis to data manipulation. They should also ensure that data are distributed to all key institutions within the sector in a comprehensible format. Where feasible, programme managers should also

take responsibility for ensuring public access to water quality information through the publication of annual reports on water quality.

Other responsibilities will vary between the two agencies. Within the water supply agency, the programme manager must be responsible for the reporting of data to the surveillance agency and liaison with the surveillance agency in cases of water quality failure. They should also make both the operational and senior management staff immediately aware that a water quality failure has occurred and suggest remedial and preventative action.

Within the surveillance agency, the programme manager should co-ordinate enforcement action taken against water suppliers and should be responsible for initiating legal actions where these are to be undertaken. In some circumstances, as the person bearing ultimate responsibility for the water data, the programme manager should act as the expert witness in cases of water quality failure, although this may also be the responsibility for the head of analytical services.

The importance of good senior management in monitoring programmes cannot be overstated. It is vital that senior managers understand the programme and pressures staff face and be sympathetic to their needs. Good direction and an active interest in the staff is vital for the success of the programme.

Head of Analytical Services

The Head of the Analytical Services is another key member of the senior management team of monitoring programmes and much of the routine operational management of laboratories, sample collection and reporting of data should come under the remit of the Head of Analytical Services. Clearly a fundamental role of the Head of Analytical Services is to ensure that the reporting of analytical results is done in a comprehensible and timely fashion and in the event of a water quality failure should immediately alert the programme manager.

Key responsibilities will include writing standard operating procedures and ensuring that they are followed by all analytical staff in the laboratory. This member of staff should also actively liaise with the quality assurance officer and when problems are identified in the quality of data produced, should follow this up and identify the cause of the quality failure and implement steps to rectify the problems in the shortest possible time frame.

The Head of the Analytical Services will also be expected to ensure that all the necessary equipment and consumable are available to carry out comprehensive analysis of water quality on both a routine and non-routine basis and have budgetary control of the laboratory services. They should also ensure that adequate health and safety procedures are in place and fully understood by all staff working within the laboratories. As head of section, they will be expected to monitor and evaluate staff performance and identify training needs and appropriate training opportunities.

Other Managerial Staff

The other managerial staff within the programme will depend on the size and structure of the programme, but may include information management, legal advice or administration. All these are key roles, but which may be carried out by other staff members as part of their responsibilities so no further detail will be discussed here.

Analytical, field and data management staff

The bulk of the technical staff employed on a monitoring programme will be involved in the collection and analysis of samples and the processing of analytical data. Some duties of the staff will overlap between several roles, therefore a member of staff who undertakes analysis may also be responsible for sample collection or data management etc. It is essential that staff are recruited who have the necessary skills and experience to do the job they have been given and receive ongoing training whilst in post.

Analytical staff

The analytical staff will report to the Head of the Analytical Services, either directly in the small programmes or through section heads in larger programmes. Analytical staff will normally be divided into chemical and microbiological sections and possibly have further subdivisions depending on the scope of the programme and the size of the analytical facilities. In

some countries, sections will also include biological monitoring and sub-division of chemistry into wet chemistry, organics and trace metals etc.

It is essential that each section has at least one degree educated analyst who can supervise the analysis of other members of staff. Much of the analysis may actually be done by technicians with a lower level of education, but who have experience of routine analysis. They will be commonly supported by assistants who effectively learn whilst in post. It is important that the laboratory has sufficient analysts to perform the numbers of analyses required for routine and non-routine investigations of water quality, but that it is not overstaffed. Underemploying staff tends to lead to motivation problems and boredom and may lead to a loss of good staff.

A check list of key activities is given in box 1 below.

Box 1: Check list of laboratory staff activities

- Routine and non-routine analysis of water quality
- Care and maintenance of all laboratory equipment
- Storage and maintenance of consumables and keeping up to date stock records
- Calibration of laboratory and field equipment
- Training of laboratory assistants and field staff in relevant analytical techniques
- Maintaining a laboratory safety programme
- Recording of results in a comrehensible format and transfer to data base
- Preparation of sample bottles

- Participation in the QA programme

A key member of the analytical staff is the quality control/assurance officer who is responsible for ensuring that the quality of data produced by the laboratories is acceptable and who reports directly to the most senior member of staff. This member of staff will have to monitor analytical and field work, prepare and submit blank samples to analysts and carry out audits of all documentation, including methods, SOPs and field and laboratory notebooks, to ensure that information provided is correct and complete.

Good quality control is essential for monitoring programmes to maintain credibility in their results. It is often a false economy not to recruit a QA officer on financial grounds as the lack of demonstrable quality assurance and control may result in limited ability for water suppliers or regulators to perform effectively.

Where financial constraints prohibit the recruitment of a specific quality assurance officer, a member of staff may be nominated as QA officer, although this will require that this persons work is also monitored by a fellow staff member. In these circumstances, it is important that senior staff minimise conflicts of interest.

It is important that all analytical staff are aware of and follow the standard operating procedures and keep a clear record of all operations performed.

They should be actively involved in the quality control/assurance programme and understand its value to them as analysts in improving techniques and maintaining high standards.

Field staff

In some programmes, field staff are specifically employed for the collection of samples and carrying out field tests so a restricted number of parameters. In other programmes, these roles are performed by the analytical staff. Where field staff are employed, it is essential that they have sufficient skills to be able to perform the activities assigned to them and an understanding of the wider implications of their role.

Training should be provided in standard operating procedures for sample collection, storage and transport and the proper labelling of samples and the information to be included when sending samples. It is essential that sampling procedures are designed to be representative of water quality and that field staff have an appreciation of the risks and implications of sample contamination. Field staff should also be clearly aware of the handling procedures for any preservative agents which may be used when transporting samples.

Where field staff will carry out some basic analyses on-site, they obviously require adequate training in the techniques to be employed, recording of the results and interpretation of the data. Such on-site analyses may include pH,

chlorine residual, thermotolerant (faecal) coliform analysis and conductivity. In some circumstances, field staff will be expected to make recommendations for actions based on water quality data, particularly when they are dealing with community managed rural water supplies in remote areas. It is essential that these staff are provided with the skills to do this effectively.

A key role field staff should undertake is sanitary inspection and risk assessment of water supplies and sources. This data may be used by themselves to implement remedial or preventative actions, but should also be submitted to the central or regional data store. Again, field staff will require training in appropriate techniques and in the interpretation and use of data generated. A check list of key activities for field staff is given in box 2.

Box 2: Check list of field staff activities

- Sampling of water supplies and sources
- Sample labelling, preservation, storage and transport
- On-site analysis of pH, chlorine residual, microbiological quality
- Sanitary inspection and risk assessment
- Providing feedback to communities and suppliers
- Identifying remedial and preventative actions with communities
- Routine maintenance of field equipment

Information management staff

Information management staff are responsible for the collation and manipulation of all data generated in monitoring programmes. They should process data into standard reporting sheets and produce regular water quality reports.

Information management may be done by a member of the analytical staff who takes responsibility for data processing. This is acceptable when the throughput of data is limited and where only standard analytical reports are being produced. However, this approach limits the use of the data and serious consideration should be given to appointing a full time information management system administrator who can produce and manage a national water quality databank and produce summaries of water quality data for the general public or other agencies. There are many uses of water quality data and effective management of available information can greatly enhance national decision-making regarding priorities for investment and selection of appropriate alternatives.

Staffing structure

It is important that all monitoring programmes, whether quality control or surveillance, have a staffing structure which clearly defines lines of responsibility and accountability and which provides a framework for career development within the programme. Each monitoring programme will be

structured in slightly different ways, but in many circumstances, a clear demarcation of roles played by the enforcement wing of the water quality department and the analytical wing is established.

In all organisational structures, it is essential that there are clear lines of accountability and responsibility which allow senior managers to run departments and programmes effectively. Usually, if programmes are to be successful, there should be a high degree of delegation to senior staff and regular meeting of senior management to discuss progress.

Delegation of key responsibilities allow staff to feel that they have a greater investment within the programme and more closely identify with the programme's success or failure. However, it is important that delegation is not seen as abrogation of responsibility by the programme manager, who must retain an overall responsibility for the performance of the programme.

Training and professional development

Training of staff will be essential in most circumstances. Although staff should be recruited with appropriate qualifications, apart from the senior staff, they may have limited professional experience. Therefore, training in the aims and objectives of the programme, use of equipment and quality control procedures will have to be given. Ongoing training will also be required in safety and other aspects, such as data processing. Training should be focused on the needs of staff and aim to assist them in optimising

their performance. However, it is also valuable to provide staff with opportunities to acquire new skills and develop into new areas of activity as this will help to motivate staff. If this is done, it is important that staff are able to use new skills developed during training within the workplace. This is important as otherwise these skills may be rapidly lost without practice and because restricting potential to take new areas of responsibility and put theory into practice may well lead to frustration amongst staff.

Training programmes may be either established as in-house programmes utilising resources within the agency or programme, or may involve outside agencies. In-house training is only likely to be cost-effective where very large numbers of staff will require similar training and therefore is possibly most appropriate for training in analytical techniques or sanitary inspection or as part of an orientation programme. In-house training is less likely to be able meet all the ongoing professional needs of individuals and in these circumstances outside courses should be used.

In addition to training, staff should also be encouraged to undertake applied research, attend conferences and seminars and join professional bodies as means of improving professional knowledge. Training should also be linked to a broader process of improvement which encourages progression on the basis of merit and provides a career structure for staff. Unless this is done, staff-turnover will be high and motivation low.

Conclusion

Human resources are a key element in the success or failure of monitoring programmes to meet their objectives. Without an adequate strategy to develop the human resources available and attract high calibre staff, monitoring programmes rapidly stagnate. Whilst poor quality of staff in water quality monitoring programme may reflect a wider difficulty in attracting staff to the sector, every effort should be made to invest in staff at all levels.

Human resources development should encompass a much wider remit than training and should address issues such as career structures and professional development. It should also provide all levels of staff with the support and framework within which to function effectively and efficiently.

References

Bartram, J. *Resources for a Monitoring Programme,* in Bartram, J. and Ballance, R. (eds) *Water Quality Monitoring*, 1996, Chapman and Hall, London, pp 61-70.

Howard, G. *National Water Analysis Laboratory, Zimbabwe, Report 7*, ODA Project Report, 1996.

Mtetwa, S., Howard, G. and Jackman, R., *Strategic Plan for the National Water Quality Inspectorate and the National Water Quality Analysis Laboratory*, Paper for the Management of Change Task Force, department of

Water Resources, Zimbabwe, 1996.

Presentation Plan

Section	Key points	OHP
Introduction	• monitoring programmes are reliant on good human resources	**1**
	• need to have human resources development strategies in surveillance and supply agencies	
	• HRD strategies are not merely training programmes but should address wider issues such as staff numbers, career structures and pay scales	
	• recruitment should be focused on need for staff	
Staffing requirements	• these vary according to level of development of monitoring programmes, institutional framework and availability of staff	**2**
	• staff may be divided into 4 categories: managerial; analytical; field; and data processors	
	• many staff may have roles which overlap more than one area	
Managerial staff	• responsible for planning, implementation and monitoring of programmes	**3,4**
	• should also be responsible for strategic development of programme	

	• will include programme managers and other key senior staff such as head of analytical services/laboratory	
	programme manager	
	• bear ultimate responsibility for data quality in their institution	
	• responsible for overall administration of programmes and need to work closely with heads of section and QA officer	
	• need to ensure that monitoring programmes conform with national goals and that data is distributed to appropriate agencies	
	• in the supply agency, the manager should ensure that information sent to surveillance agency in timely manner when failure in quality occurs	
	• make operational and senior staff immediately aware of water quality failure & suggest remedial/preventative action	
	• surveillance agency: co-ordinates enforcement action and for initiating legal action when required	
	• may also act as expert witness	
	• good senior management is essential for smooth running of programmes, good direction and active interest in staff vital for success of programme	
	head of analytical services	

	• responsible for routine operation of laboratories	
	• must ensure data reporting is in a format which is comprehensible and done in a timely fashion	
	• immediately alert programme manager in the event of water quality	
	• should prepare SOPs and ensure that these are followed by all analytical staff	
	• ensure that health & safety procedures in place	
	• ensure that laboratories are able to carry out all routine and non-routine analysis requested by programme manager and that is consistent with programme goals	
	• also identify staff training needs and evaluate staff performance	
Analytical, field and data management staff	• bulk of staff involved in the collection and analysis of samples and processing of data produced	**5,6,7**
	• individual staff members may have roles which overlap more than one area, therefore essential they have the skills to perform all tasks assigned	
	analytical staff	

	• normally divided into two or more sections according to discipline	
	• each section should have at least one degree educated member of staff as a supervisor, although analysis may be done by technicians	
	• technicians may be supported by assistants who learn in post	
	• need sufficient analysts to perform analysis required, but should not overstaff laboratories as this will lead to under-employment and a possible loss of motivation	
	• check list of key tasks is given	
	• key analytical staff member is the QA officer as they are responsible for ensuring that data produced is of an adequate quality	
	• should monitor use of SOPs, submit blank samples, audit documentation and reports to most senior member of staff	
	• where specific QA officer cannot be recruited, then appoint a member of staff to do this in conjunction with other roles, but ensure that conflicts of interest are minimised and that QA officers work is also monitored	
	field staff	
	• may have specific field staff employed to collect samples and	

	undertake on-site analysis	
	• staff should be trained in sample collection, storage and transeport and be aware of their role in the monitoring programme and the need for quality control in sampling	
	• where on-site analysis is carried out by field staff, training will also be required in this	
	• field staff should also be effective communicators, particularly where they are providing feedback to communities and initiating remedial and preventative actions	
	• field staff should also undertake sanitary inspection and risk assessment of water sources	
	information management staff	
	• responsible for input and manipulation of data and generation of water quality reports	
	• analytical staff may undertake some data processing, although this limits use of data and consideration should be given to appointing a full time member of staff	
Staffing structure	• all programmes should have a staff structure which shows clear lines of responsibility and accountability	
	• structure should also provide a framework for career development	
	• enforcement and analytical wings in a monitoring body	

	• enforcement and analytical wings in a monitoring body should be clearly separated	
	• delegation is important, but should not be allowed to become abrogation of responsibility	
Training and professional development	• training is essential in most circumstances, including for staff with high qualifications	**8,9**
	• training will include programme aims and objectives, SOPs, QA procedures etc.	
	• staff should also be provided with an opportunity to acquire new skills, however, it must be possible to practice these in the workplace to maintain motivation	
	• training may be either in-house or use external trainers	
	• in-house training only cost-effective in large programmes where many staff require the same training at one time	
	• otherwise make use of training opportunities outside the programme which may be more focused on individual needs	
	• staff should also be encourage to undertake applied research, attend conferences and join professional bodies	
Conclusions	• human resources are vital to monitoring programme to meet objectives	
	• HRD strategy is essential and should address training, career	

	structures and ongoing professional development	
	• monitoring programmes must be able to attract and retain high quality staff	

Human Resources Development: Constraints

- **Lack of adequate numbers of trained staff is often a key constraint**
- **Training should be ongoing and for all levels of staff**
- **Training opportunities are often limited**
- **Training must be matched to job requirements and likely future development of staff**
- **Training needs assessment is vital for human resources development**

Staffing Requirements

- **This depends on:**

  - size of programme
  - frequency of sampling
  - numbers of samples
  - whether on-site or laboratory testing used

- **In a microbiology laboratory doing 70 samples per day by membrane filtration (or 40 by MPN):**

  - 2 laboratory staff (1 scientist, 1 technician)
  - 2-3 (minimum) field staff
  - 1 (possibly) data processing staff

- **Using field testing approach:**

  - 16 samples per day can be processed
  - Therefore up to 16 point sources or 1-3 piped water supplies may be visited per day

- **Provincial and national levels:**

  - staff to collate information, provide feedback & identify trends
  - these may not be full-time posts

Managerial Staff

Programme Manager

- **Responsible for planning and management of monitoring programmes**

- **Make sure programme conforms with national goals for the sector**

- **Water supply agency: liases with surveillance agency and makes sure data is shared**

- **Water supply agency: ensures remedial action taken promptly**

- **Surveillance agency: responsible for enforcing relevant legislation**

- **Surveillance agency: liasing with suppliers to help improve water supply quality**

- **Both provide direction and leadership and oversee staff development**

- **Both receive QA data from QA officer and take ultimate responsibility for data**

- **Oversee information dissemination, staff development and QA**

Head of Analytical Services

- **Responsible for routine operation of laboratories and for quality of data produced**

- **Should report findings in a comprehensible and accessible format**

- **Should alert programme manager when results indicate water quality failure**

- **Should develop SOPs and ensure these are followed**

- **Should ensure health & safety measures are in place and observed**

- **Should identify staff training needs and evaluate performance**

Analytical Staff

- **Usually divided into sections by discipline**

- **Each section should be headed by a degree educated supervisor**

- **Much of analysis may be done by technicians**

- **QA Officer is vital to ensure that results produced are reliable**

- **QA Officer reports to most senior staff member - usually programme manager**

Field Staff

- **May collect samples and/or carry out on-site testing**

- **Important to provide field staff with adequate training and support**

- **Field staff must be effective communicators, particularly where community supplies are monitored**

- **Field staff should undertake sanitary inspection and risk assessment**

Information Management Staff

- **Responsible for input and manipulation of data**

- **Maybe dedicated member of staff or member of analytical staff**

- **Must have support to maintain software and hardware**

- **Must be trained in use of appropriate software and understand basic data manipulation**

Human Resources Development: Training

- **Training should be provided in a number of ways, including:**

  - short courses
  - 'on-the-job'
  - longer formal training

- **Refresher training is vital for ongoing good operational performance**

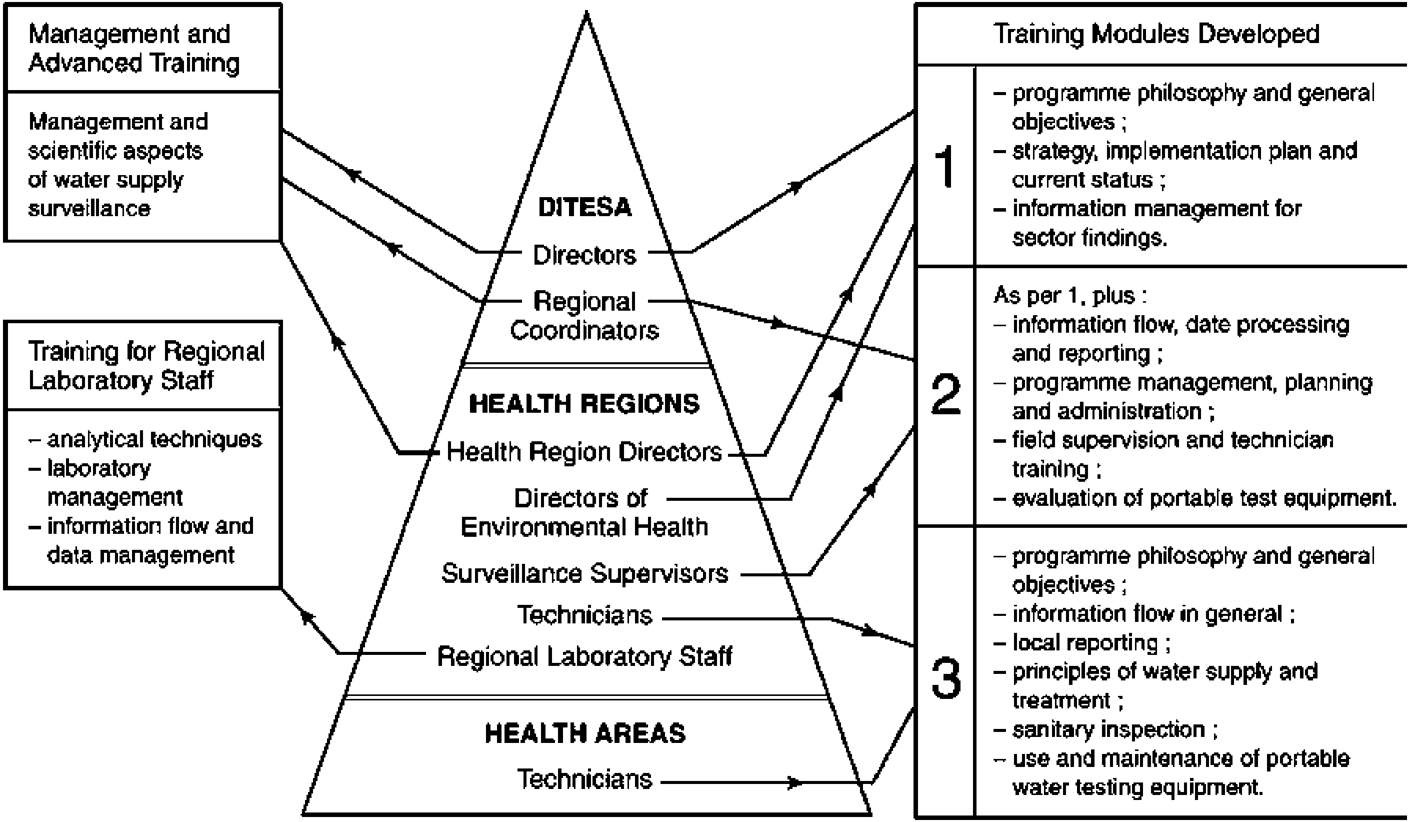
- **Senior staff should respond to training needs of their staff and identify suitable opportunities**

- **Training is not the only means of acquiring additional knowledge & expertise**

- **Applied research has great value for HRD**

- **All training should be linked to career development**

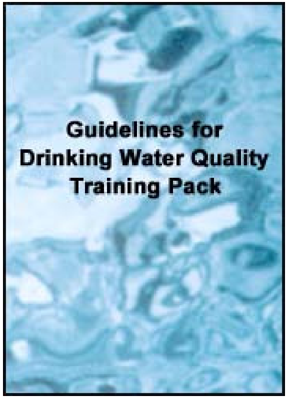
- **Training should be evaluated**



Example of Human Resources Development for Water Supply Surveillance

Source: Lloyd et al, 1991

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw



Cost Recovery

Session Objectives

- **To highlight the need for cost recovery by some mechanisms in the water sector to ensure sustainability and to highlight the consequence of under-investment in water supply.**

- **To describe some of the commonly used mechanisms for recovering costs, including the use of tariffs and subsidies.**

- **To describe some common charging policies and highlight the need to implement charging mechanisms which promote both universal coverage and the rational use of water.**

- **To highlight the need to keep water charges affordable and to highlight the dangers of disconnection policies for public health.**

Introduction

The production and provision of clean water to consumers entails a cost both in terms of initial capital outlay and in ongoing operation, maintenance, management and extension of services. However, because of poor planning for cost recovery, a lack of government funding and inadequate tariff rates, the ability of the sector to recover costs is often limited even for routine operation and maintenance. This has led to problems in providing sustainable water supplies.

Cost-recovery and application of water charges is a very political issue as many consumers have been used to provision of water supply as a free service or one for which only nominal payment is made. There is still a widely held view (in developed countries as well as less developed countries) that water is 'free' and that water supply should remain a free social service.

To a certain extent this concept is correct in that if a person wishes to

collect untreated water they can often do so at no cost, apart from their time and potentially their health. However, water supply treated so as to represent no health risk, is not a free service and the cost of water supply largely reflects the 'added value' cost of treatment and delivery.

It is essential for long-term sustainability of the sector that costs are recovered by some mechanism, whether through application of full cost-based charges to consumers or by Government support to the sector. Where cost recovery and sector funding has been ignored, the effect has been a deterioration of infrastructure which eventually leads to the breakdown of systems, absence of an adequate water supply and an increased public health risk. It is also important to recognise that costs for treatment and disposal of return flows of wastewater must also be recovered for the sector to be sustainable.

It is essential that the profile of the need to pay for water supplies amongst consumers is maintained at a high level. Unless consumers are convinced of the need to pay for services, cost-recovery will remain problematic and the long-term sustainability of the drinking water provision will be compromised. However, this also means that service quality needs to be sufficiently good to encourage payment and that water suppliers are seen to be responsive to the demands of consumers.

Consequences of poor cost-recovery

In many countries, the issues of cost-recovery and sector sustainability were ignored for a long period. As a result, tariffs set were unrealistic and frequently there was insufficient Government subsidy to make up the shortfall in the costs of the service provided. In consequence, the infrastructure has deteriorated and service quality has declined. This process is outlined in figure 1 below.

Inadequate cost-recovery, will result in an inability to operate and maintain existing supplies properly with consequent increased of leakage, water supply interruption and likely deterioration in both the quality and quantity of the water supplied. This will lead to increased public health risks, a likely increase in morbidity and mortality rates and an increased burden on the health care system.

Inadequate cost-recovery will also result in an inability to extend water supplies to unserved areas, thus continuing a cycle of inequitable access to water supplies. This not only fails to satisfy the basic human right of all peoples to have access to an adequate water supply (UN, 1977), but will continue to place a continued extra burden on the health care system. It is vital that sufficient resources are raised from existing water supplies not just to ensure their continued functioning, but also to extend services to the urban and rural populations who lack access to an adequate water supply.

A good example of this is the water supply in Lusaka, Zambia, where a prolonged lack of investment has led to an almost complete breakdown of

existing services and an inability to extend services to serve new settlements within the urban conurbation. As a result, only in the region of 30 per cent of the population are connected to a water supply, although the figure for coverage with an adequate, continuous water supply is far lower.

The protection of the water resource base is a key factor in water supply and where revenue generated has been insufficient to cover the costs of treatment of wastewater, water resources are likely to become at risk from pollution. If poorly or untreated wastes are discharged into streams or excessive leakage of waste to groundwater is allowed, then this will lead to a deterioration in natural water quality. This has two principal effects: firstly it increases the treatment requirements for the production of drinking water and therefore increases the cost of water supply; secondly, if pollution is allowed to continue and where certain pollutants (such as aromatic hydrocarbons) are present there can be a long-term loss of resources resulting in the need to develop new, possibly less accessible, water resources.

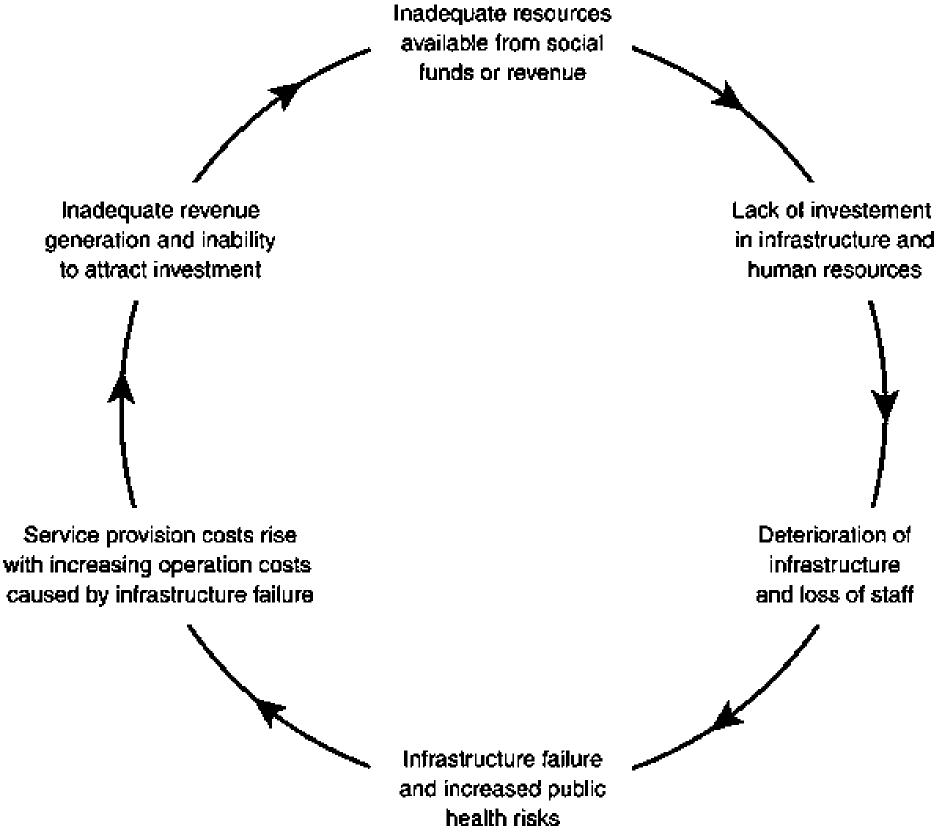


Figure 1: Consequences of poor cost-recovery

Recovering costs

Costs are usually recovered, at least in part, through the levying of a charge on consumers by the supply agency. A certain proportion of the costs may be recovered directly from Government. However, increasingly the sector is expected to be self-financing with limited support and water suppliers are expected to raise funds for on-going costs and to raise sufficient funds for major rehabilitation and extension works.

In many countries there is now a political decision that the subsidisation of social services will no longer be carried out and the water supply sector is expected to become self-sustaining in a very short period of time. This may have grave consequences for public health as water suppliers increase tariffs in order to recover costs and new policies, such as disconnection, are enacted. In these conditions, plans for extending water supplies to unserved areas are often shelved and low-income areas risk to disconnection for non-payment of bills.

An important factor in cost-recovery is the setting of adequate standards of service. It has been shown that consumers are willing to pay for good quality services and are prepared to pay increased costs for improved services in terms of water quality and supply continuity. However, where water supply services are poor, the collection of revenue is difficult and costs are rarely recovered. In some situations, consumers may be willing to be disconnected from a water supply whose service quality is poor and whose costs are high. This leads to a fundamental question of water supply improvement: does service quality improvement or cost-recovery

improvement take priority and therefore should tariffs be raised in order to improve service quality or should service quality be improved to allow increased revenue to be collected?

Many water suppliers argue that in order for them to raise the capital required to improve service quality, tariffs which reflect the cost of doing this need to be charged immediately. Once sufficient revenue is collected then service improvements can be implemented. However, from a public health point of view, it is vital that service quality improvement in areas where this is poor, should be implemented immediately. There is a significant risk that users will be willing to disconnect themselves from an expensive but poor quality service rather than pay what they see as unrealistic prices. This will inevitably lead to greater health risks as unprotected water sources are used for water supplies.

Another significant risk arises from the shift towards user-only funding of the water supply sector is that it will continue to marginalise the poor in unserved areas. These users will continue to rely on poor quality water supplies unless some form of subsidy is made available to support the provision of services to them. Furthermore, these sections of the population are also frequently forced to pay higher unit costs for drinking water from vendors where no connection to some form of centralised water supply is made available.

Where Government subsidies the supply of water to poorer sections of the

community, it is important that some element of household payment, however nominal, is retained to encourage responsible use of water supplies and infrastructure. It is also important that all users of the water supply pay for the services that they receive. In many countries, the worse defaulters on payment of water bills are Government Institutions, the military and the wealthier sections of society. In many countries, low-income groups actually subsidise the high-income groups.

The need to pay for drinking water supplies should remain a high profile issue nationally. Promotional campaigns on payment and the implications for service quality in the event of nonpayment and clearly described and the link between payment of fees and improving water supplies should be clearly shown. In some cases, water suppliers provide annual statements of water supply quality and expenditure. These allow consumers to be able look at how their money has been spent and what improvements that has led to. Water suppliers and surveillance bodies should be proactive in their efforts to raise the profile of the need to raise revenue and the responsibility of all consumers to pay bills.

Charging policies

Charging policies can be established in a number of ways. The key principle of charging policies however, should be to ensure that water supply remains accessible for all consumers whilst still recovering overall costs of the water supply. Charging policies should be established which are fair and equitable,

provide incentives to conserve water and are simple and comprehensible to consumers.

The tariff set will depend on the determination of costs and the ability and willingness of consumers to pay. Consideration should be given to whether a pay-for use system is employed or a rates system used. Pay-for-use systems require household water meters to be installed to gauge individual household consumption, whereas rate systems rely on estimation of property value and the use of bulk meters to determine bulk demand. If a flat rate system is employed it is essential that consideration be given to how excessive consumption will be dealt with and whether fines for consumption of a certain level of water will be introduced.

Often a mixture of flat rate and pay-for-use systems are used to set tariffs. These systems generally employ low flat rates for a given amount of water per household and thereafter use a progressive rate for increasing water use. The advantage of this system is that it provides some security to the poor as low rates of water use are inexpensive, whilst allowing wealthier members of society use the water they require and also allows transparency of charging.

The problem with this system is the determination of the maximum allowable supply charged at a flat rate. A number of solutions have been employed. At the most basic level, an equivalent of 5 litres per capita per day can be used as the water required for consumption and this may be used

as the flat rate maximum. However, in most countries where combined tariff systems are in place a flat rate is used which includes sufficient water for all basic domestic use, which will raise this figure to about 30-50 litres per capita per day.

This approach can be implemented using a *block rate* system or a *step rate* systems. The step rate system employs progressively higher charges for bands of consumption. Thus the initial band will be a volume sufficient for basic domestic needs and charged at the minimum rate. Increased consumption therefore brings a penalty of a higher unit charge, which increases in a series of steps. The principle of this method is to encourage conservation of water and to penalise those who use excess amounts. Block rates work in the reverse, with the maximum rate charged for volumes sufficient for all domestic use and thereafter low unit charges for increased consumption with minimum charges for very high consumption. This works on the principle that although unit charges decrease, as the number of units consumed increases, sufficient revenue is generated.

Keeping water charges affordable

It is essential that water charges remain affordable for all consumers, this may be achieved through employing cross-subsidisation techniques. Cross-subsidisation allows different tariffs to be set according to the ability to pay of different groups of consumers. The principle is that richer consumers pay an increased proportion of costs in order to ensure that poorer consumers

can afford their water bills. Cross-subsidisation can be an effective mechanism for ensuring that costs charged reflect ability to pay. However, it is frequently contentious, difficult to implement and requires careful and detailed planning if it is to be successful.

One way in which costs can be reduced is to encourage greater community or consumer involvement in operating and maintaining the supply. This is an approach commonly used in less developed countries. However, with sophisticated systems utilising treatment plants and an in-house level of supply, it is much more difficult to rely on community involvement to reduce costs because specialist skills and a large amount of time are required.

Careful consideration should also be given to whether domestic water bills should be the same as industrial water charges. Industry uses a great deal of high-quality water and this forms part of its raw materials. As industry uses a large amount of water and as it is essentially profit making in most circumstances, there is much to be said for subsidising domestic water tariffs through application of higher rates to industry. This is further strengthened by the fact that industry accounts for a great deal of the pollution of water resources and thus directly contributes to increased treatment costs.

Agricultural water use is generally covered by the water resource management body, although there needs to be close liaison to ensure that farming activities do not pollute water sources used for drinking water

supplies and that priority for use as drinking water is always maintained.

The difference between in ability to fully recover costs in rural and urban areas must also be considered. There is greater potential for revenue collection in urban areas where there are more people living in restricted surroundings. In rural areas, the low density of population often makes full cost-recovery difficult. In these circumstances the possibility of subsidising rural water supplies by urban consumers should be considered.

One aspect of cost-recovery which is often difficult to address is the funding of surveillance activities undertaken by watchdog bodies. In most situations this activity is funded from local or national government through taxing of the population. This approach is workable as long as there is a sufficient tax base to raise revenue for all the competing demands. However, in many countries such funds are not available and water suppliers must contribute to the funding of a watchdog body.

Non-payment issues

The issue of non-payment of water charges is an issue which provokes considerable debate and great care must be taken when dealing with non-payment issues to ensure that public health is not unacceptably compromised.

Many water suppliers insist that policies of disconnection in cases where

there is continued nonpayment of bills are essential if revenue collection and hence cost-recovery is to be maintained. However, it should be stressed that there is no evidence of significantly increased levels of nonpayment of bills where there is no threat of disconnection. It should also be stressed that disconnection from a public water supply represents a significant health risk to the whole community and not just the disconnected household. Significant increases in disease are noted in areas where disconnections have taken place.

In many areas where disconnection is heavily promoted, water supplies have been privatised. In these circumstances, disconnection may be more related to profits of the company rather than inability to recover costs. There are real dangers in disconnecting users from water supplies and it is not method that can be recommended because of the public health risk.

Where household resource are limited and non-payment becomes problematic, other solutions should be identified. These may include a minimum amount of water provided effectively free of charge, employing large scale subsidisation from wealthier domestic users and industry or installing flow limiters on households with a history of persistent non-payment.

Conclusion

Cost-recovery is vital if water supplies are to sustainable and if they are to

meet future demands. It is important that the revenue raised covers operation and maintenance costs and generates capital for extension and rehabilitation of water supplies.

Some element of subsidy is often required, whether from Government social funds or through the application of differential tariffs for low and high income residential areas and differential tariffs for domestic and industrial water users.

Disconnection policies represent a significant health risk which is likely affect the wider community and not just those disconnected. Disconnection of households from piped water supplies for non-payment of bills can never be justified from a public health standpoint and such policies should not be enacted.

References

OFWAT (1993) *Annual Report 1992*. HMSO. London.

Robens International Centre for Public and Environmental Health, *Water and Health*, Paper Presented at the Institution of Civil Engineers-Royal Institute of British Architects Meeting Who is Making Britain Sick?, 1996.

U.N. (1977), *World Water Conference, Mar del Plata, Argentina,*

WHO (1990), *Handbook of Financial Principles and Methods*, World Health

Organization Working Group on Cost-Recovery. WHO/CWS/90.10.

Presentation Plan

Section	Key points	OHP
Introduction	• production and provision of clean water has both capital and ongoing costs, it is not free	**1,2**
	• poor cost recovery leads to inability of the water sector to meet the demands placed upon it	
	• cost-recovery is often contentious, but is essential	
	• costs may be recovered from Government, from consumers or through a mixture of both	
	• where water charges are levied, quality of service must be good and reflect charges made	
Consequences of poor cost-recovery	• cost-recovery has been ignored by some countries and so tariffs were too low and government subsidy insufficient to make up shortfall	**3,4**
	• in consequence, infrastructure has deteriorated and service declined	
	• inadequate cost-recovery results in an inability to operate and maintain supplies properly and will lead to increased leakage, interruptions and deterioration in quality & quantity	
	• inadequate costs-recovery also prevents extension of	

	• inadequate costs recovery also prevents extension of services to unserved areas	
	• poor cost-recovery may also lead to loss of water resources through pollution from inadequately treated wastewater	
Recovering costs	• costs recovered usually at least in part through levying of charge on consumers	**5,6**
	• increasingly government support is being withdrawn from the sector which is expected to become self-financing	
	• this may lead to reduction in programmes to extend coverage and disconnection for non-payment, both of which cause public health risks	
	• it is essential that service provided is adequate to ensure costs may be recovered	
	• this raises difficult questions such as whether service improvement or increased charges come first	
	• arguments exist for both approaches, although it is clear that poor service will significantly limit cost recovery	
	• community management can help reduce costs and assists in extending coverage	
	• defaulters who can pay bills (e.g. government departments etc.) must be made to pay/the poor should not subsidise the rich	
	• the need to pay should be promoted and the consumers	

	made aware of the consequences of non-payment on service quality	
Charging policies	• these can be established in a number of ways	**7,8,9**
	• key principle should be to ensure that water remains accessible and affordable to entire population	
	• charging should be fair and equitable and encourage conservation of water	
	• rates or pay-per-use systems may be employed	
	• pay-for-use systems require the installation of water meters	
	• rates system usually work on property values as a mechanism of determining ability to pay	
	• can use systems which employ elements of both approaches with minimum amount supplied at a flat rate and extra consumption charged per use	
	• this protects poor whilst encouraging water conservation	
	• problem is setting minimum to be supplied, although this should reflect health requirements	
	• rate systems may use block rates or step rates	
	• step rates employ increasing rates for increasing consumption and therefore promote conservation of water	

	• block rates use decreasing rates for increasing consumption which penalises low-volume users	
Keeping charges affordable	• costs must kept affordable for all consumers in order to protect public health	**10**
	• cross-subsidisation may be used	
	• community operation and management will also reduce costs	
	• industrial use of water can also be used to subsidise domestic use of water through use of differential tariffs	
	• urban areas may subsidise rural areas as revenue generation easier in urban areas with larger, more concentrated populations	
	• cost-recovery should also help to fund surveillance activities	
Non-payment issues	• water suppliers may request on a policy of disconnection for non-payment as a means to ensure costs are recovered	
	• however, there is no evidence of increased non-payment where disconnection is illegal and may reflect a desire for profit rather than cost recovery	
	• disconnection causes serious public health risks and can never be recommended	
	• for persistent non-payment, other options may include flow	

	limitors	
	• keeping costs affordable will reduce non-payment as an issue	
Conclusions	• costs-recovery by some means is essential for sustainable water supply	
	• government subsidy or application of differential tariffs may be employed to keep costs affordable	
	• disconnection policies should not be implemented because of the public health risk	

The Cost of Using Water (UK Example)

Flushing toilet	1p
Shower	3.5p
Dishwasher	5.5p
Bath	8p
Washing Machine	11p
Hose pipe (1 hour's use)	54p

(Assuming average cost of water, including disposal, of 0.1 pence per litre and typical consumption figures)

Investment Requirements

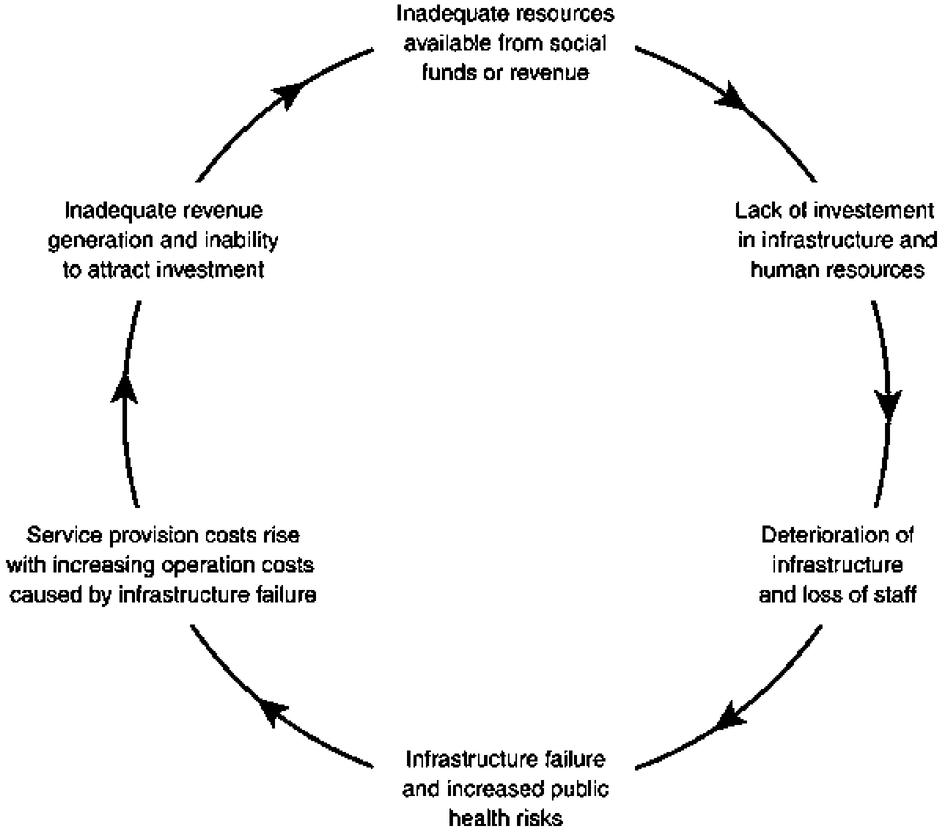
- **Investment required in water supply and sanitation in lower income countries is approximately $50 billion per year.**

Actual spending is $10 billion per year.

(Christmas and LeRoy, 1990)

Consequence of Poor Cost-Recovery

- **Inadequate cost-recovery will mean that water supply provision is not sustainable and will eventually lead to deterioration in infrastructure and human resources.**



Water Supply Service Deterioration Caused by Poor Cost-recovery and Cost Covering

Recovering Costs - Priorities

- **Improved service quality or improved cost recovery?**

Therefore:

» Does increased revenue fund service quality improvements?

or

» Do service quality improvements lead to increased revenue generation?

Sale price of water

World Bank (1990) reported that the average effective sale price of water is only about one-third of the marginal cost of production.

Charging Policies

Should aim to achieve:

- **fairness and equity**
- **sensible incentives**
- **simplicity and comprehensibility**

Keeping Water Charges Affordable

- **Rich subsidise poor**
- **Community-based approaches**
- **Industry subsidises domestic**
- **Urban areas sinsidiserural**
- **How is surveillance funded? Water levy or other tax?**

Nonpayment and Disconnection

- **There is no evidence that disconnection policies have any impact on reducing non-payment of bills**

- **Disconnection from a public water supply represents a serious public health risk**

- **Disconnection can never be justified on health grounds**

Keeping charges affordable

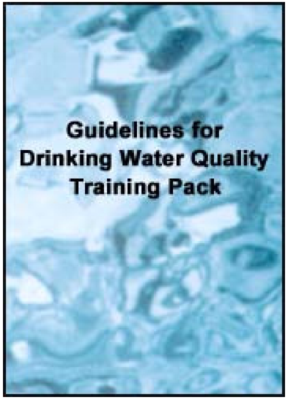
- **To protect public health costs must be affordable for all consumers**

- **Cross-subsidation may be used**

- **Cost reduction may be achieved by community management and operation**

- **Industrial tariffs may subsidise domestic use**
- **Urban areas may subsidise rural ones**

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw



Guidelines for Drinking Water Quality - Training Pack (WHO)

Microbiology (Practical Exercise)

Session Objectives

- **To discuss the relative advantages and disadvantages of the membrane filtration and multiple tube methods of analysis.**

- **To provide participants with a practical experience of the membrane filtration technique.**

- **To provide participants with a practical example of the use of different volumes of filtration for different qualities of water.**

- **To review results and discuss precision of analysis.**

Outline

NB: It is assumed that whoever takes this practical has a good working knowledge of microbiological techniques.

1. Collect two samples for testing (at least 1 litre of each) - one clean water and one contaminated water (from a river, stream, pond etc.).

2. Demonstrate the membrane filtration technique and describe dilution methods (e.g. to make a 1 per cent solution add 1ml of sample to 99ml of distilled water).

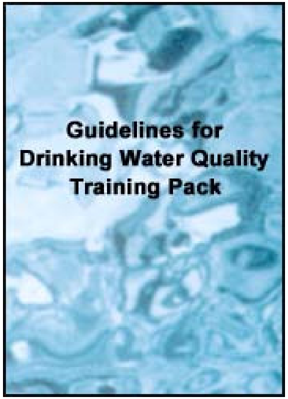
3. Highlight the advantages and disadvantages of both the membrane filtration and the multiple tube methods of analysis.

4. Ask the participants to prepare and filter the following samples: 100ml; 50ml; 10ml; and 1ml.

5. Ask the participants to read the results the following day and record and compare the results.

6. A demonstration of other techniques - e.g. colilert - may also be given if resources permit.

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw



Disinfection (Practical Exercise)

Session Objectives

- **To provide a practical example of how to calculate chlorine demand**

in a water supply.

- **To discuss and provide practical examples of different methods of chlorine residual analysis, with an emphasis on use of DPD tablets and comparators as a quick and reasonably accurate method.**

- **To discuss why free chlorine may be lost and the significance of high levels of combined chlorine.**

Outline

NB:. It is assumed that whoever takes this practical has a good working knowledge of chlorine testing techniques and the relative advantages and disadvantages of different disinfectants.

1. Make up a range of chlorine solutions using HTH or chlorine tablets. It is suggested that 4-5 different concentrations of chlorine solution are prepared.

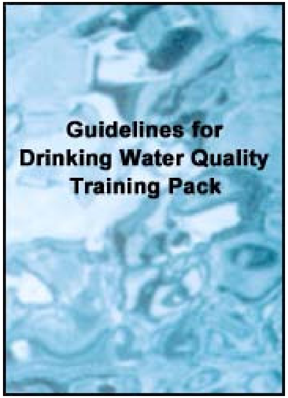
2. Ask the participants to test the free and total chlorine residual in each solution and calculate the combined chlorine (combined chlorine = total residual - free residual).

3. Add contaminated water to solutions and ask the participants to re-test chlorine residuals.

4. Discuss the results and the need for maintaining residuals during distribution. Highlight the relative advantages and disadvantages of different disinfectants using the disinfectant session notes.

5. Discuss the ways in which free residual may be lost and highlight that highlight that high combined chlorine indicates sanitary integrity of the system is compromised.

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw



Guidelines for Drinking Water Quality - Training Pack (WHO)

Sanitary Inspection (Practical Exercise)

Session Objectives

- **To demonstrate the need for sanitary inspection in the management of water supplies.**

- **To demonstrate the value of sanitary inspection as a means of promoting improvements in water supply.**

- **To describe the sanitary inspection techniques and the development of inspection forms based on risk scoring schemes.**

Outline

1. Ask the participants, in small groups, to study the photographs and identify any sanitary risks present.

2. Ask the groups to rank the systems. Make sure they do this independently and compare the findings of different groups.

3. Use these findings and the attached overheads to describe the key problems often faced with sanitary inspection.

4. Using the overheads, highlight that sanitary inspection data may be classified into broad groups indicating different levels of risk and that such data may also be used to rank systems on the basis of risk.

Participant Notes

1. Study the photographs carefully and note all the potential sanitary risks that you can identify.

2. Rank the water supplies on the basis of greatest risk, with the supply at greatest risk first.

3. Briefly highlight some key common factors which should always be assessed when undertaking a sanitary inspection.

Typical Problems Preventing Effective Sanitary Inspection When Practiced

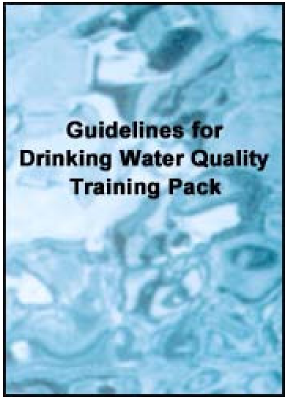
- **No standardised methodology**
- **Field interpretation of results varies between staff**
- **Data are difficult to quantify or compare due to subjectivity in interpretation and 'observational' style.**
- **No reporting structure to regional or national level**
- **No effort made to consolidate or analyse data at regional level in order to investigate general trends or common problems**

Categories for Sanitary Inspection

Value	Risk

0	No risk
1-3	Little risk
4-6	Intermediate risk
7-10	High risk

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw



Guidelines for Drinking Water Quality - Training Pack (WHO)

Planning (Practical Exercise)

Session Objectives

- **To provide a practical example of the process of planning water**

supply monitoring programmes which cover a wide range of conditions.

- **To reinforce the need to develop monitoring programmes which are linked to decision-making and management needs.**

Outline

1. **Divide the participants into at least two groups.**

2. **Provide the participants with the attached description and ask one or more groups to design a health-based drinking-water quality surveillance programme for the town and the remaining groups to design a quality control monitoring programme for a water supplier.**

3. **Ask the groups to make a presentation on the programmes designed and discuss these in plenary.**

NB: This practical is best run over several days. Therefore, the groups should be given the background information at the start of the workshop and asked to present their findings on the last day.

Monitoring Programme Design

The town of Terebaka serves a total population of 105,000. The town is a regional centre of importance and has a busy market selling foodstuffs and a

variety of hardware and clothes and an industrial area. The town is the centre for the surrounding district and the population is significantly increased on market days. The town is also an important rail and bus terminus and the short-term transient population is high.

The town has a centralised piped water supply which serves 85 per cent of the population with a mixture of in-house and yard level water supply service (roughly a 40-60 split). In addition, a number of public tapstands are located in the market and at the bus and rail stations. The piped water supply utilises two main sources: a reservoir situated 20 kilometres to the north of the town and connected to the water treatment plant; and a well field (series of boreholes) 10 kilometres to the west of the town which joins the distribution system at the major storage tank on the western extremity of the town.

The treatment plant utilises coagulation-flocculation-settling through two conventional settlers set in parallel. This is followed by rapid sand filtration and the plant has two filters per settler. The water is disinfected with hypochlorite does through a pulse doser into the final clear well. The water is then pumped to the main town storage tank which feeds the distribution systems which passes through 6 subsidiary tanks spread around the city.

The well field water is pumped to a central collector tank where it is chlorinated using a gas chlorinator and the water is then pumped to the major tank on the west of the city, form where the water is distributed

through the main system.

The treatment plant has suffered a number of failures during the recent past and the coagulation-flocculation-settling in particular is known to be inefficient. Problems have arisen through the lack of coagulant and insufficient settling time. Some problems have also been encountered with the chlorination of water form both sources.

The distribution system is old and has a leakage rate of around 3- per cent. Several "hotspots" of pipe leakage are known and there are also several areas of known low pressure within the system.

The parts of the town not served by the main pipe system are on the periphery of the town and utilise hand-dug wells in most areas, although several private boreholes have been sunk.

Design a monitoring scheme for Terebaka, indicating the range of analysis, frequency of sampling, type of sampling points, location of sampling points and frequency of sanitary inspection. Indicate the objectives of your monitoring programme and highlight the actions you would take on the basis of the results received.

Figure

Figure

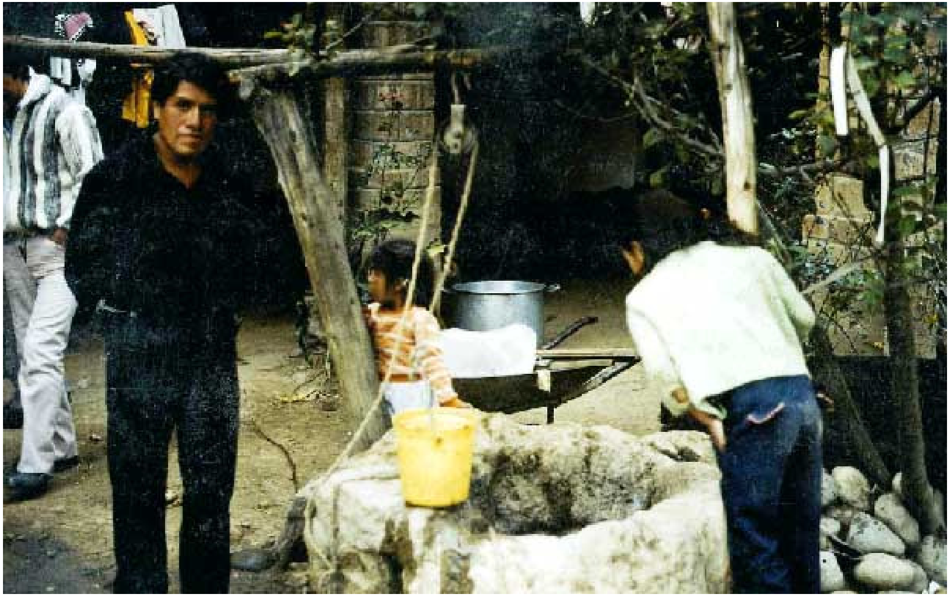
Figure

Figure

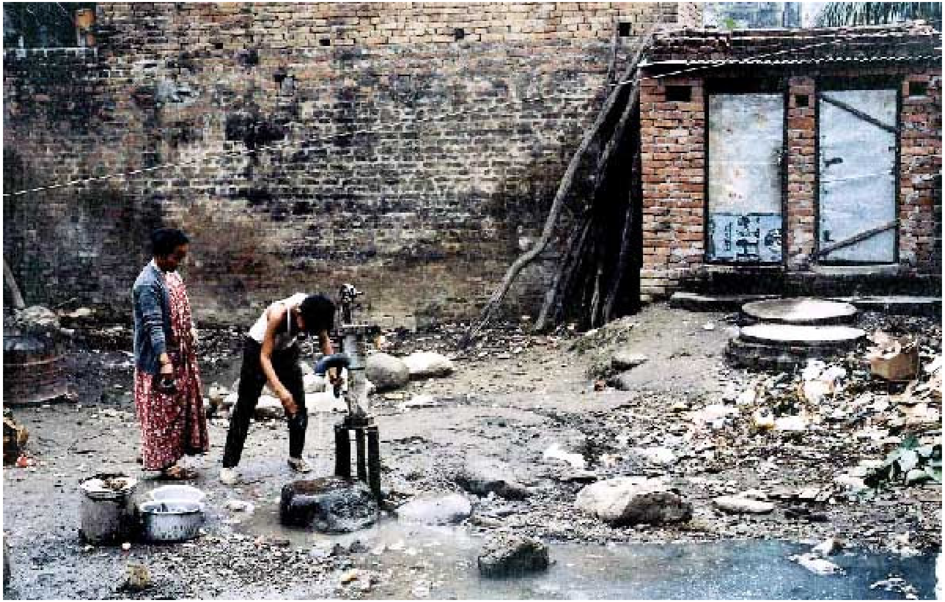
Figure

Figure

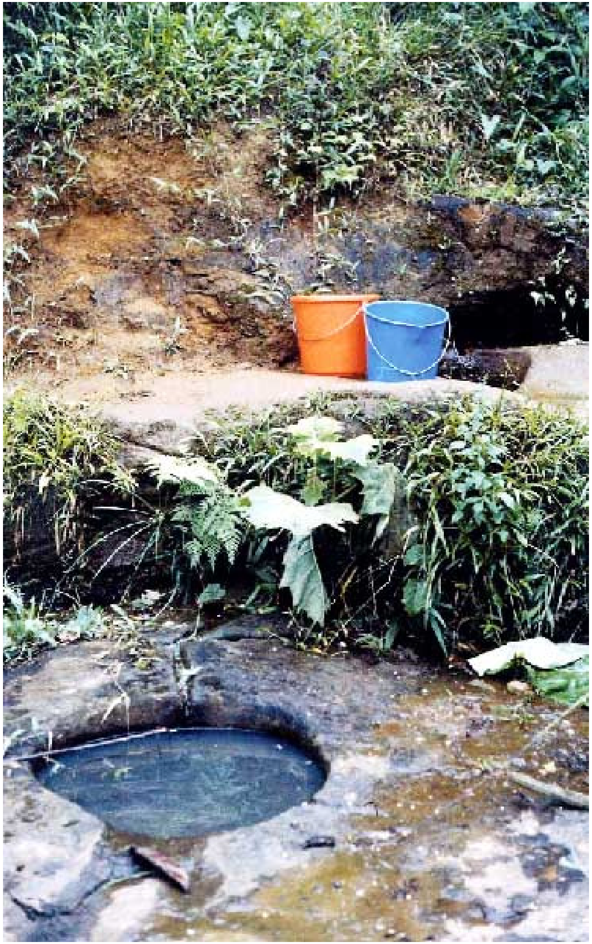
Figure



Figure

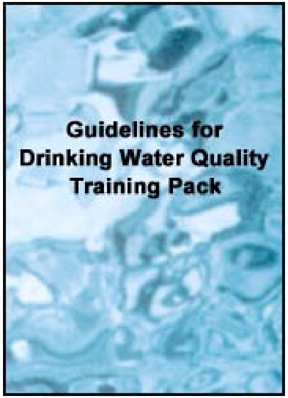


Figure



Figure

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw



Water and Public Health

Session Objectives

- **To demonstrate the link between water and health and show the profound influence of water supply and quality on public health.**

- **To describe the basic classification of water-related disease.**

- **To describe the concept of the faecal-oral route of disease transmission and the classic waterborne disease cycle.**

- **To describe how improvements in water supplies will lead to improvements in health and a reduction in morbidity and mortality rates.**

Introduction

Water has a profound influence on human health. At a very basic level, a minimum amount of water is required for consumption on a daily basis for survival and therefore access to some form of water is essential for life. However, water has much broader influences on health and wellbeing and issues such as the quantity and quality of the water supplied are important in determining the health of individuals and whole communities.

The first priority must be to provide access for the whole population to some form of improved water supply. However, access may be restricted by low coverage, poor continuity, insufficient quantity, poor quality and excessive cost relative to the ability and willingness to pay. Thus, in terms of drinking-water, all these issues must be addressed if public health is to improve. Water quality aspects, whilst important, are not the sole determinant of health impacts.

The quality of water does, however, have a great influence on public health;

in particular the microbiological quality of water is important in preventing ill-health. Poor microbiological quality is likely to lead to outbreaks of infectious water-related diseases and may causes serious epidemics to occur.

Chemical water quality is generally of lower importance as the impact on health tend to be chronic long-term effects and time is available to take remedial action. Acute effects may be encountered where major pollution event has occurred or where levels of certain chemicals are high from natural sources, such as fluoride, or anthropogenic sources, such as nitrate.

Microbiological drinking-water quality and human health

The microbiological quality of drinking-water has been implicated in the spread of important infectious and parasitic diseases such as cholera, typhoid, dysentery, hepatitis, giardiasis, guinea worm and schistosomiasis.

Many other diseases are associated with water in other ways. Water may act positively in the control of some through its use in hygiene, and may act as a source or vector for others where contact with water is required for disease transmission or where agents of disease or insect vectors require water in which to complete their life cycle. The various relationships between water and disease are summarized in Table 1.

Water-related disease incidence worldwide

Water-related disease places an excessive burden on the population and health services of many countries worldwide and in particular those in developing countries. Table 2 shows estimates of the morbidity and mortality rates of some major water-related diseases worldwide, figures which are likely to be conservative estimates.

Table 1: Diseases related to water and sanitation

Group	Disease	Route leaving host	Route of infection
Diseases which are often water-borne	Cholera	faeces	oral
	Typhoid	faeces/urine	oral
	Infectious hepatitis	faeces	oral
	Giardiasis	faeces	oral
	Amoebiasis	faeces	oral
	Dracunculiasis	cutaneous	percutaneous
Diseases which are often associated with poor hygiene	Bacillary dysentery	faeces	oral
	Enteroviral diarrhoea	faeces	oral
	Paratyphoid fever	faeces	oral

	Pinworm (Enterobius)	faeces	oral
	Amoebaisis	faeces	oral
	Scabies	cutaneous	cutaneous
	Skin sepsis	cutaneous	cutaneous
	Lice and typhus	bite	bite
	Trachoma	cutaneous	cutaneous
	Conjunctivitis	cutaneous	cutaneous
Diseases which are often related to inadequate sanitation	Ascariasis	faecal	oral
	Trichuriasis	faecal	oral
	Hookworm (Ancylostoma/Necator)	faecal	oral/percutaneous
Diseases with part of life cycle of parasite in water	Schistosomiasis	urine/faeces	percutaneous
Diseases with vectors passing part of their life cycle in water	Dracunculiasis	cutaneous	percutaneous

adapted from Bradley, D J, London School of Hygiene and Tropical Medicine, various

Forty per cent of mortality in children under five years of age is related to diarrhoeal disease and it has been estimated that in 1995 more than 1,500,000,000 episodes of diarrhoea occurred in children under five years of age in the developing world (excluding China) and that some 4,000,000 of these resulted in death.

Table 2: Morbidity and mortality rates of some important water-related diseases (after WHO, 1995)

Disease	Cases per year (thousands)	Deaths per year (thousands)
Cholera	384	11
Typhoid	500	25
Giardiasis	500	low
Amoebiasis	48,000	110
Diarrhoeal disease	1,500,000	4,000
Ascariasis	1,000	20
Trichuriasis	100	low
Ancylostoma	1,500	60
Dracunculiasis (Guinea worm)	> 5,000	-
Schistosomiasis	200,000	800
Trachoma	360,000 (active)	9,000 (blind)

These diseases are caused by the ingestion of contaminated faecal material transmitted by the transmitted by the faecal - oral route. Infectious agents of all types may be transmitted by the faecal - oral route via water, including viruses (such as infectious hepatitis, rotavirus and Norwalk agent); bacteria (such as cholera, typhoid and dysentery); and parasites (such as *Giardia*, *Cryptosporidium* and *Entamoeba*).

Faecal pollution of drinking-water may be sporadic and the degree of faecal contamination may be low or fluctuate widely. In communities where contamination levels are low, supplies may not carry life-threatening risks and the population may have used the same source for generations. However, where contamination levels are high, consumers (and especially the visitors, the very young, the old and those suffering from immuno deficiency-related disease, for instance through malnutrition or AIDS) may be at a significant risk of infection.

Improving water and sanitation and improvements in health

Results of epidemiological studies into the relationship between the quality of water supply and sanitation versus human health vary widely and there are severe methodological difficulties involved in undertaking such studies. Nevertheless there is sufficient evidence to support the conclusion that improving water supply and sanitation can have a significant impact on human health. Table 3 summarizes the findings of an extensive review of studies of this type.

Table 3: Percentage reduction in the diarrhoea morbidity rate attributed to improvements in water supply or excreta disposal

Type of Intervention	**Number of Studies**	**Percentage reduction Median**	**Range**
All	53	22	0-100
Water quality improvements	9	16	0-90
Improvements in availability	17	25	1-100
Improvements in availability *and* quality of water	8	37	0-82
Improvements in excreta disposal	10	22	0-48

Source: after Esrey, Feachem and Hughes, 1985

One of the reasons for the difficulty in undertaking studies on the health impact of improvements in water supply quality is that the faecal - oral route includes several and multiple routes to infection as summarized in Figure 1 below.

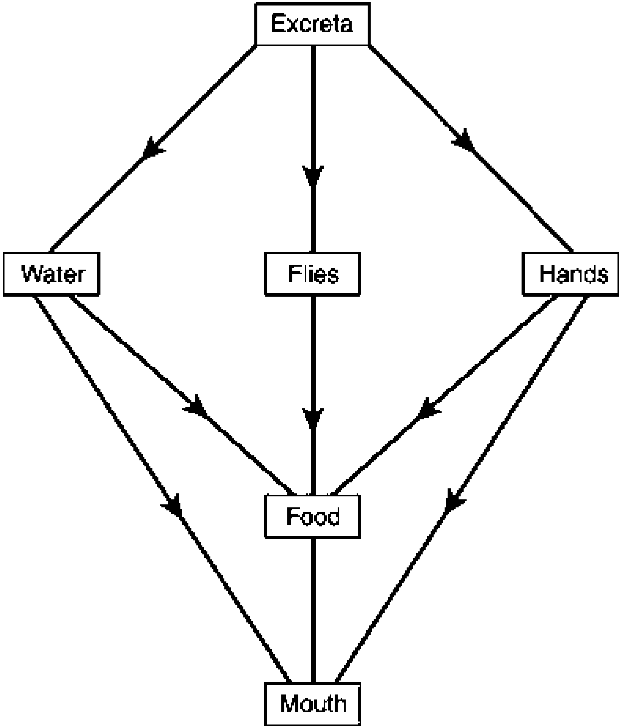


Figure 1: Principal elements of faecal - oral disease transmission

This complexity of routes also demonstrates the importance of various aspects of hygiene as complementary actions to water quality improvements.

Clearly, the likelihood of acquiring a waterborne infection increases with the level of contamination by pathogenic (disease-causing) microorganisms. However, the relationship is not necessarily a simple one and depends very much on factors such as infectious dose and host susceptibility.

Moreover there remains some doubt as to the relative importance of drinking-water quality and other aspects of water supply on the prevalence of infections with a faecal-oral route of transmission. For example, some agents with a low infectious dose may be transmitted primarily from person to person and thus improving the quality of drinking-water may not make a dramatic impact on their prevalence in the community. Human rotavirus and some species of *Shigella* fall into this category. Bacteria which are capable of multiplication in food may follow a food-borne transmission route more readily than waterborne.

Conversely there are other agents for example *Salmonella typhi, Vibrio cholerae, Giardia lamblia* and hepatitis A virus which are frequently transmitted via contaminated drinking-water. Where this is the case, improvements in water quality may result in substantial reductions in prevalence.

In those cases where transmission is not primarily water borne, improvements in water availability and personal hygiene may be much more important in reducing morbidity from diarrhoea and other water-borne infections.

The relative importance of drinking-water quality to the maintenance of public health may vary with respect to a number of geographical, social, seasonal and microbiological factors. It is not possible to state with any confidence which aspect of water supply is the most important at any one time or in any one location. What is becoming increasingly clear however is that *all* factors relating to the quality and availability of drinking-water are potentially important and must be taken into consideration. In this context it is worth emphasizing that one of the few general conclusions that may be drawn about drinking-water quality is that if faecally-derived pathogens are not present, then endemic or epidemic waterborne disease will not occur.

Other aspects of microbiological quality

As noted above, water borne disease is not exclusively transmitted by the faecal-oral route, although this route of disease transmission is of overwhelming importance globally. Some other microbiological aspects of importance are as follows:

Opportunistic and other water-associated pathogens

Opportunistic pathogens are naturally present in the environment and normally present no risk to human health. They are able to cause disease in people with impaired local or general immune defences. These people include the elderly and the very young; persons with extensive burns; persons undergoing immuno-suppressive therapy (such as following

transplant surgery) and those with immuno deficiency-related diseases (such as AIDS). Examples of opportunistic pathogens of this type include *Pseudomonas aeruginosa*, certain species of *Flavobacterium, Acinetobacter, Klebsiella, Serratia, Aeromonas* and some 'slow growing' mycobacteria.

Inhalation of water containing certain infectious agents may also cause disease. This is the case with, for example, *Legionella spp* (Legionnaire's disease) and *Naeglaria fowleri* (an occasional cause of primary amoebic meningoencephalitis).

Cyanobacterial Toxins

Some cyanobacteria ('blue-green algae') are capable of producing toxins, including hepatotoxins, neurotoxins and lipopolysaccharides. Few epidemiological studies have been undertaken and little information is available regarding the true importance of this problem. Where blooms of cyanobacteria occur in lakes and reservoirs used for drinking-water supply a potential risk to health exists and therefore impounded surface waters used for drinking-water supply should be protected from contamination with nutrients.

Nuisance organisms

A number of organisms of no public health significance are undesirable because they produce turbidity, taste or odour or because they are visible to

consumers of drinking-water. Their presence indicates that water treatment and supply system maintenance may be defective. These include: tastes and odours from *Actinomyces* and *Cyanobacteria*; and infestation of water mains by animal life feeding upon microbial films, such as the crustacean *Gammarus pulex, Nais* worms and the larvae of chironomids.

Chemical contamination and health

Chemical contamination of drinking-water may also have effects on health, although in general these tend to be chronic rather than acute, unless a specific pollution event has occurred and are therefore generally considered of lower priority than microbiological contamination.

Chemical pollutants which affect health include nitrate, arsenic, mercury and fluoride. In addition, there are an ever-increasing number of synthetic organic compounds released into the environment whose effect on human health is poorly understood, but which it appears may be carcinogenic.

Some details are given below on the four substances noted above, however, it must be recognized that raised concentrations of any chemical known to have an impact on human health may lead to long-term problems. In general, water sources used for drinking-water supply should be protected from chemical contamination through land-use control, definition of protection zones and application of adequate wastewater treatment.

Nitrate

Excess nitrate in drinking-water has been linked to methaemaglobinamenia in infants, the so-called 'blue-baby' syndrome. Nitrate leads to the oxidation of normal haemoglobin to methaemoglobin which is unable to transport oxygen to the tissues. This may result in cyanosis (a dark blue coloration) and in some cases, asphyxiation and death.

The Guideline Value (GV) for nitrate of 50 mg/l has been set on the basis of the acute health risk to infants and is unusual for this reason as most GVs are set for long-term risks. Many countries are now experiencing problems with elevated nitrate, particularly in groundwaters caused through poor treatment and disposal of excreta, intensification of animal husbandry and large-scale applications of inorganic and organic fertilizers.

In some countries, notably in the Countries of Central and Eastern Europe (CCEE) such as Moldova and Romania, levels have been recorded in shallow groundwater at up to 1000 mg/l, whilst in India anecdotal evidence suggest levels of up to 1500 mg/l. At these levels, more widespread chronic effects are likely to be noted including a possible greater likelihood of gastric cancer.

Nitrate is a conservative element in natural groundwaters and therefore once large-scale nitrate contamination has occurred, it will take a considerable period of time before it is naturally attenuated through de-

nitrification or diluted. In these circumstances, short term measures will include identifying alternative sources of water, for instance deeper boreholes, or through blending with low-nitrate waters. Removal of nitrate by ion exchange in treatment plants is expensive as most anion exchangers are non-selective for nitrate and therefore nitrate specific resins must be used.

Long-term solutions must involve the reduction in the release of nitrate into the environment through, for example, control of fertilizer application and improvements in human and animal excreta treatment and disposal.

Arsenic

A provisional GV of 0.1 mg/l has been set for arsenic on the basis of an excess cancer risk of 6×10^{-4}. In some parts of the world, natural sources of arsenic may contaminate water supplies and lead to poisoning of the users. The most well-documented cases of arsenic poisoning from drinking-water have come from India, where there is arsenic contamination of large numbers of rural water supplies. Common symptoms include inflamed eyes and skin lesions. Arsenic contamination has also been noted in southern Thailand and the CCEE.

Most natural arsenic comes from the reduction of arsenic complexes caused through changing redox and pH conditions and from the oxidation of arsenic containing minerals exposed by falling groundwater tables induced through

over abstraction or reduced recharge.

There is also increasing evidence that there is a tendency for arsenic levels to increase in shallow groundwaters under urban areas. This has been particularly noted where conditions become anoxic, organic rich sediments are present and arsenate compounds associated with iron are common. This has significant implications for water supply in these areas, particularly in low-income areas where community-based water projects may involve the sinking of dug and wells and shallow tube wells. Arsenic may also be discharged in effluent from a variety of industrial processes.

Control options for arsenic contamination will vary according to the source. Arsenic derived from industrial effluents should be controlled through proper treatment of wastes and monitored by the pollution control agency. The control of arsenic from natural sources must include sustainable groundwater resource management. Many of the problems noted in India result from over-abstraction of groundwater, primarily by the agricultural sector. Arsenic problems noted under urban areas may be more difficult to control given the range of factors which influence whether arsenic is released.

In all cases, short-term options will include treatment of water in home using, use of alternative sources or a switch to an alternative source, such as deep groundwater unaffected by arsenic contamination. Arsenic may be removed at treatment plants through a variety of processes, although like

most treatment aimed at chemical removal, increase the costs of producing drinking-water.

Fluoride

Fluoride in drinking-water can have toxic effects in both excess and deficiency, although WHO only set a GV of 1.5 mg/l for excess fluoride as susceptibility in deficiency is highly dependent on nutritional status.

Excess fluoride may lead to dental or skeletal fluorosis, the latter being a crippling disease which affects a number of areas including the Rift valley of East Africa and parts of India, Mexico and the former Soviet Union. However, a lack of fluoride may cause dental caries, a weakening of the teeth, thus in some circumstances fluoride may be added to the drinking-water supply.

The acceptable concentration of fluoride in water is in part related to climate, as in warmer climates the quantities of water consumed are higher thus leading to a greater risk of fluoride related problems as overall intake increases. Susceptibility of individuals to fluorosis may also be determined by renal impairment.

Control options for fluoride contamination of water include blending of fluoride-rich waters with waters of low fluoride content, selection of low-fluoride sources and removal of fluoride by treatment at public water supply or household level. Fluoride can be successfully removed by precipitation by

use of coagulants (commonly an alum-lime mix), adsorption on activated carbon substrates, osmosis or ion exchange. Fluoride removal is often more effective at a water supply level and the Nalgonda technique, developed in India, has been proven as a low-cost techniques which can operate on a variety of water supply options ranging from piped water supplies to handpump units.

References

Anon. *World Health Organization Guidelines for Drinking-water Quality, Volume I, 2nd Edition,* WHO, Geneva, 1993

Anon., *World Health Organization Guidelines for Drinking-water Quality, Volume II, 2nd Edition,* WHO, Geneva, 1996 Anon. Report of a National Water Quality Seminar, Romania, WHO-EURO, Rome, 1995

Esrey, S.A., Feacham, R.G. & Hughes, J.M., *Interventions for the control of diarrhoeal diseases among young children: improving water supplies and excreta disposal facilities,* Bulletin of the World Health Organization, vol. 63, No. 4, pp. 757-772, 1985.

Hofkes, E.H. (Ed), *Small Community Water Supplies,* John Wiley & Sons. Chicester. 1986.

Presentation Plan

Section	Key points	OHP
Introduction	• water has a profound influence on health, at the most basic level this means that a minimum amount is required for consumption each day for survival	**1**
	• the influence of water on health goes far beyond this as water is a principal medium for disease prevention	
	• WHO recognises that access to adequate water supplies is a fundamental human right	
	• this was confirmed at the Mar del Plata conference in 1977	
Water-related disease incidence	• water-related diseases account for over 80 per cent of all deaths in developing countries	**2**
	• infectious and parasitic diseases are the major cause of morbidity in developing countries and cause important outbreaks world-wide	
	• many of the water-related diseases lead to epidemics which may have relatively high mortality/morbidity ratio	
Water supply improvements	• improved water supply and sanitation will lead to reduced	**3,4**
	• incidence of morbidity and mortality	
	• this may be up to 100 per cent for some diseases such as	

	typhoid or dracunculiasis	
	• need improvements in water supply and sanitation to achieve these objectives as improvement in one aspect aloe will not produce the full health benefits expected	
	• water quality is only one aspect of water supply that should be improved	
	• increased coverage, continuity of supply and quantity of water supplied at a reasonable cost are all important	
	• infant mortality rates (a key sentinel community) can be significantly reduced with improved water supply	
Water-related disease types	• very many water-related diseases	**5**
	• not all water related diseases are fatal or lead to epidemics, but all debilitating to some degree	
	• water-related diseases may be classified on the basis of transmission	
	• the principal classes are: water-borne; water-washed; water based; and water-related insect vectors	
	• many infectious diseases can be classified in more than one group, for instance most diarrhoeal disease may be transmitted by a classic water-borne route, but are also related to inadequate quantities of water (hygiene)	

Disease transmission	• many diseases may be transmitted via the faecal-oral route	**6,7**
	• these include infectious diseases such as cholera and hep A	
	• transmission occurs when human faecal matter is ingested through drinking contaminated water or eating contaminated food	
	• water is an important medium for transmitting disease as contamination with excreta can lead to ingestion of faecal matter(see infection cycle)	

Water Quality

"All people, whatever their stage of development and social and economic condition, have the right to have access to drinking water in quantities and of a quality equal to their basic needs."

(UN Conference at Mar del Plata, 1977)

Global Morbidity and Mortality Rates

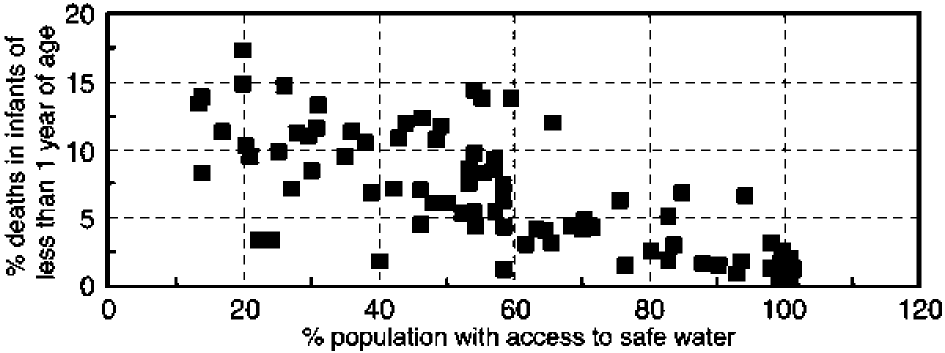
	Number/Year or Total Reported	
	Cases of disease	**Deaths**
Cholera	384,000	11,000

Cholera	384 000	11 000
Typhoid	500 000	25 000
Giardiasis	500 000	low
Amoebiasis	48 000 000	110 000
Diarrhoeal disease	1 500 000 000	4 000 000
Dracunuliasis (guinea-worm)	> 5 000	-
Schistosomiasis	200 000 000	800 000

World Health Report, 1995

Potential Reductions in Morbidity for Different Diseases as a Result of Improvements in Water Supply and Sanitation

Diseases	**Projected reduction in morbidity (%)**
Cholera, thyphoid	80-100
Diarrhoeal diseases, dysentery, gastroenteritis	40-50
Dracunuliasis	100
Schistosomiasis	60-70



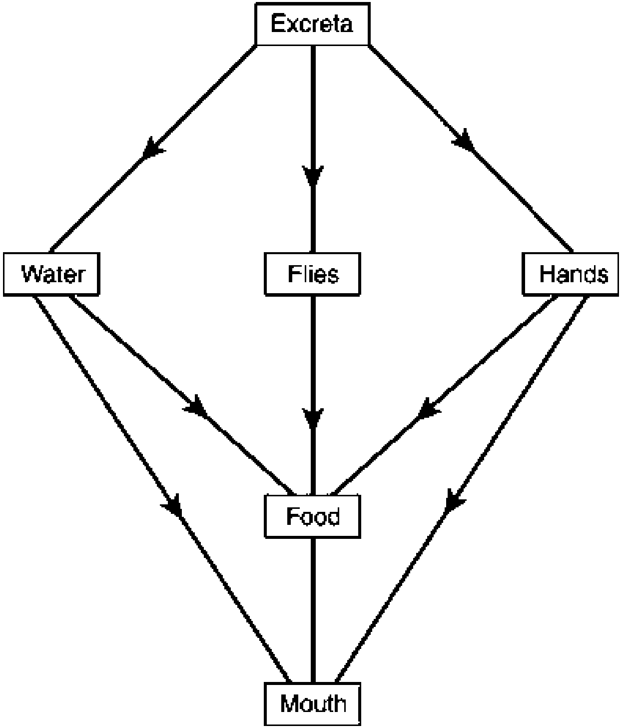
Infant Mortality versus Access to Safe Water

Source: Regli et. al 1993

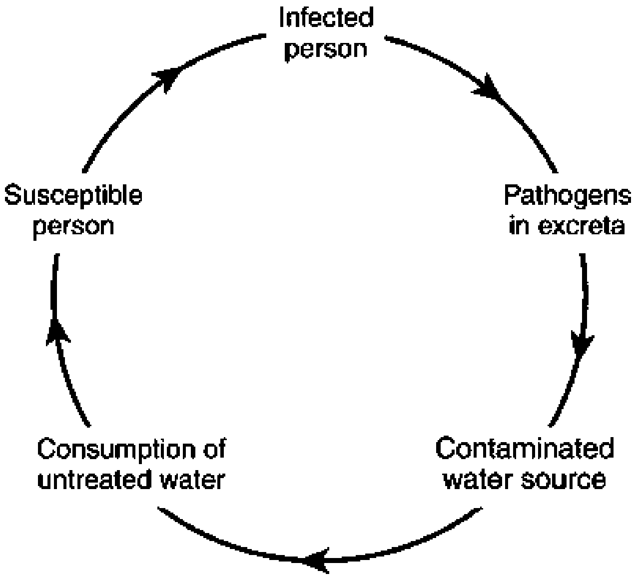
Water and Sanitation-related Diseases

Group	**Diseases**
Water-borne diseases (diseases transmitted by water)	Cholera; Typhoid; Bacillary dysentery; Infectious hepatitis; Giardiasis
Water-washed diseases (caused by lack of	Scabies; Skin sepsis and ulcers; Yaws; Leprosy; Lice and thypus; Trachoma; Dysenteries; Ascariasis; Parathphoid

water)	
Water based diseases	Schistomiasis; Dracunuliasis; Bilharziosis; Filariasis; Threadworm
Water-related insect vector diseases	Yellow fever; Dengue fever; Bancroftian filariasis; Malaria; Onchocerciasis



The Faecal-Oral Route of Disease Transmission

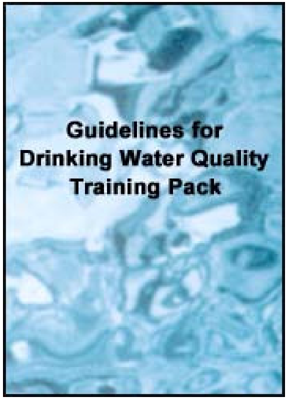


The Classical Waterborne Infection Cycle

Source: Tebbutt, T.H.Y., 1992

Home"" """"> **ar**.**cn**.**de**.**en**.**es**.**fr**.**id**.**it**.**ph**.**po**.**ru**.**sw**

Guidelines for Drinking Water Quality - Training Pack (WHO)


Guidelines for
Drinking Water Quality
Training Pack

The WHO Guidelines for Drinking-Water Quality

Session Objectives

- **To introduce the latest edition of the *Guidelines*; identifying all three volumes and the information contained within each.**

- **To emphasise the basic concept and the advisory nature of the *Guidelines* and to describe the difference between scientific risk assessment and risk management.**

- **To provide an outline of the consultation process that resulted in the revised 2nd edition of the *Guidelines.***

- **To discuss the reasoning behind the prioritisation of microbiological quality of drinking water in the *Guidelines.***

- **To provide a basic overview of the criteria used in the selection of contaminant substances that are contained within the *Guidelines*.**

- **To explain the nature of Guideline Values, highlighting substances and parameters to which they apply.**

- **To explain the process of the rolling revision of the *Guidelines.***

Introduction

An established goal of WHO and its Member States is that:

> **all people, whatever their stage of development and their social and economic conditions have the right to have access to an adequate supply of safe drinking-water.**

In this context, 'safe' refers to a water supply which is of a quality which does not represent a significant health risk, is of sufficient quantity to meet all domestic needs, is available continuously, is available to all the population and is affordable. These conditions can be summarised as five key words: quality; quantity; continuity; coverage; and, cost.

The importance of these key words cannot be over-emphasized since the impact of contaminated drinking-water on health has been well documented and range from massive outbreaks of infectious and parasitic diseases to subtle chronic toxicological effects. It is vital that all these key issues are

addressed, if clear policies and programmes on water supply and quality are to be established and maintained.

To assist governments in dealing with these and related issues regarding water quality, WHO has over the years, been involved in the review and evaluation of information on health aspects of drinking-water supply and quality and in issuing guidance material on the subject.

The first WHO publication dealing specifically with drinking-water quality was published in 1958 as *International Standards for Drinking-Water*. It was subsequently revised in 1963 and in 1971 under the same title. Because of the ever-continuing research on water quality, the 1971 standards were again reviewed, and in 1984 the *WHO Guidelines for Drinking-Water Quality* were published.

The philosophy and content of these *Guidelines* constituted a significant departure from the old *International Standards* as they were designed as advisory in nature based solely on the impacts on human health of the various substances and organisms considered. Standards have, by their nature, to take other considerations into account such as social, economic, environmental, political and financial considerations and have to balance a number of criteria.

In 1989, work was started on a second edition of the *Guidelines*. These new *Guidelines* which were published in 1993-97 rely to a great extent on the

pioneering concepts of the 1984 *Guidelines*.

The purpose of this paper is to briefly describe the second edition of the *Guidelines*, the revision process and the scope and new concepts incorporated into the *Guidelines* for the 1990s.

Presentation

The *Guidelines* have been published in three volumes:

> **Volume 1 - Recommendations describes the criteria used in selecting the various microbiological, chemical and radiological contaminants considered, the approaches used to derive the guideline values, and brief information supporting the values recommended, or explaining why no health-based guideline value was recommended.**
>
> **Volume 2 - Health Criteria and Other Supporting Information is essentially an environmental health criteria document covering the contaminants that were examined with a view to recommending guideline values. Volume 2 elaborates greatly on the health risk assessment of microbial and chemical contaminants presented in Volume 1 and should be considered as a vital companion document.**
>
> **Volume 3 - Surveillance and Control of Community Supplies deals specifically with small communities, predominantly those in rural**

areas of developing countries.

Preparation

At the time the *Guidelines for Drinking-Water Quality* were published in 1984, it was recognized that as new information on the potential health risks of contaminants in drinking-water became available, the basis of the recommended guideline values would need to be reviewed and revised. New or changed guideline values would therefore have to be recommended.

In 1988, the decision was made within WHO to initiate the revision of the *Guidelines*. As with the 1984 *Guidelines*, responsibility for carrying out this revision was shared between WHO's Headquarters and the Regional Office for Europe (EURO). Within Headquarters, both the Urban Environmental Health Unit (UEH) and the International Programme on Chemical Safety (IPCS) were involved; IPCS providing a major input to the health risk assessment of chemicals in drinking-water.

From the onset, it was agreed that the general philosophy of the 1984 *Guidelines* remained sound and valid and should therefore not be changed.

A series of planning and co-ordination meetings took place to establish the scientific approach and mechanism for the preparation of evaluation documents, substance by substance, for the revision of the *Guidelines*. This was followed by a series of Review Group Meetings dealing with specific

subject areas. A total of 19 meetings were held involving the participation of numerous institutions, and over 200 experts from some 40 different countries.

The preparation of the *Guidelines* required intensive human and financial resources. The *Guidelines* could not have been developed without the scientific and/or financial support of the following organisations and countries: DANIDA, NORAD, SIDA, ODA (UK), Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Poland, Sweden, United Kingdom, and the United States of America.

Microbial contaminants and some 128 chemicals were selected for evaluation. For each selected chemical, a lead country prepared a draft evaluation document examining its occurrence in drinking-water, exposure from food and air, effects on laboratory animals and humans. Based on the evaluation of available data, a guideline value was also proposed. The outline of such an evaluation document is given as Annex 1. These evaluations constitute Volume 2 of the *Guidelines.*

The draft evaluation document was then circulated for review by the Co-ordinator to the "support countries" and selected experts. The Co-ordinator worked with the lead countries to incorporate the comments received and prepared overviews of scientific issues to be resolved. This documentation was then submitted for evaluation to a Review Group meeting which took a decision as to the health risk assessment and recommended a guideline

value. The role of the seven Co-ordinators was crucial in the revision process.

During the preparation of draft evaluation documents and at the Review Group meetings, careful consideration was always given to previous risk assessments carried out by the WHO/ILO/UNEP International Programme on Chemical Safety in its Environmental Health Criteria Monographs, by the International Agency for Research on Cancer, the Joint FAO/WHO Meeting on Pesticide Residues and the Joint FAO/WHO Expert Committee on Food Additives which also evaluates contaminants such as lead and cadmium in addition to food additives.

Basic Concept

As reflected in the title, the *Guidelines* are of an advisory nature and are intended to be used by national or regional authorities as a basis for the development of drinking-water standards and regulations appropriate to their own socio-economic and exposure situation. The *Guidelines* clearly recognize the desirability of adopting a risk-benefit approach (qualitative or quantitative) to national standards and regulations. The establishment of drinking-water quality standards by individual governments must follow a very careful process in which the health risk is considered alongside other factors, such as technical and economic feasibility. Standards achieve nothing unless they can be implemented and enforced. When establishing national standards, consideration must be given to the practical measures

that will need to be taken with respect to finding new sources of water supply, instituting certain types of treatment, and providing for adequate surveillance and enforcement.

Priorities

Since water is essential to life, the first priority is that it must be made available to consumers even if the quality is not entirely satisfactory.

As with the 1984 *Guidelines*, the new 1993 *Guidelines* place the greatest emphasis on the microbiological quality of drinking-water. The microbial contamination of drinking-water has been implicated, directly or indirectly, in the spread of major infectious and parasitic diseases such as cholera, typhoid, dysentery, hepatitis, giardiasis and guinea-worm infection. In 1992, the United Nations Conference on Environment and Development (UNCED) estimated that '..80 per cent of all diseases, and over one-third of deaths in developing countries are water-associated, and on average as much as one-tenth of each person's productive time is sacrificed to water-related diseases' (Agenda 21, UNCED, Chapt. 18, p175). Diseases associated with water are heavily concentrated in the developing world, and within the developing world, among the poorer urban and rural households of the poorer countries.

Diseases arising from the ingestion of pathogens in contaminated water have the greatest impact worldwide. Table 1 shows the morbidity and

mortality rates of the major water-related diseases. These figures provided to WHO by Member States are in many cases underestimated. For instance, no figures are available for certain diseases such as hepatitis which are often waterborne, some countries with numerous cases of typhoid do not report any to WHO, whilst others do not have the infrastructure to conduct the necessary surveys. There can be little doubt that true annual morbidity and mortality rates are well over these figures. It would be erroneous to ascribe these diseases exclusively to unsafe drinking-water. With the exception of dracunculiasis which is transmitted solely by drinking-water, a variety of non-water sources are also important.

Table 1: Morbidity and mortality rates of some important water-related diseases (after WHO, 1995)

Disease	**Cases per year (thousands)**	**Deaths per year (thousands)**
Cholera	384	11
Typhoid	500	25
Giardiasis	500	low
Amoebiasis	48,000	110
Diarrhoeal disease	1,500,000	4,000
Ascariasis	1,000	20
Trichuriasis	100	low

Trichuriasis	100	low
Ancylostoma	1,500	60
Dracunculiasis (Guinea worm)	> 5,000	-
Schistosomiasis	200,000	800
Trachoma	360,000 (active)	9,000 (blind)

The toll of human suffering from the microbial contamination of drinking-water is indeed heavy. As with the 1984 *Guidelines*, the 1993 *Guidelines,* justifiably, stress protection of water supplies from microbial contamination and call for uncompromised disinfection of drinking-water despite the potential formation during this process of compounds with potentially harmful long-term health effects.

Selection Criteria

Thousands of organisms and substances have been identified in drinking-water supplies around the world. It is neither necessary nor feasible to develop recommendations for all these.

Microorganisms selected for evaluation were selected through an international consultation process, on the basis of the presence in water and likely risk to human health. Particular emphasis was given to developing guidance on selection of indicator organisms that can give early warning of faecal contamination and likely potential risks of disease. The *Guidelines*

adopted a clear policy from the outset that microbiological quality must be the key water quality priority.

Chemicals for evaluation were selected through an international consultative process, guided by three main criteria:

- **The substance presents a potential hazard for human health;**
- **The substance was detected relatively frequently and at relatively high concentrations in drinking-water indicating that there may be significant exposure to humans;**
- **The substance was of major international concern (i.e. of interest to several countries).**

On this basis, some 128 priority chemicals were selected for evaluation in the *Guidelines* and health-based acceptable levels of exposure from drinking-water (Guideline Values) recommended for 95 of these, taking into account all sources of exposure. *Guideline* values were not recommended for certain substances because they were found to be not hazardous to health, because of inadequate health effects information, or because the concentration of the chemical normally found in drinking-water does not represent a hazard to human health. Contaminants evaluated included chlorinated alkanes, ethylenes and benzenes, aromatic hydrocarbons, pesticides, inorganic chemicals, disinfectants and disinfectant by-products.

The Guideline Value

The recommendations made concerning water quality are expressed as Guideline values (GVs). Guideline values are not formal standards or regulatory limits and are not to be taken as strict limits such as "maximum permissible concentrations". They are intended to provide quantitative risk assessment information for regulatory authorities, risk managers, and others to make decisions concerning human health protection and to be adapted to national requirements and situations in prescribing limits and standards.

Guideline Values require adaptation because they relate to a "reference" human in a specified exposure environment. National populations and exposure situations will be different.

What is a guideline value?

- ***Guidelines*** **are set for indicator bacteria -** ***E.coli*** **or thermotolerant (faecal) coliforms and total coliforms. These have been selected as they give a good indication of the likelihood of faecal contamination and the integrity of a water supply.**

- **Unlike chemical guideline values, the presence of indicator bacteria will always represent a health risk. However, when faecal contamination is indicated, water supplies should not be closed off unless a better source of water is available for use. The**

microbiological *Guidelines* should be used as a desirable end-point and improvement in microbiological water quality should be the priority for water supply.

- **A guideline value represents the concentration of a chemical constituent that does not result in any significant risk to the health of the consumer over a lifetime of consumption.**

- **Short-term deviations above the guideline values do not necessarily mean that the water is unsuitable for consumption. The amount by which, and the period for which, any guideline value can be exceeded without affecting public health depends upon the specific substance involved.**

- **Although the guideline values describe a quality of water that is acceptable for life-long consumption, the establishment of these GVs should not be regarded as implying the quality of drinking water may be degraded to the recommended level. Indeed, a continuous effort should be made to maintain drinking-water quality at the highest possible level.**

- **When a guideline value is exceeded, the authority responsible for public health should be consulted for advice on suitable action, taking into account the intake of the substance from sources other than drinking-water (for chemical constituents), and the practicability of**

remedial measures.

- **When developing national drinking-water standards based on these guideline values, it will be necessary to take account of a variety of geographical, socioeconomic, dietary and other conditions affecting potential exposure. This may lead to national standards that differ appreciably from the guideline values.**

The recommended GVs must be both practical and feasible to implement as well as protective of public health. Guideline values are therefore not set at concentrations lower than the detection limits achievable under routine laboratory operating conditions. Moreover, guideline values are recommended only when control techniques are available to remove or reduce the concentration of the contaminant to the desired level.

Contrary to the 1984 *Guidelines*, the 1993 *Guidelines* do not propose guideline values for substances and parameters that affect the acceptability of drinking-water to consumers. The Review Groups were of the opinion that guideline values should be recommended only for those substances that are directly relevant to health.

Many of the inorganic and aesthetic constituents evaluated in the *Guidelines* are known to be essential for life. No attempt was made in the *Guidelines* to define minimum desirable concentrations of essential elements in drinking-water.

Contaminants derived from water treatment chemicals, construction materials, paints or coatings were not specifically addressed. The control of such contaminants is best accomplished by appropriate specifications for and control of the quality of the products themselves rather than the quality of the water.

The recommended guideline values are set at a level to protect human health; they may not be suitable for the protection of aquatic life.

The *Guidelines* apply to bottled water and ice intended for human consumption but do not apply to natural mineral waters, which should be regarded as beverages rather than drinking-water in the usual sense of the word. The Codex Alimentarius Commission has developed Codex standards for such mineral waters.

Future Revision

Understanding of water quality and the health risk from microbes and chemicals is constantly increasing and the knowledge base expanding. As a result, it has been agreed that there will be a continuing process of updating of the *Guidelines* with a number of substances or agents subject for evaluation each year. New editions of the *Guidelines* will be published at about ten-year intervals. For the 3rd edition of the *Guidelines*, the protection and control of water quality will be prioritised and issues such as development of monitoring and assessment methodologies in urban areas,

resource and source protection and control of chemicals and materials used in water treatment fully addressed. This will lead to the preparation of a volume 4 of the *Guidelines*, either as a single volume or in the form of a series of documents in the *Guidelines* series.

Biennial addenda to the *Guidelines* are to be issued, beginning in 1997 containing evaluations of new substances or substances already evaluated for which new scientific information has become available. Substances for which provisional guideline values have been established will receive high priority for re-evaluation. Table 2 overleaf summarises the priorities for the first addendum in 1997.

Table 2: Priorities for the first addendum, 1997

MICROBES	CHEMICALS			
	Inorganics	**Organics**	**Pesticides**	**Disinfectants & DBPs**
Hepatitis A & E	aluminium	cyanobacterial toxins	1,2-dichloropropane diquat	chloroform
Aeromonas spp.	boron	EDTA	ethylene dibromide	sodium dichloroisocyanaurate
Cyanobacteria	copper	PAHs	pentachlorophenol	

Legionella spp.	nickel		carbofuran	
Vibrio cholerae	nitrate & nitrite		2,4-D	
Cryptosporidium parvum	uranium		glycophosphate cyanazine terbuthylazine	
Giardia lambia				

Conclusions

The *Guidelines* are based on international consensus assessment of the risks to human health from the presence of microbial and chemical contaminants in drinking-water and provide a sound scientific basis for establishing standards with respect to health protection.

It is the hope of the Organization that the *Guidelines* will be utilized by governments at all levels to set new drinking-water quality standards where they do not yet exist, or to update and expand existing ones. Thus, legislators and policy makers now have access to more comprehensive and detailed information to match health criteria with economic and technological when establishing drinking-water quality standards.

Table 1: Priorities for the first addendum, 1997

MICROBES	CHEMICALS

MICROBES	CHEMICALS			
	Inorganics	**Organics**	**Pesticides**	**Disinfectants & DBPs**
Hepatitis A & E	aluminium	cyanobacterial toxins	1,2-dichloropropane diquat	chloroform
Aeromonas spp.	boron	EDTA	ethylene dibromide	sodium dichloroisocyanaurate
Cyanobacteria	copper	PAHs	pentachlorophenol	
Legionella spp.	nickel		carbofuran	
Vibrio cholerae	nitrate & nitrite		2,4-D	
Cryptosporidium parvum	uranium		glycophosphate cyanazine terbuthylazine	
Giardia lambia				

Presentation Plan

Section	**Key points**	**OHP**
Introduction	• an established goal of WHO is to ensure all population have access to an adequate water supply	
	• WHO provides advice on health-related aspects of drinking-	

	• WHO provides advice on health related aspects of drinking water	
Guidelines presentation	• *Guidelines* published in 3 volumes:	**1**
	Volume I - recommendations	
	Volume II - health criteria and other supporting information	
	Volume III - small community water supplies	
Guidelines presentation	• when 1st edition of the *Guidelines* published in 1984, it was recognised that they would need updating	**2,3**
	• 2nd edition published in 1993-97	
	• preparation went through a series of planning and co-ordination meetings to establish the scientific approach & mechanism; by review meetings	
	• microbial contaminants and 128 chemicals selected for evaluation	
	• for each microbe and chemical a lead country prepared draft document and, where appropriate, suggesting a preliminary guideline value (GV)	
	• documents circulated to review group (over 200 scientists from 40 countries) and GVs revised and approved	
Basic concept	• *Guidelines* are advisory In nature	**4**
	• intended that GVs are used as a basis for establishing	

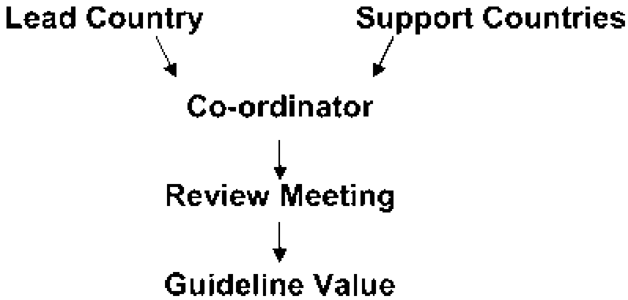
	national and regional standards based on risk assessment and prevailing socio-economic conditions	
	• the *Guidelines* stress the use of risk-benefit approaches to standard setting	
	• standards must be developed which are achievable and enforceable; this may mean setting interim standards	
Priorities for standards	• access is key priority even where quality is inadequate	**5**
	• the priority water quality concern is microbiological quality because of the link to health and acute disease	
	• 1992, UNCED estimated >80% of all disease and >1/3 deaths in developing countries are caused by the consumption of contaminated water	
	• disease associated with water heavily concentrated in less-industrialised countries in the poorer households in these countries	
	• greatest impact on health is from ingestion of pathogens	
	• available global figures on disease are likely to be underestimated	
	• improvement in microbiological quality of water should lead to a reduction in disease incidence and severity	
Selection	• major pathogens reviewed but no GVs set as routine	**6,7**

criteria	surveillance of pathogens is not practical	
	• GVs set for indicator bacteria and operational parameters such as turbidity and chlorine residual	
	• of 128 substances reviewed, GVs set for 95	
	• are not strict standards, but advisory guidelines	
Guideline Values	• provide quantitative risk assessment for authorities, but require adaptation as refer to reference human in specified exposure environment	**8,9**
	• exceeding microbial GV indicates faecal contamination and therefore health risk	
	• most chemical GV set for health risk from lifetime consumption	
	• exceedance of chemical GV for short periods does not necessarily mean water unfit for consumption	
	• no GV for aesthetic parameters	
	• no minimum concentrations specified	
	• do not address environmental/ecological concerns	
	• do not specifically address treatment chemicals, construction materials etc.	
	• do not apply to natural mineral waters	
	• rolling revision started, with addenda published every 2	

	years	
Future developments	starting 1997	**10,11, Tab 1**
	• 3rd edition will see greater emphasis on risk management	
	• new Volume IV to be prepared on protection and control of water quality	
	• GV based on international consensus of health risk	
Conclusions	• GV should be used to set or revise national/regional standards using a risk-benefit approach	
	• Guidelines require continuous updating as knowledge increases	

WHO Guidelines for Drinking-water Quality

- **Volume 1 - Recommendations**
- **Volume 2 - Health Criteria and other supporting information**
- **Volume 3 - Surveillance and control of community supplies**



Consultation Process for Setting Guideline Values (Part 1)

Consultation Process for Setting Guideline Values (Part 2)

Co-ordinators	Review Meetings
Microbiology	2
Inorganics	2
Organics and pesticides	4
Disinfectants and by-products	1
Radionuclides	1
Volume 3	2
Planning consultations	4
Other consultations	3
TOTAL	19

What is a Guideline Value?

- **For microbes: no significant risk of pathogen presence at infectious dose.**

- **For most chemicals: no significant risk to health over a lifetime of consumption.**

- **Some chemicals (e.g. nitrate): no significant risk of acute intoxication of vulnerable group.**

- **National standards may be appreciably different from guideline values.**

Priority Microbes considered in the GDWQ

- **Orally transmitted pathogens of high priority (microbes associated with human faeces)**

- **Opportunistic and other water associated pathogens (moderate priority)**

- **Toxins from cyanobacteria**

- **Nuisance organisms causing rejection**

- **Guideline values for indicator bacteria and operational parameters**

Selection Criteria

1. Adverse effects
2. Magnitude, frequency and duration of exposure
3. Population exposed
4. International concern

IARC Groups

Group 1:	The agent is carcinogenic to humans
Group 2A:	The agent is probably carcinogenic to humans
Group 2B:	The agent is possibly carcinogenic to humans
Group 3:	The agent is not classifiable as to its carcinogenicityto humans
Group 4:	The agent is probably not carcinogenic to humans

IARC overall evaluation of chlorinated drinking-water: Group 3

Guideline Values

- **No GV for individual pathogens: use indicator bacteria, turbidity and chlorine residual**

- **No GV for aesthetic parameters**

- **Treatment chemicals and construction materials not addressed**
- **No environmental effects**
- **Not for mineral water**
- **No minimum desirable level**

Provisional Guideline Values

- **Limited health effects information and/or UF>1000**
- **Health-based GV below quantitation level**
- **Health-based GV cannot be achieved through practical treatment methods**
- **Disinfection likely to result in health-based GV being exceeded**
- **GV at 10^{-5} lifetime excess cancer risk not feasible**

WHO *Guidelines for Drinking-Water Quality*

1983-4 Publication of first edition
1993-6 Publication of second edition

1997 First addendum to second edition

1999 Second addendum to second edition

2001 Third addendum to second edition

2004 Third edition

Protection and Control of Water Quality

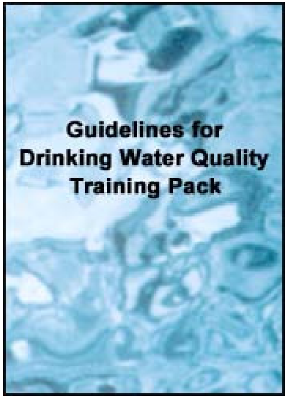
Aim to include balanced, integrated guidance on monitoring and assessment of drinking-water supply and quality and on the elements of risk management in the Guidelines in 2003.

Monitoring and assessment of water supply and quality:

» Volume 3 coverage good for rural areas
» Guidance for urban settings will be developed, field tested and revised

Risk management:

» resource and source protection
» water treatment
» chemicals and materials
» significant expansion



Guidelines for Drinking Water Quality - Training Pack (WHO)

Microbiological Aspects

Session Objectives

- **To highlight the number and range of pathogens that may be found in water.**
- **To describe some of the key preventative and monitoring actions which maintain and improve microbiological water quality.**
- **To introduce the concept and use of indicator bacteria in water quality monitoring.**

- **To describe the principal indicator bacteria used and their key characteristics which make them suitable for use as indicators.**

- **To emphasise the value of *E.coli* and thermotolerant faecal coliforms as routine indicators.**

Summary

The wide variety of waterborne diseases is the most important concern about water quality, and their public health impact has far-reaching implications. The pathogens concerned include many types of viruses, bacteria, protozoa and helminths, which differ widely in size, structure and composition. This implies that their survival in the environment and resistance to water treatment processes differs significantly. However, the waterborne transmission of infectious diseases can be controlled effectively by practical and economic methods. The approach must be based on protection of the source, selection of appropriate treatment methods, fail-safe application of the treatment methods, well protected distribution networks and appropriate quality monitoring. Relatively simple and inexpensive indicator methods are available for routine monitoring of the microbiological safety of water and the efficiency of treatment processes. Most reliable results are obtained by high frequency testing for indicator organisms selected for particular purposes. For instance, routine monitoring programmes for drinking-water may be based on tests for faecal streptococci, thermotolerant coliform organisms or *Escherichia coli*. Under

certain circumstances, tests for the heterotrophic plate count and coliphages may be included. These tests are simple, inexpensive and yield results in a relatively short time. More complicated and expensive tests such as those for human viruses and protozoan parasites are required only for particular purposes, including research and assessment of the efficiency of treatment processes.

1. Introduction

Waterborne diseases are the most important concern about the quality of water. Developing countries and rural communities are particularly vulnerable. In developed countries the mortality due to waterborne diseases is low, but the socio-economic impact is phenomenal (Avendano *et al*, 1993; Payment, 1993).

Waterborne diseases are typically caused by enteric pathogens which belong to the group of organisms basically transmitted by the faecal-oral route. In other words, they are mainly excreted in faeces by infected individuals, and ingested by others in the form of faecally contaminated water or food. Some of the pathogens may be of animal origin. Some may also be transmitted by personal contact, droplet transfer, or inhalation of contaminated aerosols. Water may also play a role in the transmission of pathogens which are not faecally excreted. These include opportunistic pathogens which are members of the normal flora of the external human body. Some of these pathogens are natural inhabitants of certain water environments. Most waterborne

pathogens are distributed world-wide, but outbreaks of some, for instance cholera and hepatitis E, tend to be regional. Dracunculiasis is geographically limited to rural areas in India, Pakistan, and sixteen countries in sub-Saharan Africa.

1.1 Enteric pathogens typically transmitted by the faecal-oral route

Bacteria:	*Salmonella* spp, *Shigella* spp, pathogenic *Escherichia coli*, *Campylobacter* spp, *Vibrio cholerae* and *Yersinia enterocolitica*.
Viruses:	Hepatitis A and E, enteroviruses, adenoviruses, small round structured viruses including Norwalk virus, astro and rota viruses.
Protozoa:	*Entamoeba histolytica*, *Giardia intestinalis*, *Cryptosporidium parvum*.

1.2 Helminths

Infections contracted by exposure to, or ingestion of, infectious larval stages of human parasites released by specific snails or cyclops:

> ***Schistosoma* spp (schistosomiasis, bilharziasis) and *Dracunculus medinensis* (dracunculiasis guinea worm). The latter is not faecally excreted but typically transmitted by water and of major public health importance in some countries.**

1.3 Opportunistic pathogens

Infections of the skin and mucous membranes of the eye, ear, nose and throat:

> ***Pseudomonas aeruginosa*, *Aeromonas*, and species of *Mycobacterium*.**

Infections contracted by the inhalation of contaminated aerosols:

> ***Legionella* spp (legionellosis), *Naegleria fowleri* (primary amoebic meningo-encephalitis) and *Acanthamoeba* spp (amoebic meningitis, pulmonary infections).**

1.4 Toxins from cyanobacteria

Toxins released by blooms of cyanobacteria (blue-green algae) such as *Microcystis aeruginosa* may adversely affect the health of animals and possibly also humans.

1.5 Nuisance organisms

A variety of non-pathogenic micro-organisms, and small plants and animals, may under undesirable conditions thrive in water supplies and cause turbidity, taste and odour, or visible animal life, which are aesthetically objectionable.

Bacterial contamination of drinking-water has resulted in numerous cases of infectious disease. The massive cholera epidemic in Latin America, which

spread from Peru to several other countries, and the recent one in Rwanda, are reminders of the speed with which certain waterborne diseases can spread.

Viruses feature prominently among the wide variety of waterborne pathogens. Examples include the 1991 outbreak with 70,000 cases of hepatitis E caused by polluted drinking-water in Kanpur (Grabow *et al*, 1994a). Reasons for the high incidence of waterborne viral infections include excretion in exceptionally high numbers by infected individuals, relatively high resistance to unfavourable environmental conditions including water treatment and disinfection processes, and a minimal infectious dose which may be as low as a single viable viral particle (Payment, 1993). The impact of viral infections is aggravated by secondary and even tertiary transmission by routes other than the water which caused the original infection (Morens *et al*, 1979). Epidemiological studies on waterborne viral infections are complicated by the absence of clinical symptoms in many individuals, particularly children, while all infected individuals excrete viruses at similar rates.

Recent years have seen a substantial increase in the number of waterborne *Giardia* and *Cryptosporidium* outbreaks. The cysts and oocysts of these protozoan parasites are extremely resistant to water treatment and disinfection processes, and their minimal infectious dose is low (Casemore, 1991; Craun, 1991).

Despite modern technology and know-how, waterborne diseases continue to have a major public health and socio-economic impact, and at least in parts of the world their incidence may even increase (Craun, 1991). Challenges to control waterborne diseases are complicated by continuous changes in the composition and priority of waterborne pathogens. Factors which affect the occurrence of pathogens include changes in population densities, socio-economic situations, standard of living, education, vaccination, climate, geography, urbanisation, migration and travelling, and public health policies.

The role of microbiological analysis is very important in a strategy for the control of waterborne diseases based on appropriate treatment systems, appropriate operation of the treatment systems, and appropriate quality monitoring.

2. Water Treatment and Disinfection Technology

A wide variety of treatment systems and disinfection processes are available to ensure the safety of water supplies. At the low technology and inexpensive end of the range there are methods such as simple sand filtration of water, the addition of household bleach to a bucket of drinking-water, storage of water, the exposure of water to sunlight, or boiling of drinking-water. At the other end of the range there are multiple-barrier treatment trains capable of the direct reclamation of drinking-water from waste water. All of these systems are capable of producing safe water. Consideration of the quality of available raw water sources is an integral

part of the selection of appropriate treatment methods. The challenge is to select the appropriate system for each particular situation. Each situation has to be evaluated in its own merit, based on considerations such as the raw water quality, intended use of the water, financial resources, and technological capabilities.

3. Operation of Water Treatment Systems

The wide variety of treatment systems capable of producing safe water mentioned above, are without exception subject to potential breakdown and human failure in operation, supervision and quality surveillance. There is not even an indication that in the foreseeable future we can hope for a practical fail-safe water treatment system. Successful operation and supervision of treatment systems, improvement of technical capabilities, and training programmes aimed at meeting water quality requirements, are very important. The production of safe water is not possible without fail-safe operation and supervision of treatment systems (Bellamy, 1993).

4. Microbiological Water Quality Monitoring

Transmission of diseases by treated water supplies can be ascribed to inappropriate treatment methods, failure in operation and supervision, or shortcomings in quality monitoring. In fact, it can theoretically be argued that all waterborne diseases can be prevented by appropriate monitoring and corrective measures taken in good time. Since there is no indication that

we can expect to see practical fail-safe treatment systems, or an elimination of human failure or error in the operation and supervision of treatment systems, appropriate microbiological quality monitoring will remain an indispensable component of strategies for the control of waterborne diseases.

Regular inspection of sanitary and hygienic aspects of raw water sources, treatment facilities and distribution networks is an important component of quality monitoring programmes, and is particularly important with regard to pathogens such as viruses and protozoan parasites which are not readily detectable in water.

4.1 Indicator organisms

Since it would be practically impossible to test water for each of the wide variety of pathogens that may be present, microbiological water quality monitoring is primarily based on tests for indicator organisms. There is no single indicator organism that can universally be used for all purposes of water quality surveillance. Each of the wide variety of indicators available for this purpose has its own advantages and disadvantages, and the challenge is to select the appropriate indicator, or combination of indicators, for each particular purpose of water quality assessment.

Indicators most commonly used are of faecal or sewage origin, and the following are some of the most important requirements of such indicators:

a) Present whenever pathogens are present.

b) Present in the same or higher numbers than pathogens.

c) Specific for faecal or sewage pollution.

d) At least as resistant as pathogens to conditions in natural water environments, and water purification and disinfection processes.

e) Non-pathogenic.

f) Detectable by simple, rapid and inexpensive methods.

Ideally, various other properties are desirable, such as counts which are directly related to those of pathogens. However, the fundamental and most important requirement is that pathogens should be absent or inactivated whenever indicators are absent or inactivated.

Many indicators have been studied and recommended for water quality assessment (ISO, 1990; Standard Methods 1992). Evaluation of the reliability of indicators is carried out by comparison of their incidence and survival in water and treatment processes with that of selected pathogens, by epidemiological studies on the consumers of water supplies, by calculations based on the minimal infectious dose of pathogens, and by experiments with human volunteers (Regli *et al*, 1991). The following is a summary of the most important features of commonly used indicators:

4.1.1 *Escherichia coli*

This species is a member of the group of faecal coliform bacteria. *Escherichia coli* has the important feature of being highly specific for the faeces of man and warm-blooded animals. For all practical purposes these bacteria cannot multiply in any natural water environment and they are, therefore, used as specific indicators for faecal pollution. They are generally distinguished from other thermotolerant coliforms by the ability to yield a positive indole test within 24 hours at 44.5°C. More recently, *E. coli* is also identified by possession of the enzyme -glucuronidase, which hydrolyses the fluorogenic substrate 4-methyl-umbelliferyl--D-glucuronide (MUG) with release of the fluorogen which can be observed in liquid media under ultraviolet light. Media based on hydrolysis of MUG are commercially available under names such as "Colilert". Such complex sets of tests for the final confirmation of *E. coli* are not recommended as a routine.

4.1.2 Thermotolerant coliform bacteria

This term refers to certain members of the group of total coliform bacteria which are more closely related to faecal or sewage pollution, and which generally do not readily replicate in water environments. This group of bacteria is also known as faecal coliforms, presumptive *E. coli*, faecal *E. coli*, faecal coli, etc. Thermotolerant coliforms are primarily used for the assessment of faecal pollution in waste water and raw water sources. They are detectable by simple and inexpensive tests, and are widely used in

routine water quality monitoring. The test methods used are the multiple tube and membrane filtration using mFC medium and incubation for 24 hours at 44.5°C. In the membrane filtration individual colonies can be identified, and the presence of *Escherichia coli* provides strong evidence of faecal pollution.

4.1.3 Coliform bacteria (total coliforms)

The term "coliform bacteria" refers to a vaguely defined group of Gram-negative bacteria which have a long history in water quality assessment. In outdated literature these bacteria go by all sorts of names, including coliforms, colis, etc. Some of the bacteria included in this group are almost conclusively of faecal origin, while other members may also replicate in suitable water environments. These bacteria, which can be determined by simple and inexpensive tests, are primarily used for assessment of the general sanitary quality of finally treated and disinfected drinking-water. Methods used are multiple tube or membrane filtration using LES Endo agar and incubation for 24 hours at 35-37°C. More recently coliform bacteria are also identified by their possession of the enzyme -D-galactosidase, which hydrolyses chromogenic substrates such as ortho-nitrophenyl--D-galactopyranoside (ONPG), resulting in release of the chromogen and a colour change in liquid media.

The primary purpose of coliform tests is not to detect faecal pollution but to screen the general sanitary quality of treated drinking-water supplies.

4.1.4 Enterococci

Enterococci, sometimes referred to as faecal streptococci, is a group of bacteria more closely related to faecal pollution than total coliforms because most members of this group do not replicate as readily in water environments. These Gram-positive bacteria tend to be more resistant than faecal coliforms (Gram-negative), and are detectable by practical techniques, such as membrane filtration using m-enterococcus agar and incubation at 44.5° or 37°C for 48 hours. Presently the group is considered to primarily include only *Enterococcus faecalis*, *E. faecium*, *E. durans* and *E. hirae*. More recently enterococci are identified by the ability to hydrolyse 4-methyl-umbelliferyl--D-glucoside (MUD) in the presence of thallium acetate, nalidixic acid and 2,3,5-triphenyl-2H-tetrazolium chloride (TTC) resulting in release of the fluorogen which in liquid media is readily detectable under ultraviolet light.

4.1.5 Sulphite-reducing clostridia

An important advantage of these Gram-positive anaerobic bacteria is that their spores are more resistant to conditions in water environments, as well as treatment and disinfection processes, than most pathogens, including viruses. Clostridia are sometimes considered as too resistant, and their inclusion in water quality guidelines as too stringent. One of the members of the group, *Clostridium perfringens*, is like *E. coli* highly specific for faecal pollution. Clostridia generally occur in lower numbers in waste water than

coliform bacteria. Detection methods are relatively expensive and time-consuming.

4.1.6 Heterotrophic plate count

This test is also known as the total or standard plate count. The test detects a wide variety of organisms, primarily bacteria, which give an indication of the general microbiological quality of water. The test is simple and inexpensive, yields results in a relatively short time, and has proved one of the most reliable and sensitive indicators of treatment or disinfection failure. The generally used test method is pour plates using a rich growth medium such as yeast extract agar and incubation for 48 hours at 37°C.

4.1.7 Other indicators

A variety of other indicators has been used in water quality assessment, including cytopathogenic human viruses, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, acid-fast bacteria, *Legionella* species, *Candida albicans*, and endotoxins. All of these have advantages for certain purposes.

4.2 Protozoan parasites

The cysts and oocysts of intestinal parasites such as Giardia and Cryptosporidium species are exceptionally resistant, and they generally occur in low numbers in raw and treated water supplies (Casemore, 1991;

Bellamy *et al*, 1993). In addition, they are not readily detectable, and their behaviour in water treatment and disinfection processes differs extensively from that of commonly used indicators. Quality control is, therefore, generally based on specifications for raw water quality and the efficiency of treatment processes rather than indicators or testing for cysts and oocysts (Regli *et al*, 1991).

4.3 Human viruses

The incidence and behaviour of human viruses in water environments and treatment processes may differ extensively from that of faecal indicators for reasons such as:

> **a) Viruses are excreted only by infected individuals, and coliform bacteria by almost all people and warm-blooded animals. Numbers of viruses in water environments are, therefore, generally lower than those of indicators such as faecal coliforms by several orders of magnitude.**
>
> **b) Viruses are excreted for relatively short periods in numbers of up to 10^{12}/g of faeces, while coliform bacteria are excreted fairly consistently in numbers of about 10^{9}/g of faeces.**
>
> **c) The structure, composition, morphology and size of viruses differs fundamentally from that of bacteria, which implies that behaviour and**

survival in water differ.

In view of the above differences it is not surprising that bacterial indicators such as coliform bacteria have shortcomings as indicators for viruses. These shortcomings have been confirmed in epidemiological studies and research on the incidence of indicators and viruses in water supplies. Ideally water quality surveillance should, therefore, include tests for viruses. Unfortunately, however, tests for viruses are relatively expensive, complicated and time consuming, and require sophisticated facilities and know-how. In addition, the great majority of viruses concerned are not detectable by conventional virological cell culture techniques. Control of the virological safety of water is, therefore, as in the case of protozoan parasites, often based on raw water quality and specifications for purification and disinfection processes rather than testing of the treated water (Regli *et al*, 1991).

4.4 New developments in microbiological water quality monitoring

4.4.1 Bacteriophages

Bacteriophages (phages) are viruses which infect bacteria. In terms of size, structure, morphology and composition they closely resemble human viruses. The behaviour of phages in water and related environments, and their resistance to unfavourable conditions, treatment systems and disinfection processes do, therefore, more closely resemble those of human

viruses than bacterial indicators of faecal pollution.

Phages can replicate only in specific host bacteria, which implies that the phages of *E. coli* (coliphages) are, like their hosts, related to faecal pollution. Phages commonly used in water quality assessment include the groups of phages known as somatic and male-specific coliphages, which each have their own indicator advantages and disadvantages. Phages which infect *Bacteroides fragilis* strain HSP40 are highly specific for human faeces, and can be used to distinguish between faecal pollution of human and animal origin (Grabow *et al*, 1994b). Evidence supporting the indicator value of phages is accumulating, and their inclusion in quality monitoring protocols is gaining ground rapidly.

4.4.2 Virological analysis of water

Although desirable, virological analysis is not included in many routine surveillance protocols because of cost, complexity and time. In addition, the great majority of viruses concerned are not detectable by conventional techniques. However, progress is being made in the development of more practical and meaningful techniques, and virological monitoring for certain purposes is becoming more feasible. Challenges include the recovery of small numbers of viruses from large volumes of water, the detection of a wider variety of viruses, and reduction in the cost of testing (Standard Methods, 1992).

4.5 Indicator strategies in water quality surveillance

Since no single indicator can fulfil all the needs of water quality surveillance, best results are obtained by using appropriate combinations of indicators for various purposes. Each of these indicators offers certain information, which in combination yields a reliable picture of the quality of the water under investigation. For instance, indicators selected for monitoring the quality of treated drinking-water supplies may primarily be based on tests for *Escherichia coli* to detect faecal pollution. However, under certain circumstances indicators such as the heterotrophic plate count, total coliforms and somatic coliphages may yield valuable additional information.

Breakdown in treatment plants, and human error in operation and supervision, generally take place without warning, in fact, like a thief at night they tend to strike when least expected. This implies that quality surveillance programmes should make provision for microbiological monitoring at the highest possible frequency, in order to detect problems at the earliest possible stage. Since monitoring programmes are subject to many variables and considerations, including the raw water source and treatment system concerned, as well as available financial resources, facilities and manpower, it is not possible to formulate universal sampling protocols. Each case has to be evaluated in its own merit. With regards to sampling frequencies, it is important to keep in mind that it is better to run simple and inexpensive tests at high frequency than complicated and expensive tests at low frequency.

Important principles in sampling procedures include aseptic collection in sterile containers, and delivery at the laboratory for testing preferably within two hours of collection. The inclusion of samples collected at the consumer's tap is advisable, and so is the collection of samples at different times of the day and different days of the week.

5. Microbiological Water Quality Guidelines

Water quality guidelines and standards recommended by various authorities are similar in that they intend to ensure the minimum risk of infection. However, they differ in detail because of considerations such as economic and technical capabilities, and perceptions of acceptable risks of infection.

The *Guidelines* state that drinking-water must not contain waterborne pathogens. More specifically, *E. coli* or thermotolerant coliforms should not be present in 100 ml samples of drinking-water at any time, for any type of water supply, treated or untreated, piped or unpiped. In the case of large supplies, where sufficient numbers of samples are examined, total coliforms are acceptable in the distribution system in a maximum of 5% of samples taken throughout any 12 month period (Annex 1).

If guideline values are exceeded, immediate investigative action must be taken, including repeat testing, and thorough inspection of the treatment plant and its operation, the raw water source, and general hygiene of the water distribution system.

It is recognised that, in the great majority of rural water supplies in developing countries, faecal contamination is widespread and achieving the guideline values for *E. coli* or thermotolerant coliforms is often not possible. Under these conditions, the national surveillance agency should set medium-term targets for the progressive improvement of water supplies, as recommended in Volume 3 of *Guidelines for drinking-water quality* (Surveillance and control of community supplies).

Because routine monitoring techniques are not available for viruses, protozoa and helminths of health significance, the *Guidelines* recommend protection of the source and treatment techniques to ensure their absence. The degree of treatment required is a function of the nature (ground or surface water) and level of faecal contamination of the source.

To ensure the absence of viruses, the *Guidelines* recommend that the following conditions of disinfection with chlorine be met:

Residual free chlorine	≥ 0.5 mg/litre
Contact time	≥ 30 minutes
pH	< 8.0
Median turbidity	≤ 1 Nephelometric Turbidity Unit (NTU)
Maximum turbidity	= 5 NTU

The control of pathogenic protozoa and guinea-worm requires efficient

filtration since these organisms are rather resistant to disinfection.

6. Conclusions

- **Waterborne diseases have a major public health and socio-economic impact, and are the most important concern of water quality.**

- **Strategies for the control of waterborne diseases must be based on the selection of appropriate water sources and treatment systems, fail-safe operation of these treatment systems, and reliable bacteriological quality monitoring.**

- **A wide variety of treatment and disinfection systems is available for reliable production of microbiologically safe drinking-water.**

- **Reliable guidelines for the microbiological safety of drinking-water are available.**

References

Avendano P, Matson D O, Long J, Whitney S, Matson C C and Pickering L K (1993). Costs associated with office visits for diarrhea in infants and toddlers. Pediatric Infectious Diseases Journal 12, 897-902.

Bellamy W D, Cleasby J L, Logsdon G S and Allen M J (1993). Assessing

treatment plant performance. Journal of the American Water Works Association 85, 34-38.

Casemore D P (1991). The epidemiology of human cryptosporidiosis and the water route of infection. Water Science and Technology 24, 157-164.

Craun G F (1991). Causes of waterborne outbreaks in the United States. Water Science and Technology 24, 17-20.

Grabow W O K, Favorov M O, Khudyakova N S, Taylor M B, and Fields H A (1994a). Hepatitis E seroprevalence in selected individuals in South Africa. Journal of Medical Virology (in press).

Grabow W O K, Neubrech T E, Holtzhausen C S and Jofre J (1994b). *Bacteroides fragilis* and *Escherichia coli* bacteriophages: excretion by humans and animals. Water Science and Technology. (Submitted for publication).

ISO (1990). Detection and enumeration of coliform organisms, thermotolerant coliform organisms, and presumptive *Escherichia coli*.

Part 1: Membrane filtration method (9308-1:1990).
Detection and enumeration of coliform organisms, thermotolerant coliform organisms, and presumptive *Escherichia coli*.
Part 2: Multiple tube (most probable number) method (9308-2:1990).

Morens D M, Zweighaft R M, Vernon T M, Gary G W, Eslien J J, Wood B T, Holman R C and Dolin R (1979). A waterborne outbreak of gastroenteritis with secondary person-to-person spread: Association with a viral agent. The Lancet i, 964-966.

Payment P (1993). Prevalence of disease, levels and sources. In: Safety of Water Disinfection: Balancing Chemical and Microbial Risks. International Life Sciences Institute, Washington DC.

Regli S, Rose J B, Haas C N and Gerba C P (1991). Modelling the risk from giardia and viruses in drinking-water. Journal of the American Water Works Association 92, 76-84.

Standard Methods (1992). Standard Methods for the Examination of Water and Wastewater, 18th Edition. Eds.: A E, Clesceri L S, Eaton A D. American Public Health Association, Washington DC. pp 9-1 - 9-147.

Annex 1
BACTERIOLOGICAL QUALITY OF DRINKING-WATER

Organisms	Guideline value
All water intended for drinking	
E. coli or	Must not be detectable in any 100-ml sample

thermotolerant coliform bacteria	
Treated water entering the distribution system	
E. coli or thermotolerant coliform bacteria	Must not be detectable in any 100-ml sample
Total coliform bacteria	Must not be detectable in any 100-ml sample
Treated water in the distribution system	
E. Coli or thermotolerant coliform bacteria	Must not be detectable in any 100-ml sample
Total coliform bacteria	Must not be detectable in any 100-ml sample. In the case of large supplies, where sufficient sample are examined, must not be present in 95% of samples taken throughout any 12-month period.

Presentation Plan

Section	Key points	OHP
Introduction	• very many different types of microorganisms in water, some of which are harmful (pathogens) and some of which are not	**Table 1 & 2**
	• pathogens may be bacteria, viruses or parasites	
Pathogens in water	• *Guidelines* considered many types of pathogens including bacteria, viruses, protozoa and helminths	**1**
	• Pathogens have distinguishing properties that make them very different from chemical pollutants and influence GV setting	
	• GV not set for pathogens as there is no lower tolerable limit, any ingestion of pathogens represents some risk to health	
Monitoring and preventative actions	• water quality is prone to rapid variability and failures often discrete events	**2**
	• water quality failure may be caused by poorly protected sources, inadequate or failures in treatment or leaking distribution systems	
	• to ensure water quality need to use four key approaches: water quality analysis, sanitary inspection, source protection &	

	minimum treatment requirements	
	• water quality analysis only identifies contamination once it has occurred, sanitary inspection identifies potential risks and source protection and minimum treatment limit risks	
The need for indicators	• analysis of pathogens difficult, expensive and is essentially a reactive process - fails to provide a warning about potential problems	**3**
	• therefore need a system to identify water supplies which represent a health risk before disease outbreaks occur	
	• risks associated with faecal contamination, so use indicator bacteria which indicate faecal contamination	
Properties of indicators	• faecal indicators should be present in water where there is faecal contamination	**4, 5**
	• indicators should be present in greater numbers than pathogens	
	• they should have the same resistance to disinfectants and environmental stress as the most resistant pathogens	
	• they should not multiply under environmental conditions	
	• should be easy and cheap to carry out analysis of indicators	
Examples of indicators	• number of indicators may be used	**6**
	• these have different characteristics and may be used for	

	different purposes or under different conditions	
	• examples of indicator bacteria include: total coliforms, thermotolerant coliforms, *E.coli*, faecal streptococci, *Clostridium* and *Pseudomonas*	
	• these all derive purely or in part from human faeces and are present in large numbers	
	• indicator bacteria are not particularly effective in indicating presence of viruses which are more resistant and persistent than bacteria	
	• coliphages may also be used as indicators, although this is under debate at present	
Principal indicator bacteria	• the most commonly used indicators are total, thermotolerant coliforms and *E.coli*	**7**
	• total coliforms grow at 37^{o}C, but do not come from a purely faecal origin	
	• presence of total coliforms in water supplies indicates a leakage or biofilm problem and thus a potential risk from ingress of surface water	
	• *E.coli* is the most commonly used faecal indicator bacteria for which thermotolerant (faecal) coliforms are an accepted substitute	

	• there should be zero thermotolerant coliforms in 100 ml of drinking water	
The use of other indicators	• other indicators may be used for other reasons such as indication of operational problems or because they are more resistant to disinfection than coliforms	
	• faecal streptococci are more persistent than *E. coli* and rarely multiply in polluted water, but may come from animal faeces	
	• however, they tend to be present in lower numbers than *E. coli*	

Problems in Setting Guideline Values for Individual Pathogens

- **Pathogens are discrete and not in solution**
- **Pathogens often in clumps or adhere to suspended solids**
- **Cannot predict likelihood of infectious dose from average concentration**
- **Infection and disease development dependent on invasiveness, virulence and immunity**
- **Dose-response not cumulative**

Ensuring Microbiological Quality

- **Water quality analysis**
- **Sanitary inspection**
- **Source protection**
- **Minimum treatment requirements**

Need for Faecal Indicator Organisms

- **Pathogen analysis:**

  » expensive
  » impracticable
  » techniques may be time consuming
  » reactive

- **Reliance is therefore placed on relatively simple and more rapid tests for the detection of certain intestinal bacteria which indicate that faecal contamination could be present.**

Characteristics of the Ideal Faecal Indicator

1. Should be present in wastewater and contaminated water when there are pathogens

2. Should be present when there is a risk of contamination by

pathogens

3. Should be present in greater numbers than the pathogens

4. Should not multiply in environmental conditions under which pathogens cannot multiply

5. The indicator population should correlate with the degree of faecal contamination.

6. The survival time in unfavourable environmental conditions should exceed that of pathogens

7. Should be more resistant to disinfectants and other stresses than the pathogens

8. Should present no health risk

9. Should be easy to enumerate and identify by simple methods

10. Should have stable characteristics and give consistent reactions in these analyses

Examples of Indicator Organisms

	Percentage in mammal faeces	LOG_{10}/g

Total coliforms	Viable, but many environmental sources	
Thermotolerant coliforms	100 (environmental source in tropical waters?)	7-9
E. coli	100	7-9
Faecal streptococci	100	5-6
Clostridium perfringens	13-35	6-7
Pseudomonas aeruginosa	3-15	3-5
Bacteriodes fragilis	100	7-10
Coliphages		
• **Somatic**	60	1-8
• **F-Specific**	6	1-2

Principal Indicator Bacteria

Principal indicator bacteria are:

- ***Escherichia coli***
- **Faecal coliforms (95% are *E.coli*, ± 44^{o}C)**
- **Faecal streptococci**

Table 1: Examples of Pathogens Considered in the Guidelines

Pathogen	Health significance	Persistence in water supplies	Resitance to chlorine	Relative infectious dose	Important animal reservoir
Bacteria					
Camplyobacter jejuni, C.coli	High	Moderate	Low	Moderate	Yes
Pathogenic *E.coli*	High	Moderate	Low	High	Yes
Salmonella typhi	High	Moderate	Low	High	No
Shigella spp.	High	Short	Low	High	No
Vibrio cholera	High	Short	Low	High	No
Yersina enterocolitica	High	Long	Low	High (?)	Yes
Pseudomonas aeruginosa	Moderate	May multiply	Moderate	High (?)	No
Aeromonas spp.	Moderate	May multiply	Low	High (?)	No
Viruses					
Adenoviruses	High	?	Moderate	Low	No
Enterovirus	High	Long	Moderate	Low	No
Hepatitus A	High	?	Moderate	Low	No

Norwalk virus	High	?	?	Low	No
Rotavirus	High	?	?	Moderate	No (?)
Small round virus	Moderate	?	?	Low (?)	No
Protozoa					
Entamoeba histolytica	High	Moderate	High	Low	No
Giardia intestinalis	High	Moderate	High	Low	Yes
Cryptosporidium parvum	High	Long	High	Low	Yes
Helminths					
Dracunculus medinensis	High	Moderate	Moderate	Low	Yes