Access to safe water and sanitation is a universal need and a basic human right.
This presentation will deal with the close links between children's health and the quality and availability of water.
LEARNING OBJECTIVES

❖ To understand the global context of water availability and quality

❖ To review the major categories of water pollutants and their sources

❖ To learn about the effects of exposure to these pollutants on children’s health

❖ To consider some of the options for treatment of drinking water
Outline of this module: main points to address

<< READ SLIDE>>
Liquid water is responsible for life as we know it!

Viewed from space the earth appears to be mostly water, but only 2.5% of that water is fresh, and most of that lies frozen and inaccessible.

As a result, less than 1% of fresh water is accessible in lakes, river channels and under ground.

Geography, environment and pollution from human activities reduce this amount by a further two thirds, and what remains is unequally distributed around the world.

It should be noted that access to safe water, provision of sufficient supplies of water, and access to sanitation are three factors that together can contribute to the health and safety of the world’s population. A lack of adequate supplies of good-quality water, together with poor sanitation, exacts a high health toll, particularly in rural areas, hindering both social and economic development. This makes the promotion of hygienic behaviour a high priority.

Ref:
• UNICEF/WHO. Progress on drinking water and sanitation. Special focus on sanitation. 2008.
Where is Earth's water located and in what forms does it exist?
The distribution of water is illustrated in the bar charts. The left-hand bar shows where the water on Earth exists; about 97% of all water is in the oceans. The middle bar represents the 3% of the "other" part of the left-hand bar (that portion of all of Earth's water that IS NOT in the oceans). Most (77%), is locked up in glaciers and icecaps, mainly in Antarctica and Greenland, and in saline inland seas. Twenty-two per cent of this portion of the Earth's water is groundwater. The right-hand bar shows the distribution of the "other" portion of the middle bar (the remaining 1%). Notice how rivers make up less than 4/10th of one per cent of this remaining water – yet this is where we get most of the water for our everyday use!

*This graph and the above text are in the public domain and can be found at wwwga.usgs.gov/edu/waterdistribution.html*
This pie-chart shows that Africa and Asia are the regions most affected by the lack of safe water supplies.

Developing countries are the most stressed, as they lack safe water to serve the projected growth and have large young populations groups.

Ref:
The world is on track to meet the MDG drinking water target. Current trends suggest that more than 90 per cent of the global population will use improved drinking water sources by 2015. Sub-Saharan Africa is making the slowest progress. Population forecasts suggest that an additional 784 million people worldwide will need to gain access to improved drinking water sources to meet the MDG target. Accelerated progress is needed especially in sub-Saharan Africa, home to more than a third of those using unimproved drinking water sources.

At the beginning of the 20th century over 86% of humans lived rural lives, now the proportions are about 50/50 urban/rural.

Cities and mega cities continue to evolve.

It is estimated that, between 1990 and 2000, the global population increased from 5.25 billion to over 6 billion, an increase of over 15%. This total reflects a 25% increase in the urban population, and an 8% increase in the rural population. This increase meant that an additional 800 million people required access to safe water supplies, just to maintain coverage at a constant level. During this period an additional 900 million people gained access to an improved source of water, resulting in an increase in coverage from 77% to 82%. Despite these gains, there are still more than 1.1 billion people, or 1/6 of the world’s population, who lack access to adequate sources of drinking-water.

The decade also saw a marked shift in the urban–rural population ratio; by 2000 the proportion of urban dwellers had risen from 43.5% to 47%, and the growth rate showed no signs of slowing. The rate of urbanization is greater in the developing world, particularly in Africa and Asia, and this, together with lower levels of access to a safe water supply, make these locations particularly vulnerable to the risk of water-related diseases. By 2000, 81% of Asians and only 64% of Africans had access to safe sources of drinking-water, despite worldwide efforts.

Refs:
Water is the essence of life and human dignity. As a fundamental human right “sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic uses” is vital for all. Governments are responsible for ensuring that this human right is progressively fulfilled. As a result of their action, in collaboration with partners, 900 million more people gained access to an improved water supply during the 1990s. Yet 1.1 billion people in rural areas and urban slums still rely on unsafe drinking-water from rivers, lakes and open wells. Children, in particular, suffer from water-related illnesses. Each episode of diarrhoea sets back a child’s growth by lowering their appetite and reducing their calorie and nutrient uptake. Persistent diarrhoea and severe diseases, such as typhoid and dysentery, jeopardize children’s healthy development. Every year, nearly 2 million children do not survive this struggle. Continued progress towards providing everyone with access to protected wells and, ultimately, piped water supplies will radically reduce childhood illness. In the meantime, disinfection and filtration at home are simple and cheap measures that make an immediate difference to the lives of the worst affected.

Ref:
Recalling the special vulnerabilities of children.
(See Module “Children are not Little Adults”.)

<<READ SLIDE>>

Refs:

Diarrhoea is the major public health problem caused by unsafe water and lack of sanitation. To give an indication of the scale of the health problems caused by lack of safe water, there are approximately 4 billion cases of diarrhoea each year, causing 1.8 million deaths. These deaths occur mostly among children under the age of 5 years and represent 15% of all deaths in this age group in developing countries.

Waterborne intestinal worms infect nearly 10% of the population of the developing world, leading to malnutrition, anaemia and retarded growth. Some 6 million people are blind as a result of trachoma, and research suggests that provision of safe water could reduce infections by 25%. Some 200 million people are infected with schistosomiasis, while the provision of safe water and sanitation could reduce infections by as much as 77%.

Contamination of drinking-water by chemicals, particularly arsenic and fluoride, has been increasingly recognized as a major health problem in some parts of the world.

Ref:
Although the main concern is safe DRINKING-water and access to sanitation, we must not forget that “children's work is to play” and that they may spend many hours swimming, bathing and playing in recreational waters. The water quality of pools, lakes, rivers and ponds should be considered, as well as the many other risks that exist in a “water” environment where children spend time. By far the most serious risk menacing children's life is DROWNING.

**Burden of disease**

**Physical hazards: drowning and injuries**

In 2000 an estimated 450,000 people drowned, making it the second leading cause of death from unintentional injury worldwide after road traffic injuries. However, of the various age groups, children under 5 years of age have the highest drowning mortality rates worldwide. Over half of the global mortality and 60% of the total number of disability-adjusted life years (DALYs) lost due to drowning occurs among children aged between 0 and 14 years. Ref: www.who.int/violence_injury_prevention/unintentional_injuries/drowning/types/en/

**Microbial hazards: infections**

Millions of litres of raw or partially-treated sewage are pumped into seas every day, polluting the environment and resulting in an estimated 250 million cases of bathing-related gastroenteritis and upper respiratory disease each year. Pathogenic viruses and bacteria such as *Escherichia coli* O157 are commonly found in untreated sewage, putting swimmers, surfers and children at risk from infection.

Although the water quality in swimming pools and spas is generally well-monitored, there
may be outbreaks of disease due to contamination. The majority of outbreaks are caused by viruses or bacteria linked to faecal contamination. An increasing number of infections are associated with protozoa such as Cryptosporidium, which are resistant to commonly used pool disinfectants. Spas present particular risks and require particularly stringent monitoring, as the warm, nutrient-containing, aerobic waters provide an ideal habitat for bacteria to proliferate. Ref: www.who.int/features/2003/10/en/

Contamination of water can be conveniently divided into two categories – biological and chemical.

<<READ SLIDE>>

*Picture on the right: WHO, C. Gaggero. Environment water, Americas*
*Picture on the left: WHO, C. Gaggero. Environment water pollution, Mexico*
Water contains many trace elements and minerals which, depending on their concentration, may be inert, beneficial or toxic. Some minerals can be beneficial at low concentrations, but toxic at higher ones. These minerals may occur naturally, arising from the surrounding geological features, particularly in groundwater.

Chemicals may also be introduced into water from human activities, particularly into surface waters. Contamination may be from agricultural chemicals, such as pesticides and fertilizers; human activity, such as waste disposal; urban run-off from human settlements; industrial chemicals; or the process of water treatment itself. Many of these substances are not harmful to humans, or are present in concentrations so low as to cause no health effects. However, some are known to cause serious health effects at low concentrations, and treatment is needed to remove them or to reduce their concentration in drinking-water.
Pollutants move through the water cycle and can be transported long distances.

Picture: www.unep.org/vitalwater

Water is transported in different forms within the hydrological cycle or 'water cycle'. The water cycle consists of precipitation, evaporation, evapotranspiration and runoff. This graphic explains the global water cycle, showing how nearly 577,000 km³ of water circulates through the cycle each year.

*Picture and text: www.unep.org/vitalwater*
Picture: www.unep.org/vitalwater

The primary public health concern regarding water contamination is **microbiological** contamination of drinking-water.

Water-related infections can be classified into four categories:

- **waterborne diseases**: directly acquired from drinking water (contaminated);
- **water-washed**: indirectly acquired diseases due to lack of hygiene;
- **water-based diseases**: caused by aquatic organisms that spend part of their life-cycle in the water and another part as parasites of animals; and
- **diseases transmitted by water (or humidity!) -related insect vectors** (includes African trypanosomiasis (tse-tse fly) and leishmaniasis (sandfly) that require only humid environments) (Dr D. Engels, WHO, personal communication).

Microbial contamination usually results from the contamination of water with human or animal faeces. If drinking-water is contaminated with faeces, pathogens are likely to be widely and rapidly dispersed. If the contamination is recent, and if the faeces are from carriers of communicable enteric diseases, the microorganisms (bacteria, viruses or protozoa) that cause these diseases may be present in the water.

The diseases range from mild gastroenteritis to severe and sometimes fatal diarrhoea, dysentery, hepatitis, cholera and typhoid. Helminths and amoebae may also be transmitted in water and are common in poor-quality water supplies.

There are also some organisms in the environment that may cause disease in humans in certain circumstances, e.g. *Legionella* may be transmitted through aerosols.

Adverse health effects arise primarily from the ingestion of pathogenic bacteria. People with low immunity, including infants, young children, the sick and the elderly are particularly vulnerable to microbial contamination even from ordinarily mild pathogens. Outbreaks of waterborne disease can lead to spread of infection across a wide community. *Cryptosporidium* and *Giardia*, for instance, cause regularly diarrhoea outbreaks. They cause problems due to the following factors:

- cyst formation (cysts are resistant in the water environment);
- cysts have a small size (problems in filtration processes);
- no specific hosts;

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<th>Waterborne diseases</th>
<th>Water-based diseases</th>
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<td>Cholera</td>
<td>Schistosomiasis</td>
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<td>Poliomyelitis</td>
<td>Dracunculiasis (guinea-worm)</td>
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<td>Diarrhoeal diseases</td>
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<td>Roundworm</td>
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<td>Enteric fevers: typhoid</td>
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<td>Whipworm</td>
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<td>Hepatitis A</td>
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<td>Cryptosporidium</td>
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<td>Giardia</td>
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<th>Water-washed diseases</th>
<th>Diseases transmitted by water-related insect vectors</th>
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<td>Scabies</td>
<td>Malaria</td>
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<td>African trypanosomiasial</td>
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-cysts are resistant to chlorine.
In addition, risks are posed by some toxins that occur naturally in water, particularly in nutrient-rich surface waters where there is profuse algal growth.

Ref:
Arsenic (As) is a naturally occurring element, which can be introduced into water through the dissolution of minerals, from industrial effluent (drainage from goldmines) and from atmospheric deposition (burning of fossil fuels and wastes). These sources make significant contributions to the arsenic concentrations in drinking-water and may be harmful to health. The body rapidly excretes organic forms of arsenic, and it is the inorganic trivalent form that is of most concern.

Although concentrations in natural water are generally less than 0.005 mg/litre, some countries have reported very high concentrations, particularly in groundwater supplies. In Bangladesh, for example, over 25,000 wells are contaminated with arsenic at levels above 0.05 mg/litre. Food is also a significant source of arsenic, but usually in highly complex forms that are biologically unavailable and essentially non-toxic.

Although studies indicate that arsenic may be essential for some animal species, there is no indication that it is essential for humans.

Arsenic compounds are readily absorbed by the gastrointestinal tract, and then bind to haemoglobin and are deposited in the liver, kidneys, lungs, spleen and skin. Inorganic arsenic does not appear to cross the blood–brain barrier, but can cross the placenta.

Approximately 45–85% of ingested arsenic is excreted in the urine within 1–3 days.

The major health effects are caused by chronic exposure to low levels from the consumption of arsenic-contaminated water. A number of studies in Bangladesh and West Bengal have documented the effects of consuming water containing elevated concentrations of arsenic (> 0.3 mg/litre). Consumption over periods of 5–25 years was reported to produce skin lesions, skin cancer, vascular disease, effects on the nervous system and possibly cancer of other organs.

The only available treatment for chronic arsenic poisoning is to remove the patient from the source of exposure and provide supportive care.

Refs:
• Kreiss K et al. Arsenic toxicity. Atlanta, GA, US Department of Health and Human Services, Agency of Toxic Substances and Disease Registry, 1990 (Case Studies in Environmental Medicine, No. 5).
Photographs by Nasrine Karim, NGO: Earth Identity Project, Bangladesh. Hands and feet "before" from an arsenicosis patient. Used with permission.
Fluoride occurs naturally in soil and water, and is a byproduct of industrial activities such as the aluminum and fertilizer industries. It is also added to drinking water to help prevent dental caries. Concentrations in surface water are usually relatively low (< 0.5 mg/litre) while deeper groundwater wells in areas high in fluoride minerals may have concentrations as high as 10 mg/litre.

An estimated 100 million people suffer health effects from overexposure to fluoride. A wide strip from North to South Africa, and including the Syrian Arab Republic, Jordan, Egypt, Sudan, Ethiopia, Kenya, the United Republic of Tanzania and South Africa, is known to have high concentrations of fluoride in groundwater. In one village of 2000 people, 95% of children are affected by dental fluorosis. Other effects, such as skeletal fluorosis and crippling fluorosis, are also seen in some inhabitants of this village, as in other parts of the so-called “African fluoride belt.”

Fluoride is absorbed quickly following ingestion, but is not metabolized, and diffuses throughout the body. About 40% is excreted in urine within 9 hours, and 50% over 24 hours.

Fluoride has an affinity for mineralizing tissues of the body – in young people the bones and teeth, and in older people the bones. As the excretion rate is greater in adults, mineralization is proportionally less than in children.

The most readily identifiable health effects of consuming water with elevated levels of fluoride are a mottling of the teeth, known as fluorosis, and sclerosis of the bones. Children are particularly affected by fluorosis, because teeth take up fluoride during their formation.

Fluoride has been shown to be effective in preventing dental caries, from the observed association of low incidence of dental caries with naturally occurring fluoride in drinking-water (at about 1 mg/litre). As a result, many health authorities around the world, including the World Health Organization, recommend fluoridation of public water supplies as an important public health measure. However, at concentrations above 1.5 mg/litre fluoride may affect tooth mineralization in children leading to a mottling of the teeth, which can in some cases be unsightly. The regular consumption of water with fluoride concentrations above 4 mg/litre, however, can cause progressively increasing skeletal fluorosis.

Refs:

Pictures: A. K. Susheela of Fluorosis Research & Rural Development Foundation of India (used with permission)

Note the discoloured teeth of the children with fluorosis.
Discoloration appears as brown or black streaks (lines)
These have a horizontal orientation – not vertical.
The discoloration is away from the gums.
The discoloration is seen in the teeth in pairs and not in single teeth.
The discoloration seen here is the classical depiction of dental fluorosis in children.
High levels of lead may be found in drinking water. This is most commonly a result of human activities, particularly where lead piping is still being used, or water supply fittings use leaded solders. Concentrations are affected by factors such as water acidity, water hardness and duration of contact with water. Urban run-off, particularly where leaded fuels are common, is a source of lead contamination, particularly of surface waters.

Lead is a neurodevelopmental toxicant. It interferes with haem synthesis, and can damage the central and peripheral nervous systems, the kidneys and the reproductive system. It can be absorbed by the body through inhalation, ingestion or placental transfer. In adults, approximately 10% of ingested lead is absorbed, but in children this figure can be 4–5 times higher. After absorption, the lead is distributed in soft tissues such as the kidneys, liver and bone marrow, where it has a biological half-life in adults of less than 40 days. In skeletal bone, lead may persist for 20–30 years. Lead is a cumulative poison, and can severely affect the central nervous system. Infants and fetuses are the most susceptible. Placental transfer of lead occurs in humans as early as the 12th week of gestation and continues throughout development.

Many epidemiological studies have been carried out on the effects of lead exposure on the intellectual development of children. Other adverse effects associated with exposure to high amounts of lead include kidney damage and interference with the production of red blood cells and the metabolism of calcium needed for bone formation.

Refs:


Nitrates and nitrites occur primarily as a result of run-off from the agricultural use of fertilizers and from bacterial action on animal wastes. The intensification of farming practices, and sewage effluent disposal to streams have led to increasing amounts of nitrate in some waters, particularly groundwater. Whereas food is the major source of nitrate intake for adults, bottle-fed infants may be exposed to nitrates if contaminated water is used for mixing formula milk.

The toxicity of nitrate in humans is thought to be solely due to its reduction to nitrite. The major biological effect of nitrite in humans is its involvement in the oxidation of normal haemoglobin to methaemoglobin, which is unable to transport oxygen to the tissues, a condition known as methaemoglobinaemia or more commonly, “blue baby syndrome”. Young infants and pregnant women are most susceptible to methaemoglobin formation.

Refs:

Mercury occurs naturally in drinking-water at extremely low levels, but contamination can result from industrial emissions or spills. Inorganic mercury compounds are generally insoluble in water and the major concern is the organic methylmercury, formed from inorganic mercury by bacteriological action. Methylmercury is known to accumulate in fish and fish products, and the consumption of these foods may cause human illness.

Methylmercury is a developmental neurotoxicant. *In utero* exposure leads to interference with neuronal migration, organization of brain nuclei and layering of the cortex. These experimental findings are consistent with the severe cerebral palsy, seizure disorders, blindness, deafness and mental retardation that have been documented in children whose mothers ate heavily contaminated fish during pregnancy. More subtle neurodevelopmental deficits have been observed in some children who received much lower exposures *in utero*. Methylmercury can also damage the brain after birth. Long-term exposures outside the developmentally vulnerable periods also cause damage to the central nervous system. Progressive signs include paraesthesia, ataxia, tremor and muscle spasticity, leading to coma and death.

Methylmercury compounds are almost completely absorbed by the gastrointestinal tract and can cross biological membranes, especially the placenta, the brain, spinal cord and peripheral nerves. The main effects of methylmercury poisoning are severe, irreversible, neurological disorders and mental disability.

Less than 15% of inorganic mercury in drinking-water is absorbed by the gastrointestinal tract. Inorganic mercury compounds have a long biological half-life, accumulating in the kidneys where the toxic effects may lead to kidney failure.
Refs:


Pesticides are a cause of increasing concern due to their widespread and often indiscriminate use. In both urban and rural settings, pesticides may reach water supplies from agricultural run-off. Although they are not specifically removed by conventional water treatment processes, natural filtration and biodegradation prior to and during treatment means that these substances are rarely detected in treated water. However, elevated levels are often found in rural areas where intensive agricultural practices can result in direct contamination of the water source (as shown in the diagram).

Public health concerns regarding pesticides in water arise from their potential to accumulate in the body. These chemicals can be absorbed orally; health effects depend on the specific type of pesticide.
Disinfection by-products (DBPs) occur when chemicals such as chlorine are added to water to control microbial contamination, where they combine with organic materials. Four of the DBPs regulated by the US EPA are listed in the table along with their “potential” health effects. There are few data available on the effects of low doses on humans, particularly infants and children. Although there is some concern that these chemicals may pose a health risk, the potential risks arising from not treating drinking-water are considerably greater, and the disinfection of water should never be compromised as a result.

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<<READ QUOTATION>>
This historical quotation remains true today, and particularly critical in developing countries where large portions of the population have no access to safe drinking water.

Refs:
* Booker SM. TNP taps disinfection by-products for study. Environmental Health Perspectives, 2000, 108:A64.
Radionuclides occur naturally in the environment from deposits of radioactive minerals, and from the disposal and storage of radioactive materials. Concentrations in surface waters are likely to be extremely low, and groundwater concentrations vary according to the type of aquifer minerals and dissolved anions.

Radioactive materials cause changes in the DNA of cells, with an increased risk of cancer being the most serious outcome. The most common exposure route is via the respiratory system by inhalation of aerosolized droplets. People can be exposed when they take showers. The US Environmental Protection Agency estimates that 168 cancer deaths per year in the USA are related to radon in water, of which 89% are lung cancers, and 11% stomach cancers.

Refs:

Picture on the right: The risk of living with radon, www.epa.gov/iaq/radon/pubs/citguide.html
In this summary slide, we see the complexity of the issues related to children’s environmental health.

Hazards are introduced into environmental media with variable efficiency in different settings. A child’s activities bring him or her into contact with these hazards. Depending upon the individual susceptibility of the child, based upon age, general health and social supports, the exposure may cause harm varying in severity from subtle changes in function to death.

Children’s environmental health is the field that synthesizes these complex issues and attempts to make fundamental changes to improve children’s environments and prevent environment-related illnesses.

*Picture: WHO, J. Taylor. Water, Zimbabwe*
The diagnosis of illnesses suspected to be caused by contaminated water supplies require:

• a thorough knowledge of history of exposure;
• a complete physical examination of the patient; and
• where possible, confirmatory laboratory tests.

Standard stool cultures, tests for ova and parasites, and measurement of antibody titres may be feasible in patients who present at hospitals or health care centres. Laboratory tests are more likely to be useful in cases of microbial exposures and acute effects from chemical exposures than for chronic exposures to low doses of chemicals. Testing for low concentrations of chemicals requires sophisticated analytical techniques unlikely to be available outside research settings. Measuring methaemoglobin in the blood will confirm acute nitrate poisoning. Testing blood lead levels can indicate lead exposure. Measurements of urinary arsenic levels are of limited value as arsenic is rapidly excreted from the body. None of these tests, however, will identify the source of exposure, which is important for case-management and prevention of further exposure. If elevated levels of chemical contaminants are known to exist then exposure can be inferred, and confirmed by detailed patient and environmental histories and by chemical and microbiological analyses.

Treatment depends on the type of disease that has resulted from exposure to unsafe water or lack of water (e.g. from the microbial or chemical contamination, or dehydration), the systems affected and the degree and severity of disease.
Picture above: WHO, C. Gaggero. Environment water, Mexico
Picture below: WHO, P. Merchez. Cholera, Peru
Diarrhoeal illness is treated by controlling the infection and by aggressive fluid management. Antimicrobial drugs are used only in cases of severe cholera and bloody diarrhoea (dysentery). In young children, the most common cause of death is from dehydration. Correct management may prevent up to 90% of deaths. Dehydration can usually be treated using oral rehydration fluids. Intravenous rehydration may be needed in cases of severe dehydration, or where the patient cannot drink or absorb water.

Sources of infection should be identified and made safe. If the infected person is potentially contagious, isolation, strict hand-washing by staff, and the safe disposal of faeces are the recommended control measures. For non-infectious diseases resulting from contaminated water supplies, treatment involves removing the patient from the source of exposure and providing supportive care. In some cases the use of a specific pharmaceutical preparation or antidote may be indicated (e.g. succimer for lead, atropine for organophosphorus pesticides, methylene blue for reversal of methaemoglobinaemia).

<<NOTE TO USER: Please insert the appropriate amounts of oral rehydration solution in the bottom row of the table using local measures.>>

Ref:
“Pooling” results of good quality studies from different regions (meta-analysis) can provide useful insights into the overall impact of interventions. In a recent systematic review of the literature on diarrhoeal disease (Ref: Fewtrell et al, 2005), 2000 abstracts were screened, and then 50 studies were analysed; of these 50 studies, 38 were used in the meta-analysis. The overall results of the meta-analysis are summarized in the table above. These results are generally in line with those of earlier studies. However, the investigators detected a greater impact of intervention in drinking-water quality than had been detected in previous reviews. This likely arises from assessment of the actual quality of water consumed as opposed to the quality of the water at the source, as was commonly done in earlier studies. Water, sanitation and hygiene interventions interact with one another, and available evidence indicates that the impact of each may vary widely according to local circumstances. Prioritizing should therefore be based on local conditions and evidence from implementation rather than from pooled data, such as the average impacts summarized in the table above.


Ref:
Prevention of contamination is an essential feature of effective water quality management. A comprehensive assessment of the water supply system enables effective risk management strategies to be identified from the source to the consumer. When a situation that can give rise to water contamination is recognized, preventive strategies to minimize the exposure can be identified.

Surface and groundwater sources should be protected from contamination. Possible sources of contamination include animal and human waste, agriculture, industry, mining and quarrying run-off, and the disposal of hazardous wastes. These and other polluting activities should be identified and controlled, or where feasible, excluded from the water catchment area.

Groundwater in deep or confined aquifers is usually protected from local sources of contamination and microbiological quality is generally high. However, groundwater supplies may contain high concentrations of naturally occurring elements that affect health or the taste/appearance of the water.

Groundwater with a high salinity may be unpalatable, whereas high levels of nitrates, arsenic, boron, fluoride and radionuclides may make water unfit for use. Groundwater may also be polluted by certain practices, such as the drilling of wells.

Even in areas without safe drinking-water supplies, home treatment is possible. Filtration can remove some microbial contamination and parasites, as can disinfection and boiling. Although it is possible to remove some chemical contaminants, methods for this tend to be expensive and the costs must be weighed against the risks involved in drinking water with potentially high levels of chemical contaminants. Water treatment carried out in the home requires scrupulous and continuous maintenance to ensure a safe and effective supply.

Education is vitally important to ensure that consumers of water understand the routes by which contaminants may enter the system. Health promotion activities are needed to demonstrate the importance of correct hygiene regarding both sanitation and water supply, particularly for those most at risk.

Ref:


Picture above: WHO, P. Virot. Sustainable development healthy environment hygiene water photography, India. Safe water system The Tappankala Sector 1 Resettlement Area, Delhi, India, Asia, November 2002
Picture below: WHO. Health Education.
Protection of the source is the most important way to protect drinking-water. Both surface and groundwater must be protected, although surface water is more immediately vulnerable. Contamination from human and animal waste causes microbial contamination and poses a major threat of waterborne and water-washed infections. Industrial discharges from legal and illegal industry, contamination from mining operations, and run-off from farms and urban centres all contribute to contamination. Riparian buffer zones and storm-water management in cities are necessary to control non-point sources. Point-source pollution from sewage treatment plants and industrial discharges can be controlled by appropriate technology, monitoring and enforcement of laws and regulations on drinking-water quality.

<<NOTE TO USER: Many of these issues are covered in depth in the sanitation and waste modules in this series>>

Municipal water treatment plants usually treat drinking-water using a standard series of steps. These are as follows:

1) **coagulation** which removes dirt and other particles suspended in water. Alumina and other chemicals are added to water to form tiny sticky particles called "floc" which attract the dirt particles. The combined weight of the dirt and the alum (floc) is heavy enough to sink to the bottom during

2) **sedimentation**, and the clear water moves to

3) **filtration** where the water passes through filters made of layers of sand, gravel and charcoal that help to remove even smaller particles.

4) Finally the water reaches the **disinfection** tank where a small amount of chlorine is added, or some other disinfection method is used, to kill persistent bacteria or microorganisms that may be present in the water and to provide continuing protection against recontamination during storage and distribution.

5) Water is stored safely.

*Ref :
*www.epa.gov/safewater/dwh/treat.html*
Drinking-water management requires that quality standards be developed, applied and enforced. The components of a proper plan involve the following:

1) health-based targets that are set according to a critical evaluation of the health concerns;
2) system assessment to determine whether the water-supply chain as a whole (from source through treatment to the point of consumption) can deliver water of a quality that meets the above targets;
3) operational monitoring of the control measures in the supply chain which are of particular importance in ensuring drinking-water safety;
4) management plans documenting the system assessment and monitoring protocols and describing actions to be taken in normal operation and following incidents; including upgrade and improvement documentation and communication; and
5) a system of independent surveillance that verifies that the above are operating properly.

Ref:
When treated, high-quality drinking-water is not available, there are home treatment options.

• Microbial contamination can be eliminated by boiling water, but care must be taken not to over-boil.

• Home filtration and chlorination are also viable options (known as “point-of-use” treatment systems).

• Proper storage is critical to prevent recontamination.

**Question:** Can water be treated by individuals at the point of use?

Yes. There are several ways of treating water at home, or at the point of use, including by boiling, exposure to sunlight and filtration. Probably the simplest, and certainly the best-studied method, is to use a disinfectant. By adding 0.6 ml of 1% chlorine solution to 1 litre of water and allowing it to stand for 30 minutes, a residual chlorine content between 0.2 and 0.5 mg/litre can be achieved. If the water is cloudy, it should be filtered before chlorination to decrease the quantity of organic material with which the chlorine can combine. The chlorine solution must be stored in a clearly labelled container, out of the reach of children to prevent poisoning. More details are available online at: [www.who.int/emc-documents/cholera/docs/whocdr954.html](http://www.who.int/emc-documents/cholera/docs/whocdr954.html)

**Question:** How should I store water at home?

The choice of storage vessel is very important. The ideal container holds 10–30 litres, is made of durable, unbreakable and oxidation-resistant materials, equipped with handles and has an opening large enough for cleaning and filling, but small enough to prevent a child’s hand holding a cup to be inserted. A screw-on lid is ideal and a spigot attachment is very helpful. Recycling used containers can be dangerous if they once contained toxic chemicals and should therefore be avoided. More information is available at: [www.cdc.gov/safewater/manual/1_toc.htm](http://www.cdc.gov/safewater/manual/1_toc.htm)
Refs:
• Department of Health & Human Services, Centers for Disease Control and Prevention. Safe water systems for the developing world: A handbook for implementing household-based water treatment and safe storage projects (www.cdc.gov/safewater/manual/1_toc.htm)
• World Health Organization. Guidelines for the control of epidemics due to Shigella dysenteriae type 1 (www.who.int/emc-documents/cholera/docs/whocdr954.html).
Water

WHICH CONTAMINANTS ARE REMOVABLE BY WHICH TYPE OF HOME TREATMENT SYSTEM?

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Cation exchange</th>
<th>Anion exchange</th>
<th>Activated carbon</th>
<th>Reverse osmosis</th>
<th>Distillation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Fluoride</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Lead</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Organic Hg*</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Nitrate</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>VOC**</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Radium</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Coliforms</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Hg, mercury.
**VOC, volatile organic compounds.

<<NOTE TO USER: The systems here may not be available or feasible for your area. Please substitute a regionally appropriate menu of options for home treatment and storage of drinking-water.>>

Other kinds of treatment can be used to reduce chemical contaminants, but they are often expensive and difficult to maintain. Proper maintenance is critical, otherwise home treatment systems can be both ineffective and dangerous.

Products must be quality controlled. A complete listing of certified home treatment systems can be found at the web site of NSF, The Public Health and Safety Company at: www.nsf.org/Certified/DWTU/
<<NOTE TO USER: To be completed locally.>>
Finally, water is critical to life; it is essential for drinking, cooking, hygiene, agriculture and recreation. As the world’s population increases, increasing numbers of people are living in areas that are water stressed or where water is scarce. Not only is water a quality issue, it is also a quantity issue. Projections indicate that some constraints on water use will be placed on 40% of the world’s population by 2025, and water scarcity may affect up to one quarter of the world’s population by 2050. Protecting this precious resource from pollution is critical to assuring public health.

Refs:

We must learn to live within the limits of the renewable, rechargeable freshwater budgets of our region.

Deep aquifers can take centuries or millennia to recharge.

Excessive withdrawal is not sustainable.

*Picture: [www.unep.org/vitalwater/05.htm](http://www.unep.org/vitalwater/05.htm)*
The water cycle consists of precipitation, evaporation, evapotranspiration and runoff. This graphic explains the global water cycle, showing how nearly 577 000 km$^3$ of water circulates through the cycle each year.

*Picture: www.unep.org/vitalwater/05.htm*
Health and environment professionals have a critical role to play in maintaining and stimulating changes that will ensure children’s access to safe water and protect their health.

Although the human genome project is very important and scientifically exciting, we all know that genes express themselves within an environment and that understanding the gene–environment interactions is what will keep our children healthy.

So, as we look to our political and personal lives to support sustainable development, we can look to our practices for ways of enhancing the environmental health of our patients. All of us can do something.

- At the one-to-one patient level we can include environmental etiologies in our differential diagnoses and in our preventive advice: is the disease linked to the quality or availability of water? It is important to limit the number of diagnoses given as “idiopathic” and to look hard for environmental, water-related, causes of disease and disability.

- Health care providers should be alert and detect the "sentinel" cases. Their detection and study will be essential for developing, proposing and supporting community-based interventions. Publication of cases and research studies enables the communication of knowledge and experience that will benefit other communities and countries.

- It is important to inform and educate our patients, families, colleagues and students didactically, on the importance of water-related diseases and how to avoid them.

- Finally, we must all become vigorous advocates for the protection of water sources from pollution, the appropriate treatment and storage of water, respect for drinking-water quality standards, and water conservation. These and other measures are crucial for protecting the environmental health of our children and future generations. It is not enough to be an informed citizen, we need to write letters, testify at hearings, convince decision-makers, approach our elected officials with information, education and clear messages based upon the evidence.

- And, we must all recognize that as professionals with an understanding of both health
and the environment, we are powerful role models. Our choices and opinions with respect to water and to other environmental factors will be noticed: they should be thoughtful and sustainable.
<<NOTE TO USER: Add points for discussion according to the needs of your audience.>>
ACKNOWLEDGEMENTS

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