

Chapter VI: Water Quality and Sanitation

A. Overview

Throughout the last century, water use has been growing at more than twice the rate of the population increase, and already a number of regions are chronically short of available water resources. As populations continue to grow, lack of clean water supplies will soon be recognized as the world's most critical concern. While seventy percent of the Earth covered by water, the reality is that 97.5 percent of all water on earth consists of salt water, leaving only 2.5 per cent as fresh water. Of the amount of non-brackish freshwater available, seventy percent of it is frozen in the icecaps of Antarctica and Greenland leaving less than one per cent of the world's fresh water readily accessible for direct human uses.¹³

Intense water scarcity tends to occur in economically volatile areas that have low amounts of freshwater but increasingly high levels of population, which is particularly the case throughout the Middle East region. In these areas, most available water supplies are used for agriculture, as neither the extra water nor the financial resources exist which would enable a shift in development away from intensive irrigation and into other sectors that would create employment and generate the income needed to import food.¹⁴

In fact, irrigation for agricultural purposes accounts for seventy percent of water taken from lakes, rivers, and groundwater sources on a worldwide basis. The result is that at least one-fifth of all people do not have access to safe drinking water, while more than one-half of the world's population lacks adequate sanitation, most of whom are poverty-stricken. The effects on human health are also costly: at any given time, an estimated one-half of the people in developing countries are suffering from water or food associated diseases caused either directly by infection through the consumption of contaminated water or food, or indirectly by disease-carrying organisms (vectors), such as mosquitoes, that breed in stagnant water pools. Heavy chemical pollution from industrial discharge and agricultural and urban runoff also render water unsuitable for consumption, further decreasing the available amount of existing safe drinking water.¹⁵ (for more details, refer to Appendix B.)

Global Water Crisis¹⁶

The lack of clean water resources and sanitation facilities looms as one of the most serious environmental health problems faced today by a large fraction of the world's population, especially those living in developing regions. Around the world, water supply and sanitation facilities are rapidly deteriorating and are operating at a fraction of their installed capacities. This situation is particularly serious in many developing countries of Asia, Africa, and Latin America, where the poor have very limited access to clean water supplies and sanitation facilities. This poses serious and life-threatening diseases to the population, especially among infants and young children. The situation is even more pronounced in rural areas of developing regions, where the problems of water resources and inadequate sanitation facilities largely remain unresolved for a large majority of the population. Added to this is the rapid industrialization and urbanization of a number of highly populated developing countries (such as China, India, Brazil, and Mexico) where in the past few decades, water contamination by a variety of toxic chemicals and hazardous wastes has aggravated an already serious water pollution problem related to microbial diseases.

The World Health Organization (WHO) has estimated that 1.1 billion people lack basic access to drinking water resources, while 2.4 billion people have inadequate sanitation facilities, which accounts for many water-related acute and chronic diseases. Some 3.4 million people, many of them young children, die each year from water-borne infectious diseases, such as intestinal diarrhea (cholera, typhoid fever and dysentery), caused by microbially contaminated water supplies that are linked to deficient or non-existent sanitation and sewage disposal facilities. In addition, many freshwater streams, lakes and groundwater aquifers around the world are increasingly becoming contaminated with industrial discharges and agricultural runoffs that carry high concentration levels of toxic chemical substances and hazardous wastes. These contaminated water sources

13 United Nations *Comprehensive Statement of Freshwater Resources of the World*. Available online at: <http://www.un.org/esa/sustdev/freshwat.htm>.

14 WRI, UNEP, UNDP, WB. (1999). *World Resources 1998-99. A Guide to the Global Environment*. New York: World Resource Institute (WRI), United Nations Environment Programme (UNEP), United Nations Development Programme (UNDP), World Bank (WB).

15 United Nations *Comprehensive Statement of Freshwater Resources of the World* <http://www.un.org/esa/sustdev/freshwat.htm>.

16 Excerpted from: Ahmed, A. Karim. *op. cit.*

contain a number of highly toxic heavy metals, pesticides, fertilizers and other agricultural chemicals, along with a variety of persistent organic pollutants (POPs) and disinfection by-products, many of which remain intact in the environment for long periods of time and bioaccumulate in the food web. The presence of these chemical substances in surface and ground water resources is linked to many acute and chronic illnesses, ranging from severe skin and liver disorders to developmental abnormalities, neurological diseases and human cancer.

Broadly speaking, the global problem of water resources and sanitation may be generally looked upon as consisting of: (1) increasing scarcity of water supplies with rising population, (2) uneven and inequitable distribution of water resources and sanitation facilities, (3) high water pricing rates and charge schedules, (4) prohibitive costs associated with operating and maintaining sanitation facilities, (5) insufficient funds available for building water treatment and sewage disposal facilities, (6) lack of availability of appropriate and innovative water treatment technologies, (7) failure to implement water conservation programs, (8) poor management in protecting aquatic ecosystems, (9) inadequate prevention of microbial and chemical contamination of surface and ground water resources from human activities.]

B. Sources of Water Contamination

The quality of drinking water can be determined through the intensity of its exposure to human technology and natural systems. The first is through the costly services of human technology, which offers treatment systems, purification processes and desalinization, among others. The second is through natural systems, where water is cleaned and purified as it filters through the Earth to replenish ground aquifers. The best approach to obtain safe drinking water relies on a combination of both systems. Although natural watersheds and ground cover provide an automatic filtration system for water, these systems are often highly exploited. Storm-water runoff plays a particularly large role in the health of watersheds, and can vary from region to region.

For example, during a rainstorm, surface runoff in an urban area can accumulate numerous debris in its path. Oil slick and leakage from automobiles, scattered leaves and other organic matter, as well as random garbage in the street are found most frequently in runoff systems. In times of heavy rainfall, or if the storm water runoff system is inadequate in matching the pace of its urbanizing surroundings, the storm water can become direct runoff, meaning it is deposited directly into freshwater bodies without being filtered or treated. The extra organic matter can lead to an increased state of eutrophication, whereby the amount of nutrients in a water body increases, demanding more and more oxygen in order to decompose; decreasing the quality of water while degrading natural ecosystems. In urban or other areas where there is a serious shortage of natural land cover due to deforestation or impervious surfaces (i.e. road and parking area pavements), the degree of storm water runoff systems flooding will be that much more extreme.

Storm water runoff found in rural areas can be similar to its urban counterpart, although it usually consists of primarily agricultural runoff, such as nitrous oxides and pesticides. If no regulations on farming practices exist, anything found on the crops is likely to be found in the freshwater supplies. Additionally, if unsustainable farming is practiced, much sediment due to erosion is often found downstream of plots, further endangering the ecosystem of the freshwater body.¹⁷ Industrial pollutants, such as wastes from chemical plants, and municipal wastes are often dumped directly into fresh waterways, such as rivers, lakes, wetlands and estuaries.

C. Drinking Water Standards

Generally, safe drinking water standards all over the world are based on the World Health Organization (WHO) guidelines for water quality, whose primary goal is to ensure “all people, no matter what their stage of development...have a right to have access to an adequate supply of safe drinking water.”¹⁸ WHO water quality standards are meant to promote safe and acceptable standards of water quality that countries can feasibly achieve via appropriate treatment and distribution systems. The primary aim of the standards is to protect public health from the effects of contaminated drinking water. Notwithstanding the original objectives of promoting and maintaining human health, however, the WHO does make an effort to ensure that the guidelines are not so stringent or technologically advanced that more developing nations would have no hope of achieving them.

¹⁷ See Natural Resources Defense Council’s Clean Water and Oceans webpage: <http://nrdc.org/water/default.asp> .

¹⁸ Drinking water standards can be viewed online at the WHO Water and Sanitation homepage: http://www.who.int/water_sanitation_health/GDWQ/index.html

The guidelines outline the lowest threshold amounts that are allowed of certain substances. There are also a separate set of more rigorous guidelines for vulnerable groups, like children and the elderly living in areas of poverty without access to environmental hygienic facilities. Yet in spite of these efforts to account for different circumstances, individuals can still vary widely in immunity and rate of infection. Thus, the degree of illness may not be uniform among groups of individuals depending upon factors such as environment, age, sex, history of health, and degree of immunity. In addition to the WHO drinking water standards, the United States Environmental Protection Agency (USEPA) also provides a source of information on drinking water guidelines.¹⁹

There are mainly three components used for testing which are the most crucial to the successful outcome of safe drinking water for the public: microbial contaminants, chemical contaminants, and “nuisance organisms.”

- **Microbial contaminants:** these refer primarily to bacterial disease found in human and animal excreta. The most dangerous of all contaminants, no amount of microbial contamination is tolerated because any amount of ingested bacterial pathogens may result in acute illness. Microbiological contamination tests can have varying results in accuracy, however, because the growth medium and the conditions of incubation, as well as the nature and age of the water sample can influence species isolated and the count. The two most common pathogens used in microbial testing that are indicators of fecal contamination are *E. coli* and thermo-tolerant coliform bacteria, since these pathogens always indicate the presence of animal and human excreta.
- **Chemical Contaminants:** Unlike microbial testing, where the analysis depends on a search for viable bacterial organisms not confined to any group, chemical and physical analysis is defined within the boundaries of a chemical entity or a physical property. Also unlike microbial pathogens found in feces, there may exist a concentration dose for most chemicals acutely toxic to human health below which no health effects may occur. The WHO guidelines for drinking water regarding chemical contaminants are based on an approach called the Tolerable Daily Intake (TDI). This is “an estimate of the [minimal] amount of a substance in food and drinking water expressed on a body weight basis that can be ingested daily over a lifetime without appreciable health risks.” The TDI approach is also used by the WHO to monitor the dangers to human health from other sources such as food and air.
- **Nuisance Organisms:** sensory aesthetic factors such as taste, odor, and color of the drinking water that must be acceptable to a human consumer or else it will reject it, even if the water is completely safe to drink. Organisms which affect such aesthetic qualities of drinking water without making it harmful are called “nuisance organisms.”

D. Sanitation and Waste Disposal

The second major component of water indicators takes issues of sanitation into consideration. Safe drinking water indicators measure concerns of safety and quality whereas sanitation indicators measure problems of distributing safe water while focusing on the opportunity for equal access and the presence of reliable facilities. Issues of safe drinking water cannot be acknowledged without addressing the inseparable issue of access to sanitation services.

Sanitation services are generally known as infrastructures of sewerage disposal and waste management. Access to reliable toilets and safe municipal waste management systems are important to maintaining public health, as many diseases are contracted from open sewage pits and garbage scattered in public places. Dysentery, which is generally contracted from unsanitary conditions and/or lack of hygiene, is the second leading cause of infant mortality worldwide, yet also one of the easiest diseases to prevent with the presence of proper sanitation facilities. Also of equal importance when contemplating issues of sanitation is promoting hygiene education and awareness. Water and sanitation related diseases are as much dependent on behavioral practices of households as is the quantity and quality of water used.²⁰

Education on the positive effects of proper hygiene practices and access to private sanitation facilities can have a huge impact. The concern that the sanitation facilities be private is of special concern to women, who often are forced to relieve themselves in unclean areas for the sake of privacy if clean toilets are not available within the immediate area of their homes. Also, women are generally the primary educators in the home regarding personal hygiene practices.

The United Nations Children’s Fund (UNICEF), in its document, *Towards Better Programming: A Water Handbook*, states that sanitation services, including hygiene education, are now becoming at least as important as water supply

19 These can be viewed online at: <http://www.epa.gov/safewater/sdwa/sdwa.html>

20 Shyamsundar, Priya. 2002. *Poverty Environmental Indicators*. Washington, DC: World Bank Economics Series.

in UNICEF's assisted programs around the world. Most sector professionals agree that: (a) isolated water supply interventions are not effective in the prevention of disease, (b) sanitation alone has a larger impact on health than does water alone, and (c) hygiene education, together with sanitation, has more of an impact on the reduction of diarrhea than does water. The UNICEF handbook concludes, "*Water interventions are an important component of public health programmes but only if integrated with hygiene education and sanitation interventions.*"²¹

E. Recommended Environmental Health Indicators and Benchmarks for Water Quality and Sanitation

Basis for Selection:

The recommendations on primary environmental health indicators and benchmarks on water quality and sanitation consists of determining the safety of public drinking water supply in three categories: (i) microbial safety standards that have been established by national, regional or local regulatory agencies, which generally consists of establishing the allowable level of fecal coliform microorganisms, such as E. coli bacteria, present in the public drinking water supply, (ii) chemical safety standard or recommended guidelines that have been issued by regulatory agencies on a large number of toxic substances, such as metal ions and organic chemical compounds that are hazardous to human health, where the choice of specific chemical safety standards as an indicator will vary from region to region, and (iii) nuisance guidelines, such as a level of turbidity, odor and other surrogate measurements of degraded water quality. As an important measure of adequate amount of potable and safe drinking water available in a region, the per capita consumption of water by residential households in a community is a recommended indicator or benchmark. Finally, a primary indicator of the impact of unsafe drinking water on vulnerable members in a community can be developed by obtaining data on morbidity and mortality rates of infant diarrheal diseases in a region, where bacterially contaminated drinking water sources are still one of the main causes of childhood illnesses and deaths in many developing countries.

Among secondary water quality and sanitation indicators and benchmarks, the determination of percentage of population that are served piped water, including community pumps and publicly accessible taps can serve as an indirect measure of the availability of potable and safe drinking water in a developing region. Similarly determination of percent of population in a region served with primary and secondary wastewater treatment is an environmental health indicator of adequate sanitation services in a community. In many urban areas of developing regions, another indicator of water quality and sanitation is the percent of population who have actual access to household sewerage or toilette services, since a large fraction of the low-income families live in shanty towns and in poorly served urban slums. In rural areas, a recommended secondary water quality and sanitation indicator is determining the percentage of population who has properly installed latrines, septic tanks and sewage drainage systems in the community.

For the development of tertiary water quality and sanitation indicators and benchmarks, determining the ratio of impervious ground cover to drainage area in an urban watershed environment is recommended. In addition, the determination of the extent of polluted aquifers and groundwater sources of drinking water in a region, and the percent use of recycled wastewater may serve as a tertiary water quality and sanitation indicator or benchmark in a community.

Summary of Recommended Indicators and Benchmarks:

- (i) Primary Indicators
 - Safety of Public Drinking Water Supply—Microbial Safety Standards (Coliform Organisms)
 - Safety of Public Drinking Water Supply—Chemical Safety Standards (Toxic Substances)
 - Safety of Public Drinking Water Supply—Nuisance Guidelines (Turbidity, Odor)
 - Per Capita Daily Consumption of Drinking Water (Residential Use)
 - Child's Morbidity Rate via Ingestion of Contaminated Water (Diarrheal-related)
 - Child's Mortality Rate via Ingestion of Contaminated Water (Diarrheal-related)

21 UNICEF (1999) *Towards better programming: A water handbook*. http://www.unicef.org/wes/files/Wat_e.pdf

- (ii) Secondary Indicators
 - Percent of Population with Access to Piped Water, Pumps, Public Taps, etc
 - Percent of Primary/Secondary Wastewater Treatment in a Region
 - (Urban) Percent of Population with Access to Sewerage (Toilette) services
 - (Rural) Percent of Population with Access to Latrines, Drainage, Septic Tanks, etc.
- (iii) Tertiary Indicators
 - (Urban) Ratio of Impervious Ground Cover: Natural Ground and Watersheds
 - Extent of Polluted Aquifers and Groundwater Sources (Site-Specific)
 - Percent Use of Treated Wastewater (if and how it is recycled)
- (iv) Modifying Factors
 - Population Density
 - Rate of Urban Growth
 - Geographic Location and Climate Type
 - Education on proper hygiene