

Water pollution and health

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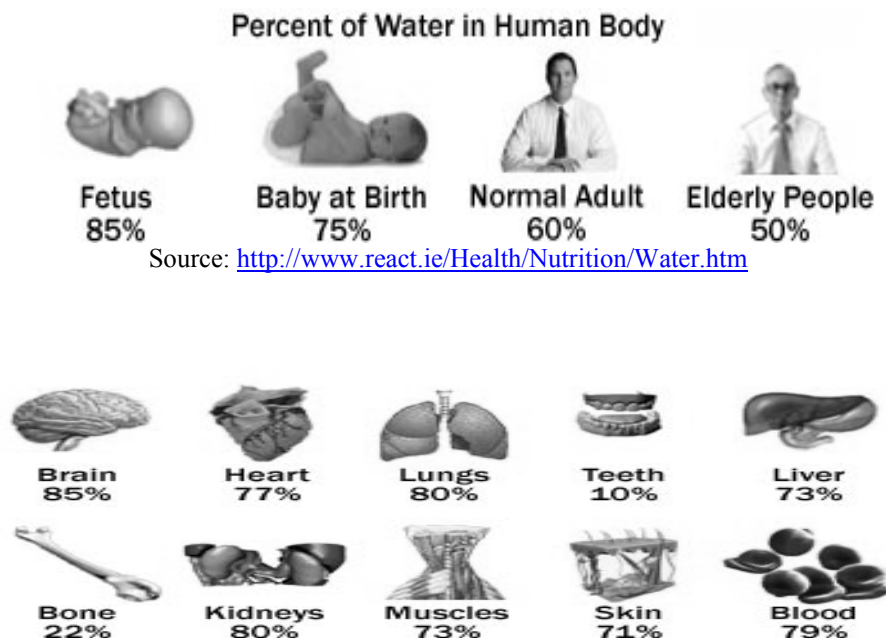
Abstract

Water is the important constituent of life support system. No one can live and even dream to live without water. Most of our water bodies have become polluted due to industrial growth; urbanization and man made problems mainly the result of population growth. Poor sanitation and contaminated drinking water arising from human activity and natural phenomena create serious problems in human health. The chief sources of water pollution are sewage and other waste, industrial effluents, agricultural discharges and industrial wastes from chemical industries, fossils fuel plants and nuclear power plants. They create a larger problem of water pollution rendering water no longer fit for drinking, agriculture and, as well as for aquatic life. More than 2.6 billion people-40% of the world's population – lack basic sanitation facilities and over one billion people still use unsafe drinking water sources. As a result thousands of children die everyday from diarrhoea and other water, sanitation and hygiene related diseases and many suffer and are weakened by illness.¹

Key words: Water pollution, Poor sanitation, contaminated drinking water, human health

The human body is two-thirds water. Water is essential nutrient that is involved in every function of the body. It helps transport nutrients and waste products in and out of cells. Water dissolves the carbon dioxide, oxygen and salts present in the body and distribute to the different parts through the

process of blood circulation. Water helps in the utilization of the water-soluble vitamins as well as in removing the waste materials from body. It is also needed for the maintenance of proper body temperature.



Source: <http://www.react.ie/Health/Nutrition/Water.htm>

Source: Nestlé Water Institute (<http://www.water-institute.com/>)

Although we can live without food for a month or longer but we can go less than a week without water. Water is absolutely essential to life. A loss of just ten to fifteen percent can kill us.

Water is very important for all living beings and is consumed by all and as such it is essential that all should get pure and clean drinking water. Simple access to safe water and adequate sanitation is an essential first step to protect human health, and a basic human right. Lack of access to safe drinking-water and poor sanitation still threatens the health of millions of people.

Approximately one sixth of the world's populations have to bend without water and two fifths have no access to sanitation. Most of the unserved population lives in Asia and Africa, although even in Eastern Europe and Central Asia, poor water, sanitation and hygiene are among the ten most important risk factors for disease².

Water is so important for all living beings that it should always remain pure but unfortunately it gets polluted through various sources. The recommended standard for potable water or drinking water is that it must be free from pathogenic microorganisms and chemicals that are harmful to human health. All over the world water pollution is posing a threat to human life both in rural and urban areas. Water pollution is the cause of many diseases and consequently of atmospheric pollution. Most inhabitants are served by surface waters i.e. rivers, streams and lakes. The raw water from these sources is frequently polluted with human waste or sewage and industrial waste. Nearly 80 % of the world's diseases, particularly in developing world, can be linked with contaminated water. About 90 % pollution load in river system is due to human waste. The degradation of both surface and ground water resources has had adverse impact on the quality of drinking water for human use, as well as harmful effects on aquatic life³.

Surface water in the Kathmandu Valley is severely polluted by industrial effluence, domestic waste, and by the discharge of untreated sewage from residential areas.

Domestic pollution

Important source of water pollution is domestic sewage system, which pollutes well and rivers, which are important source of drinking water. It is estimated that Kathmandu produces 150 tons of waste each day, nearly half of which is dumped into the river. More than 40 million liters a day of wastewater is

generated in Kathmandu and a whopping over 80 percent of this is generated by households⁴.

The problem of excreta disposal is clearly as old as mankind itself and the need for careful disposal is highlighted in a number of religious books including Hindu, Islamic and Christian texts. The proper management of excreta acts as the primary barrier to prevent the spread of pathogens in the environment. It directly impacts disease transmission through person-to-person contact, water and the food chain. At least 2500 million people in developing countries lack an adequate system for disposing of their faeces. For the poor in many developing countries, faeces deposited near their homes constantly threaten household hygiene, by direct contact with people or by being inadvertently carried into homes and kitchens by children, domestic animals or insects. Domestic neighbourhood or district water supplies such as wells, tanks and reservoirs may be contaminated by poorly designed or maintained sewage disposal systems⁵.

The potable water contaminated with faeces is the chief cause of some important disease of man. About 98% of the people of rural areas use open field for defecation. They deem that latrines are meant for city dwellers, where there are no fields for defecation. Faeces are the most common pollutant of potable water. They consist primarily of intestinal bacteria. Empirical studies of drinking water throughout Nepal have found that faecal coliform contamination in the water consistently exceeds WHO guidelines for water considered fit for human consumption. A report by international consultants concludes, "Kathmandu's drinking water is hosting disease-causing microbes and hazardous chemicals." According to the same study, when tap water from representative locations of Kathmandu's urban areas was analyzed in the laboratory, almost 90% of the sample was not potable⁶.

An increase in the quantity of water has a greater health impact than improved water quality, because an adequate water supply makes it possible or at least more feasible for people to adopt safe hygiene behaviors. Since a primary cause of contamination of water is inadequate or improper disposal of human and animal excreta, better water quality only improves health when sanitation is improved as well and when the quantity of water is sufficient⁷.

Deteriorating water quality is a particular threat in developing countries, where hundreds of millions of people lack access to clean drinking water and the

vast majority of sewage is discharged into surface waters without wastewater treatment⁸. When untreated or inadequately treated wastewater or excreta (faecal sludge) is applied to soil and crops, disease transmission can occur. The persons at risk are the farmers, farm workers and their families as well as consumers of crops produced in such a way.

Industrial pollution

Sewage is not the only cause of water pollution, industrial waste is also a significant polluter - giving rise to contamination with heavy metals. A recent research conducted by the Community Development Organization has concluded that the chemicals discharged by the factories are more harmful than the sewerage that flows into the river⁹. Out of the 4,271 industrial establishments around the country, 72 percent are concentrated in the capital city. Most of them discharge untreated water into the river¹⁰. The effluent discharged by the factories contains detergents, non-biodegradable materials and toxic chemicals hazardous to health and hygiene.

Other sources of water pollution are distillery potassic fertilizers, electroplating plant, which contains harmful heavy metals, and cyanides which causes excessive acidity in water, which is harmful for aquatic life. Intensive use of pesticides and fertilisers has increased the level of nitrates in water. This can lead to brain damage and even death among children¹². The IUCN survey noted that water pollution ranged from moderate to very high in case of textiles, jute, leather, vegetables fats and brewery. Moderate pollution was noted from dairy and canning establishments. Surface and ground water pollution have been regarded as the most serious environmental problem in the Kathmandu urban areas⁶.

River state

The poor water quality of the river has numerous detrimental effects from the ecological, social, cultural and health aspects. Domestic sewage, industrial effluents and agricultural residues and chemicals are the most significant wastes causing urban rivers pollution in Kathmandu valley. All kinds of pollutants are discharged without pre-treatment directly through the public sewerage system or indirectly through runoff and open drainage into rivers¹².

Most rivers in Nepal's urban areas are polluted and their waters unfit for human use. The latest UN report presented at the ongoing 3rd World Water Forum in Japan says that the drinking water in Kathmandu

Valley has been found to contain coliform bacteria, iron, ammonia and other contaminants¹³.

Many rivers and water bodies are becoming saturated with organic compounds from industrial effluents, posing a major threat to both human health and aquatic life¹⁴. Bagmati and Vishnumati rivers in the Kathmandu valley which must be the most polluted rivers in Nepal also serve as a source of water for drinking, washing, bathing and irrigating. Both the Bagmati and Vishnumati receive raw sewage from the metropolitan area, untreated effluents from industrial estates, hospital wastes, toxic chemicals and acid from carpet washing plants, pesticides and chemical fertilizers washed by rainwater from the field, and the detritus of cremation. Around 68 industries and nearly 2 million people pour industrial effluent and human waste directly into the holy river, which is the backbone of the civilization of the Kathmanduites and not just a river of religious, cultural and social importance¹⁵.

The principal causes of deteriorating water quality in Vishnumati are mainly the free and direct discharges of household and industrial wastes into the river and excessive mining of sand from the river bed¹⁶. About 4,000 persons in the Kathmandu's inner city use the Vishnumati, mostly in the morning, for their ablutions. The problem is also compounded by open slaughter of animals along the Vishnumati corridor. Hyumat (near Kalimati) area is the main point for the disposal of blood, excreta and other animal wastes directly into the river. This not only increases river pollution but also poses health hazards as the animal flesh is washed by the polluted water of Vishnumati¹⁷. Haphazard construction of industries in areas with access to one of the major river systems, and direct dumping of untreated industrial effluents into Nepal's Bagmati and Vishnumati river, have resulted in high concentration of sodium, potassium and chlorine¹⁶.

In the stretch between Sankhamul and Chobhar parameters such as phosphates, nitrates, dissolved oxygen, biochemical oxygen demanding substances (BOD), COD, coliform bacteria etc are found to be well above internationally accepted standards. Water samples from Dhobikhola show high concentration of sodium and potassium compounds contributed mostly by Bansbari Leather Industry¹⁸. Apart from these areas, some other parts also have excessively high levels of contaminants like nitrate, fluoride and salinity. The fluoride concentration is high in areas which once raised brick kilns, garbage dumping, use of fertilizers, defecating in the open areas, animal waste and leaking septic tanks lead to excessive

nitrate in ground water. Excessive nitrate, fluoride and salinity in the groundwater are the three main problems in the Valley's water¹⁹. In the Kathmandu valley, tanneries and dye factories are among the nastiest felonious. Else where, paper mills in the terai are releasing untreated effluents into the Narayani and Orahi rivers²⁰. Rivers in the valley, including the Bagmati, Vishnumati, Manohara and Hanumante are all seriously contaminated for this reason²¹

Recent studies have shown that even the ground water aquifers—both shallow and deep—are contaminated with toxic chemicals like ammonia and nitrates. It is not just the potable drinking water supplied to the residents of the capital city that has been found polluted or contaminated for drinking purpose. Now, with the rivers flowing from the heart or periphery of such large cities like Kathmandu, Bharatpur and Birgunj continually exposed to human and industrial activities, groundwater aquifers in these cities, too, are becoming polluted¹⁰.

Of the total volume of the flow in the river 90 per cent is sewage and the other 10 per cent is water, experts said at a discussion on the present condition of the rivers in the Kathmandu valley, organised by the Friends of Bagmati, a group of environment activists who have been advocating cleaner rivers in the city for a better life²².

Consequences on health

Poor sanitation and contaminated drinking water are two of the most common environmental hazards in many countries of the world. Inadequate water, sanitation and hygiene account for a large part of the burden of illness and death in developing countries. Lack of clean water and sanitation is the second most important risk factor in terms of the global burden of disease, after malnutrition.

Some 1.1 billion people do not have access to safe water; almost 2.5 billion lack basic sanitation²³. A large segment of these people live in 49 developing countries. These countries are experiencing increasing cases of water-related diseases such as cholera, diarrhoea and dysentery, says the latest UN report presented at the ongoing 3rd World Water Forum in Japan. Growing water crisis in the countries has adverse effects on their long-term development, the report further adds. A series of conferences on water and international communities' efforts to improve the overall situation of water in these countries are going on, but water scarcity and lack of access to water and sanitation still continue, the report states⁹.

There are many reports on the impact of waterborne diseases in countries worldwide revealing thousands of outbreaks due to bacterial, viral, and parasitic micro-organisms associated with the consumption of untreated or improperly treated drinking water^{24,25,26,27}. The World Health Organization (WHO) estimated in 1996 that every eight seconds a child died from a water-related disease and that each year more than five million people died from illnesses linked to unsafe drinking water or inadequate sanitation²⁸. WHO also suggest that if sustainable safe drinking water and sanitation services were provided to all, each year there would be 200 million fewer diarrhoeal episodes, 2.1 million fewer deaths caused by diarrhoea, 76,000 fewer dracunculiasis cases, 150 million fewer schistosomiasis cases and 75 million fewer trachoma cases²⁹

An important fraction of the burden of water-related diseases, in particular: water-related vector-borne diseases, is attributable to the way water resources are developed and managed. In many parts of the world the adverse health impacts of dam construction, irrigation development and flood control may lead to an increased incidence of malaria, Japanese encephalitis, schistosomiasis, lymphatic filariasis etc. 1.3 million people die of malaria each year, 90% of whom are children under 5. There are 396 million episodes of malaria every year. About 200 million people are infected with schistosomiasis, 20 million of whom suffer severe consequences. Six million people are blind from trachoma and the population at risk is about 500 million. Drinking water supplies that contain high amounts of certain chemicals (like arsenic and nitrates) can cause this type of serious disease³⁰.

Drinking and bathing in polluted water supplies are among the most common routes for the spread of infectious disease, and nearly half the world's population suffers from water-related diseases³. Children who live in unsanitary conditions, or who drink dirty water, are sick more often and more seriously; many die before the age of five from water- and sanitation-related diseases, including diarrhoea, cholera and malaria. Such diseases are the single largest killers of infants in developing countries and even when they do survive, they lag behind others in growth and development.

Faecal contaminated of drinking water and food is associated with hepatitis A, a common viral infection in all countries of the region. Bangladesh, India, Maldives and Nepal are countries with high hepatitis A endemicity. Studies from these countries indicate that 85- 95 % of children may be infected and already

immune to the disease by ten years of age. Most countries are also highly endemic for hepatitis E. Data gathered by WHO show that more than 60 water borne outbreaks of hepatitis E were reported from Bangladesh, India, Indonesia, Myanmar and Nepal during the last twenty years. Approximately four million cases of hepatitis E virus infection occur in the region every year³¹. Besides this, unsanitary excreta disposal and contamination of drinking water by pathogens as well as the use of inadequately treated wastewater in irrigation and of faecal sludges in soil amendment and fertilisation is especially associated with elevated prevalence of intestinal helminth infection as well as similar other intestinal and parasitic infections including cholera, typhoid, paratyphoid, polio, cryptosporidiosis, hookworm disease, ascariasis, and schistosomiasis³². Human excreta-transmitted diseases predominantly affect children and the poor. Most of the deaths due to diarrhoea occur in children and in developing countries³³. The World Health Organization (WHO) estimates that 1.8 million people die annually from diarrhoeal diseases including cholera; 90% a under 5, mostly in developing countries. 133 million people infected with high intensity intestinal helminthes infections. These diseases cause around 9400 deaths every year³⁰. Ten percent of the population of the developing world are severely infected with intestinal worms related to improper waste and excreta management^{2, 34} and can lead to malnutrition, anaemia and retarded growth.

About 40 million people throughout the world are infected with trematodes and that over 10% of the global population is at risk of trematode infection³⁵. In less developed countries, poor nutritional status and poverty exacerbate morbidity and mortality associated with excreta-related diseases. Diarrhoeal disease alone amounts to an estimated 4.3 % (62.5 million DALYs) of the total disability adjusted life years global burden of disease. It was estimated that 88% of that burden is attributable to unsafe water supply, sanitation and hygiene and is mostly concentrated on children in developing countries³⁶.

Other health issues indirectly associated with water resources development include nutritional status, exposure to agricultural pesticides and their residues and accidents/injuries³⁷. The different pollutants have different effects on the people. A high fluoride contents leads to dental and skeletal fluorosis, bone deformation and other disorders. Excess nitrate is known to cause holes in heart, discolours the skin and impairs the digestive system. Saline water can cause an imbalance in the salt content of the body¹⁹.

The changing demographic picture among across the world together with the rapid shift towards urbanization will have profound implications for the delivery of health services. In many least developed countries geographical, climatic and environmental factors remain a major factor of ill health. Many have wet tropical climates, which favour mosquitoes and other vector of diseases. Many still lack safe water and sanitation, upon which then control of many infectious diseases largely depends³⁸.

How to solve the problem

Nepal's environmental challenges cover a wide range of complex issues, which are interrelated and detrimental to health. The still high population growth and pervasive poverty, especially in the hills, are primary contributing factors to most of the country's environmental problems.

Water pollution is the most serious environmental quality issues in Nepal. It is caused by the disposal of solid and liquid wastes on land and surface water. The most significant waste is sewage, industrial effluent and agricultural residues and chemicals.

Research findings on the relative public health importance of providing safe drinking water supplies, sanitation and hygiene education may seem counter intuitive. Improved hygiene and sanitation have more impact than drinking water quality on health outcomes, specifically reductions in diarrhoea, parasitic infections, morbidity and mortality, and increases in child growth^{39, 40}. Combining the results of the many studies and reviews conducted, it becomes evident that improvements in excreta management, hygiene and water supply may reduce diarrhoeal morbidity, diarrhoea mortality and child mortality by significant amounts. Improvements in drinking water quality through household water treatment can lead to a reduction of diarrhoea episodes by 35%, improved sanitation reduces diarrhoea morbidity by 32% and hygiene interventions including hygiene education and promotion of hand washing can reduces diarrhoeal cases by up to 45%. Improving access to safe water sources and better hygiene practices can reduce trachoma morbidity by 27%, ascariasis by 29% and hookworm by 4%³⁰. There is no treatment plant in any industrial district and industrial effluent is directly discharged into the adjoining rivers or streams. Intensified irrigation, dams and other water related projects contribute importantly to disease burden. Better management of water resources reduces transmission of malaria and other vector borne diseases.

Solid waste is also an aesthetic or visual pollutant. There is no systematic management of solid waste in industrial districts. The municipalities are helping a lot in solving the problem of solid wastes but the services are not as effective as expected. There are numerous technical options for excreta management, many of which, if properly designed, constructed, operated and maintained will provide adequate and safe service as well as health benefits. Research conducted in South Asia demonstrates that involving women in sanitation programmes has resulted in higher coverage, better maintenance of the facilities, increased hygiene awareness, and lower incidence of faecal-oral disease in the community⁴¹. In addition, for sanitation programmes to be sustainable there must be the political will and institutional capacity to ensure adequate public services and the proper maintenance of sanitation systems⁴².

Conclusion

Approximately one sixth of the world's population is without water and two fifths have no access to sanitation. Most of the unserved population lives in Asia and Africa, although even in Eastern Europe and Central Asia, poor water, sanitation (i.e. excreta disposal) and hygiene are among the ten most important risk factors for disease². Worldwide, it is estimated that there are approximately 4 billion cases of diarrhoea per year (resulting in 1.8 million deaths), 200 million people with schistosomiasis, 396 million episodes of malaria every year (resulting in 1.3 million deaths), and as many as 133 million people infected with high intensity intestinal helminthes infections³⁰.

Out of the total population of Nepal, only 84% have access to safe drinking water. In rural Nepal, millions of people do not have access to safe drinking water or basic sanitation sources. Only 27% of the population as a whole has access to sanitary facilities⁴³.

All water is susceptible to contamination. It may accumulate contaminants from the air, the ground, or from rocks. Some of these contaminants, such as low levels of certain minerals or compounds, are not harmful to health, whereas others, such as pathogens, may be.

In cities in the developing countries of the region, most water bodies are now heavily polluted with domestic sewage, industrial effluents, chemicals and solid wastes. Most rivers in Nepal's urban areas have been polluted and their waters are now unfit for human use, whereas drinking water in Kathmandu is contaminated with coliform bacteria, iron, ammonia and other contaminants⁴⁴.

References

1. UNICEF, "Water, Environment and Sanitation", <http://www.unicef.org/wes.html>.
2. Murray, C.J.L. and Lopez, A.D. (eds), "The Global Burden of Disease, Vol. II, Global Health Statistics: A Compendium of Incidence, Prevalence and Mortality Estimates for Over 200 Conditions", Harvard School of Public Health on Behalf of the World Health Organization and The World Bank, Cambridge, MA, 1996.
3. Royal Nepal Academy of Science and Technology (RONAST), "Water Quality of Bagmati River in the Pashupati Area", Mimeograph Report, Kathmandu, RONAST, 1988.
4. Razen Manandhar, "Bagmati's Dirty, Stinking Sand", Sunday Post, 21/10/2001.
5. World Health Organization, "The World Health Report 1996 – Fighting Disease, Fostering Development", Geneva, World Health Organization, 1996: Pp43.
6. Adhikari Ambika P. "Environmental Problems in the Kathmandu Valley." In, Urban and Environmental Planning in Nepal. IUCN, The World Conservation Union, 1998.
7. Esrey S, "Water, Waste and Well-being: A Multi-Country Study", American Journal of Epidemiology, 143 (6), 1996: Pp 608-623.
8. Robin Clarke, "Water: The International Crisis", Cambridge: MIT Press, 1993.
9. Kathmandu Post, "Most Rivers in Urban Areas Polluted", Kathmandu Post, 20/03/2003.
10. Surendra Phuyal, "Urban Water Quality Continues to Deteriorate as 'Stringent' Laws Gather Dusts", Kathmandu Post, 08/04/2002.
11. <http://www.unep.org/geo/2000/pressre/water.htm> . (Water, Water Everywhere.... Tackling the Global Water Crisis)
12. Spotlight, "Water Pollution", The National News Magazine, Spotlight, Vol. 20, No. 20, Dec 01 - Dec 07, 2000.
13. Bishnu Budhathoki, "Most Rivers in Urban Nepal Unfit for Human Use", Rising Nepal, 20/03/2003.
14. UNICEF, "Water, Environment and Sanitation" <http://www.unicef.org>
15. Kathmandu Post, "Major Works on Bagmati River Cleaning Completed", Kathmandu Post, 01/01/2001.
16. Umesh Silwal, "Pollution Stalks Vishnumati River", Rising Nepal, 20/10/2001.

17. Kathmandu Post, "Water Pollution Likely to Pose Health Hazards", Kathmandu Post, 01/04/2001.
18. EMAG, "Environmental Problems of Urbanization and Industrialization: The Existing Situation and the Future Direction", Final Report Submitted to UNDP/Kathmandu, 1992.
19. P. Gopakumar, "Water Pollution", Rising Nepal, 09/06/2002.
20. PNK, "Rosy' Future for Dhobi Khola", Rising Nepal, 19/12/2001.
21. Nepal Net an Electronic Networking for Sustainable Development in Nepal, Nepal Net Key Development Sector > W a t e r , E a r t h & A t m o s p h e r e >
22. Himalayan News Service, "Vishnumati River is Sewage, Not Water; Says Expert", Himalayan Times, 05/05/2003.
23. International Water and Sanitation Center <http://www.irc.nl>
24. Ford, T.E. and Colwell, R.R., "A Global Decline in Microbiological Safety of Water: A Call for Action", American Academy of Microbiology, Washington DC, 1996.
25. Hunter, P.R., "Waterborne Disease: Epidemiology and Ecology", Wiley, Chichester, UK, 1997.
26. WHO, "Guidelines for Drinking-Water Quality. Volume 1: Recommendations", Second Edition. World Health Organization, Geneva, 1993.
27. WHO, "Guidelines for Drinking-Water Quality. Volume 2: Health Criteria and Other Supporting Information", Second Edition. World Health Organization, Geneva, 1996.
28. Anon, "Water and Sanitation: WHO Fact Sheet No. 112", World Health Organization, Geneva, 1996.
29. WHO, "Cholera and Other Epidemic Diarrhoeal Diseases Control. Fact Sheets on Environmental Sanitation", World Health Organization, Geneva, 1996.
30. WHO, "Water, Sanitation and Hygiene Links to Health; Facts and Figure Updated November 2004", http://www.who.int/water_sanitation_health/index.html
31. World Health Organization, "Health Situation in the South East Asia Region 1994-1997", New Delhi: WHO Regional Office for South East Asia, 1999.
32. Richard Carr, "Excreta Related Infections Disease and the Role of Sanitation in the Control of Transmission", In World Health Organization (WHO). Water Quality: Guidelines, Standards and Health. Edited by Lorna Fewtrell and Jamie Bartram. Published by IWA Publishing, London, UK. 2001.
33. WHO, "WHO Report on Infectious Diseases – Removing Obstacles to Healthy Development", World Health Organization, Geneva, 1999.
34. WHO, "Global Water Supply and Sanitation Assessment", World Health Organization, Geneva, 2000a.
35. WHO, "Control of Food-Borne Trematode Infections". Technical Report Series 849, World Health Organization, Geneva, 1995.
36. WHO, "Burden of Disease and Cost – Effectiveness Estimates", http://www.who.int/water_sanitation_health/index.htm
37. WHO, "Health in Water Resources Development", http://www.who.int/water_sanitation_health/index.htm
38. World Health Organization, "The World Health Report 1995 – Bridging the Gaps", Geneva, World Health Organization, 1995:Pp40-41.
39. Esrey S, J Potash, L Roberts, C Shiff, "Effects of Improved Water Supply and Sanitation on Ascariasis, Diarrhoea, Dracunculiasis, Hookworm Infection, Schistosomiasis, and Trachoma", WHO Bulletin, 69 (5),1991:Pp 609-621
40. Hutley S, S Morris, V Pisana, "Prevention of Diarrhoea in Young Children in Developing Countries", WHO Bulletin, 75 (2), 1997: Pp163-174.
41. Neto, F. and Tropp, H., "Water Supply and Sanitation Services for All: Global Progress During the 1990s", Natural Resources Forum 24, 2000, Pp225–235.
42. Simpson-Hébert, M. and Wood, S. (eds), "Sanitation Promotion", Unpublished Document WHO/EOS/98.5, World Health Organization/Water Supply and Sanitation Collaborative Council (Working Group on Promotion of Sanitation), Geneva, 1998.
43. UNICEF, "State of the World's Children Report 2005", UNICEF, 2005.
44. UNEP, "Global Environment Outlook 3 Past, Present and Future Perspectives" Home -> GEO-3-> Chapter 2->freshwater->Asia and Pacific, 2000.