SMALL AND RURAL COMMUNITY WATER SUPPLY

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Contents

Summary

Access to clean water in adequate quantities is a basic need for human welfare. The first and foremost consequence of lack of this amenity to the community is diseases. Close to 65% of world population are living as small communities in rural areas, a major

proportion of them in developing countries with no access to safe drinking water. Unlike large urban areas, conventional methods of water sourcing, extraction and supply will not be cost-effective in rural communities. While rural community water supply systems are not difficult to design and construct, the selection of simpler, reliable and easily maintainable technologies is of paramount importance. Major considerations for water supply systems to small communities include lower costs, minimal use of mechanical equipment and chemicals, and ease of operation and maintenance. Rain water harvesting, use of surface and groundwater sources with simple intake and in-built treatment structures can, in most cases, provide water with adequate quality. A variety of simple filtration techniques that can effectively remove conventional organic impurities have been developed to suit local water quality requirements. Also, simple technologies for removal of non-conventional impurities, referred as 'specific impurities' such as iron, manganese, fluoride, etc., suitable for small-scale water treatment, as required in rural communities, are available.

1. Introduction

One of the main reasons for great civilizations of ancient era thrived on the banks of perennial rivers is the access to water in adequate quantities. Even in ancient cities that were not located close to any large rivers, when local supplies were inadequate, aqueducts were built to convey water from distant sources. Later, pipes made of wood, clay or lead that were laid at hydraulic grade line were used to convey water to individual homes. Development of cast iron pipes and gradual cost reduction, together with the invention of pumps driven by steam in the middle of seventeenth century, made it possible to provide public supplies and deliver the water to individual residences.

Provision of an adequate quantity of water is only one part of the human water need, the other important part being the quality of water so supplied. Safe drinking water is of primary importance for human health and well-being. Though the basic drinking need for a person is less than five liters a day, water needs for a variety of other uses such as cooking, utensil cleaning, personal hygiene, take the requirement to a level of 40 liters per day, which has now been standardized as the minimum level to effect health improvement at community levels. This is the targeted water supply level that has been fixed for a hundred percent coverage of population of the world, by the Vision-21 program, the successor to the International Drinking Water Supply and Sanitation Decade (1981–1990). With close to 65% of the world population living as small communities in rural areas, and a major proportion of them in developing countries without access to safe water supplies, not surprisingly, the task of providing safe drinking water revolves around these small and rural communities.

2. Various Aspects of Water Supply to Small and Rural Communities

2.4. Health Aspects

Name of microorganisms	Major diseases	Major reservoirs and primary sources
Bacteria		
Salmonella typhi	Typhoid fever	Human feces

Salmonella paratyphi	Paratyphoid fever	Human feces
Other salmonella	Salmonellosis	Human and animal feces
Shigella	Bacillary dysentery	Human feces
Vibrio cholera	Cholera	Human feces
Enteropathogenic E.coli	Gastroenteritis	Human feces
Yersinia enterocolitica	Gastroenteritis	Human and animal feces
Campylobacter jejuni	Gastroenteritis	Human and animal feces
Legionella pneumophila and related bacteria	Acute respiratory illness (legionellosis)	Thermally enriched water
Mycobacterium tuberculosis	Tuberculosis	Human respiratory exudates
Other mycobacteria	Pulmonary illness	Soil and water
Oppurtunistic bacteria	Variable	Natural waters
Enteric Viruses		
Enteroviruses		
Polioviruses	Poliomyelities	Human feces
Coxsackieviruses A	Aseptic meningitis	Human feces
Coxsackieviruses B	Aseptic meningitis	Human feces
Echoviruses	Aseptic meningitis	Human feces
Other enteroviruses	Encephalities	Human feces
Reoviruses	Mild upper respiratory and gastrointestinal illness	Human and animal feces
Rotaviruses	Gastroenteritis	Human feces
Adenoviruses	Upper respiratory and gastrointestinal illness	Human feces
Hepatitis A virus	Infectious hepatitis,	Human feces
	Gastroenteritis	Human feces
Norwalk and related GI viruses		Soil and water
Protozoans		
Acanthamocba castellani	Amoebic meningoencephalitis	Human feces
Balantidium coli	Balantidosis (dysentery)	Human and animal feces
Cryptosporidium	Cryptosporidiosis	Human feces
Entamoebal histolytica	Amoebic dysentery	Human and animal feces
Giardia lamblia	Giardiasis (gastroenteritis)	Soil and water
Naegleria fowleri	Primary amoebic meningoencephalitis	
Blue-green algae		
Anabaena flosaquae	Gastroenteritis	Natural waters
Microcystis aeruginosa	Gastroenteritis	Natural waters

Table 1. Water borne disease causing organisms

The first and foremost consequence of lack of safe water for community consumption is diseases. World Health Organization (WHO) estimated that as much as 80% of all diseases in the world is associated with water. The plight of over two-thirds of world's population that lives in developing countries due to exposure to the dangers of unsafe water was highlighted during the United Nations International Drinking Water Supply and Sanitation Decade (1981 –1990). An exhaustive list of groups of microorganisms that cause waterborne diseases and their primary sources is presented in Table 1. The diseases that are caused by lack of protected water supply may take any or all of the forms presented in Table 2.

Supply of safe water will directly help to minimize the water-borne diseases. Availability of good quality water, in turn, will make people refrain from going to contaminated water sources thereby avoiding water-based and water-related diseases. With adequate quantity of supplies, water-washed diseases also can be controlled.

Group	**Diseases**
1. Water-borne diseases: Diseases spread through water in which water acts as a passive carrier for the infecting pathogens. These diseases depend also on sanitation	Cholera, Typhoid, Bacillary dysentary, Infectious hepatitis, Leptospirosis, Giardiasis, Gastro-enteriris etc.
2. Water-related diseases: Diseases spread by vectors and insects that live in or close to water. Stagnant ponds of water provides the breeding place for the disease spreading vectors such as mosquitoes, flies and insects.	Yellow fever, Dengue fever, Encephalitis, Malaria, Filariasis (all by mosquitoes), Sleeping sickness (Tsetse fly), Onchocerciasis (Simulium fly) etc.
3. Water-based diseases: Diseases caused by infecting agents spread by contact with or ingestion of water. Water supports an essential part of the life cycle of infecting agents such as aquatic snails.	Schistosomiasis, Dracunculosis, Bilharziosis, Philariosis, Oncholersosis, Treadworm etc.
4. Water-washed diseases: Diseases caused by the lack of adequate quantity of water for proper maintenance of personal hygiene. Some are also depended on poor sanitation.	Scabies, Trachoma (eye-infection), Leprosy, Conjuctivitis, Salmonellosis, Ascariasis, Trichuriasis, Hookworm, Amoebic dysentery, Paratyphoid fever etc.

Table 2. Water supply related diseases

2.5. Socioeconomic Aspects

Contribution of safe water supply to socioeconomic development of communities is profound. Savings in terms of energy and time in fetching drinking water and substantial reduction in diseases will enhance the economic productivity of a community. Especially in rural communities of developing countries, where almost all the population is engaged in subsistence agriculture, the health improvements will have a direct effect in poverty alleviation by increased production. When productive work is stimulated and personal hygiene, health care and food preparation are improved through water supply, a positive socioeconomic development can be achieved.

2.6. Technological Aspects

Community water supply systems for the urban areas of developing countries can be similar to that of industrialized nations. The technologies that were developed for large water supply systems of cities and towns of developed countries (generally identified as 'conventional technologies') can suit the cities of developing countries, with appropriate adaptations, due to economies of scale. Usually, the number of people to be served and lower densities of population in rural communities, make 'conventional technologies' very costly, and hence, non-viable. The technological requirements for water supply to rural communities have to be different from the conventional ones. While rural community water supply systems are not difficult to design and construct, the selection of simpler, reliable and easily maintainable technologies is of paramount importance.

3. Planning for Small Community Water Supply Systems

It has been estimated that providing access to clean water to the rural communities of developing countries will need a six-fold increase of current level of water quantities over the next four decades. Supply of potable water to all such communities by a conventional system that supplies water with qualities matching international guidelines/standards, is not feasible. Traditionally, people in rural areas obtained water from locally available water sources such as ponds, open wells, streams and rivers and have adopted some simple and rudimentary treatment techniques to improve its quality. Though these simple methods do not provide water necessarily of what would be considered under the present day situation as quality drinking water, in most cases, with a further simple step of disinfection, pathogen-free water can be obtained. Planning for rural water supply systems in developing countries, therefore, essentially means:

1. Assessment of water quantity requirement for the selected rural community so that an appropriate source of water that can supply in adequate quantities can be identified. To ensure the safety of drinking water so supplied, detailed quality standards for physical, chemical and microbiological parameters have been proposed by various countries and international organizations. An assessment of quality requirements, in view of current water quality standards, hence, is a pre-requisite for rural water supply systems too, so that the level of treatment requirements can be ascertained.
2. Identification, assessment and recognition of traditional wisdom and knowledge, and augmentation of such practices with further simple steps to improve the quantity and quality of water.
3. Where traditional practices cannot be adequate to achieve safe water criteria, adoption of 'low-cost' and 'appropriate' alternatives to identify water sources, extract water from sources, and treat the water wherever required. Development and adoption of 'appropriate' alternatives may be particularly required in cases where

available water sources are contaminated with some specific impurities due to special geological conditions and compositions of natural environment.

4. Assessment of Quantity and Quality of Water

4.3. Water Quantity

In organized water supply systems, community water consumption refers to the amount of water taken from a distribution system, though only a small proportion of it would actually have been consumed, and a major proportion is used for a number of other domestic and non-domestic purposes. Water consumption data are usually expressed in liters per capita (person) per day.

The basic factors to be considered in the assessment of quantity of water are:

- population and area to be served;
- design period;
- availability of water sources;
- treatment requirements;
- nature and extent of water transmission and distribution.

It is difficult to accurately estimate the future requirement of water for small community. A tentative estimate for the projected population of a rural community over the design period can be made based on the following criteria:

- about 0.3 Ls^{-1} per 1000 people when the water is mainly distributed by means of public stand pipes; and
- about 1.5 L s^{-1} per 1000 people when house connections for water supply is planned.

4.4. Water Quality

Although appearance, taste, and odor are useful indicators of the quality of water, in terms of public health, suitability of drinking water is determined by various physical, chemical, microbiological and radiological characteristics. The purpose of developing standards is to establish limits, which will minimize detrimental effects without affecting the benefits. As such, these limits have no absolute value, nor can they be definitely established. Often, the evolution of water quality standards related to public health is not controlled by toxicological or epidemiological findings. Economic interest, socio-cultural characteristics, hygiene practices, public awareness and sensitivity and technological development have been the main thrust in the establishment of these standards.

The World Health Organization (WHO) suggests an elaborate array of physical, chemical and microbiological characteristics as guidelines, which is considered as a basis for developing similar standards by various countries. The WHO guidelines for drinking water quality states clearly that “in developing national drinking water standards based on these guidelines, it will be necessary to take into account a variety of local geographical, socioeconomic, dietary and industrial conditions”. The water quality standards so developed can vary from nation to nation, or even region to region within a nation, with respect to scientific development, economic constraints as well as changing tendencies towards acceptance or rejection of practices affecting the cultural value of the society. Many industrialized countries, which are increasingly concerned about risks affecting health, have adopted national standards for drinking water quality that are more stringent than WHO guidelines. In contrast, many developing countries have adopted standards that are more relaxed than those prescribed by WHO, because they cannot afford advanced treatment systems as well as sophisticated laboratories for monitoring and surveillance. A comparison of water quality standards of a few developed and developing countries (Appendix 1) clearly indicates this aspect.

In small community water supplies (particularly, for those in developing countries), the water quality problems are mainly due to physical and bacteriological contamination. Most of the water supply systems of rural communities are likely to be contaminated by microorganisms of fecal origin. It may not lead to any solution if all such sources are to be condemned, especially when the alternative source of water is more contaminated. Instead, it would be appropriate if contributing factors to such contamination are identified and controlled. Moreover, it would be appropriate if the level and the amount of fecal contamination of alternative sources are examined for comparison and selection. It is not practical to test water for all microorganisms that it might possibly contain. Instead, water is examined for specific type of bacteria that originates in large numbers from human and animal excreta and whose presence in water is indicative of fecal contamination. *Escherichia coli* (E-coli) and fecal streptococci have found to be more suitable. When these organisms are found in water, it indicates:

- possibility of fairly fresh fecal contamination of water;
- possibility of the presence of pathogenic bacteria and viruses.

The following bacteriological quality criteria are generally applicable for small and rural drinking water supplies:

- Coliforms (average numbers present in drinking water samples should be less than 10 per 100 ml.
- E-coli should be less than 2.5 per 100 ml.

There are cases where the water from community water supply is bacteriologically acceptable, yet unacceptable as drinking water due to the presence of mainly physical contaminants. Important physical quality parameters include turbidity, color, odor, pH, and taste. High turbidity levels are usually associated with increased number of microorganisms. Turbidity in a water source might be made up of suspended matter such as clay, silt, inorganic and organic matter, plankton, and microscopic organisms. Turbidity also decreases the disinfection efficiency during a treatment process. Problems are also caused by iron, manganese, fluoride, and nitrates.

The first article of this topic, ‘Water quantity and quality’ provides a comprehensive overview of the quantity and quality aspects of drinking water supply. It also compares the water quality standards and guidelines of various countries of the world.

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Biographical Sketches

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