Drinking water quality risk management

Water & Waste Engineering
2020/05/08

名古屋大学減災連携研究センター
Disaster Mitigation Research Center, NAGOYA UNIVERSITY

Water & Waste Engineering

Keywords: water system, waste treatment system, water supply engineering, wastewater engineering, waste management engineering

Outline: We will give lectures on the water and wastewater system, waste management system, the management system and cutting-edge technologies for water, waste, and human health and the environment. In addition, we consider the water and waste system from the viewpoint of natural disaster, climate change, and depopulation society. And, we will discuss the emergency environmental management.

Objectives:

- To management system and technology for water and waste management system
- To discuss and explain on water, wastewater and waste management.
- To discuss the future water and waste system with the influence on natural disaster, climate change, and depopulation society.
- To understand emergency environmental management.

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Credits: 2

Grading criteria:

Participation 45%
Presentation 25%
Report 30%

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Self-Introduction

- Name, Affiliation
- Topic of your research
- Your interests in water & waste engineering.

What is 'RISK'?

risk

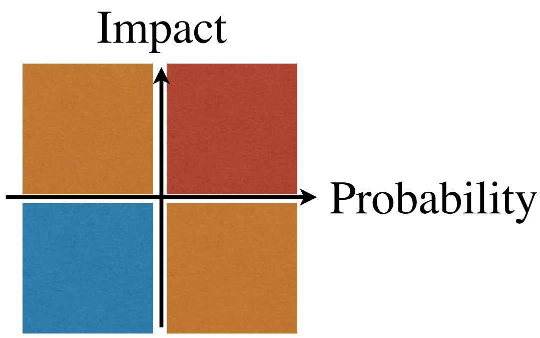
- a situation involving exposure to danger:
- the possibility that something unpleasant or unwelcome will happen:
- a person or thing regarded as likely to turn out well or badly, as specified, in a particular context or respect:
- a person or thing regarded as a threat or likely source of danger:
- a possibility of harm or damage against which something is insured.
- the possibility of financial loss:

risk management

- Risk management — Vocabulary, ISO Guide 73:2009
  - coordinated activities to direct and control an organization with regard to risk
- Risk management framework
  - set of components that provide the foundations and organizational arrangements for designing, implementing, monitoring, reviewing and continually improving risk management throughout the organization

risk management

- Risk = Impact × Probability
  - prioritization process
  - balancing resources



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risk management: method

- Method consist of the following elements, performed, more or less, in the following order.
  1. identify, characterize threats
  2. assess the vulnerability of critical assets to specific threats
  3. determine the risk
  4. identify ways to reduce those risks
  5. prioritize risk reduction measures based on a strategy

risk management strategy

- Make a plan
  - a list of individual risks
  - a rating of each risk based on likelihood and impact
  - an assessment of current controls
  - a plan of action
- Consider the effectiveness of those actions
  - very inadequate, or non-existent, inadequate, satisfactory, strong, very strong
- Decide how to handle each risk
  - avoid, reduce, transfer, accept

risk management strategy

- A risk management strategy provides a structured and coherent approach to identifying, assessing and managing risk.
- Risk management framework
  - set of components that provide the foundations and organizational arrangements for designing, implementing, monitoring, reviewing and continually improving risk management throughout the organization.

Environmental Management System

- **ISO14000;**
  - **a family of standards** related to environmental management that exists to help organizations
  - **minimize** how these operations negatively affect the environment
  - comply with applicable laws, regulations, and other environmentally oriented requirements
  - **continually improve**
- **The current version of ISO14000 is ISO 14001:2015 which was published in Sept. 2015.**

ISO 14001; Basic principles and methodology

- **the well-known Plan-Do-Check-Act cycle.**
- **Plan:**
  - establish objectives and processes required
- **Do:**
  - implement the processes
- **Check:**
  - measure and monitor the processes and report results
- **Act:**
  - take action to improve performance of EMS based on results

Environmental risk

- Environmental risk = Toxicity × Exposure
  - Risk = Impact × Probability

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a case study; Environmental Risk Management in Panasonic

- To identify environmental risks and implement the management system, environmental risks are identified for each Company and for each region in the world each year.
- From these risks, environmental risks on a group-wide level are selected.
- The risks that show a high level of frequency or seriously impact business management are designated as major risks and prioritized in planning and executing risk-reducing measures.
- These measures are implemented for each major risk, and progress is monitored and followed up on a quarterly basis in the PDCA cycle.

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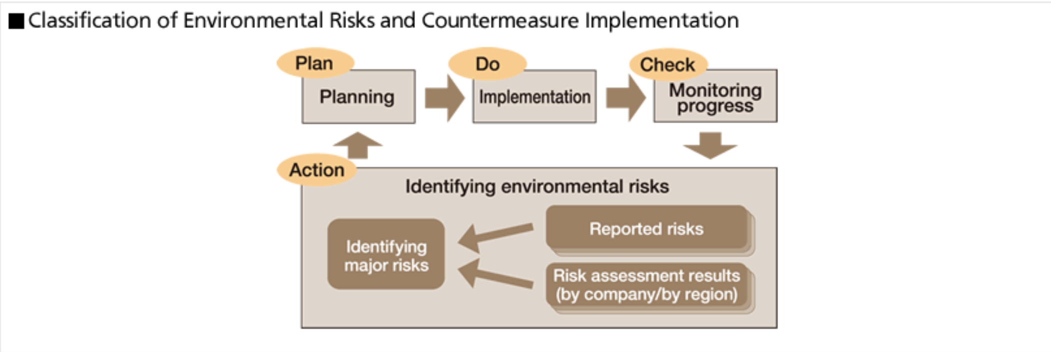

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a case study; Environmental Risk Management in Panasonic

- **Environmental Compliance Management at Factories**
  - Panasonic manages its environmental systems in full compliance with laws and regulations. We regularly measure emissions of gas, wastewater, noise, odor, etc., and introduce preventative measures for cases that may lead to serious violations.
  - Environmental pollution; air, water quality, noise, odor, waste

a case study; Environmental Risk Management in Panasonic

> **Measures Against Soil and Groundwater Contamination**

- In the latter half of the 1980s, soil and groundwater contamination due to chlorinated organic solvents was detected at some Panasonic sites.
- Specifically in 1991 we created the Manual for Preventing Contamination of Soil and Groundwater and began conducting necessary surveys and measures.
- In 1995, we discontinued the use of chlorinated organic solvents, and in 1999 created Guidelines on the Prevention of Environmental Pollution to ensure there would be no recurrence of similar problems at our sites.

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a case study; Environmental Risk Management in Panasonic

> **Measures Against Soil and Groundwater Contamination**

- In fiscal 2003 we began enhancing our surveys and measures to comply with relevant laws and regulations, including the Soil Contamination Countermeasures Act, which was enforced in Japan in 2003, and in fiscal 2004 started implementing measures to place all our bases across the globe under management supervision with regard to soil and groundwater.
- Specifically, we conduct onsite inspections and interviews at the bases, in addition to surveying their use of VOCs and heavy metals.

a case study; Environmental Risk Management in Panasonic

Soil and Groundwater Risk Management Policy; Pollution dispersion prevention beyond Panasonic premises

1. Conduct historical surveys
2. Determine and install monitoring wells at the premises' borders
3. Analyze groundwater at the borders
4. Check possibility of pollution from external sources
5. Report to management department
6. Determine the external pollution dispersion prevention methods
7. Install the external pollution dispersion prevention methods
8. Install assessment wells
9. Begin assessments (monitoring)

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Soil and Groundwater Risk Management Policy; Thorough pollution source elimination

1. Conduct brief status check
2. Horizontal direction detailed analysis
3. Vertical direction detailed analysis
4. Determine the magnitude of pollution
5. Discuss the areas and methods of purification
6. Conduct purification and install pollution dispersion prevention measures
7. Monitor pollution source (groundwater) after purification
8. Report purification completion to management department

a case study; Environmental Risk Management in Panasonic

Initiatives for PCB Pollution

- Panasonic discontinued the production of equipment containing polychlorinated biphenyls (PCBs) in Japan in 1972 and has since been strictly managing its PCB waste.
- With the enforcement of the Law concerning Special Measures for Promotion of Proper Treatment of PCB Waste in July 2001, optimized storage, decontamination, and notifications are being practiced in compliance with the law.

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a case study; Environmental Risk Management in Panasonic

Initiatives for PCB Pollution in 2016

- 124 of 2,281 units, including transformers and capacitors using PCBs submitted under the early registration scheme were treated, by Japan Environmental Storage & Safety Corporation (JESCO) as our subcontracted PCB waste disposal operator.
- Approx. 38 tons of stabilizers and other waste with a high PCB concentration were consigned for treatment to JESCO, and approx.
- 126 tons of low-concentration PCB waste was contracted to a private incineration facilities certified by the Japanese Ministry of the Environment.
- We will continue to treat PCB waste towards March 31, 2027, which is the legally designated deadline by which decontamination is to be completed.

Recovery of clean water; laws, regulations and technology for water pollution control

- the historical background of water pollution and the conditions of under which the Minamata and Itai-itai diseases occurred are explained.
- the purpose of laws; to prevent water pollution
- more stringent prefectural standards, wastewater treatment systems and technologies for improving of water quality, and monitoring systems by telemeter.

Risk analysis

A preliminary example

- A player in a casino with an initial capital of V_0
- After the game the capital is V_1
- We denote the profit by a random variable $X = V_1 - V_0$
- $X = \begin{cases} 0.6 \text{ with probability } p, \\ -0.4 \text{ with probability } 1 - p. \end{cases}$

Dealing with risk

- **Risk analysis is;**
  - the systematic study of uncertainties and risks we encounter in business, engineering, public policy, and many other areas.
  - to identify the risks faced by an institution or business unit, understand how and when they arise, and estimate the impact (financial or otherwise) of adverse outcomes.
  - **Quantitative Risk Analysis**
  - **Models and Simulation**
  - **Monte Carlo Simulation**

Risk assessment

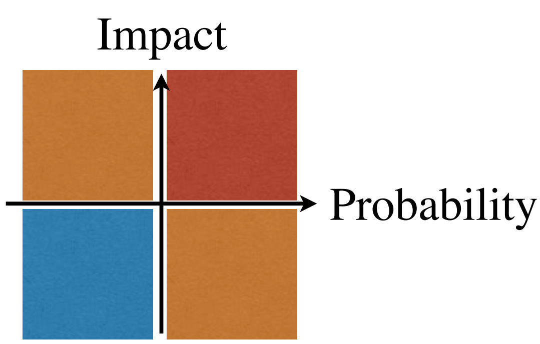
- **Risk assessment has three parts…**
  - Risk identify
  - Risk analysis
  - Risk evaluation
- Risk evaluation is;
  - concerned with assessing **probability** and **impact** of individual risks, taking into account any interdependencies or other factors outside the immediate scope under investigation

Risk evaluation

- **Probability**
  - the evaluated likelihood of a particular outcome actually happening (including a consideration of the frequency with which the outcome may arise).
- **Impact**
  - the evaluated effect or result of a particular outcome actually happening.
    - ✓ time
    - ✓ quality
    - ✓ benefit
    - ✓ people/resource

Concept of risk management

- **Risk = Impact × Probability**
  - **prioritization process**
  - **balancing resources**



Global Burden of Disease

- Global Burden of Disease (GBD) analysis provides comprehensive and comparable assessment of mortality and loss of health due to diseases, injuries and risk factors for all regions of the world.
- The assessment of GBD started from 1990 and the latest open to the public is 2004 by WHO.
- Global health risks, 2009, http://www.who.int/healthinfo/global_burden_disease/en/

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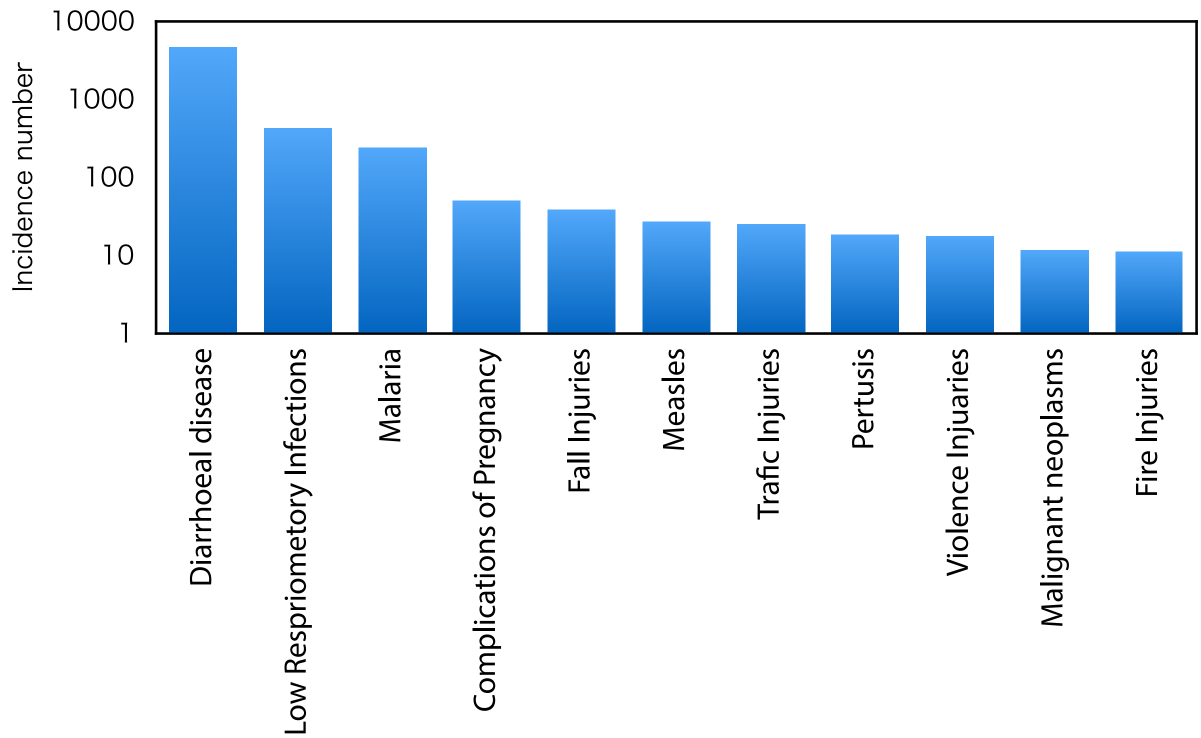
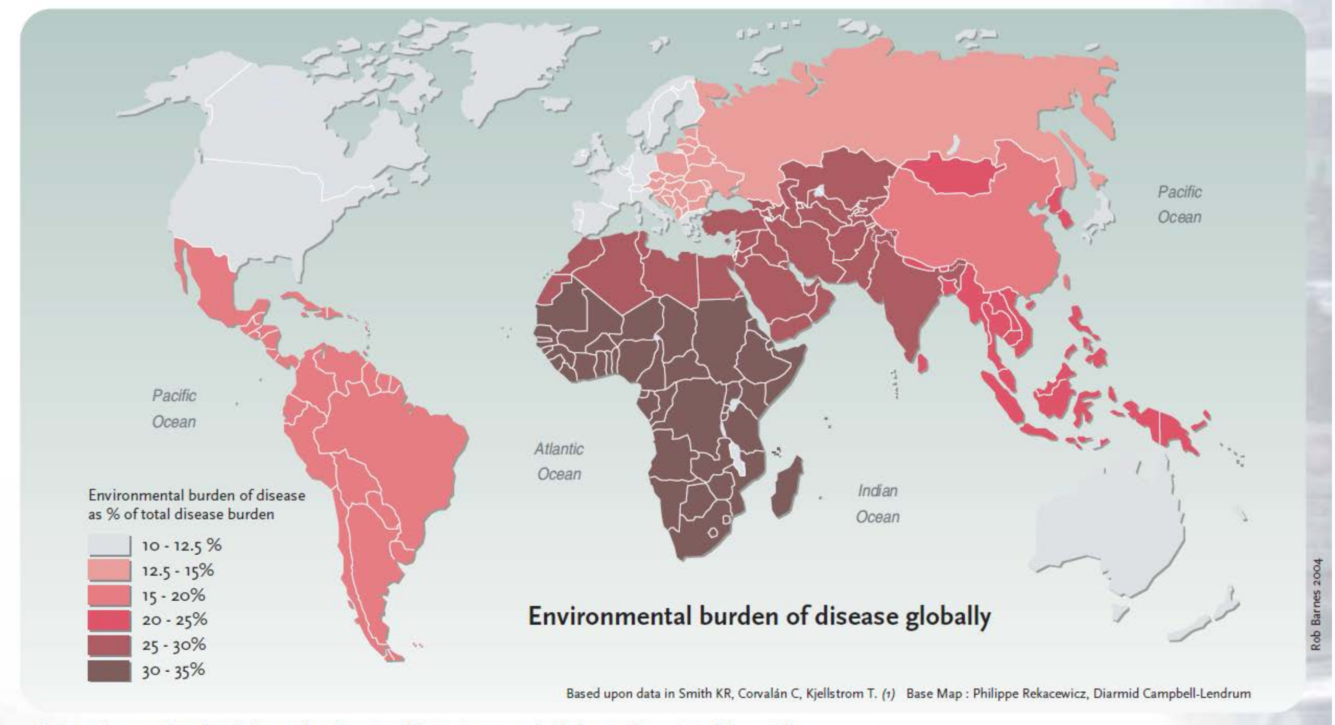
Incidence number in 2004



Environmental burden of disease globally



Estimated proportion of total disease burden caused by environmental risk factors, by region of the world.

More damage in developing countries

- The health impacts of environmental risks are **heaviest among poor and vulnerable populations in developing countries.**
- The poor in developing countries generally have the **least access to clean water sources**, and those same populations also may be the most **directly exposed to environmental risks**.
- At the same time, poor people also may be the most dependent on natural resources as sources of livelihoods and well-being, and thus be most impacted by unsustainable exploitation or depletion of those resources.

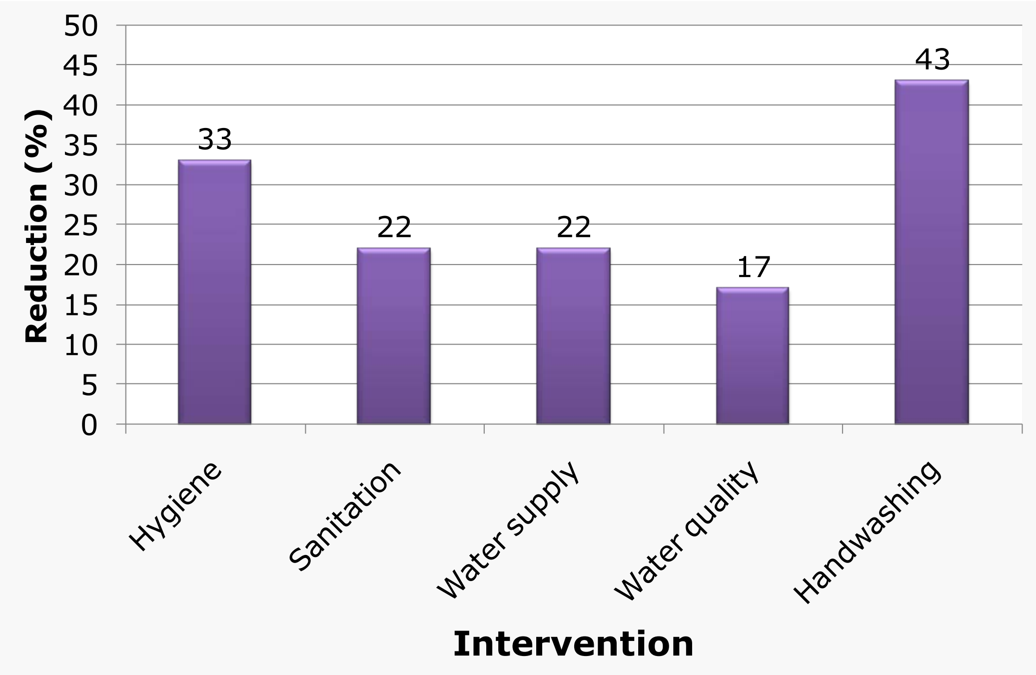
GBD — selected water-related diseases

- **Diarrhoea:**
  - ✓ **1.8 million people**, mostly children, die of diarrhoea every year.
- **Malaria:**
  - ✓ **1 million people**, mostly children, die of malaria every year.
- **Schistosomiasis:**
  - ✓ **200 million** are infected, **20 million** suffer severe consequences.
- **Trachoma:**
  - ✓ **6 million** visually impaired, 146 million threatened by blindness.

What can be done ?

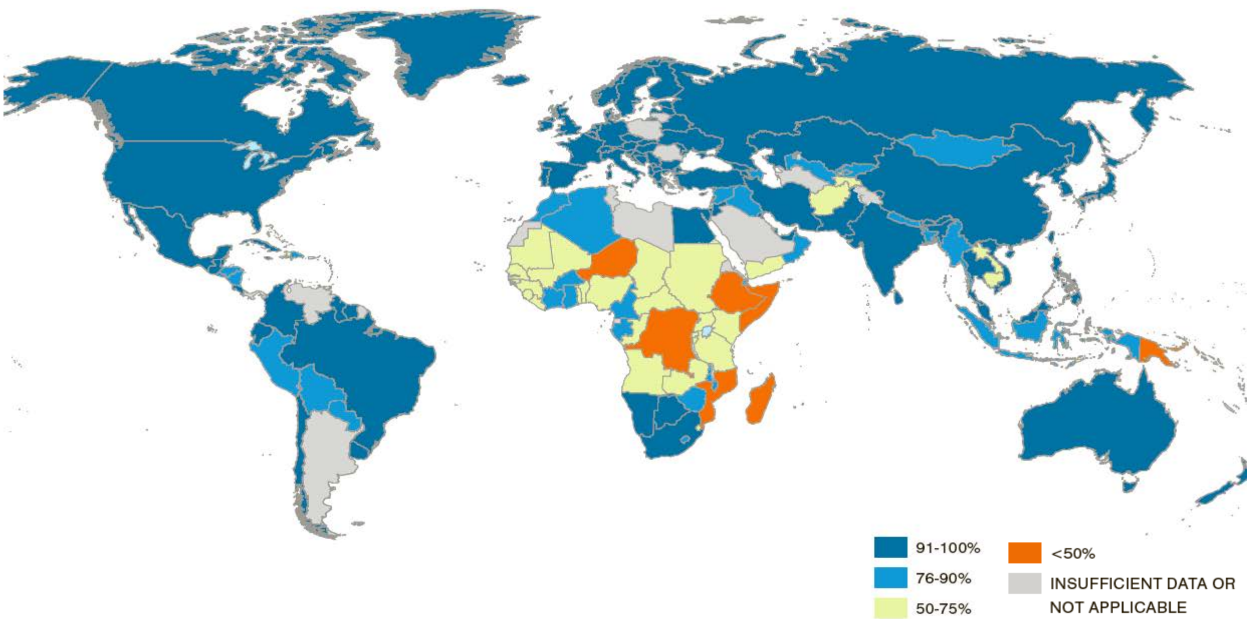
- **Diarrhoea:**
  - ✓ **drinking water and sanitation improvements**
- **Malaria:**
  - ✓ **Better management of water resources reduces Malaria transmission.**
- **Schistosomiasis:**
  - ✓ **Basic sanitation reduces the Schistosomiasis by up to 77%.**
- **Trachoma:**
  - ✓ **Improved sanitary conditions and hygiene practices prevents trachoma.**

Diarrhoeal disease reduction from drinking water and sanitation improvements



©Fewtrell L et. al.,Water, sanitation, and hygiene interventions to reduce diarrhoea in less developed countries: a systematic review and meta-analysis. Lancet Infectious Diseases, 2005

Proportion of the population using improved drinking water sources in 2010



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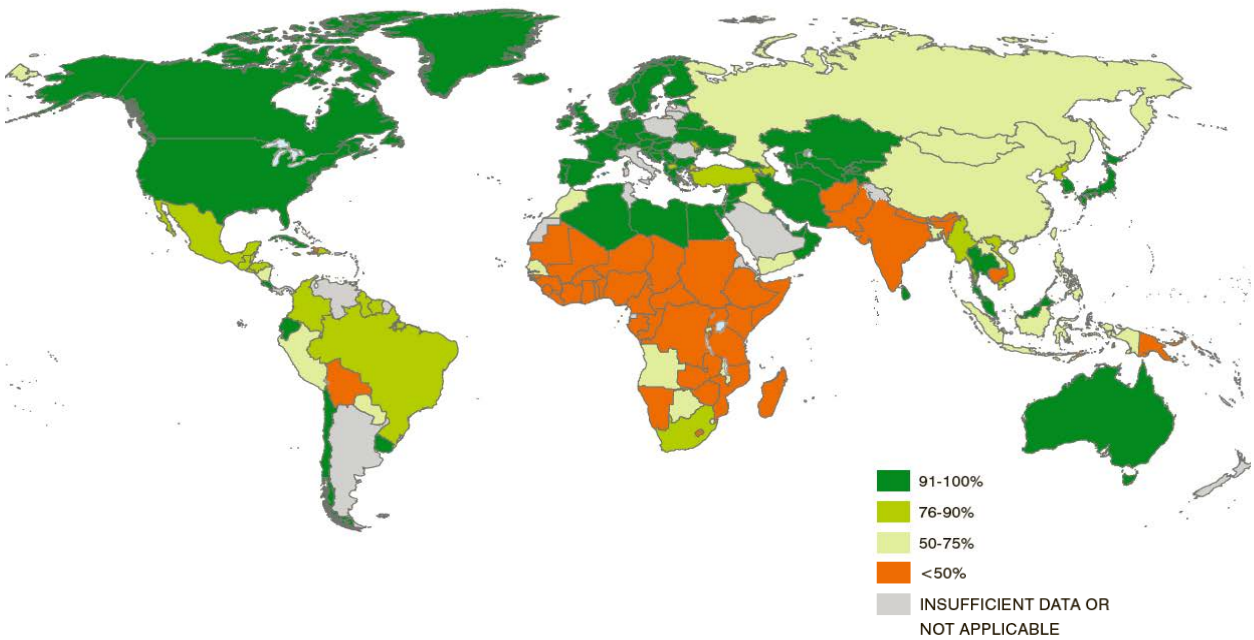
Proportion of the population using improved sanitation in 2010



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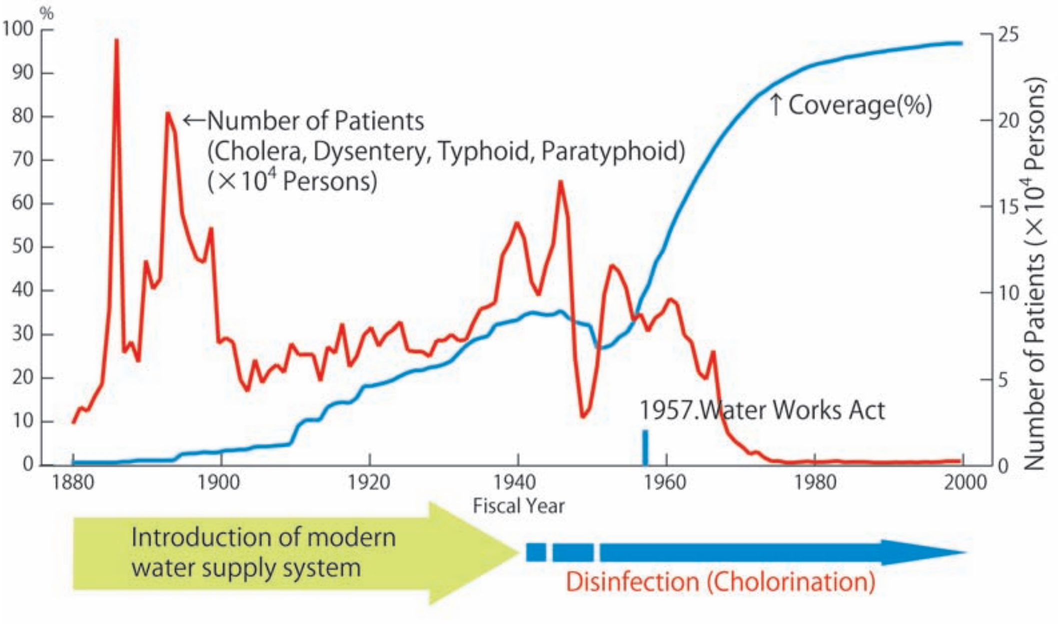
Water and sanitation

- 2.1 billion people **CANNOT** access clean and safe drinking water, 63% of which are in Asia-Pacific Region (UNICEF/WHO).
- 7.9 % of water supply systems in Asian cities retain appropriate residual chlorine over 0.1 mg/L, 21. 5% **CANNOT** comply with national standards (UNEP).
- 2.4 billion people **CANNOT** use appropriate sanitation systems, 3/4 of which are in Asia-Pacific Region (UNICEF/WHO)

History of Water Supply in Japan



Development modern water works

Water facts

- 663 million people are still without access to clean drinking water, despite the Millennium Development Goal target for clean water being met in 2010.
- In SDGs, GOAL 6 Clean Water and Sanitation
- 8 out of 10 people without access to clean water live in rural areas.
- 159 million people use untreated water from lakes and rivers, the most unsafe water source there is.
- Since 1990, 2.6 billion people have gained access to improved drinking water and today, 91% of the world's population drink clean water.

6 CLEAN WATER AND SANITATION

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Safe drinking water

- Diseases related to contamination of drinking-water constitute a major burden on human health.
- Interventions to improve the quality of drinking water provide significant benefit to health.

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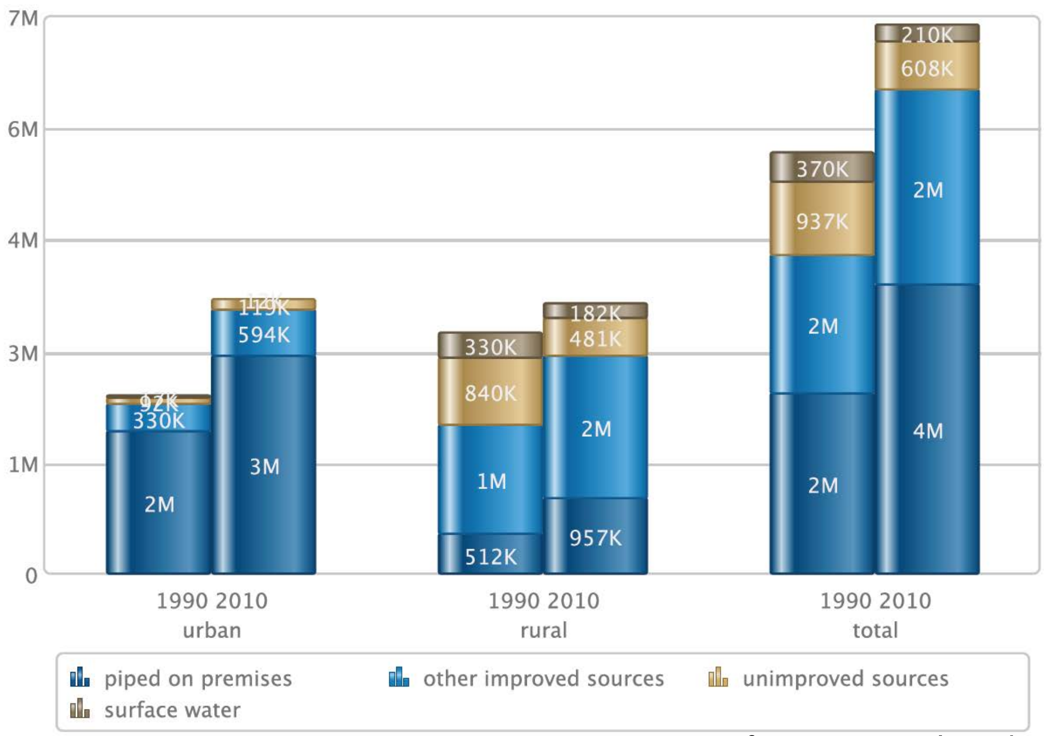
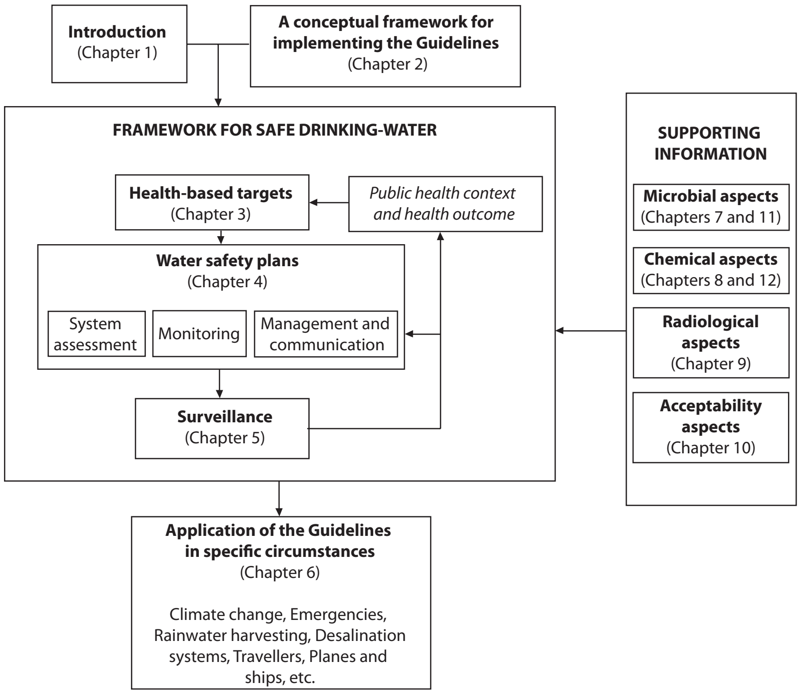
Population with access to drinking water in the world



Framework for safe drinking water



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Microbial aspects

- Securing the microbial safety of drinking-water supplies is based on the use of multiple barriers, from catchment to consumer, to prevent the contamination of drinking- water or to reduce contamination to levels not injurious to health.
- Safety is increased if multiple barriers are in place, including protection of water resources, proper selection and operation of a series of treatment steps and management of distribution systems (piped or otherwise) to maintain and protect treated water quality.
- preventing or reducing the entry of pathogens into water sources and reducing reliance on treatment processes for removal of pathogens.

Disinfection

- Disinfection is of unquestionable importance in the supply of safe drinking-water.
- Disinfection is an effective barrier to many pathogens (especially bacteria) during drinking-water treatment and should be used for surface waters and for groundwater subject to faecal contamination.
- Chemical disinfection
- The use of chemical disinfectants in water treatment usually results in the formation of chemical by-products. However, the risks to health from these by-products are extremely small in comparison with the risks associated with inadequate disinfection.

Chemical aspects

- The great majority of evident water-related health problems are the result of microbial (bacterial, viral, protozoan or other bio- logical) contamination. Nevertheless, an appreciable number of serious health concerns may occur as a result of the chemical contamination of drinking-water.
- The Guidelines do not attempt to define minimum desirable concentrations for chemicals in drinking- water.
- A guideline value normally represents the concentration of a constituent that does not result in any significant risk to health over a lifetime of consumption.

Radiological aspects

- The guidance levels for radionuclides recommended in these Guidelines do not apply to drinking-water supplies contaminated during emergencies arising from accidental releases of radioactive substances to the environment.

Acceptability aspects: taste, odour and appearance

- Water should be free of tastes and odours that would be objectionable to the majority of consumers.
- In assessing the quality of drinking-water, consumers rely principally upon their senses.
- Microbial, chemical and physical constituents of water may affect the appearance, odour or taste of the water, and the consumer will evaluate the quality and acceptability of the water on the basis of these criteria.

Disability-Adjusted Life Year (DALY)

- Definition: One DALY can be the thought of as one lost year of "healthy" life. The sum of these DALYs across the population, or the burden of disease, can be thought of as a measurement of the gap between current health status and an ideal health situation where the entire population lives to an advanced age, free of disease and disability.
- DAYLs for disease or health condition are calculated as the sum of the Years of Life Lost (YLL) due to premature mortality in the population and the Years Lost due to Disability (YLD) for people living with the health condition or its consequences.

Calculation of DALYs

- **DALY = YLL + YLD**
- The YLL basically correspond to the number of deaths multiplied by the standard life expectancy at the age at which death occurs. The basic formula for YLL (without yet including other social preferences discussed below), is the following for a given cause, age and sex:
- **YLL = N x L**
- where:
  - ✓ N = number of deaths
  - ✓ L = standard life expectancy at age of death in years

Calculation of DALYs

- Because YLL measure the incident stream of lost years of life due to deaths, an incidence perspective has also been taken for the calculation of YLD in the original Global Burden of Disease Study for year 1990 and in subsequent WHO updates for years 2000 to 2004.

Calculation of DALYs

- To estimate YLD for a particular cause in a particular time period, the number of incident cases in that period is multiplied by the average duration of the disease and a weight factor that reflects the severity of the disease on a scale from 0 (perfect health) to 1 (dead). The basic formula for YLD is the following (again, without applying social preferences):
- **YLD = I x DW x L**
- where:
  - ✓ I = number of incident cases
  - ✓ DW = disability weight
  - ✓ L = average duration of the case until remission or death

The various hazards that can be present in water can have very different health outcomes

- Some outcomes are **mild** (e.g. diarrhoea), wheres others can be **severe** (e.g. chlera, hemolytic uremic syndrome associated with Escherichia coli O157 or cancer).
- Some are **acute** (e.g. diarrhoea), whereas others are **delayed** (e.g. infectious hepatitis or cancer).
- Some especially relate to **certain age ranges and groups** (e.g. skeletal fluorosis in older adults often arises from long-term exposure to high levels of fluoride in childhood; infection with hepatitis E virus has a very high mortality rate among preg- nant women).
- In addition, any one hazard may cause **multiple effects** (e.g. gastroenteritis, Gullain- Barré syndrome, reactive arthritis and mortality associated with Campylobacter).

DALY provides the common metric

- In order to support public health priority setting, a **common metric** is required that can be applied to all types of hazard and takes into account different health outcomes, including probabilities, severities and duration of effects.
- The disability-adjusted life year (DALY) provides this metric.

Basic principle of the DALY

- The basic principle of the DALY is to weight each health impact in terms of severity within the range of 0 for good health to 1 for death.
- The weighting is then multiplied by duration of the effect and the number of people affected.
- In the case of death, duration is regarded as the years lost in relation to normal life expectancy.
- Using this approach, a mild diarrhoea with a severity weighting of 0.1 and lasting for 7 days results in a DALY of 0.002, whereas death resulting in a loss of 30 years of life equates to a DALY of 30.

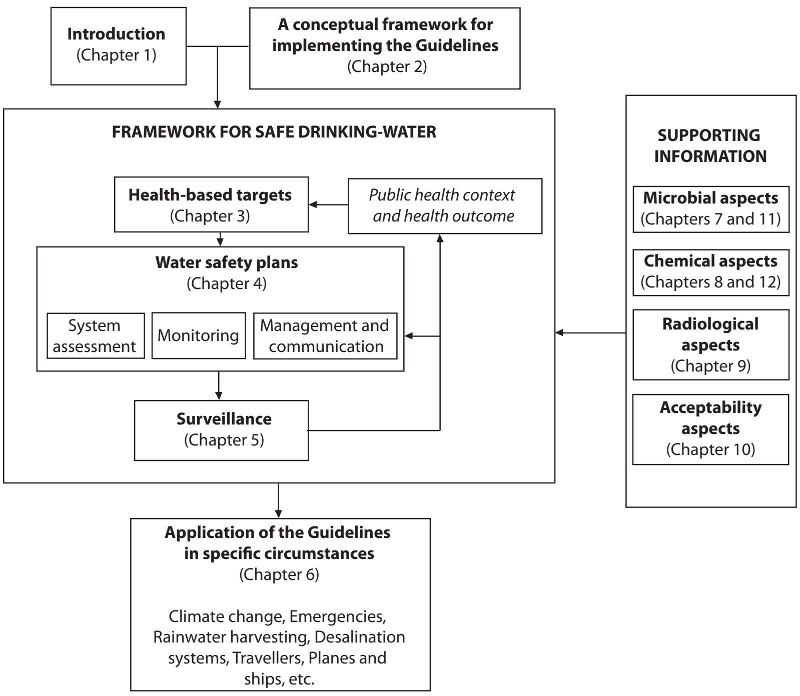
infection with rotavirus (in developed countries)

- mild diarrhoea (severity rating of 0.1) lasting 7 days in 97.5% of cases;
- severe diarrhoea (severity rating of 0.23) lasting 7 days in 2.5% of cases;
- rare deaths of very young children in 0.015% of cases.
- The DALY per case can be calculated as follows:
  - ✓ DALY = (0.1 x 7/365 x 0.975) + (0.23 x 7/365 x 0.025) + (1 x 70 x 0.00015) = 0.0019 + 0.0001 + 0.0105 = 0.0125

infection with Cryptosporidium

- Infection with Cryptosporidium can cause watery diarrhoea (severity weighting of 0.067) lasting for 7 days with extremely rare deaths in 0.0001% of cases.
- This equates to a DALY per case of 0.0015.

Framework for safe drinking water



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