Μεταπτυχιακή εργασία
στα πλαίσια του Β' Εξαμήνου
του έτους σπουδών 2010-2011

Water-borne diseases and access to safe water for Sub-Saharan Africa populations

ΣΠΑΝΟΥ ΑΓΓΕΛΙΚΗ

ΙΟΥΝΙΟΣ 2011

Water-borne diseases and access to safe water for Sub-Saharan Africa populations.

Abstract

Water-borne diseases represent a major burden on human health worldwide. Every year, 1.8 million people die from diarrheal diseases, of which 1.5 million are children under the age of 5(1). Access to safe drinking water, basic sanitation and proper hygiene education could not only prevent diarrheal diseases by nearly 90%(2) but furthermore lead to improved health, poverty reduction and socio-economic development(3). Goal 7 of the Millenium Development goals (MDG) set by the United Nations in 2000 is to halve by 2015 the proportion of people without sustainable access to safe drinking water and basic sanitation. Today, with only 4 years left till 2015 the world is on track to meet the drinking water target, but sub-Saharan Africa (SSA) lags behind (4).Chronic political conflicts, natural disasters, disparities in urban-rural settings and rapid population growth are only some of the obstacles to accelerating the rate of progress for African populations (4,5). In rural Africa 2 out of 3 people don't have access to an improved water supply. Today, as basic infrastructure for wide surveillance of water sources is unavailable, a household water management approach appears to be the most attractive short term intervention (3,6).

Introduction

Water-borne diseases are caused by ingestion of contaminated water from pathogens contained in human or animal excreta. SSA's population suffers markedly from water-borne infections due to lack of safe and sanitary water supply and disposal. In 18 countries in SSA a less than a quarter of the population uses an improved sanitation facility (7). Diarrhoea caused by these pathogens is the second leading contributor to global burden of disease, ahead of heart disease and (HIV/AIDS). International organizations and local governments seem to neglet this huge disease burden and direct the focus elsewhere, while millions of people continue to die over easily preventable illnesses.

Seemingly, water-borne diseases are simple to explain but very complex to understand. Constant humanitarian aid over the last decades has yet failed to deliver to the people in need the basic human priorities by not implementing serious, locally adjusted water management programs that secure long lasting infrastructure and maintain a dignified level of public health.

Classification of Water-borne diseases

Bradley (White et al. 1972) developed the first environmental classification for water-related diseases introducing the very important category of ''water-washed'' diseases, whose transmission is facilitated by insufficient quantities of water (regardless of its quality) for personal and domestic hygiene. Bradley showed that all waterborne diseases can also be transmitted by the water-washed route, which is epidemiologically more important under conditions of water scarcity as in rural and periurban areas in developing countries (8).

Feachem in 1975 classification united the water-borne and water-washed categories by introducing the term feco-oral (9). The proposed unitary classification by Mara and Feachem that combines them is presented in **Table 1**.

Most water-borne diseases cause diarrhoeal illness. Other water-borne diseases can cause malnutrition, skin infections, and organ damage. Pneumonia and diarrhoeal diseases are the two biggest killers of children under 5 years old, accounting for 18% and 15% of all deaths respectively in 2008. The highest burden of mortality is found in SSA and South-East Asia (11).

Category	Pathogens		
Feco-oral waterborne and water-washed diseases	Viral: Hepatitis A, E, and F Poliomyelitis Rotaviral diarrhea Adenoviral diarrhea Bacterial: Campylobacteriosis Cholera *Helicobacter pylori inf.* Helminthic: Pathogenic *Escherichia coli* inf. Salmonellosis Typhoid and paratyphoid Yersiniosis	Protozoan:	Amebiasis Cryptosporidiosis *Cyclospora cayetanensis* diarrhea *Enterocytozoon bienusi* diarrhea Giardiasis *Isospora belli* diarrhea Ascariasis Enterobiasis Hymenolepiasis
Non-feco-oral water-washed diseases	Skin infections (scabies, leprosy, yaws) Eye infections (trachoma, conjunctivitis) Louse-borne fevers		
Water-based Diseases	Bacterial: Leptospirosis Tularemia Legionellosis Helminthic: Schistosomiasis Clonorchiasis Fasciolopsiasis Guinea worm infection	Fungal:	Pulmonary hemorrhage due to *Stachybotrys atra* infection
Insect-vector Diseases	Water-related: Malaria Yellow fever Rift Valley fever Onchocerciasis Bancroftian filariasis Dengue African sleeping illness	Excreta-related:	Fly-borne and cockroach-borne excreted infectionsa Bancroftian filariasis
Rodent-vector Diseases	Rodent-borne excreted infections Leptospirosis, Tularemia		
Taeinases	Beef and pork tapeworm infections		
Geohelminthiases	Ascariasis; trichuriasis;hookworm infection		

Table 1. Unitary Environmental Classification of Water- and Excreta-Related Diseases.(10)

Endemic or high prevance water-borne pathogens in Sub-Saharan Africa.

Dracunculus medinensis

Guinea worm disease, considered a Neglected Tropical Disease, is caused by the parasite *Dracunculus medinensis*. Of all the water-borne pathogens, this helminth is unique in that it is the only pathogen that is solely transmitted through drinking water. The disease affects poor communities in remote parts of Africa that do not have safe water to drink. People become infected with Guinea worm by drinking stagnant water containing copepods (tiny "water fleas") that carry Guinea worm larvae (immature forms of the worm). Currently, only four countries continue to report cases of Guinea worm disease: Southern Sudan, Mali, Ethiopia, and Chad. There is no drug treatment for Guinea worm disease nor a vaccine to prevent it. Thanks to the Guinea Worm Eradication Program, there were fewer than 3,200 cases reported worldwide in 2009. More than 85% of the cases in 2009 were from Sudan. The rest were from Ghana, Mali, and Ethiopia (12).

Schistosoma

Schistosomiasis also known as snail fever, remains a public health problem in several parts of the world, particularly in Africa, with over 200 million people infected in 2009. Of the parasitic diseases in SSA, it is second to malaria as a public health problem. Its natural host is buffalo by 90 %. The tiny parasitic worms burrow through the skin of farmers tending crops and children and women who swim and perform household chores in infested freshwater rivers and ponds. The worms burrow into snails where they multiply and change into an infectious form. The number of people treated for schistosomiasis in 2009 was 116% more than in 2006 but still accounts only to 8.2% of all people infected. More than half were school-aged children. The African Region accounted for 74.1% of the total number of people treated worldwide which has increased 7.8% since 2008 (13).

Salmonella

Salmonellosis has two forms: 1.typhoid and paratyphoid fever, 2. gastroenteritis. The principal habitat of *Salmonella* is the intestinal tract of humans and animals. Salmonellae are constantly found in environmental samples, because they are excreted by humans, pets, farm animals, and wild life. Municipal sewage, agriculture pollution are the main sources of these pathogens in natural waters (14).

Salmonellae isolated from environmental sources are predominantly non-Typhi or Paratyphi serovars. In the developing world, the new multi-drug resistant strains causing bacteraemia are far more common and serious. Fatality rates among children under two years old can be as high as almost one in four and are even higher in HIV-infected adults. Invasive non-Typhi *Salmonella* (NTS) is endemic in SSA. Seasonal peaks of NTS disease occur with the rainy season. Fecal organisms are found at highest concentrations in drinking water sources in Africa at the onset of the wet season and this may correspond with increased risk of waterborne NTS (15).

Typhoid fever remains a serious public health problem in Africa as SSA has the second highest incidence of TF after Southeast Asia.

In the last outbreak in the Democratic Republic of Congo, between 27 September 2004 and early January 2005, 42 564 cases of typhoid fever were reported. The incidence of typhoid fever decreases when the level of development of a country increases (control of water sewage systems, pasteurization of milk and dairy products). Where these hygienic conditions are missing, the probability of fecal contamination of water and food remains high and so is the incidence of typhoid fever (14).

Shigella.

Shigellosis is endemic throughout the world causing 165 million cases of severe dysentery with blood and mucus in the stools, the overwhelming majority of which occur in developing countries and involve children less than five years of age. More than one million people are estimated to die from Shigella infection each year. In addition, some 580 000 cases of shigellosis are reported among travellers and military personnel from industrialized countries. Since the late 1960s, pandemic waves of Shigella dysentery have hit SSA, often striking areas of political upheaval and natural disaster. During the 1994 genocide in Rwanda, approximately 20.000 Rwandan refugees who had fled into the North Kivu region of Zaire died in the first month alone from dysentery caused by a strain of Shigella that was resistant to all commonly used antibiotics. The combination of Shigella and HIV infections has deleterious consequences, due to compromised immunity in HIV-positive persons (16) Epidemics of shigellosis occur in crowded communities and where hygiene is poor. It is predominantly transmitted by the faecal–oral route through person-to-person contact, contaminated food and water.. The control of *Shigella* spp. in drinking water supplies is of special public health importance (17).

Cholera

Vibrio cholerae serotypes O1 and O139 cause the classical cholera illness, characterized by fulminating and severe watery diarrhoea. The O1 serotype has been further divided into "classical" and "El Tor" biotypes. The classical biotype is considered responsible for the first six cholera pandemics, while the El Tor biotype is responsible the current "seventh" cholera pandemic started in 1961 and still in progress. As many as 60% of untreated patients may die as a result of severe dehydration and loss of electrolytes, but well established diarrhoeal disease control programmes can reduce fatalities to less than 1%. Cholera is typically transmitted by the faecal–oral route, and the infection is predominantly contracted by the ingestion of faecally contaminated water and food. The presence in drinking-water supplies is of major public health importance and can have serious health and economic implications in the affected communities. The disease is now endemic in many parts of Africa and Asia. Africa accounts for over the 94 % of cases reported to the WHO annually. Explosive outbreaks usually occur in areas with inadequate sanitation, poor hygiene, and lack of safe water supplies (16).

The current wave of cholera outbreaks affecting Central Africa resulted in 40 468 cases and 1 879 deaths in four countries (Cameroon, Chad, Niger and Nigeria). Seasonal factors, such as the rainy season with flooding, as well as poor hygiene conditions and population movements in the area contribute to this unusually high incidence of cholera (17).

E. coli.

Enterotoxigenic E. coli, (ETEC) is an under-recognized but extremely important cause of diarrhoea in the developing world where there is inadequate clean water and poor sanitation. ETEC is the most commonly isolated bacterial enteropathogen in children below 5 years of age in developing countries, and account for several hundred million cases of diarrhoea and several ten of thousand deaths each year.

Disease caused by ETEC follows ingestion of contaminated food or water and is characterized by profuse watery diarrhoea lasting for several days that often leads to dehydration and malnutrition in young children. ETEC was thought to account for approximately 200 million diarrhoea episodes and 380 000 deaths annually. In infants living in the Nile delta area, who experienced between 4.6 and 8.8 diarrhoeal episodes per year, ETEC accounted for 66% of these episodes (18).

Rotavirus

Human rotaviruses (HRVs) are the most important single cause of infant death in the world. Domestic sewage and any environments polluted with human faeces are likely to contain large numbers of HRVs. The viruses have been detected in sewage, rivers, lakes and treated drinking water. HRVs are transmitted by the fecal-oral route. Although ingestion of drinking-water is not the most common route of transmission, the presence of HRVs in drinking water constitutes a public health risk (17).

Safe water and proper sanitation are still a challenge for the developing world.

The global use of improved water sources is up to 87% but still 884 million people don't have access to safe drinking water. Nearly 340.000 of them, a bit more than one third lives in sub Saharan Africa (SSA). SSA has the lowest drinking water coverage and the lowest sanitation coverage in the world . Along with improved water supply, proper sanitation and adequate hygiene practices are pivotal for sustaining high water quality and reduce water related diseases. Today, only 61% of global population uses improved sanitation facilities, which leaves out 2.6 billion people. This number includes nearly the 70 % of sub-Saharan Africa population. Unless huge efforts are made, sub Saharan Africa will fail to meet the 2015 MDG target to halve the proportion of people without sustainable access to safe drinking water (19).

Access to safe drinking water is estimated by the percentage of the population using improved drinking water sources. An improved drinking water source is one that by the nature of its construction adequately protects the source from outside contamination, .in particular with faecal matter (19). An improved sanitation facility is one that hygienically separates human excreta from human contact. (**Table 2**). Also, water should be provided in sufficient quantities to enable proper hygiene. Hands should be washed immediately after defecation, after handling babies' faeces, before preparing food and before eating. Water, sanitation and hygiene improvements can be classified into two groups of related interventions (Esrey et al. , 1991) (20):

- Provision of an improved source of water and/or improved distribution, such as piped water or standpipes, provided either at public (source) or household (point-of-use) levels.
- Provision of improved means of excreta disposal, through latrines or connection to the public sewer. Eventhough the percentage of people practicing open defecation is decreasing worldwide, in Southern Asia and SSA open defecation is practised widely (44% and 27% respectively) (19).

DRINKING WATER SOURCES	
IMPROVED	**UNIMPROVED**
Piped water into dwelling, plot, yard	Unprotected dug well
Rainwater collection	Unprotected spring
Public tap/standpipe	Cart with small tank
Tubewell/borehole	Bottled water
Protected dug well	Tanker-truck
Protected spring	Surface water (river, lake, pond, stream, canal)

SANITATION FACILITIES	
IMPROVED	**UNIMPROVED**
Flush or pour -flush to: Piped sewer system	Public/shared latrine
Septic tank Pit latrine	Hanging latrine
Ventilated improved pit latrine	No facilities
Pit latrine with slab	Open pit latrine
Composting toilet	Bucket latrine

In SSA the substantial increase in the absolute number of people without an improved water source by 190 million between the period 1990-2006 is due to population growth (7). This increase represents the 23% of SSA's population while the number of people without sanitation increased by over 30% (21).

Table 2. Sources of drinking water and sanitation facilities characterized as improved and unimproved Adopted by WHO/UNICEF (19).

The change from open defecation to the use of an improvised latrine is unlikely to offer health benefits unless the latrine provides an adequate barrier between the users and their excreta and is well maintained. The health benefit of household water connections is substantially greater than that from an improved public source such as a protected well or standpipe (22).

Benefits of improved water supply and adequate sanitation on health.

Safe water, adequate sanitation, and proper hygiene education (WSH) can prevent illness and death, leading to improved health, poverty reduction, and socio-economic development.
It is found that WSH can reduce diarroeal prevalence by up to one third. Greater reductions (up to 63%) are associated with water piped to one or more taps (20). Different levels of access provide widely varying health benefits. Piped water within a household and access to private covered pit latrines significantly reduces the prevalence of diarrhea by 20%.
Clean, uncontaminated water when is well managed by the communities, will substantially prevent water washed and insect-borne diseases such as typhoid fever and malaria which are significant killers in Sub-saharan Africa. Their incidence is interrelated and as so, a drop in one will necessary lead to a drop in the others (23).

Safe water combats HIV/AIDS.

HIV/AIDS is a major public health concern and cause of death in Africa. Although Africa is home to about 14.5% of the world's population, it is estimated to be home to 67% of all people living with HIV and to 72% of all AIDS deaths in 2009 (24). An estimated 22.5 million people are living with HIV in the region. People weakened by HIV/AIDS are likely to suffer the most from the lack of safe water supply and sanitation, especially since diarrhoea and skin diseases are two of the more common infections. Inexpensive interventions that prevent diarrhea could be important components of a care package for persons with HIV whether or not antiretroviral treatment is available. A study in rural Uganda evaluated the effectiveness of Safe Water System (SWS), among persons with HIV and their family members living in rural Uganda. SWS is a household-based water quality intervention developed by the Centers for Disease Control and Prevention (CDC). HIV viral load increased by 0.40 $\log_{10}$ per person/year for persons with HIV using SWS compared with 0.71 $\log_{10}$ per person/year for those not using SWS. SWS was associated with 25% fewer episodes of diarrhea, 33% fewer days with diarrhea, and 24% fewer episodes of diarrhea with blood or mucous in stool (25).

Investments in improved water supply and sanitation would also make a difference for many neglected tropical diseases (such as intestinal nematode infections, lymphatic filariasis, trachoma) that have environmental transmission pathways.

"Point-of-use" water treatment can reduce waterborne diseases.

Improved sources may still contain harmful substances, and water can be contaminated during transport and storage. Although 'improved drinking water sources' provide a good indicator for progress, it is not a direct measure of it. The proportion of the population using safe drinking water is therefore likely to be lower than that using improved drinking water sources. Community-based water facilities (e.g., protected springs) often have poor water quality due to poor maintenance (22)**.** Policies that aim to improve water quality through source improvements may be compromised by post-collection contamination. Safer household water storage and treatment is recommended to prevent this, together with point-of-use water quality monitoring (26)

Point-of-use water management:

- dramatically improves microbial water quality
- significantly reduces diarrhoea
- is among the most effective of water, sanitation and health interventions
- is highly cost-effective
- can be rapidly deployed and taken up by vulnerable populations

Examples of household water treatment include boiling, filtration, chemical, solar and UV lamp disinfection, flocculation for the removal of turbidity, and other techniques.

Safe storage refers to techniques that minimize the risk of recontamination, including the use of narrow-mouth, screened, and covered containers, as well as dispensing devices such as taps or spigots (1). 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 (17).

Safe drinking water is essential for the protection of public health.

Microbial contamination has the potential to cause large outbreaks of waterborne diseases. Community drinking-water supplies worldwide are more frequently contaminated than larger drinking-water supplies, may be more prone to operating discontinuously (or intermittently) and break down or fail more frequently. Water safety plans (WSPs) consistently ensure drinking water quality and the prevention of contamination during storage, distribution and handling of drinking-water. These objectives are equally applicable to large piped drinking-water supplies, small community supplies and household systems. Surveillance operated by community-based managers assures proper hygiene in the collection and storage of household water. In assessing the adequacy of the drinking-water supply, the following basic service parameters should normally be taken into consideration (17):

- Quality: whether the supply has an approved WSP that has been validated and is subject to periodic audit to demonstrate compliance .
- Quantity : the proportion of the population using water from different levels of drinking-water supply (e.g., no access, basic access, intermediate access and optimal access);
- Accessibility: the percentage of the population that has reasonable access to an improved drinking-water supply;
- Affordability: the tariff paid by domestic consumers; and
- Continuity: the percentage of the time during which drinking-water is available (daily, weekly and seasonally).

Tackling waterborne diseases reduces child morbidity and mortality and therefore, poverty.

Water- and sanitation-related diseases are one of the major causes of under-five mortality in the world. At the same time 90 % of waterborne diseases concern children of the developing world. In fact we know from recent World Health Organization (WHO) reports, that the impact of diarrhoeal disease on children is greater than the combined impact of AIDS, tuberculosis and malari (2).

It is shown that 7 % of WSH disease burden is associated with malnutrition. Finally, when malnourished children are recovering from an episode of diarrhoea, they are unusually susceptible to pneumonia; this diarrhoea-induced susceptibility may be associated with as much as 26% of all childhood pneumonia episodes (27). Similarly, reductions in diarrhoea also reduce the incidence of diseases that are the consequence of malnutrition and that accounts for 29% of the disease burden. (**Figure 1)**

Jones and colleagues concluded that the interventions needed to achieve the millennium development goal of reducing child mortality by two-thirds by 2015 are available, but are not being delivered to mothers and children who need them (28). The under-five mortality rate is an important social indicator of development. Through combating water-borne diseases Sub-Saharan Africa countries will eventually move towards actual progression.

Prevention of waterborne diseases lowers the disease burden in developing countries and improved health leads to poverty reduction. Sanitation and water programmes can weaken the link between poverty and disease. Most WSH interventions in developing countries are highly cost-effective. Indeed, hygiene promotion is the most cost-effective of all (**Table 3**).

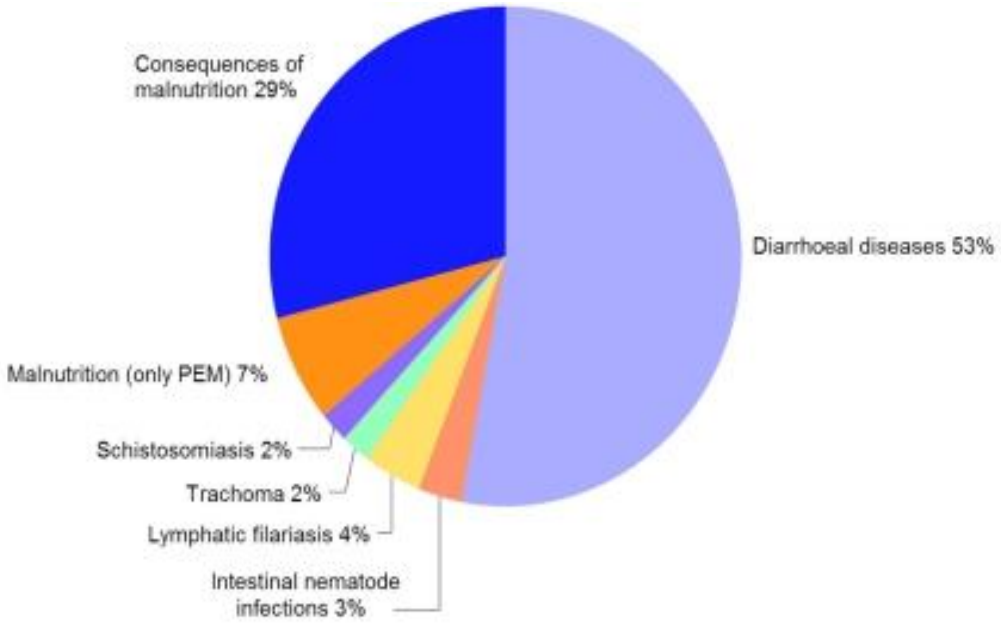

Figure 1. Preventable WSH-associated disease burden. Adopted from Bartram J, Cairncross S (2010) (23).

INTERVENTION	**COST-EFFECTIVENESS RATIO** (DALYs Averted per US$1,000 Spent)
Diarrhoeal disease	
Hygiene promotion	200
Sanitation promotion	90
Water regulation and advocacy	12
Cholera or rotavirus immunization	0.5
HIV/AIDS	
Condom promotion and distribution	10–12
Antiretroviral therapy	1–3
Malaria	
Insecticide-treated bednets	80–140
Intermittent preventive treatment in pregnancy	120
Tuberculosis	
Directly observed short course (DOTS)	8–90

Table 3. Cost Benefit from introducing disease-related interventions. Adopted from Bartram J, Cairncross S (2010) (23).

Sub-Saharan Africa is the least likely region of the world to meet the MDG for water and sanitation standards.

Unless huge efforts are made, SSA will be the only country to miss the UN's MDG for safe drinking water. Many of the reasons that contribute to this off-track course are well known facts that characterise the regions chronic undermined situation.

1. Emergencies and natural disasters

SSA is challenged by crises and natural disasters in increasing frequency. Between 1992 and 2004, 22 of the 33 humanitarian crises occurred in Africa. A total of 21 out of 31 humanitarian appeals in 2006 and nine out of 13 in 2007 were from African countries. These emergencies comprised natural disasters such as floods; droughts and disease outbreaks as well as conflicts of various degrees (5). Drinking-water safety is one of the most important public health issues in most emergencies and disasters. The greatest waterborne health risk in most emergencies is the transmission of faecal pathogens, due to inadequate sanitation, hygiene and protection of water sources. Different types of disasters affect water quality in different ways. When people are displaced by conflict and natural disaster, they may move to an area where unprotected water sources are contaminated. When population density is high and sanitation is inadequate, unprotected water sources in and around the temporary settlement are highly likely to become contaminated. Malnutrition increases the risk of waterborne disease outbreak. The quality of urban drinking-water supplies is particularly at risk following earthquakes, mudslides and other structurally damaging disasters. Sewers and water transmission pipes may be broken, causing contamination of drinking-water in the distribution system. Floods may contaminate wells, boreholes and surface water sources with faecal matter washed from the ground surface or from overflowing latrines and sewers. During droughts, people may be forced to use unprotected water supplies when normal supplies dry up; as more people and animals use fewer water sources, the risk of contamination is increased.(17)

2. Unfavourable geographical conditions

Adverse geographical conditions include: high transport costs (eg, landlocked areas or mountainous regions), adverse disease ecology (eg, high burden of tropical diseases such as malaria), and adverse conditions for agriculture (eg, dependency on rain-fed agriculture in subhumid or arid regions) (29).

3. Water Management

The continual donation of drugs and treatment could control many waterborne diseases effectively by 2015, which is the target for reaching the MDGs. However, disease transmission will still continue unless we tackle the root causes of these diseases, which are poor access to safe water and basic sanitation. Supplying basic sanitation is neither difficult nor costly, especially in rural areas. A key requirement is sustainability. Services should still work in 10-20 years.

Ownership of water and sanitation initiatives by the community needs to be encouraged by donors and governments. If people can afford to pay, even a small amount,
it is likely to look after their facilities in the long-term. Similarly, an incentive is important for service providers-they should be paid if they can ensure the running, repair, and maintenance of systems (30). An estimated 50,000 water supply points have effectively died. The root cause is the water community's failure to plan for maintenance of the infrastructure in a systematic way. Interventions in water management should be focused on local capacity to manage boreholes and wells rather than the communitys passive attitude on allowing the government ,donors and NGO's to step in and do the job. By empowering local authorities sustainability is ensured (31).

4. Urban-rural disparities and the water crisis.

In developing regions, 88% of the people without improved water sources, live in rural areas. In rural Africa it is generally women who shoulder the burden of water collection. Broken down, unsafe or nonexistent water supplies, forse people to walk longer in order to collect water for household use. So if a village supply fails, women and children may have to go back to walking several hours to collect water each day. The alternative water from more distant rivers and marshes may carry dangerous pathogens, the lower volumes carried mean less family hygiene, the energy dissipated to carry water further than usual weakens, and the longer time spent walking diverts time from economically productive alternatives for women, and often from school participation for girls. (**Diagram 1**).Thus, the provision of safe water constitutes the basis of human development (32).
For every urban dweller, 6 people in rural settings lack access to a safe water source and 3 people live without improved sanitation. It is estimated that by 2015 still only the 50 % of rural dwellers will have basic sanitation. Strategies to reduce rural poverty need to focus on improving productivity in agriculture. Interventions should focus on water management of water resources.

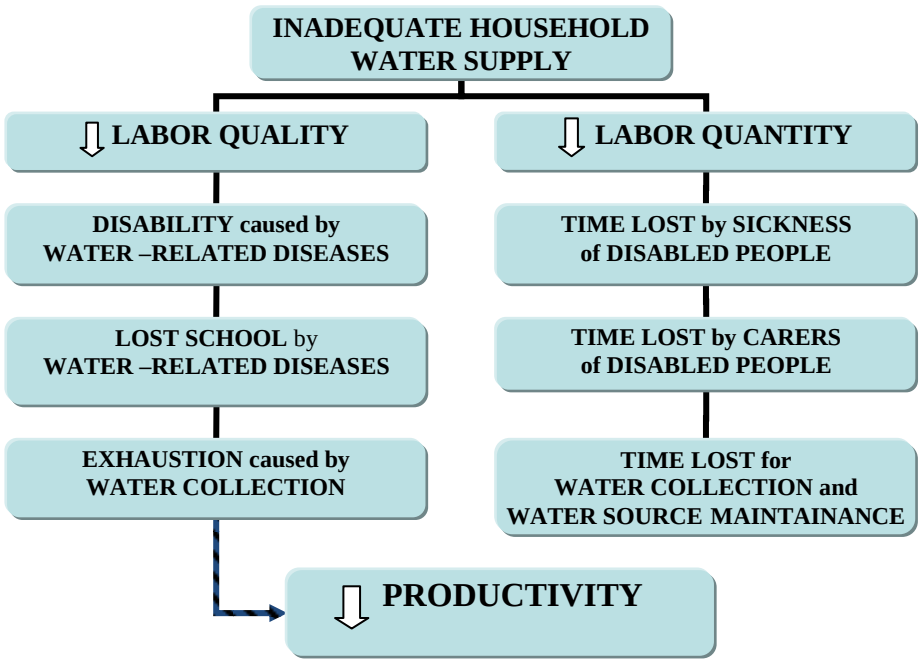

Diagram 1. Connections between household water supply and reduced productivity. Adopted from Rosen S, Vincent JR (2001) (32).

5. **The impact of rapid population growth and fast urbanization on health.**

Sub-Saharan Africa represents one of the fastest population growing regions in the world. More than 60% of the world's population growth between 2008 and 2100 will be in sub-Saharan Africa (32%) and South Asia (30%).

From 1990 till 2004 SSA's urban population has grown 85%. This led to a two fold increase of the number of people without access to safe drinking water and good hygiene. As people tent to gather densely in urban areas, the community fails to meet the high demand and forces them to find different sources for water supply. Consequently, the urban poor often use inexpensive pit latrines and at the same time may draw domestic water from nearby wells. Overcrowding in slums limits the adequate distance between wells and pit latrines leading to contamination of these wells. A study which examined 40 water samples from Langas slum, Kenya found 40% of the pit latrines in a distance shorter than 15m from the wells. The laboratory analysis results of water samples show that fecal matter heavily contaminated the water sources and especially the shallow wells (33).

Slum areas are informal settlements that create a viscious circle of poverty. Disease impoverish people and poverty sustains low sanitation levels. At the slums, child mortality rates are found increased compared to rural areas. Furthermore people in slums have to pay more in order to buy safe drinking water. The financing of water services is the key to expanding access, but the illegal status of the large majority of slum dwellers is often a barrier to access to finance or support. As slums are home to about 70% of all urban residents in sub-Saharan Africa massive effort is substantial in order to overcome such disparities (21).

6. **How can climate change interfere with water scarcity or availability.**

Carbon is a measure of the anthropogenic causes of climate change – water is a measure of its impacts. Low available water per capita because of low annual rainfall is forecast to worsen where population growth is still high, as in sub-Saharan Africa. Tropical SSA regions suffer from extreme rainfall, causing floods. Climate models show that extremes of rainfall are likely to worsen, resulting in more floods and droughts often in regions with low income levels per capita, widespread absolute poverty, high population growth and rapid urbanization (21).

Conclusions

Access to safe drinking water will eliminate vast part of water-borne disease cases, but that is not enough in order to improve and sustain human health. Focusing on Sub-Saharan Africa, HIV/AIDS, tuberculosis, and malaria, usually referred to as 'the big three' kill less young children than one disease alone, diarrhea (23). A disease burden that is preventable through clean water and basic sanitation standards. Surprisingly this burden is carried only by the poorest countries in the world. The key is to work simultaneously and in parallel to end the poverty traps. Surprisingly, this burden can be carried out by the richest countries which can help Sub-Saharan Africa make the necessary investments in health, education, and basic infrastructure. Once extreme poverty is reduced with the support of external assistance, low income countries can begin to achieve self-sustaining public health systems that will monitor and drive their way out.

Acronyms and Abbreviations

SSA: Sub-Saharan Africa
MDG: Milleniumm Development Goal.
HIV/AIDS: Human Immunodeficiency Virus/Acute Immunodeficiency Syndrome.
UN: United Nations.
WSH: Water, sanitation, hygiene.
NTS: Invasive non-Typhi *Salmonella*.

References

1. WHO (2007). Combating Waterborne Disease at the Household Level.

2. UN.(2010). Glaass 2010. Global annual assessment of sanitation and drinking water. Targeting resources for better results.

3. Fewtrell L., Kaufmann R.B., Kay D., Enanoria W., Haller L., Colford J.M. (2005). Water, sanitation, and hygiene interventions to reduce diarrhoea in less developed countries: a systematic review and meta-analysis. The Lancet Infectious Diseases (Vol. 5, Issue 1, Pages 42-52) DOI: 10.1016/S1473-3099(04)01253-8

4. WHO/UNICEF (2006). Meeting the MDG Drinking Water and Sanitation Target: The Urban and Rural Challenge of the Decade.

5. WHO (2008). African Health Monitor. Regional office for Africa, VOL 8, No 2

6. Mintz E, Bartram J, Lochery P & Wegelin M (2001). Not just a drop in the bucket: expanding access to point-of-use water treatment systems. Am. J. Pub. Health 91(10): 1565-70

7. WHO/UNICEF (2010). A Snapshot of Drinking-water and Sanitation in the MDG region sub-Saharan Africa. Update.

8. White, G. F., Bradley, D. J., and White, A. U. (1972). Drawers of water: Domestic water use in East Africa. Chicago Univ. Press, Chicago, Ill.

9. Feachem, R. G. (1975). ''Water supplies for low-income communities in developing countries. J. Envir. Engrg. Div., ASCE, (1975) 101, 687–703.

10. Mara DD (1999) Unitary environmental classification of water- and excreta-related diseases. J Environ Engineering 335

11. Who(2011). World Health Statistics.

12. http://www.cdc.gov/parasites/guineaworm/

13. WHO. Weekly epidemiological record 25 (02/2011), 86th year. No. 9, 2011, 86, 73–80

14. Cabral JP (2010). Water Microbiology, Bacterial Pathogens and Water. Int J Environ Res Public Health;7(10):3657-703. Epub. Review

15. Susan C. Morpeth, MB, ChB, DTM&H, Habib O. Ramadhani, MD, MHS and John A. Crump (2009) Invasive non-Typhi Salmonella disease in Africa, Clin Infect Dis. 49(4): 606–611. doi: 10.1086/603553

16. http://www.who.int/vaccine_research/diseases/diarrhoeal/en/index7.html

17. WHO (2008). Guidelines for Drinking Water, 3rd ed., 2nd Addendum.

18. http://www.who.int/csr/don/2010_10_08/en/index.html

19. WHO/UNICEF (2010). Progress on Sanitation and Drinking Water; update. Joint Monitoring Programme for Water Supply and Sanitation.

20. Esrey SA, Potash JB, Roberts L, Shiff C.(1991). Effects of improved water supply and sanitation on ascariasis, diarrhoea, dracunculiasis, hookworm infection, schistosomiasis, and trachoma. Bull World Health Organ. 1991;69:609–621

21. UN (2009). Water in Changing World. World Water Development Report.

22. CEEPA Policy Brief. (2010). Battling water-borne disease amongst children. An assessment of policy options from Uganda. No 45.

23. Bartram J, Cairncross S (2010) Hygiene, Sanitation, and Water: Forgotten Foundations of Health. PLoS Med 7(11): e1000367. doi:10.1371/journal.pmed.1000367

24. Global Report (2010). UNAIDS Report on the Global AIDS Epidemic 2010

25. Lule JR, Mermin J, Ekwaru JP, Malamba S, Downing R, et al. (2005) Effect of home-based water chlorination and safe storage on diarrhea among persons with human immunodeficiency virus in Uganda. Am J Trop Med Hyg 73: 926–933

26. Wright J, Gundry S, Conroy R (2004) Household drinking water in developing countries: a systematic review of microbiological contamination between source and point-of-use. Trop Med Int Health 9: 106–117.

27. Schmidt WP, Cairncross S, Barreto ML, Clasen T, Genser B. (2009). Recent diarrhoeal illness and risk of lower respiratory infections in children under the age of 5 years. *Int J Epidemiol.*doi: 10.1093/ije/dyp159.

28. Jones G, Steketee RW, Black RE, Bhutta ZA, Morris SS, Bellagio.(2003) Child Survival Study Group. How many child deaths can we prevent this year? Lancet; 362: 65–71.

29. J D Sachs, J W McArthur (2005). The Millennium Project: a plan for meeting the Millennium Development Goals, Lancet; 365: 347–53

30. Watching the world wash its hands of sanitation. (2006). The Lancet Infectious Diseases (Vol. 6, Issue 10, Page 615) DOI: 10.1016/S1473-3099(06)70583-7

31. Jamie Skinner (2009). Where every drop counts: tackling rural Africa's water crisis. IIED Briefing Papers IIED code: 17055.

32. Rosen S, Vincent JR. Household Water Resources and Rural Productivity in Sub-Saharan Africa: A Review of the Evidence. Cambridge, MA*:* John F. Kennedy School of Government, Harvard University*;* African Economic Policy Discussion Paper 69. 2001.

33. Quality of Water the Slum Dwellers Use: The Case of a Kenyan Slum. Elizabeth Wambui Kimani-Murage, Augustine M. Ngindu. J Urban Health. 2007 November; 84(6): 829–838

34. Hutton G, Haller L, Bartram J. Global Cost-Benefit Analysis of Water Supply and Sanitation Interventions. *J Water Health.* 2007;5:481–502.