I C H D 1996/97

S y l l a b u s

Environmental Health, Water and Sanitation

33rd International Course in Health Development
September 4, 1996 - June 20, 1997

Health Care Training

Block	Environmental Health, Water and Sanitation
Part [1]	
Duration	4 half days (Monday 24/2 - Wednesday 26/2/97)
Facilitator(s)	R. Slooff
Learning objectives	At the end of the block/session the participants should be able to: -understand the relationship between environment and health; -understand the role of water in this relationship; -contribute to the scoping of water resources development projects, as part of environmental assessment.
Activities/topics to be covered	1. Health and environment 2. Water in the world 3. Water and health 4. Water resources development and health
Methods	Individual presentations (1 above), discussions (2 and 3 above), exercise in groups (4 above)
Materials used in class	Handouts, exercise materials
Required reading beforehand	S, Cairncross & R. Feachem, Environmental Health Engineering in the Tropics, an Introductory Text, John Wiley & Sons, Ltd.,1993: **Part I, section 1:** "Engineering and infectious disease", pp 2-20 **Part IV, section 15:** "Dams, irrigation and health", pp 221-231
Recommended further reading	WHO Regional Office for Europe/Centre for Environmental Management and Planning (CEMP), Environmental and Health Impact Assessment of Development Projects, a Handbook for Practitioners, 1992 A. McMichael et al, Climate Change and Human Health, WHO publication WHO/EHG/96.7, 1996
Evaluation method	Written examination

Block	Environmental Health
Part [2]	Water and Sanitation
Duration	4 half days (Wednesday 26/2 - Friday 28/2)
Facilitator(s)	I. van Hooff, D. de Jong, E. Bolt, J. Smet, B. Westerhof,
Learning objectives	At the end of the block/session the participants should be able to: - explain that to improve health by containing water and sanitation related diseases both hardware and behavioural changes are needed - understand the process and options in technology selection for long-term sustainability - state key aspects of water quality and to assess the feasibility of water quality monitoring - propose some effective approaches on water and sanitation for district health departments, including issues related to interdepartmental integration and cooperation - assess the importance of hygiene education as intermediary between health care and water supply projects and to know the steps involved in setting up a hygiene education programme - get a basic idea about the type of documents available in the IRC library and the kind of services the documentation unit can provide
Activities / topics to be covered	Introductory session on water supply, sanitation and health Relation between water supply, sanitation and health; technical aspects Monitoring of water quality, co-operation between departments, integration of water supply and sanitation in own District Health Plan Hygiene education; risk identification, message development and communication approaches.
Methods	lectures, role play, discussions, group work
Materials used in class	video

Required reading beforehand	Required reading beforehand: - Cairncross, S. and Feachem, R. (1993) Environmental Health Engineering in the Tropics, John Wiley and Sons, Chichester. (Thursday morning session: chapter 5 and 8) . (Thursday afternoon session: chapter 3 and 9) - Boot, M. (1991) Just Stir Gently, the way to mix hygiene education with water supply and sanitation, IRC International Water and Sanitation Centre, The Hague. (Friday afternoon session: Chapter 1, 2 and 5)
Recommended further reading	Recommended further reading - WHO (1996) Guidelines for Drinking Water Quality. Vol. III; WHO Geneva Lloyd, B. and Helmer, R. (1991). - Surveillance of Drinking Water Quality in Rural Areas. Longman, Harlow, UK. Feachem et al. (1983) - Sanitation and Disease, Health aspects of excreta and waste water management. John Wiley & Sons, Chichester
Evaluation method	written test

HEALTH AND ENVIRONMENT

author: Dr. R. Slooff

IMPORTANT CONCEPTS (1):

ENVIRONMENTAL COMPARTMENTS

- water
- air
- soils
- biota (microbes, plants, animals)

ECOSYSTEMS (water, air, soils, biota)

BIODIVERSITY

IMPORTANT CONCEPTS (2):

- Hazard (yes/no)
- Risk (quantifiable)
- Exposure (yes/no, dose, level & duration)
- Exposure pathway (from source to human target)
- Exposure route (oral, dermal, by inhalation, sensory)
- Absorption (absorbed dose)

KINDS OF RISKS:

- physical (heat/cold, explosion, radiation, noise)
- chemical (toxic, mutagenic, carcinogenic)
- biological (pathogenic, vector, carrier, toxic)
- social (violence, inequity, poverty, work/family-related)
- aesthetic (environmental degradation, lack of "harmony")

IMPORTANT PUBLIC HEALTH TOOLS:

- Risk assessment (hazard identification, risk characterization, exposure assessment & risk estimation)
- Risk management (risk evaluation, exposure control & risk monitoring)
- Environmental Impact Assessment (EIA)
- Environmental Health Impact Assessment (EHIA)
- Standard setting
- Epidemiology & monitoring

WATER IN THE WORLD

MAJOR ISSUES AND CONCERNS:

- Only 0.26% of freshwater stocks are *usable* (90000 km^3)
- Only half of that is *available*
- It is unevenly distributed
- The demand is growing, due to development and demographic growth
- Greatest users: agriculture and industry
- Scarcity of water for human consumption (20 countries with < 1000 m^3/person/yr today, 45 countries by 2050)

FRESHWATER POLLUTION:

- Quantity and quality closely linked
- Pollution increasing (sewage, industrial effluents, run-off from agricultural areas), affecting surface and groundwater sources
- Concerns related to development:

1950s:	oxygen balance
1960s:	+ eutrophication
1970s:	+ heavy metals
1980s:	+ acidification, organic micro pollutants, nitrates
1990s:	+ groundwater contamination
2000s:	+ POPs?

THE MARINE ENVIRONMENT, MAJOR ISSUES:

- POLLUTION (sewage, POPs, radioactive substances, heavy metals, oils/hydrocarbons, nutrients)
- SEDIMENT MOBILIZATION, LITTER
- OVERFISHING
- ALGAL BLOOMS
- CORAL DIE-OFFS
- RISING SSTs AND SEA LEVELS

WATER-RELATED INFECTION, 4 APPROACHES FOR CONTROL:

- Water-borne	Improve water quality Prevent use of unimproved sources
- Water-washed	Increase water quantity Improve accessibility/reliability Improve hygiene
- Water-based	Decrease water contact Control aquatic disease hosts Improve sanitation
- Water vectors	Environmental management Vector control Self-protection/prophylaxis

HEALTH AND ENVIRONMENT IN SUSTAINABLE DEVELOPMENT, WHO, *IN PRESS*

1 Water use

The saying, "Water is life", is found in different forms in many cultures around the world as sufficient clean water is clearly an absolute necessity for healthy living. Yet, for a large fraction of the world's population, water supplies are neither safe nor adequate. Understanding the driving pressures that affect water quantity and quality is the first step to rectifying this situation and crucial to assuring sustainable supplies.

1.1 Global freshwater resources

The world's freshwater resources are limited. Of the total 35 million km^3 of freshwater stocks available on a long-term basis, only 90 000 km^3, or just 0.26%, is usable. But most of this is stored in ice caps, glaciers and in permanent snow covers in the Antarctic and Arctic regions. The remainder — that is, the only fresh water which is *available* for use — amounts to a total global average of about 40 700 km^3 per year (Gleick, 1993). Moreover, freshwater resources are unevenly distributed over the global land mass, and about two-thirds of fresh water runs off to the oceans. This leaves about 14 000 km^3 as a relatively stable supply (FAO, 1994, p.236).

Most renewable freshwater resources are concentrated in the temperate climatic zone and in the humid tropics. In the tropical, subtropical, semi-arid and arid regions, where most of the world's population lives, the already limited nature of water resources, combined with extreme uneven regional and seasonal distribution often leads to severe water shortages and growing water scarcity. However, geographical distribution of water resources is actually more important than national water availability per capita since agglomerations of population centres are often not matched by concurrent water resources. However, water management can do much to alleviate the unevenness of freshwater distribution. Since the sum of available water remains nearly constant and the population is increasing rapidly, particularly in the developing countries, the maximum per capita demand that a country can support is decreasing correspondingly.

Most future population growth (about 95%) will take place in the developing countries of Africa, Asia and Central and South America. Per capita water availability can therefore be expected to decrease in these regions. Currently, per capita availability is highest in South America and lowest in North Africa and the Near

East. In Europe and North America per capita water availability is not expected to change greatly in the near future. In addition to population growth, economic activities such as industry, mining, irrigation, agriculture and hydropower plants are also having a significant impact on water availability. In many parts of the world they have been responsible for altering the natural fluctuations of stream flow and the ecological state of freshwater resources, thereby affecting annual flow regimes and water quality.

1.2 Global freshwater use

Unlike some other natural resources, not all water used in socio-economic activities is consumed in its entirety. A portion of water *withdrawals* is returned to the environment fairly immediately, e.g. in the form of sewage or drainage, and thus is available for subsequent uses. In addition, some water evaporates, is incorporated into products, or is contaminated or otherwise rendered unavailable or unsuitable for use by others. These various water uses combined constitute water *consumption.*

Demand for water is increasing in several sectors - for drinking water (domestic needs), food production (agriculture) and product manufacturing (industry). Combined with declining water availability per capita, due to population growth, this growing demand results in increased water consumption and increased water withdrawals. Water use figures differ significantly in terms of continent/region/country/area and types of use, but globally, the total demand for water increased by six times between 1900 and 1990. This growth rate is more than double the rate of population growth for the same period and can be attributed to increasing reliance on irrigation to achieve food security, as well as growth in industrial water uses and increased water use per capita for domestic and sanitation purposes. The amount of water used for irrigation, for example, has increased by a factor of 10 this century and plans are being elaborated for further expansion. If water resource management and water policies aimed at more efficient water use are not implemented, growth in water demand will continue unabated into the next century (CFWA-report, in preparation).

There are considerable differences between the various continents. Water demand for each region depends mainly on factors such as population density and the level of economic and social development . An important role is also played by hydro-climatic conditions which determine the amount of readily available water and the need for irrigation in agriculture. Forecasts for the year 2000 suggest that Asia will consume approximately 60% of the world's water, North America 15%, Europe 13% and Africa less than 7%. South America's share of world water consumption is forecasted to be less than 5% in 2000, although the region's consumption has nearly quadrupled since 1950 (FAO, 1994, p. 236).

Despite trends towards stabilization of water needs, and even slight decreases in a few countries (USA, Sweden, Great Britain and the Netherlands, for example), water requirements for the world as a whole are growing for all types of socio-economic activity. Agriculture takes the lion's share, although in the long term this will decrease in relative terms due to increasing industrial development. Agricultural water demand is mostly for irrigation and livestock watering, while industrial water demand includes water required to manufacture goods and to operate thermal power plants. Community water use includes domestic uses in urban and rural areas. Reservoir consumption represents evaporative losses from the surface of reservoirs. Incremental evaporation from lakes and reservoirs constitutes a large portion of unrecoverable water losses throughout the world: in total this exceeds consumptive use by industry and municipal services combined (Gleick, 1993, p.20-21).

1.3 Freshwater scarcity

Water scarcity today is mostly a local problem caused by uneven distribution, climatic changes, misuse, poor management and population growth. But it is increasingly becoming a regional problem, as seen in large parts of northern Africa, central Asia and southern India. Currently, over one billion people do not have access to an adequate supply of safe water for household consumption and 2.9 billion do not have adequate sanitation.

Areas with the greatest need of fresh water, such as large urban agglomerations, industrial complexes and agricultural areas with sizeable irrigation systems, often face severe problems in meeting freshwater needs in terms of both quantity and quality. In fact, in many regions, freshwater scarcity is increasing and leading to severe ecological degradation, which in turn limits agricultural and industrial production, threatens human health, and increases the potential for international conflicts over water resources.

According to scenarios based upon conservative assumptions, more than one-third of the world's population will be living in countries suffering more or less severely from water scarcity by the year 2025. "Water scarcity" is not easily defined, however. One definition uses an index of vulnerability — if a country's annual per capita water availability is 1000 m^3 or less it is considered to be suffering from water scarcity (Falken-Mark). According to this index, some 20 countries already today suffer from water scarcity; by 2050 this figure will rise to about 45 countries.

Depending on their economic and political situation, high-income countries might be able to cope with water scarcity through effective water management — for example, by improving irrigation systems, promoting safe reuse of water through construction of wastewater treatment facilities, introducing realistic water pricing, applying best available water-saving technologies in industry, and using desalinization facilities. These countries also are able to import most of their food requirements. Thus the 1000 m^3/capita/year threshold does not necessarily indicate water scarcity in real terms.

Low-income countries are obviously much less able to cope with water scarcity. Most of them do not have the economic resources necessary either to introduce safe reuse of wastewater or to import food. If a country's annual per capita water availability amounts to no more than 1000 m^3, and if this amount includes national food production and industrial activities, not only water scarcity, but ongoing deterioration of the environment through water pollution and soil degradation, can be expected.

Since each country or region has its own geographical, political, economic and cultural features, solutions to the problem of water availability will vary. However, proven strategies such as integrated land use and water resources management along rivers and lake basins, improvements in irrigation practices, cultivation of crops requiring less water, agricultural reuse of wastewater and minimizing of water pollution, can do much to increase water availability. Even scarce water supplies can be stretched through efficient management and modern technology, as has been proven in several semi-arid countries. International political and economic agreements like those in international river basins can also relax pressures on water.

1.4 Freshwater pollution

The environmental stresses imposed on freshwater resources by various human activities have existed for a long time. Industrial development, the advent of chemically enhanced agricultural production, the exponential development of human settlements and the ever increasing use of synthetic organic substances have led to ecological degradation of water resources from local to global scales. In the industrialized countries of today, each decade has witnessed the emergence of a new water pollution problem. Developing countries, particularly the newly industrializing countries, are faced with all these pollution problems within the timespan of one generation, without having yet resolved the "traditional" problems of water supply and sanitation.

Water quantity and water quality issues are closely linked, as riverine run-off is needed to maintain aquatic life, to sustain the self-purification process of surface water and to dilute polluted effluents. Recent studies estimate that nearly 450 km^3 of wastewater enters surface waters worldwide annually.
About 6000 km^3 of fresh water, equivalent to two-thirds of total reliable annual run-off are needed to dilute this amount of wastewater and carry it ultimately into

the world's oceans (UNEP, 1991).

In many parts of the world, pollution of surface water and groundwater limits the usable part of available freshwater significantly. It is also the source of severe health threats when polluted water is used as drinking-water, for bathing or washing, for food processing or for irrigation of edible crops (see also Sections 2.3, 3.2, 3.5, and 4.1). Depending on intended uses of fresh water, minimum water quality criteria must be met in order to avoid expensive treatment technology prior to its use.

Global water resources are threatened not only by overexploitation of groundwater and surface water, and poor resource management, but also by continuous deterioration of water quality and the ecological status. Discharges of untreated sewage into rivers and lakes, dumping of industrial wastes and run-off from chemically treated agricultural fields are the main sources of water pollution. On a global scale, organic matter discharged with domestic sewage is the most widespread form of water pollution.

In most of the industrialized countries, municipal and industrial wastewater treatment facilities have been put in place in recent years at considerable cost. However, in developing countries, growing urban centres and rural areas have few, if any, such facilities. Pollution from untreated or inadequately treated domestic sewage contaminates nearly all available water resources, leading to pollution of drinking-water and serious epidemics of water-related diseases. In industrialized countries, industrial effluents, in the form of discharges of heavy metals and persistent organic pollutants, and agricultural chemicals such as fertilizers, pesticides and herbicides, have contaminated surface and groundwaters, pose a continuing threat to aquatic life, and necessitate costly purification treatment before the water can be reused for community water supply or industrial needs. In addition to the threats posed by sewage, rapidly developing and newly industrializing countries must also face water quality problems posed by industry and agriculture. Thus, unresolved traditional problems of organic pollution and pathogenic organisms have to be faced along with newly emerging toxic chemicals - a high price to pay for rapid modernization.

1.5 The marine environment

A major portion of the world's population lives in coastal areas, and there is a continuing trend towards concentration in these regions. The health, well-being and, in some cases, the very survival of coastal populations depend upon the health and well-being of coastal systems - estuaries and wetlands - as well as their associated watersheds and drainage basins and near-shore coastal waters. Consequently, sustainable patterns of human activity in coastal areas depend upon a healthy marine environment, and vice-versa.

Major threats to health, productivity and biodiversity of the marine environment result from human activities on land - in coastal areas and further inland. Most of the pollution load of the oceans, including municipal, industrial and agricultural wastes and run-off, as well as atmospheric deposition, emanates from such land-based activities and affects the most productive areas of the marine environment, including estuaries and near-shore coastal waters. Contaminants which pose risks to marine life and human health have been identified as (UNEP, 1995)[1]: sewage, persistent organic pollutants, radioactive substances, heavy metals, oils (hydrocarbons), nutrients, sediment mobilization, and litter. An example of the disastrous human health consequences of prolonged discharges of toxic chemicals in the coastal environment is provided in section 3.5.4, page **XXX** (Minamata: environmental contamination with methylmercury)]

These pressures on marine ecosystems are exacerbated in many parts of the world by overfishing and climate anomalies, such as increasing frequency of *el niño* episodes and rising surface water temperatures. The combined action of these stresses has already led to the collapse of previously productive fishing gounds, and to increasing frequencies of (toxic) algal blooms, with negative consequences for human health (McMichael et al, 1996)

2 When water is poorly managed

Any consideration of the health and environmental implications of the uses of water must look first at the immediate needs of people and the availability of water services to them. An essential consideration is water necessary for basic human needs, which comprise drinking water, personal hygiene, sanitation and food preparation. While the minimum physiological need for water may be only a few litres per day, basic human needs include these other essential water uses. One estimate of basic water requirements for human needs is 50 litres per person per day.

The main dimensions of water supply services are access, equity and sustainability. Access can be defined as the number of people having safe and reliable drinking water. Equity refers to the degree of distribution of water supply sources between countries as well as between the rich and the poor and rural versus urban areas within countries. Sustainability is a newer concept, but one which is at the

[1]UNEP (1995). Global Programme of Action for the Protection of the Marine Environment from Land-based Activities. Document UNEP(OCA)/LBA/IG.2/7.

heart of successful development. It can be viewed as the willingness and capability of institutions which provide water services to maintain their systems in functioning order. Other dimensions of water are also important. Pollution in the form of either bacteriological or chemical contamination can degrade water sources and, if allowed to enter drinking supplies, can pose serious risks to health. When water uses and water sources are poorly managed, pollution is probably the clearest indicator that something is wrong and changes in our relationship with water are needed.

This section will review the main issues relating to water management and point out the health-related consequences that await those who ignore problem warnings.

2.1 Water supply access and equity

Latest available estimates (WHO/UNICEF) indicate that there are around 1530 million people without access to an adequate and safe water supply in the developing countries of the world. Most of the unserved are in the rural areas, although the numbers of urban unserved in the cities of the developing world are rising because of rapid urbanization, much of which is taking place in peri-urban and slum areas.

From the above figures it can be seen that the number of people unserved with water globally has dropped from around 1530 million in 1990 to around 1470 million in 1995.

If present trends continue, by the end of the millennium, the number of unserved with water will remain about current levels. This is particularly worrying since these services are pre-conditions to achieving Health for All. Moreover, universal coverage with both water supply and sanitation is a major goal of the Plan of Action of the World Summit for Children.

Global figures, however mask regional variations and the disparity between coverage in the urban and rural areas. Although the number of people without water supply has dropped by 100 million over during the past five years, in fact, while the number unserved in Africa and in Latin America and the Caribbean has increased, almost all of the coverage gains have been in Asia. Also, there are wide variations between countries.

Disparities between urban and rural areas are also important. Of the estimated 1530 million people without water, 1100 million, or around 70%, are rural residents.

During the last five years of the millennium, the population of the world's developing countries will grow by an estimated 420 million people, of which approximately two-thirds will be in urban areas.

Given these facts, it is clear there is a need for continued attention to be paid to the rural areas, where most of the unserved reside, and increasingly to focus attention on the urban poor which is the most rapidly expanding component of the population in the developing countries.

The inequitable distribution of drinking water supplies between rural and urban areas is evident in the coverage statistics, with urban areas generally having higher coverage than rural areas. Water is often provided to areas where people can pay for services and where votes can be won. Within the cities of developing countries, inequitable distribution of water supplies is the rule, with wealthier sections receiving good supplies and poorer sections receiving poor or even no service. It is not unusual to find wealthier sections of cities having plenty of water for washing cars, watering lawns and filling swimming pools, while in poorer sections of the same city thousands of people stand in long queues at standpipes, have poor intermittent supply or even have to buy water of doubtful quality at very high rates from vendors. This inequity has many causes and is often related to the legality of the communities, whether residents have enough money to connect to water supply systems or whether city leaders consider the needs of the poorer sections of the community a priority. The health consequences of this situation are considerable, with infant mortality rates between rich and poor varying between two to ten times in magnitude.

2.2 Sustainability of water supply and sanitation services

Another major issue is that of water supply sustainability. Water supply distribution systems require constant operation and maintenance. Poor operation and maintenance can lead to intermittent services, low flow rates, high leakage losses, and contamination of clean water through leakage inflows. Leaky pipes can result in more than half of the water being lost before it reaches homes and community standpipes. Such leakage, in turn, can result in intermittent services and severe water shortages. Too often, insufficient provision is made during the budgeting process for the operation and maintenance needs of water systems, which as a result fall sadly into disrepair.

During the International Drinking Water Supply and Sanitation Decade (1981-1990), major efforts were made to increase investments in Water Supply and Sanitation. Regrettably, investments directed at improving the sustainability of water supply and sanitation services have not kept pace with capital investments to expand the size and number of systems. As a consequence, systems deteriorate for lack of maintenance. Many water systems, therefore, do not provide the full services they were designed to deliver, and the backlog of rehabilitation needs grows year by year.

The Ministerial Conference on Drinking Water and Environmental Sanitation, which took place in Noordwijk, the Netherlands, on 22 and 23 March 1994, recognized that while the International Drinking Water Supply and Sanitation Decade had resulted in a significant increase in coverage, it had made only a marginal impact on reducing the total number of unserved people. Some of the overriding causes of such a disappointing performance were insufficient measures to ensure appropriate institutional frameworks and a lack of resources to conduct operation and maintenance services.

Programmes and activities in the water supply and sanitation sector of developing countries traditionally have received strong support from donor organizations. Country needs have been so great and diverse in nature that national governments have had little difficulty in identifying projects of interest to the external support agencies. Commercial loans have been made available for large scale water activities, mainly in the urban water supply and sanitation sector; while soft loans and grants have been made available from bilateral agencies for the smaller urban and rural projects. In addition, cash and in-kind contributions have been provided by a host of nongovernmental agencies for development in areas of special interest, such as refugee camps, resettlement areas, etc.

Since the mid-1960's, investments in the water supply and sanitation sector have steadily increased, reaching a peak during the International Drinking Water Supply and Sanitation Decade. The principal objective of this development effort was to extend the provision of safe drinking water and appropriate sanitation to as many people as possible. This was recognized as an essential prerequisite for the control of water-related diseases and was accepted as indispensable for good health. Such facilities however, have not achieved their health and development objectives as they were not always accompanied by measures to ensure their sustainability. It is discouraging to note that in rural areas, where supply is frequently provided through boreholes fitted with handpumps, a high percentage of facilities, sometimes 60% or higher, are reported to be out of order.

Unaccounted-for water losses resulting from leakage, theft, and other operational problems, often exceed 50% in many large cities of the developing world. In the water service areas, wastage can be very high and tariffs are often subsidized, whereas the inhabitants of fringe areas usually remain unserved and pay 10 to 20 times more for water of questionable quality from private vendors than do the wealthier inhabitants served by private connections. By improving the performance of water supply systems, it may be possible to extend coverage to fringe and poor areas of large cities without the need for major capital investments.

Operation and maintenance (O & M) is the activity of a water supply and sanitation agency which has the most immediate impact on the user, the value of the service provided and the public perception of the agency. Operation and maintenance therefore should have the highest priority among an agency's activities. Unfortunately, operation and maintenance is rarely regarded highly by organizations with a backlog of unmet demand (unserved areas). Considerable pressure to give priority to extensions and new construction often is applied to governments, national agencies and donor organizations.

A myriad of reasons have been identified for the failure of water supply and sanitation systems. These range from poor organizational structures in the responsible agency, lack of spare parts, inappropriate technology, lack of trained staff, tied aid, absence of career opportunities, insufficient funds, inadequate legal framework, lack of motivation of sector personnel, non-involvement of the users, low profile of operation and maintenance in the sector in general, inadequate tariff systems and political interference. These causes tend to be interrelated as they rarely occur in isolation from others.

Sector transformation involving the optimization and sustainability of water and sanitation services must address all relevant factors affecting the performance of facilities and not simply technological aspects. Issues such as sector organization, policies and programming, institutional frameworks, legal aspects, physical and technical concerns, financial issues including cost-recovery, information systems, human resources development, community participation and involvement of the private sector should be amongst the concerns in the overall process of planning for sustainability.

2.3 Pollution of water resources

Water quality is closely linked to water use and level of economic development. In developed countries, faecal contamination of surface waters caused serious health problems, such as cholera and typhoid epidemics, in the mid-18th Century. Today, waterborne diseases have been virtually eliminated in the developed world, but outbreaks of cholera and endemic diarrhoeal diseases remain rampant in the developing countries. Moreover, intensified agriculture and rapid industrialization in the ever-growing cities of the developing countries have added a further dimension in the form of chemical pollution. Urban populations, particularly in developing country megacities are now exposed to hazardous chemicals in water, as well as to infectious agents in surface and groundwaters. The global picture of water pollution can be summarized as follows.

Sewage

Untreated or inadequately treated domestic wastewater is the major source of surface and groundwater pollution throughout the developing world. Only 10% of municipal sewage is estimated to receive adequate treatment and discharged in an environmentally sound manner. Organic matter in sewage causes a biochemical oxygen demand with which rivers and lakes cannot cope. Sewage also carries microbial pathogens. In rivers contaminated with sewage levels of faecal coliforms may be very high The resulting health risks, however, are much lower in developed countries where drinking-water receives extensive multi-stage treatment before it is supplied to the consumer. In developing countries, treatment is often unreliable and services intermittent; peri-urban residents and the rural poor often consume water that has not received any treatment or precaution from polluted water courses or private wells with no quality control.

Nutrients

Phosphorus and nitrogen are present in household wastes and sewage, agricultural drainage waters and many industrial effluents. An unwelcome sign of economic prosperity, they serve as nutrients for aquatic organisms and cause severe eutrophication in lakes and rivers, and ultimately in estuaries and coastal waters. A recent survey of 215 lakes showed that in the Asia/Pacific region 54% of lakes are eutrophied. The figures for Europe, Africa, North America, and South America are 53%, 28%, 48% and 41% respectively. Intensive fertilizer use in agriculture has led to nitrate levels in groundwater extractions for drinking-water which are several times the safe levels recommended by WHO.

Urban aquifers

Urbanization affectings not only rivers and lakes, but also introduces many changes to aquifers lying under cities. On-site sanitation causes severe faecal contamination of shallow aquifers and nitrate concentrations are frequently elevated beyond potable limits. There is evidence of increasing pollution levels in groundwaters worldwide. This includes not only sewage-derived pollutants and agricultural chemicals, but also heavy metals, solvents and other synthetic organic contaminants emanating from industrial activities and mining operations. In terms of human health risks, the most critical pollutants are lead, cadmium, mercury and arsenic.

Synthetic organics

Although water quality data are sparse, there is growing evidence that many of the 100 000 synthetic compounds in use today find their way into the aquatic environment and accumulate in the food chain. The most harmful group, for ecosystems as well as for human health, are the persistent organic pollutants (POPs). An international list of the twelve most dangerous POPs has been compiled including industrial chemicals such as polychlorinated biphenyls (PCBs), waste substances such as dioxin, and agricultural pesticides of high toxicity and environmental persistence, and possessing bio-accumulative properties. Rigorous control of their release into the environment is the most effective means of avoiding avoid such pollution and controlling their levels in water sources.

Acidification

Acidification of surface waters, primarily lakes and reservoirs, has become one of the major adverse environmental impacts of long-range atmospheric transport of air pollutants from power plants, smelters, other heavy industries and motor vehicles. The problem is severe in North America and Europe. In developing countries, many surface water systems are vulnerable to acidification and can be expected to suffer in the same way if industrial development occurs without implementation of air pollution control safeguards. If groundwater becomes acidified, remobilization of metals from soils and water distribution pipes takes place, necessitating costly remedial measures.

2.4 Chemicals in drinking-water

If drinking-water contains only low concetrations of essential elements, community-health problems can arise, particularly if supplements are not provided by a healthy diet. Perhaps the most important element-deficiency problem associated with drinking water globally is that of endemic goitre and cretinism, both of which are linked to dietary iodine deficiency. Smaller-scale problems, associated with selenium deficiency, have also been recognized in some areas: Keshan's disease, a chronic heart disease thought to be linked to selenium deficiency (endemic cardiomyopathy), has affected several thousand people in parts of rural China. For several elements, there is only a narrow range of concentrations in water within which beneficial effects are found.

Iodine

The main sources of dietary intake in iodine-deficient areas are food and drinking water. Some areas, such as the Alpine region, are very low in groundwater iodine. As a result, resident populations have insufficient iodine intake which causes enlargement of the thyroid gland. Goitre is the symptomatic disease which is endemic in these regions. In more severe cases, mental retardation and cretinism are the ultimate consequence. The number of people with goitre is estimated at 200 to 300 million worldwide and some six million people are affected by cretinism (Dunn and van der Haar, 1990).

Fluoride

Fluoride levels between about 0.5 and 1 mg per litre provide substantial protection against dental caries. However, the margin between beneficial and toxic levels of fluoride is rather narrow and higher levels of fluoride in drinking-water have led to adverse health effects varying from unsightly dental fluorosis to crippling skeletal fluorosis. Waters with high natural fluoride content are usually found at the base of high mountains and in areas with geological deposits of marine origin. Typical examples are the geographical belt running from Syria through Jordan, Egypt, and the Libyan Arab Jamahiriya, and from Algeria to Morocco; the Rift Valley running through Sudan and Kenya, and the geographical belt stretching from Turkey through Iraq, the Islamic Republic of Iran, and Afghanistan to India, northern Thailand, and China. Similar areas are also found in India, the USA, Japan and China.

Fluoride control options include provision of an alternate low-fluoride source of water, and blending with low-fluoride water. Appropriate technology is available for the removal of fluoride and includes conventional coagulation/sedimentation/filtration, and the use of adsorbents, such as bauxite or bone-char, which can be produced locally.

Arsenic

High natural concentrations of arsenic occur in drinking-water in certain areas of Taiwan, Hungary, India, Argentina, Chile, Mexico and the United States. Arsenic in drinking-water causes hyperpigmentation, keratosis, skin cancer, and "blackfoot disease", a local term used in Taiwan for a peripheral vascular disorder that results in gangrene of the extremities, especially of the feet.

In much of the world, groundwater uncontaminated by human activity is usually safe to drink. Recent studies in several parts of the world have indicated, for example, that naturally occurring inorganic arsenic in groundwater apparently can be a cause of serious ill-health. In Taiwan and Argentina, for example, epidemiological studies have shown a strong association of natural arsenic levels with bladder cancer. In Argentina, the bladder cancer rate of the highest exposure group is about twice that of the lowest exposed groups. Similar results were found in both places, in spite of major differences in culture, genetic make-up and diet. In 1966, tap water supplies with only trace amounts of arsenic were installed in Taiwan and use of artesian water high in arsenic content curtailed. No new cases of blackfoot disease were observed in children born after the installation of these facilities.

Lead

Lead is present in drinking-water mainly because the pipes, solder, fittings, and service connections of household plumbing systems contain lead. Lead is a cumulative general [MEANING?] poison, with infants, children up to 6 years of age, the fetus, and pregnant women the most susceptible to adverse health effects. Its effects on the central nervous system can be particularly serious. Epidemiological studies have demonstrated associations between childhood exposure to lead and a decreased intelligence.

The remedy for lead pollution consists principally of removing plumbing and fittings containing lead. This requires much time and money and not many water supply agencies can do this immediately. In the meantime, corrosion control measures can be implemented, and consumer education can go a long way to minimize exposure.

Nitrates

Nitrates in drinking-water may lead to serious, even fatal, consequences, especially for infants fed with formulations prepared with such water. In the human body, nitrate is converted to nitrite, which then combines with haemoglobin to form methaemoglobin, which is unable to bind with and therefore transport oxygen from the lung to the tissues. The result is severe cyanosis (blue baby syndrome), and can lead to death.

Technology for the removal of nitrate from drinking-water is expensive. Good agricultural practice in the use of nitrate fertilizers will go a long way to prevent this problem, and breast-feeding is an excellent measure to avoid exposure of infants to nitrate-containing water.

Pesticides

During the last two decades concern about the presence of pesticides in surface and groundwaters used for drinking-water supplies has increased. Groundwater is especially susceptible to contamination by pesticides that are mobile in soil, and once contaminated in this way extremely difficult to purify. Pesticides frequently found to contaminate groundwater include alachlor, aldicarb, atrazine, bentazone, carbofuran, isoproturon, ethylene dibromide, and simazine. Pesticide concentrations in many groundwater sources have been found to be much higher than WHO guideline values. The occurrence of such chemicals in groundwater resources is a matter of grave concern for future generations. The most harmful substances are included in the POPs list. Their health effects range from chronic toxicity to cancer to birth defects.

Application of integrated pest management systems, and the education of pesticide users in the safe and judicious application of pesticides, are among the methods that governments are using to prevent or minimize the contamination of ground water with pesticides.

2.5 Public health risks from the recreational use of water

Sewage, industrial effluents and agricultural waste are discharged into inland waterways, lakes or coastal zones, which are used for recreational purposes such as swimming, canoeing and windsurfing. Recreational exposure to polluted waters may cause a variety of health outcomes, comprising the following:

- gastroenteric symptoms
- skin irritations, mucosis
- respiratory symptoms
- typhoid fever
- leptospirosis
- cyanobacterial poisoning.

Estimating the overall public health consequences from recreational use of polluted water is difficult. We know, however, that, e.g. in Mediterranean basin, only about 41% of municipal waters undergo a secondary treatment, whereas 33% are not treated at all. The Mediterranean basin attracted about 157 million tourists in 1990, in addition to the 130 million inhabitants that may also be exposed. This represents about 35% of tourism worldwide.

In the EU, 3'000 bathing areas (17%) out of 18'000 do not respect the EC quality standards or are insufficiently monitored for compliance. For inland bathing areas, the situation is even less satisfactory, with only 30% compliance with the minimum requirements.

Control of land-based sources of pollution is the most effective measure to prevent sewage discharge into rivers, lakes, coastal beach areas and other marine waters used for body-contact water sports. Intensive bacteriological monitoring is prescribed for public beaches and recreational areas in most countries concerned.

2.6 Water related vector-borne diseases

The aquatic environment provides an essential habitat for mosquito vectors and intermediate snail hosts of parasites that cause human disease, with malaria outranking all others in severity and distribution. Vector-borne diseases have always affected humans, even in pristine environments. But the harnessing of water resources, first for agriculture and drinking water and later for energy generation, brought about conditions favourable for the transmission of vector-borne diseases. The accelerated development of water resources that started in the 1960s has led to habitat modifications and ecological conditions favouring important disease vectors.

The health issues linked to irrigation development have become a particular focus of attention, but increased transmission is also linked to the construction of dams and reservoirs, to changes in land use patterns that have an indirect effect on hydrology, and to poor water management in urban areas.

Conventional wisdom has it that sound water development is good for health. Indeed, irrigation development has many direct and indirect health benefits: food security, better nutrition, economic growth, improved infrastructure and greater access to health services. The question can be rightly asked: why is there apparently so much unsound development ? The answer has to do with economics and with the lack of communication. Irrigation development has become increasingly expensive, and planners are often forced to delete certain components (most notoriously, the drainage component) to make a proposed scheme economically viable. At the same time, the prolonged post-World War II reliance on residual insecticides for vector control has led to a lack of knowledge of public health and hygiene issues among civil engineers and a lack of communication between these engineers and the public health experts. As a result, poor water management often leads to an expansion and intensification of vector-borne disease transmission.

Poor water management occurs at different scales and at different levels. At its largest scale, the integrated development of an entire river basin can have detrimental effects on the health of large populations, such as the closure of the mouth of the Senegal river by the Diama dam to prevent the intrusion of seawater into the estuary during the dry season. The protracted, shallow freshwater lake that formed behind the dam allowed a rapid expansion of irrigated rice and sugar plantations, immediately followed by the most serious outbreak of mansoni schistosomiasis ever recorded. Other developments in the same basin, notably the construction of the Manantali dam in Mali, have also had public health repercussions, particularly a decrease in nutritional status of the population in the Middle Valley.

On a different scale, irrigated rice production in South India underwent important changes during the 1980s. An expansion of the area under cultivation into more arid zones was accompanied by an intensification of the cropping system to double or triple cropping. The environmental changes caused by the new water management characteristics (compounded by local social structures, which made small farmers dependent on major landowners who could afford boreholes) created favourable conditions for the mosquito vectors of Japanese encephalitis which in turn resulted in disease outbreaks.

Finally, at the household level, particularly in urban areas, but also increasingly in rural zones where unreliable drinking water supply systems replace the traditional wells, water storage habits in and around the house create numerous breeding places for *Aedes aegypti* and *Aedes albopictus* mosquitoes. The recent history of dengue fever outbreaks, most recently (October 1996) hitting Delhi and other big cities in India, is a witness of how poor household water management in and around the house contributes to ill health.

Malaria with its one million plus deaths annually, schistosomiasis with 200 million people infected globally and the tens of thousands of dengue fever cases in India in 1996 alone (with several thousands of hospital beds occupied) reflect the importance of water related vector-borne diseases both in terms of human suffering and in their cost to the health services. In many instances it is difficult to attribute the number of disease cases specifically to poor water management, especially there where the disease was already endemic before hydrological changes occurred and where vector ecology is complex. A solid assessment of hydraulic systems and breeding places which contribute most to disease transmission, together with intensified multidisciplinary research to redesign hydraulic structures and adapt water management practices to reduce disease transmission risks are crucial if the health situation of millions in the tropics is to be improved.

LECTURE NOTES ON:

- THE RELATION BETWEEN WATER SUPPLY, SANITATION AND HEALTH
- HYGIENE EDUCATION
- MONITORING OF WATER QUALITY

Lecture notes for session on Relation between water supply, sanitation and health: technical aspects
Thursday 27-2 9:00-13:00

Objectives
- Participants know that to improve health, to contain water and sanitation related diseases both hardware and behavioural changes are needed
- know the process in technology selection for long-term sustainability
- know technical options in water supply and sanitation

Contents
<u>Importance of changes in hardware and behaviour to improve health</u>

<u>Coverage of sanitation and water supply (sanitation gap)</u>

<u>Criteria and conditions for water supply technology selection</u>
Four areas:
-community criteria
-institutional criteria
-technical criteria
-environmental criteria

The conditions and capacities at community level should best be assessed using a participatory community servey.

Examples of community criteria:
-water consumption
-population growth
-settlement pattern
-preferred service levels
-ability and willingness to recover O&M cost

Examples of institutional criteria:
-available and required technical capacities
-training capacity
-need for departmental cooperation
-private capacity for repairs
-private capacity for implementation

Examples of technical criteria:
-present water sources
-reliability of water sources
-topography
-infrastructure level
-availability of local construction material

<u>Water supply technical options</u>
GROUNDWATER
*spring -point source

-distribution; gravity or pumped/storage tank

*dug well -point source; handpump or other water lifting devices
-distribution; pumped/storage tank

*borehole -drilled/jetted
-point source or distribution

*galleries -point source or distribution

SURFACE WATER

*rivers -point source or distribution
-dams with reservoirs
-water (hydro)-ram

*lakes -point source or distribution

RAINWATER

*surface runoff collection

*roof collection from -house
-public buildings

DISTRIBUTION SYSTEMS

*supply by -gravity
-pumped

*energy source: -electricity, diesel, solar-energy, win-power, hydro-power

*service levels -standposts (small group, neighbourhood), yard connections, house connections (single tap; multiple tap)

*size schemes -single community
-trunkline with community connections

WATER TREATMENT OPTIONS

*central treatment system -conventional chemical treatment (coagulation/flocculation/sedimentation/rapid sand filtration/disinfection)
-pre-treatment and slow sand filtration
-disinfection with on-site generated chlorine

*household treatment systems
-household filter (cloth or sand)
-prolonged storage
-UV-radiation
-boiling
-disinfection (chlorine tablets)

Criteria for sanitation technology selection

See also criteria for water supply technology selection

Typical criteria are
-availability of water
-soil condition
-cleansing material used

Social factors:
-arising from beliefs and taboos (cultural variations in defaecation practices)
-privacy particularly for women
-easy access during the night

Sanitation technology options

Sanitation is narrowed down here to human excreta disposal technology

The most common options are:

ON-SITE SANITATION HOUSEHOLD FACILITIES

- simple pit latrine
- ventilated improved pit latrine
- single pit off-set latrine
- twin-pit (alternating) latrine
- compost latrine
- single (leach) pit pour-flush latrine
- twin (leach) pit pour-flush latrine
- aqua-privy
- pour/cistern-flush toilet with septic tank and soakaway
- pour/cistern-flush toilet with septic tank, anaerobic upflow filter and soakaway/drainage

OFF-SITE SANITATION HOUSEHOLD FACILITIES

- pour/cistern flush toilet with septic tank and small bore sewerage
- pour/cistern flush toilet with shallow sewerage
- pour/cistern flush toilet with full sewerage

COMMUNITY LATRINES

PUBLIC LATRINES

SCHOOL LATRINES

Comparison of several types of sanitation system

TECHNOLOGY SELECTION MATRIX PER LOCATION (example)

	Simple pit	VIP	Twin Pit
Investment cost	1	2	3
Maintenance cost	1	2	3
Acceptability	3	2	1

Lecture notes for session on Hygiene education
Thursday27 February, 1997
14.00 - 17.00 hrs.

Objectives

Participants

- know that to improve health by containing water and sanitation related diseases both hardware and behavioral changes are needed;
- can assess the importance of hygiene education as intermediary between health care and water supply projects;
- know the steps involved in setting up a hygiene education programme.

Contents

What do we mean by hygiene education?

Hygiene education is part of health education and as such a process which aims to promote conditions and practices that help to prevent water and sanitation related diseases.

It is an important component of water supply and sanitation programmes:

i) to maximize the potential health benefits of improved water supply and sanitation facilities; and

ii) to help users to appreciate the need for their proper operation and maintenance and to create a willingness to contribute to their costs.

Approaches to hygiene education

We distinguish two different approaches: i) community managed hygiene education and ii) public health campaigns. They both have their advantages and disadvantages and which approach to select, or to use a combination of the two, depends on factors like: the context in which the hygiene education takes place, the types of behavior requiring change, the number of people to be reached.

Community managed hygiene education

In community managed hygiene programmes health educators help communities or local groups to establish and manage their own hygiene programmes and organizations to realize the changes they want. Health educators facilitate the identification of risks and resources, the development of objectives and workplans for achieving those objectives.

Public health campaign

Campaigns often combine the use of mass media with personal contacts to stimulate large numbers of individuals and households to change specific behaviors. When setting up a campaign a systematic process is followed, whereby target groups are investigated on their practices and views and key risks are determined by (often) the health department. Target groups are segmented into categories and for each of the categories different channels, messages and products are chosen that are most easy to disseminate and convince the groups concerned, so that they will adopt the altered behavior.

Steps in setting up a hygiene education programme

Information collection for risk analysis and objective setting

If hygiene education is to be started information on present behavior, diseases prevalent, beliefs, knowledge, geographical conditions, climatic circumstances is

needed. On the basis of these data a *health risk analysis* is made, we try to find out *what motivates people* to change behavior as well as *resistance to change* can be foreseen. On the basis of these insights objectives are set.
There are various ways in which information can be collected, ranging from traditional KAP-surveys and formative research to participatory appraisals. The hygiene education approach chosen determines how/by whom information is collected and how/by whom the information collected is translated into target groups and objectives. In the case of campaigns surveys and research may be used, whereby communities are sources of information for the department or programme carrying out the survey. In the case of community managed hygiene education participatory appraisals are most suitable. Communities really participate in the information collection process and make their own translation into objectives. Staff act as facilitator of the community process.

In general it can be said that hygiene related health risks are not only determined by people's behavior. Geographic and climatic circumstances have to be taken into consideration when assessing whether people's hygiene behavior indeed pose health risks requiring (urgent) action. In a hygiene education programme objectives are formulated in terms of improved conditions and/or improved behavior, rather than in terms of improved health.

Planning and implementation
In the case of community managed hygiene education planning and implementation is basically a community process facilitated by staff of the department or the programme. Staff also has to provide the necessary information for community members to be able to make informed choices on actions to be undertaken to improve hygiene conditions and behavior leading to achievement of their objectives.

In the case of a public health campaign planning and implementation is in the hands of the department or programme. The information collected for risk analysis and objective setting will guide planning and implementation. If it has become clear that most cases of diarrhea occur during the rainy season and it has been decided to promote Oral Rehydration Solution, a promotional campaign is to take place just before and during the rainy season. Planning of activities has to be done accordingly.

Monitoring
Monitoring serves various purposes. Whether we are community members or staff, we want to monitor implementation processes, the results of what we do and the impact of our activities. Monitoring data can be used to improve our work in order to achieve our objectives by improving planning and implementation.
Monitoring indicators have to be relevant, valid, reliable and efficient. Whereas in a community managed programme community members will determine their own indicators and the ways they want to collect the information. They will also decide to what additional action the information will lead.
People responsible for implementing a campaign will usually determine their own indicators to find out about the effectiveness of the campaign.
In both cases you will often find that the methods of collecting monitoring data are similar to the methods of information collection for risk analysis and objective setting.

Institutional requirements
Institutional requirements for effective hygiene promotion include:

Well qualified staff, whereby both approaches to some extent require different qualities since the methodologies are quite different. Whereas skills for effective face to face communication are most important in a community managed programme, knowledge about the use of mass-media is in particular relevant for those involved in public health campaigns.
Flexibility in terms of manpower and funds made available is needed in community managed programmes. Communities are unique and may therefore each come up with their own specific plan for hygiene improvement and the intensity of contact between staff and communities may also vary.
Cooperation between departments (eg. Water Affairs and Health) is most needed and feasible in case of community managed programmes. Provision of facilities and hygiene promotion activities can reinforce each other.

Background reading

- van Wijk, C. and Murre, T. (1995). Motivating better hygiene behavior (Chapter1,2 and 3).
- Boot, M. (1991). Just stir gently (Chapter 1,2 and 5)