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The Relevance of Hygiene to Health in Developing Countries

Edited by Natasha Potgieter and Afsatou Ndama Traore Hoffman

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Meet the editors

Prof. Natasha Potgieter is the Dean of the School of Mathematical and Natural Sciences at the University of Venda, South Africa. She obtained her PhD in Medical Virology from the University of Pretoria and has more than 25 years of teaching and training experience in the Higher Education section. For the past 6 years she has been a visiting professor at the Water and Health Research Unit, University of Johannesburg, South Africa. She is actively engaged in research on water, sanitation, hygiene, and health-related microbiology. She has led several research projects nationally and internationally and has produced several Master's and PhD graduates.

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Contents

Preface

It is well known that millions are affected daily by hygiene-related infections and life-threatening diseases. The main consequence of lack of hygiene is the increase in child mortality and is a result of poor service delivery and lack of intervention strategies.

The term "Hygiene" is a concept commonly associated with cleanliness. It is related to personal and professional care practices. The World Health Organization defines hygiene as conditions and practices that support health and thwart the spread of diseases. In developing countries, there are several challenges faced by communities to achieve good hygiene. These challenges include aspects such as lack of clean water, no access to soap, and poor/inadequate or non-existent sanitation facilities among others.

This book highlights some aspects of hygiene conditions in developing countries around the world. The chapters have been organized into two sections. Section 1 deals with hygiene problems impacting health in developing communities. Section 2 deals with water-handling aspects and their impact on health issues in the developing world. It is a combination of several reports compiled at this specific period of time and how hygiene affects the quality of life for the reported communities and their health.

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Section 1

Introduction

Chapter 1

Introductory Chapter: Perspectives on Hygiene

Natasha Potgieter and Afsatou Ndama Traore Hoffman

1. Introduction

According to the 2017 WHO/UNICEFF progress report on drinking water, sanitation, and hygiene, adequate data on hygiene aspects globally are still lacking; 159 million people still collect water directly from surface sources such as rivers; and 2.3 billion people still lack a basic sanitation service. After the 2015 Millennium Development Goals (MDG), the Sustainable Development Goals (SDG) or Global Goals were formulated as the way forward. In total, there are 17 SDGs with a total of 169 targets and they all formed the core of the SDGs to put an end to poverty, protect the planet, and ensure that all people enjoy peace and prosperity. The main challenges to the SDGs are aspects such as poverty, exclusion, unemployment, climate change, conflict, lack of humanitarian aid, building peaceful and inclusive societies, building strong institutions of governance, and supporting the rule of law [1].

The availability of water and sanitation and the sustainable management of water and sanitation aspects are essential to hygiene. To have access to safe and affordable drinking water is a basic human right and while many people take clean drinking water and sanitation for granted, many others do not have this luxury due to circumstances out of their control. It is believed that water scarcity affects more than 40% of people around the world. With increasing climate change issues, this number is projected to go even higher and it is predicted that by the year 2050, at least one in four people is likely to be affected by recurring water shortages. Water access, quality, quantity, and water point management are largely influenced by seasonality where different factors impact on the outcome. People tend to use different water sources depending on the season. In addition, seasonality also impacts on the quality and quantity of water available for use. During dry seasons people not only tend to collect and use less water but also tend to use alternative sources. People switch between safe and unsafe sources and between improved and unimproved sources based on the availability of water at specific sources [2]. Human dignity is affected by the lack of sanitation services. Globally, billions of people do not have access to even the basic sanitation services and are exposed to harmful pathogens in their drinking water and their food. Inadequate or poor sanitation is a major cause of infectious diseases and it contributes to stunting, impaired cognitive functions, and anxiety. Poor sanitation also affects the well-being through school attendance, especially of woman and girls during their menstrual periods [3].

2. Conclusion

Hygiene is usually seen by people as a condition of cleanliness; however, it is broader than this. The World Health Organization (WHO) defines hygiene as conditions and/or practices that help to maintain good standard of health and prevent

the spread of diseases. Good hygiene is an important barrier to many infectious diseases, and it promotes better health and well-being. Improved hygiene conditions will benefit vulnerable members of the communities, the elderly, children under the age of 5 years, and people suffering from immunocompromised diseases like TB and HIV/AIDS [3–5]. Globally, the most affected lives are those people living in communities with poor water and sanitation infrastructure and conditions. Therefore, tracking inequalities in access to drinking water, sanitation, and hygiene are important for achieving universal access and assuring progressive awareness of the human rights to water and sanitation. In order to achieve the best health benefits, improvements in hygiene should be made concurrently with improvements in the water supply and sanitation, and be integrated with other interventions, such as improving nutrition and increasing incomes.

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Section 2

Hygiene Problems Impacting Health in Developing Communities

Chapter 2

Challenges to Hygiene Improvement in Developing Countries

Save Kumwenda

Abstract

Hygiene is defined as conditions or practices conducive to maintaining health and preventing disease. Hygiene has been shown to reduce diarrheal diseases and assist to improve social outcomes in the community. Improving hygiene faces several problems especially in countries with low income per capita of population. Currently, many developing countries already struggle to cope with consistent water shortages and rapid urbanization causing more pressure to limited resources which in turn result in poor hygienic practices in the communities. The common types of hygiene include personal hygiene, water hygiene, food hygiene, and hygiene during waste handling. Different nongovernmental and governmental organizations face different challenges in achieving high levels of hygiene in communities. Some of these challenges include poverty, lack of political commitment, lack of full community participation, inadequate gender inclusion, inadequate data, lack of coordination among actors, and behavioral issues. To reduce these challenges, several measures have been proposed including community empowerment, pushing for equitable access to hygiene needs, advocating for political commitment, promoting gender equity, and enhancing youth involvement.

Keywords: hygiene, hand washing, soap, developing countries, communities and challenges

1. Introduction

This chapter defines hygiene in the context of developing countries. It then outlines the various major types of hygiene before tackling the challenges in the implementation of projects aimed at hygiene improvement. The chapter then suggests possible solutions to these problems.

1.1 What are developing countries?

There are different definitions of developing countries; however, the broad definition is that; this is a term often used to refer to countries with medium to low human development index (HDI) or sometimes the gross domestic product (GDP) is used. These countries are mainly found in Africa, Asia, and some in South America that generally lack a high degree of industrialization, infrastructure and other capital investment, sophisticated technology, widespread literacy, and

advanced living standards among their population as a whole [1, 2]. In short, these are countries with low income per capita of population that are trying to improve their conditions through industrialization [3]. In addition, the United Nations (UN) describes a developing country as a country with a relatively low standard of living, undeveloped industrial base, and moderate to low HDI, with a high employment share of 60–70% in agriculture [4]. Developing countries also have low life expectancies [5, 6]. However, regardless of the low income in developing countries, there is high population growth in these countries. It is this high population growth in developing countries that is seriously outstripping the capacity of most countries to provide adequate services for their citizens [5].

Currently, many developing countries already struggle to cope with consistent water shortages and they lack adequate water infrastructure. High population growth and rapid urbanization cause more pressure to these limited water resources which in turn results in poor access to improved water source and limits hygienic practices in the communities, as these hygienic practices highly depend on the availability of safe water [6]. Hygiene causes a global health challenge especially in the developing world even though thus far, hygiene has been barely prioritized on the international development agenda despite the fact that a hygienic behavior such as hand washing with soap could save lives of people annually [6, 7].

1.2 What is hygiene?

According to Oxford English Dictionary, 2018, the word *"hygiene"* is defined as *"conditions or practices conducive to maintaining health and preventing disease, especially through cleanliness"* [8].

The World Health Organization (WHO) and other studies have similar definitions as the Oxford English Dictionary, and they define hygiene as the concept of cleaning and any practice aimed at maintaining health and preventing the spread of diseases [9, 10]. Other literatures define it as the science of preventive medicine and preservation of health through cleanliness [11]. However, it should be noted that the term cleanliness is not the same as hygiene. Hygiene is far more than just cleanliness because cleanliness mostly involves the removal of dirt, wastes or unwanted things from the surface of objects using detergents and other necessary equipment. On the other hand, hygiene practices focus on the prevention of disease through the use of cleaning as one of the several inputs [12, 13]. Hygiene can be achieved through cleanliness and not vice versa. All disease control interventions to a greater extent rely on hygiene for them to achieve their goal.

1.3 Types of hygiene

Hygiene is applied in different areas with the aim of prevention of disease transmission and promoting health. The common types of hygiene include:

- Personal hygiene includes taking care on one's body and clothes. Personal hygiene encompasses oral hygiene, hand hygiene, hair hygiene, mouth hygiene, and menstrual hygiene including any form of hygiene relating to a personal body.

- Water hygiene involves the collection, transportation, storage, and use of water without contaminating it.

- Food hygiene is the practical process of ensuring that food is fit to eat. It is what the food handler does to prevent contamination.

- Waste handling hygiene relates to how solid, liquid, and gas wastes are handled from generation, collection, storage, transportation, and disposal to prevention contamination of the environment.

Hygiene can be practiced at personal, domestic, and community levels [14].

1.4 Importance of hygiene to health in developing countries

The greatest benefit of practicing hygiene is the reduction in disease transmission and improved health. The maximum benefits of hygiene are achieved, if improvements in hygiene are concurrently made with improvements in the food industry, water supply, and sanitation coupled with other interventions such as improved nutrition [14]. Good hygiene practices are among the essentials of the survival and development of children. Without hygiene, the lives of millions of people especially children and the vulnerable populations would be at risk of suffering from water, sanitation, and hygiene-related diseases which are one of the leading causes of death among children, despite being preventable [15]. In 2015, diarrhea was the leading cause of death among all ages. The most affected were children under the age of five where it claimed the lives of more than 499,000 children each day [16]. Most of the diarrhea is attributed to poor water, sanitation, and hygiene practices. Children in developing countries are the worst affected as they experience about 4–5 episodes of diarrhea each year [17–19]. Diarrhea is caused by fecal-oral transmission, whereby one ingests feces directly through contaminated hands or indirectly through contaminated food and water [20]. The organisms that cause diarrhea include bacteria, viruses, protozoa, and helminths [19]. This might be through contaminated hands when ingesting food or contaminated water. Hands (mainly fingers) can directly or indirectly be contaminated with feces of one self or of another. Contamination of the hands during activities such as defecation and changing/washing of a child's bottom facilitates the transmission of infections. Hand washing with soap is one of the most important hygiene behavior in disease transmission reduction and promotion of good health. In 2012, it was found that 35.3% of all the total deaths from diarrhea were due to poor hand hygiene [19].

Systematic reviews done from 1997 to 2010 have shown that hand washing with soap reduced diarrhea by either 32 or 48%. Furthermore, hand washing with soap including water supply and sanitation has been shown to reduce undernutrition by 50% [19]. In Kenya, water, sanitation, and hygiene intervention showed a reduction of 58% in absenteeism for girls [21]. Apart from health benefits and school absenteeism, hygiene has other social benefits including boosting confidence and status [19]. It should, however, be noted that the impact of hygiene cannot be easily evident in short term projects, and it required time for it to show significant impact especially on health [22].

1.5 Hand washing

Hand washing with soap at critical moments, such as after visiting a toilet, before cooking, and after helping a child defecate, can prevent infectious diseases by interrupting the transmission of infectious agents. Evidence suggests that hand washing with soap reduces the risk of diarrhea by 47% [23, 24], acute lower respiratory infections by up to 34% [25], and soil-transmitted helminths by 55% [26]. Hand washing with soap has been recognized as one of the most cost-effective health interventions to reduce the burden of disease [27]. Yet, only 19% of the global population is estimated to wash their hands with soap after using sanitation

facility or handling children's excreta [28]. Hand washing facilities close to toilet are important if people are to wash hands after using the toilet facility (**Figure 1**).

Good hygiene is of vital importance in Malawi due to the lack of basic sanitation in the country. Hygiene, for example, washing hands with soap after using a toilet may reduce the transmission of fecal-related diseases. Although, evidence of actual hand washing practice is scanty, but some studies done in rural areas of the country suggest that the actual practice of hand washing with soap (HWWS) at key times is between 3 and 18% but more likely on the low end of this scale, as responses tend to exaggerate actual and regular practice. Observations in Malawi and other countries show that HWWS promotion is undertaken as an ad hoc activity both at national and local level. Current efforts to promote good hygiene and HWWS, in particular, have not been sufficient to bring about mass behavior change on the scale that is needed. Efforts producing piecemeal village-by-village and pilot approaches have had some impact but nothing on a large or national scale has been attempted [29]. Our hands frequently get dirty during our normal activities, with microorganisms likely to attach to our hands along with the dirt. Hand hygiene, however, especially hand washing with soap plays a critical role in prevention of such transmissions, through hygienic hand washing. Soap helps remove dirt and microorganism from the hands. Global waters [30] in 2017 put coverage of hand washing facilities at 27% in Sub-Saharan Africa and below 50% in Africa. The critical times for hand washing with soap include:

a. Before cooking food

b. Before eating food

c. After visiting a toilet

d. After cleaning or touching dirt

e. After changing baby nappies

Figure 1.
Tippy tap close to toilet for hand washing in rural areas of Malawi.

Hand washing should not only involve getting the hands wet or a quick rinse under a tap or in a bowl, but it should rather be a hygienic hand washing, where there is removal of microorganisms from contaminated hand surfaces using soap or detergent. Hand washing with nonantibacterial soap and clean water was found to be more effective than just using water [31]. For most of the people in the rural communities of the developing countries, they cannot afford to get soap for hand washing. Nonetheless, alternatives such as wood ash and mud have been found to be better than using only water [32]. However, it should be noted that communities which can afford soap should be encouraged not to use ash and mud because of their varying abilities to remove germs from hands and other risks than may come due their use. It should be further noted that hand washing should involve the use of running water that carries away the microorganisms unlike dipping in a bowl. Washing in the same bowl may be a way of transmitting pathogens that are found in hands [33]. Clean sand with water or local seeds such as indod (Lemma's plant) can also be used as an alternative just as wood-ash, which rubs off both the dirt and the smells [34]. The correct hand washing procedure according to WHO [35], includes the following 10 modified steps:

Step one	First wetting the hands with clean water and apply enough soap to cover the hand surfaces
Step two	Rub hands palm to palm
Step three	Rub right palm over left dorsum with interlocked fingers and vice versa
Step four	Rub palm to palm with fingers interlocked
Step five	Rub backs of fingers to opposing palms with fingers interlocked
Step six	Make rotational rubbing of left thumb clasped in right palm and vice versa
Step seven	Perform rotational rubbing, backwards and forwards with clutched fingers of right hand in left palm and vice versa
Step eight	Rinse hands well with clean running water or pour from jug
Step nine	Dry hands thoroughly with a single use towel or dry in the air to avoid recontamination
Step ten	Use towel or back of hand depending on design to turn off tap

Rubbing of hands should take approximately 20–30 s to make sure germs are dislodged [35].

Hand washing with soap is also an important infection prevention tool in health facilities [36]. Daily works will involve many situations when people need to wash their hands, and sometimes people forget to wash their hands. However, it is of great importance to identify critical situations/times for hand washing. These are times, activities or incidents that indicate the possibility that pathogenic microorganisms are present on hand fingers and nail surfaces. Most people remember to wash hands after defecation than after doing other things that may equally have the risk of disease transmission [37].

To encourage hand washing, there is need to locate the hand washing facilities in suitable places such as close to the latrine and/in the kitchen where they will be needed. These hand washing facilities should be provided with soap (or its alternative) and running water. In the absence of a tap, cans and plastic bottles can be used. These alternatives are mostly used in the rural areas where communities do not have adequate access to piped water [38].

1.6 Menstrual hygiene

Another aspect of personal hygiene that greatly affects women and adolescent girls is menstrual hygiene. This is special care that is needed during the time of the

month when women and girls experience their menstruation. This special care is needed to take care of the sanitary products that are used by the women. In the developing countries, not many women can afford to buy enough sanitary products such as disposable pads, tampons or menstrual cups. The women tend to use locally available clothes which they reuse, while others have been introduced to reusable pads [39, 40]. Nonetheless, regardless of the product used, women are supposed to change their sanitary products frequently, and for those that use reusable products, there is need for soap, clean water, and proper drying area for the reusable towels. Not only does poor menstrual hygiene causes bad odor, but it can further cause fungal infections, urinary tract infections (UTI), and reproductive tract infections (RTI) [41]. Women are further vulnerable to infertility when their menstrual hygiene practices are unhygienic, for example, not changing their sanitary towels frequently, lack of adequate cleaning of reusable products, and the use of unclean water for cleaning both their bodies and their sanitary towels. Good menstrual hygiene practice further involves proper disposal of sanitary materials, but this is a problem in most developing countries [42].

1.7 Domestic and community hygiene

While hygiene measures are taken at personal, domestic, and industrial levels, some can be done at a community level. Community members have a role to play in keeping their communities clean [14]. The members play a role to ensure a clean surrounding of their households, protecting the water sources, proper disposal of wastes (solid wastes and excreta), proper drainage for waste water, control of animal rearing, and hygiene of public places such as markets, schools, health facilities, and prayer areas (e.g., churches and mosques) [6, 12, 13].

Clean compounds in communities should be encouraged, as a single unhygienic house can affect the surrounding neighbors and increase the spread of disease. Presence of shrubs, lack of drainage, and poor waste management in households can act as breeding grounds for vectors, resulting in vector-borne diseases such as malaria, affecting a larger part of the community [14, 43]. Households should be properly ventilated to allow fresh air in the house as this would also reduce transmissions of infections such as flu [44].

Most markets in developing countries lack proper water resources, sanitation facilities, proper solid waste management, and drainage. However, in most of these markets, raw food such as fruits and vegetables are usually sprinkled with water, which is at most times unclean [13]. Such unhygienic practices poses a risk to the consumers, that is why it is encouraged that a market should have a proper water source, not only for cleaning the goods but also for the sellers, since they use the same water for drinking and cooking.

The Government of Malawi in a bid to improve sanitation and hygiene coverage adopted the open defecation free (ODF) and hand washing with soap (HWWS) strategies in 2011. The strategies were up to 2015. By 2015, the strategies had improved the percentage of the country's population practicing open defecation from 29 to 4% and access to improved sanitation increased from 29 to 41%. Hand washing with soap was also improved from less than 10 to 34% [45]. The government adopted Community Led Total Sanitation (CLTS) as a technique that was used to make sure communities are using toilets and also making sure all households own and use a hand washing facility after visiting a toilet. The approach has managed to increase toilet coverage and usage especially in rural areas by 96% as stated above. CLTS encourages the use of local resources to build sanitation and hygiene facilities, and its sustainability relies on the availability of these local resources. Since CLTS was being implemented as a project, there is a need to

incorporate the approach in village and district plans for it to be sustainable. The weakness with the approach was that it did not emphasize much on hygiene behavior but rather on ownership of hygiene promoting facilities [46].

2. Challenges faced when implementing hygiene in developing nations

2.1 Poverty

Poverty is high in developing countries, most households spend less than a dollar a day, and these are classified as extremely poor [47]. This makes them prioritize income so that they buy food, clothes, and other immediate needs placing sanitation and hygiene low in the priority list. Most families struggle to find food, and to them getting food is enough than considering hygiene. Most families start prioritizing hygiene after they move up the development ladder especially when basics like food are no longer a problem [48]. Due to poverty, communities find it difficult to use the only available soap at a household for hand washing [32]. Similarly, hand washing facilities used after visiting a toilet are usually temporary and are made from local materials which are not durable (**Figure 2**).

2.2 Lack of political commitments

Most of the hygiene initiatives are implemented by nongovernmental organizations (NGOs) and rarely by the government. Despite advocating for water sanitation and hygiene (WASH), there is not enough initiatives introduced by the government through relevant ministries (i.e., Ministry of Health and Ministry of Agriculture, Irrigation and Water Development in Malawi), to enhance hygiene

Figure 2.
Hand washing facility at a toilet in rural Malawi.

practices [49]. Hygiene is the major component of provision of safe water and improved sanitation yet it is forgotten during planning of settlements [50]. In general, most countries do not provide enough resources to preventive health, which limits preventive health effectiveness, such as good hygiene practices [51]. For example, in Malawi, the government adopted a Hand Washing with Soap Campaign 2011 to 2012, but after it expired, no new efforts have been made. In addition, the government did not put aside finances to fund hand washing activities. This means hygiene activities will still continue to be implemented by NGOs whenever they have funding. The inconsistencies which the campaign wanted to eliminate will continue to exist [52]. For hygiene to improve, we need governments to plan for implementation and commit resources.

2.3 Lack of community participation during planning phase

As much as there might be a solution, if the people who are receiving the solution do not realize the need for a solution, then the solution becomes ineffective. That is why it is of utmost importance to involve the community during the whole hygiene project. This offers proper understanding of the whole project, and the people further understand the need for the project initiative hence making the projects sustainable. When the people are involved, they get a feeling of ownership of the hygiene project and also understand the benefit of the solution [51]. Additionally, hygiene technologies that are introduced may contradict with some cultural beliefs and this affects adoption and implementation of the hygiene projects in most developing nations. Most hygiene technologies are not user friendly which makes acceptability a challenge [53]. For example, most hand washing facilities have design problems. Some hand washing facilities require users to perform several steps before washing hands and this discourages users from practicing the behavior. The tippy taps are the preferred ones, but they also face problems of durability and use of unpleasant containers and sometimes unsafe water which discourages users just by looking at it [38, 54].

2.4 Lack of gender inclusion

In most cultures, women have the primary responsibility for water, sanitation, and hygiene at the household level [55]. However, most women are left out when it comes to the planning or designing of hygiene projects making the implementation of the project a challenge especially to the women that do not have enough information on the designs [56]. In addition, women sometimes need special consideration when it comes to hygiene infrastructure, for example, a menstrual hygiene management compartment in schools and homes to accommodate women's menstrual hygiene needs [57]. But most times, there is a lack of gender inclusion in the planning and designing [53]. There is less participation in hygiene issues including water supply by men. In African countries, it is the man who is supposed to construct hand washing facilities especially the tippy tap at the toilet and other sanitation facilities including a toilet, but in most of the gatherings related to sanitation and hygiene, its mostly women who participate. Nongovernmental organizations have taken a leading role to encourage women get involved in construction of hygiene facilities including tippy taps [58]. The low participation of men in hygiene intervention limits the translation of messages passed mainly through women into practices due to the lack of physical enabling environment which is supposed to be provided and supported by men as head of households. In addition, men seem to be less inconvenienced by the lack of hygiene at a household [59].

2.5 Lack of information on hygiene infrastructure and practices

There is a lack of recent, reliable information on the condition of existing hygiene infrastructure and practices, including whether or not the infrastructure are actually functioning or benefits of some hygiene practices. This makes needs and demands, particularly in remote rural areas frequently unknown, making the task of setting implementation priorities more difficult [53]. However, the rural areas may sometimes have the information but due to the high levels of illiteracy in the developing countries, the community members may not be able to understand the hygiene messages. Making implementation of hygiene is rather difficult. It has also been identified that some people access hygiene information in parts, and they are not fully aware of the hygiene benefits, hence making implementation a challenge.

2.6 Lack of coordination by hygiene actors

As regard to Malawi, a country in southern Africa, there is a lack of coordination by different sectors involved in hygiene. Different NGOs are after their targets and are not interested in other similar NGOs in the area. In addition, there is institutional fragmentation in developing nations as they lack clarity over whom or which institution(s) is responsible for hygiene. For instance, water, sanitation, and hygiene services are located to ministries of water, thus disregarding Ministry of Health who also have expertise in implementing them [53].

2.7 Lack of clean and adequate water

Hundreds of millions of people do not have access to clean water in developing nations [15, 60]. The Malawi Demographics and Health Survey, 2016 indicates that on average, 87% of households obtain their water from safe sources. Despite the high reported figure (87%), the situation reveals that most people are not accessible to these improved sources due to their concentration on one geographical location or because the water points often breakdown or sometimes the water from the source is salty especially from boreholes [61]. This makes developing nations to face challenges when it comes to hygiene implementation as most of the hygiene practices require the use of clean water. When water is inadequate and unclean, it results into contamination of hands and foods, thereby spreading infections. Furthermore, insufficient water supply limits good hygiene practices such as bathing and hand washing. Children in developing countries, sometimes clean only some parts of their bodies and not the whole body due to inadequate water and this affects their health [62].

2.8 Culture and behavioral issues

Culture shapes the behavior and beliefs of most people as it is the way of people's life. Culture makes people in developing nations to resist to new hygiene facilities and ideas. Additionally, men and women have different perspectives on hygiene due to cultural differences. Different ethnic groups have varying beliefs and customs on hygiene. Lastly, attitudes also vary among people on hygiene in rural and urban areas [7, 50]. Thus, implementation of hygiene faces more challenges due to differences in attitudes, beliefs, and lifestyles of the participants on hygiene projects. One of the hygienic practices that was common is the washing hands by dipping in the same bowl of water by a group of people or family members who eat from the same plate. This practice was common in rural areas of some African

countries, but is now slowly being replaced with a better practice where each member is poured water when hand washing. The behavior has changed due to serious communicable diseases that were transmitted through washing hands in the same container, for example, cholera [33].

3. How hygiene can be improved to promote health

3.1 Community empowerment

Households need to be taught on how to make priorities and aim to accomplish them in order of their importance. According to the vicious circle of underdevelopment by Schutte De Wet in 2015, if the very basic needs of a community are met, new and higher ones emerge until the community starts living a better life [63]. Households who are in constant poverty are those who do not use the few resources they find to address their immediate priorities instead they jump and buy things that they do not need in order to conform to society expectation and fulfill their desires. Later, they sell them at cheap price only to come back and buy the priority need. This practice makes them unable to move out of the poverty circle. Once a household is in poverty, it is difficult for them to realize the importance of hygiene and to buy soap or spend resources on hygiene infrastructure. A project in Malawi on healthy settings approach showed that using De Wet tools, it was possible to make community move out of poverty through proper planning using prioritization tools. The project also found out that in communities where people lack basic needs like food and shelter, the issues of sanitation and hygiene are not a priority [48]. In addition, governments need to come up with deliberate pro-poor policies that are aimed at uplifting lives of people in slums and rural areas. Some of the strategies that governments need to employ include targeted subsidies and loans for agriculture and businesses, respectively. In Tanzania, Kagera Region, a project showed that agriculture and trade were the routes for people to move out of poverty [64]. Nepal is one country that has managed to move out of poverty. Absolute poverty decrease by an average rate of 2.2% points between 1995 and 2011 and continued to decline to date. Despite the gains, Nepal needs to come up with policies that will equalize opportunities and level the playing field to enable all people participating in the economy [65].

3.2 Push for equitable access

Different people have different hygiene needs and requirements. As much as millions of people lack access to improved water, sanitation, and hygiene, the situation is worse for people who are physically and socially disabled. They find challenges in using most of the hygiene infrastructure. According to a study conducted in rural and urban Malawi to assess the barriers to accessing water, sanitation and hygiene for disabled people, it was found out that individuals did not report of the same set of barriers. In addition to being physically disabled, factors like being a female, being from a rural setting, and being of limited worth intensify the challenges faced by an individual [66]. It is for this reason that it is essential to understand the needs of different disabled people to ensure equitable access to hygiene, since there is no solution that can solve the challenges of all disabled people. This can be achieved by offering an accommodating hygiene infrastructure and technology for the physically challenged and also at an affordable price to ensure equal access [60].

3.3 Provision of menstrual hygiene kits

Despite being a natural process, menstrual hygiene has been considered a taboo in most parts of the world and is rarely talked about, which leads to misinformation. This results in poor menstrual hygiene management among girls and women which further leads to stigma and ill health, absenteeism in schools and increased school drop-out rates. In order for women and girls hygienically manage their menstruation, there is need for a private place to change sanitary cloths and pads, clean water and soap for hand washing, body washing, and washing of reusable clothes [39]. However, most women and girls in developing countries, lack access to clean water for hygiene management. Even worse, they lack proper sanitary cloths to use during menstruation, and they end-up using rags which may result into vaginal infections [67]. For this reason, it is important to introduce menstrual hygiene technologies such as reusable pads so that they may have a safe menstruation, reducing absenteeism in schools and offering them dignity. Furthermore, underwear should be provided to them to make sure that the sanitary pads are used as other girls and women do not have underwear at all [40, 51].

3.4 Making political commitments

Political commitments especially at high level involving senior government officials are essential toward achieving hygiene improvements. India, Indonesia, and Ethiopia are some of the countries where political commitment by the Prime Minister, Senior Civil Servants, and Ministers, respectively, led to greater achievements in sanitation [68]. Similarly, high level political commitment is required to improve hygiene in developing countries. Most of the times, hygiene is mentioned during promotion of sanitation, but it should be noted that during implementation, it is often forgotten and hence need to be advocated to separately. National governments should have commitments on hygiene by commissioning a thorough review of policy, making explicit budget allocation on hygiene programs to district and local governments, funding hygiene promotion, training and capacity building. National governments and NGOs must be in forefront in provision of safe and clean water to be used for hygiene by the users [53]. Political commitment have been found to humper scale up of policies including food and nutrition-related policies and hence need to be given priority in hygiene improvement [69]. To improve hygiene, high level political commitment is crucial.

3.5 Creating strong legislation and regulations

Governments should develop national hygiene strategy and create necessary legislation/regulation to advance the strategy. Additionally, roles and responsibilities of different national institutions to implement the law must be defined properly. Stakeholders must be involved at all the stages of the process to ensure the acceptance of the legislation/regulation by the public. In addition, there must be creation of the mechanisms for monitoring and enforcing implementation of legislation/regulation. This will help those implementing hygiene programs to request specific hygiene regulations to make their programs successful. Lastly, officials that check for compliance of hygiene requirements should be committed to reduce corruption as this will help to ensure quality production and healthy environments which will prevent the transmission of diseases and infections [70].

3.6 Promote gender and equity

Governments and NGOs should frame their policies in the way that include the idea of gender and equity on hygiene promotion. Additionally, they should invest in training or retraining frontline staff to work with men, women, and children [57]. The hygiene framework should be gender sensitive, by enabling women in the development of hygiene policy. They should also ensure that gender provisions address practical and strategic needs for both men and women by taking into consideration of differences in culture and traditions of communities.

3.7 Promoting community participation

Community participation is very important as it promotes acceptability and sustainability of hygiene projects [71]. Thus, community members must be involved from initiation phase of the hygiene project to the end phase of the project [72]. This promotes the ownership of projects and communities that are more likely to make use of innovations where they have contributed. Top down approach to projects limits community participation and ownership because the community takes the interventions as external and usually they do not have local input. For example, in Tanzania, a pilot project that used bottom up approach using community structures recorded successful results in terms of reduction of prevalence of schistosomiasis and diarrhea. The project also increased awareness in water, sanitation, and hygiene for disease control [73].

3.8 Involving the youth

Hygiene promotion campaigns are most effective when young population and students involved as beneficiaries and as agents of behavioral change within their families and their communities. Hygiene education that is included in school curricula should be taught conclusively in all schools. Early schools should be the target for hygiene behavior change interventions. Once a child learns about good hygiene at an early age, that child will grow with the behavior and will be able to influence his/her family members and in the long term, the whole community might easily change [71].

4. Conclusion

Hygiene is a broad subject with so many various aspects and is a key aspect in prevention of diseases and promotion of good health. Hygiene has been identified to reduce diarrheal diseases and infections among others, and proper hygiene practices increase dignity, self-esteem, and prestige in the social life. Hygiene can be practiced at personal, domestic, industrial, institutional, and community level, with various sectors playing various roles in enhancement of hygiene as it improves human health. However, for effective hygiene, there is need to incorporate hygiene with sanitation and adequate and clean water supply, since these go hand in hand.

Even though hygiene practices may seem basic, there are a large number of people that lack proper information on hygiene. Such lack of information on hygiene leads to poor hygiene practices that result in disease outbreaks within a society. It is thus important to ensure a proper information flow that helps to communicate to different classes of people in the easiest ways. Effective hygiene communication in schools, markets, industries, and health facilities helps to reach out to a group of people at once and in a specific area. However, for the

implementation of hygiene projects in developing countries, there is a need for promotion of community participation with high youth involvement, strive for equitable access, political commitments, creation of strong legislation, adequate financial resources, and promote gender and equity and make sure that there is the right information flow with the people and that awareness has been raised before the implementation of the projects.

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Conflict of interest

I would like to declare that I do not have conflict of interest.

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Chapter 3

Inequalities in Households' Environmental Sanitation Practices in a Developing Nation's City: The Example of Ile-Ife, Nigeria

Faniran Ghemiga and Ojo Deborah

Abstract

A new global movement that emerged as a post 2015 development agenda is the sustainable development goals (SDGs). While the central objective of SDGs is to end poverty in all its forms, focus on water and sanitation rested on the fundamental concern for equity; moving from just service delivery to service delivery for all. Hence, the study reported in this chapter was set to examine the state of households' environmental sanitation practices in different residential areas of Ile-Ife, Nigeria. A three-stage multi-sampling procedure was adopted in selecting 283 households' heads for survey. Findings of study showed that 23.6, 41.2, and 68.4% of households in the core, transition, and sub-urban residential areas of Ile-Ife, respectively, have source of water within their residential building. Study established that households' toilet facilities differ significantly in the study area, as respondents socio-economic characteristics varied across the identified residential areas of Ile-Ife. The study thus posited that, if cities in Nigeria and other developing nations will keep tract with timelines of the SDGs on water and sanitation, drastic, and realistic steps must be taken in addressing identified inequalities. This is a way to guaranty adequate hygiene and improved quality of life.

Keywords: households sanitation, environmental sanitation practices, hygiene, developing nation, inequalities

1. Introduction

There is a close relationship between man and the environment. It is essential for man to among other things, understands his environment, protects it, conquers, and harnesses it to his ultimate benefit. These are very important as the environment is a complex Web that connects man with the place he lives in; including the natural world as well as things he produces [1]. The environment is a system within which living organism interacts with the physical elements [2, 3]. As the environment constitutes an important factor in the lives of man, its continuous use and misuse have raised globally, concern about possible consequences. These consequences as opined by Taiwo [4] are complex, multi-dimensional, interactive and

cross-sectoral, and hence require inter-organizational collaborations. The coming together of 189 countries of the world in an attempt to face the future, leading to the emergence of the millennium development goals (MDGs), with a target date of 2015 [5] is one of the collaborative efforts to save the environment, and its inhabitants from many mishaps. The significance of the environment to healthy living, national growth, and stability cannot be underestimated. Indeed, almost all indicators of development in the MDGs can be linked to the environment [5].

Among many other fundamental pillars of development entrenched in the MDGs, were water and sanitation, with focus on service delivery. There are several reports on the success and failure rates of MDGs implementation from different countries of the world. Among these are [6–8]. A progress report of the MDGs for Nigeria by United Nations indicated that by 2008, the proportion of households that have access to improved water and sanitation were, respectively, 48 and 53% [9]. More specific and prior to the release of United Nations report [6], it was established that in Lagos State, 36% of households have access to portable water [9]. The report further showed that only 7% of households in the state have access to closet septic tanks. As documented in many MDGs progress reports on water and sanitation in Nigeria, efforts have been devoted to service delivery at the household levels. It is important, however, to examine if there are disparities in the delivery of water and sanitation services, across different residential areas of typical Nigerian city.

To build on many successes of the MDGs, a new global movement that emerged as a post-2015 development agenda is the sustainable development goals (SDGs) [10]. While the central objective of the SDGs is to end poverty in all its forms, focus on water and sanitation rested on the fundamental concern for equity; moving from just service delivery to service delivery for all. Goal six of the SDGs, which is to ensure availability and sustainable management of water and sanitation for all [10, 11], is very central to environmental sanitation and more importantly, developmental activity. The need for an equitable environmental sanitation service delivery cannot be overemphasized. In fact, the attainment of other SDGs, such as Goals 2, 3, 5, 10, and 11 cannot be separated from equitable water and sanitation service delivery. Although the SDG is new, with a target date of 2030, it is imperative to document the level of (in) equalities that exists in environmental sanitation practices at the household and residential neighborhood levels, especially in a developing nation's city. As documented by Osborn, Cutter, Ullah [11], in most developed countries, almost everyone has access to water and sanitation services. There is need to unmask, reduce, and eliminate inequalities in households' sanitation practices in developing nations as well. A way to start these is to first understand the state of environmental sanitation practices in and among different residential areas, social, and income groups.

Environmental sanitation has come to the fore in many developmental discusses, however, with varied definitions. According to [12], environmental sanitation is the sum total of activities embarked upon to protect human bodies from illness, transmission of diseases, or loss of life due to the unclean surrounding. It entails the safe management of human excreta, environmental cleanliness, hand-washing, garbage removal, and wastewater disposal [13, 14]. From these definitions and others [15, 16], environmental sanitation can be construed as comprising, among others; water supply, solid waste management, waste and stormwater management, toilet facilities, and hand-washing. In other words, environmental sanitation entails principles of effecting healthful and hygienic conditions in promoting public health and welfare. Environmental sanitation has input in the various area of health, social balance, urban stability, economic growth and development, and as well as hygiene [17–19]. The social, economic, and environmental health costs of ignoring adequate and effective sanitation (including hygiene) are far too great [20, 21]. Lack of sanitation facilities and poor hygiene are sources of water-borne diseases, such as

diarrhea, cholera, typhoid, and several parasitic infections. The incidence of round worm, whip worm, guinea worm, and schistosomiasis are also linked to poor sanitation. Preventable diseases associated with lack of access to potable water, inadequate sanitation, and poor hygiene have been identified as the source of death of more than 2.2 million people in developing countries [22]. As opined by Daramola, Olowoporoku, and Popoola [23], the consequences of inadequate water supply and sanitation in cities of sub-Saharan Africa are worse than the claws of a tiger.

It is unarguable that environmental sanitation practices differ both in the developed and developing nations of the world. In a study by Faniran, Afon, and Dada [24], it was established that, while there was variation in residents' age, income and education statuses, methods adopted in solid waste storage and disposal by residents across the different residential zones of Ibadan, were not different. Although efforts in [24] was on solid waste management (a fraction of sanitation), it is hypothesized that differences in households' socio-economic characteristics, as well as residential areas, account for disparities in sanitation practices at the household level. In other words, there is a need for an in-depth understanding of existing households' sanitation situation in developing nation's city, with specific attention on water and toilet facilities. The purpose of the study reported in this chapter, is therefore, to examine the state of households' environmental sanitation practices in different residential areas of a typical Nigerian city, Ile-Ife.

2. Material and methods

The study area, Ile-Ife, is an ancient city in Osun State, Nigeria. It is located approximately between latitude 7°28′ and 7°45' North and Longitude 4°30′ and 4°34′ East of the equator. It is 218 km North East of Lagos. Administratively, the city is made up of two local government areas (LGAs): Ife Central and Ife East. There are, respectively, 11 and 10 political wards in the two identified LGAs [25]. These two LGAs cover an approximately 1,791 km^2 area of land. According to National Population Commission [26], the population of Ile-Ife was 355,281 by the year 2006. Ile-Ife is widely acknowledged as the cradle of the Yoruba race, whose existence predates Nigeria British colonialism. Yoruba is an ethnic group and the predominant in Southwestern Nigeria. They are also found in other places in the country and across the globe.

The formation of the different residential settings of many Nigerian cities can be traced to different historical backgrounds [27–29, 24]. These are the pre-colonial (traditional), colonial (non-traditional) and the post-independence (modern) periods. Ile-Ife is not an exemption. Although the classification of [30], indicate the existence of a fourth residential zone in Ile-Ife, termed the post-conflict area, which emerged as a result of communal clashes in the city. Personal observation shows that the once war wreaked area is fast becoming desolate. It is, therefore, important to note that, the inclusion of this fourth zone as the residential area is often adopted in discussing crime-related issues. Residential areas that emerged during each of the earlier mentioned three periods are, respectively, referred to as the core, the transition, and the sub-urban [27–29, 24]. In some other studies [31, 32], the core is regarded as high-density residential area, while the transition and the sub-urban are referred to as the medium and low-density residential areas, respectively. Each of these residential areas is distinctively homogeneous, with respect to physical layout, housing characteristics, environmental qualities, population per square kilometer, and residents' socio-economic statuses. It is, therefore, posited that along with these identified distinctive residential areas, households' sanitation practices will also differ significantly in the study area.

In order to achieve the purpose of this study, data were collected from selected households in Ile-Ife through questionnaire administration, during the months of November and December, 2017. To select sample for the study, a three-stage multi-sampling procedure was adopted. As earlier mentioned, there were 21 political wards in the two LGAs of the study area: 11 in Ife-Central and 10 in Ife East. Identified political wards were re-grouped into the three different residential areas using stratified sampling technique. Nine of these 21 political wards were located in the core, while there were six in each of the transition and the sub-urban. Simple random sampling technique was used in the second stage in selecting one out of every three political wards in each residential stratum. In other words, seven political wards were selected for the purpose of questionnaire administration. Respondents were drawn from 10% of residential buildings in the selected political wards, using systematic sampling techniques.

In the selected residential building, a questionnaire was administered on a resident who is 18 years old and above. This was adopted, bearing in mind that an individual at this stage in life is no longer a minor; hence could sue or be sued. Similarly, a female respondent was preferred for questionnaire administration in each selected residential building. The allusion to this from the oral commentary is the fact that, among the Yoruba, females were considered as handlers of domestic chores; including household needs of water and sanitation. The practice is that, as soon as a girl child advances in age, she should know how to assist the mother; sweep and clean the house, takes care of the bathroom and toilets, washcloths and cook. The male child is most time spared from all these domestic chores; rather he goes to the farm or another profession with the father. In fact, sanitation was a reserved responsibility of the female folks.

Using the multi-stage sampling technique, 283 respondents were selected for questionnaire administration. Information collected from respondents was their socio-economic characteristics, household's access to water, availability of toilet facility, and methods of solid waste storage and disposal. Information collected from respondents was analyzed using SPSS 17 software. Frequencies of responses were compute, cross-tabbed and expressed in percentages. Responses were also presented in tables and figures. Chi-Square Analysis (χ^2) and Analysis of Variance (F) were also used for data analysis at 95% level of confidence ($\alpha = 0.005$).

3. Findings of study

Presented in this section are respondents' socio-economic characteristics and sanitation practices. More specifically, issues discussed in sub-section two covered households' access to water supply, toilet facility, solid waste storage, and disposal methods.

3.1 Respondents' socio-economic characteristics

Socio-economic characteristics of respondents examined in this study were: age, gender, educational qualification, income, and household size. Studies [23, 24, 29, 33, 34] have established the significance of these five characteristics in environmental-related issues; more importantly, when it is about water and sanitation. In other words, these variables will modulate positively or negatively, households' sanitation practices.

The gender distribution of respondents across the three residential areas of Ile-Ife is presented in **Table 1**. Evidence abounds that the proportion of female that

participated in the study was more than the male counterpart. It is instructive to note that, this does not suggest that there were more female household heads in the study area than the male household heads. Rather, it is a reflection of the consideration given to the female in the selection of respondents. Of the 283 respondents, 37.1% were male while 62.9% were female. Impliedly, those who were traditionally in the position of handling environmental sanitation and have greater sensitivity toward environmental issue as opined by Zelezny [35] were fully involved in the study. Across the three identified residential areas of Ile-Ife, the female accounted for 63.0, 60.0, and 65.8% of respondents in the core, transition, and sub-urban areas, respectively. Further analysis ($\chi^2 = 0.561$, $p = 0.756$) confirmed that there was no significant difference in gender distribution of respondents across residential areas of Ile-Ife.

For the purpose of this study, respondents' age was classified into three following the taxonomy of [36]. The groups were: 19–30 years (the youths), 31–55 years (the young adults), and 56–65 (the adults). The grouping was adapted to aid understanding. The study showed that 42.8% of respondents were young adults. On the other hand, the youth and the adult, respectively, accounted for 18.0–39.2% of respondents. As presented in **Table 1**, it is clear that as distance increase from

Residents' Characteristics	Core Frequency (%)	Transition Frequency (%)	Sub-urban Frequency (%)	Total (%)
Gender				
Male	47 (37.0)	32 (40.0)	26 (34.2)	105 (37.1)
Female	80 (63.0)	48 (60.0)	50 (65.8)	178 (62.9)
Age				
19–30	8 (6.3)	19 (23.7)	21 (27.6)	48 (17.0)
31–55	32 (25.2)	45 (56.3)	47 (61.8)	124 (43.8)
56–70	87 (68.5)	16 (20.0)	8 (10.5)	111 (39.2)
Education status				
No formal education	55 (43.3)	19 (23.8)	12 (15.8)	86 (30.4)
Primary	17 (13.4)	3 (3.7)	3 (4.0)	23 (8.1)
Secondary	30 (23.6)	20 (25.0)	9 (11.8)	59 (20.8)
Tertiary	25 (19.7)	38 (47.5)	52 (68.4)	115 (40.6)
Income status (₦*)				
Below 30000.00	67 (52.8)	38 (47.5)	29 (38.2)	134 (47.3)
30000.00–60000.00	39 (30.7)	25 (31.3)	16 (21.0)	80 (28.3)
Above 60000.00	21 (16.5)	17 (21.2)	31 (40.8)	69 (24.4)
Household size				
1–6	12 (9.4)	39 (48.8)	58 (76.3)	109 (38.5)
6–10	77 (60.6)	37 (46.2)	13 (17.1)	127 (44.9)
Above 10	38 (30.0)	4 (5.0)	5 (6.6)	47 (16.6)
N	**127**	**80**	**76**	**283**

**Naira is Nigeria currency and is denoted by ₦ (USD $1 = ₦ 360 as at 7th December, 2017).*

Table 1.
Socio-economic characteristics of respondents in different areas of Ile-Ife.

the core toward the sub-urban, the proportion of respondent in the youth and the young adult also increased. Whereas, the proportion of respondent who was adults, reduced as distance increased from the core to the sub-urban. The minimum age was 24 years and the maximum was 62 years. The mean age and standard deviation for the study were 47.8 –9.7 years, respectively. The mean age of residents in the core was 52 years, while that of the transition and sub-urban were 45–42 years, respectively. The standard deviation was 9.7. Differences in the age of respondents across the three residential areas were found to be statistically significant. The result of analysis of variance (F = 36.126 and p = 0.000) confirmed this. Impliedly, there is variation in the age of residents in the three identified residential areas of Ibadan metropolis.

A total of 197 (69.6%) of the respondents had one form of formal education or the other. As presented in **Table 2**, 8.1, 20.8, and 40.6% of household heads sampled had primary, secondary and tertiary education qualification, respectively. The highest proportion of respondents with tertiary education qualification was in the sub-urban residential area (68.4%). This group of respondents accounted for 19.7% of residents in the core area, 47.5 and 68.4% of respondents in the transition, and sub-urban areas, respectively. Respondents with no formal education were 86 (30.4%) of sampled household heads in Ile-Ife; however, 64.0, 22.1, and 13.9% of residents in the core, transition, and sub-urban residential areas where in this category. In other words, respondents without formal educational background were predominant in the core area. It can be inferred that there was a direct variation between the educational status of residents and increase in distance from the core toward the sub-urban. This finding validated the description of [37, 38] that core residential areas of many Nigerian cities are habited by people with the least formal education qualification. Chi-square test computed (₦^{2} = 54.477 and p = 0.000) also established that there was significant variation in educational status of respondents across residential areas of Ile-Ife.

Respondents' monthly income was grouped into three: low-, medium-, and high-income earners. Respondents who earned below ₦20000.00 were classified as low-income group and accounted for 47.3% of sampled household heads. On the other hand, respondents who earned between ₦20000.00 and ₦60000.00 were the medium income earner, while individuals who earned above ₦60000.00 are the high-income earners. The medium and high-income earners represented 28.3 and 24.4% of respondents, respectively. As presented in **Table 1**, the proportion of respondents in the high-income group increased from the core residential area toward the sub-urban. This pattern was based on the fact that 16.5, 21.2, and 40.8% of the respondents in the core, transition, and sub-urban residential areas, respectively, were high-income earners. Mean income of respondents in the study area was ₦29929.75 and the standard deviation was ₦14372.46. Across the three identified residential areas of Ile-Ife, however, the mean income of respondents differed: while it was ₦18647.32 in the core area, ₦41515.38 in the transition, and it was ₦37784.61 in the sub-urban. Further, One-way analysis of variance test established that there was a significant difference in monthly income of respondents in the study area (F = 141.528, p = 0.000).

Household size of respondents was expressed as the number of people or group of people living together under the same roof and eats from the same pot. It is important to add that member of a household share the use of water and another sanitary arrangement. Although in some instances where multi-habitation is prominent, such as the core area [39], sanitary facilities could be shared by more than a household. Respondents household size was thus categorized into small (1–6 people), medium (6–10 people) as well as large (above 10). Households that could be termed small accounted for 9.4% in the core, 48.8% in the transition, and 76.3% in the sub-urban. Evidently, respondents household size varied as residential areas also differed (F = 142.471, p = 0.000).

From the above, it is clear that with the exception of respondents' gender distribution, which is not significantly different across the three residential areas of Ile-Ife, other socio-economic characteristics varied as residential areas also varied. This tends to suggest that there will be a disparity in households' access to water and sanitation facilities in the different residential areas of Ile-Ife. The following sub-section is therefore devoted to examining the level of equality that exists in households' access to water and sanitation as well as sanitation practices in the study area.

3.2 Households' sanitation practices in Ile-Ife

As shown in **Figure 1**, five sources of water to the households were identified in the study. These were: pipe-borne, well, borehole, rain, and purchase from water vendors. Findings of the study showed that in the core residential area, 44.1% of households have access to pipe-borne water source. Households that sourced water from pipe-borne accounted for 36.3 and 15.8% of households in the transition, and sub-urban areas, respectively. It should be noted here that, the proportion of households that sourced water from the pipe-borne decreased as distance increased from the core to the sub-urban area. The pipe-borne water source is provided as a public service by the government. The study established that while the distance was increasing from the core to the sub-urban, the proportion of household that have access to well water and borehole were also increasing. Rainwater was not a common source in the study area, as only 1.6% of households in the core residential area, representing 0.7% of households in Ile-Ife get water from this source. As earlier stated, this study was conducted in the months of November and December, 2017. These months are regarded as dry/harmattan season in Nigeria. The activity of water vendor was thus prominent in the core area than the other two residential areas. This is despite the fact that households in the core have access to public water supply. This, signals among other things, that households augment the public water supply, which has become epileptic with other sources.

Further inquiry into household access to water showed that sources of water were at different locations. Three major locations were identified (see **Table 2**).

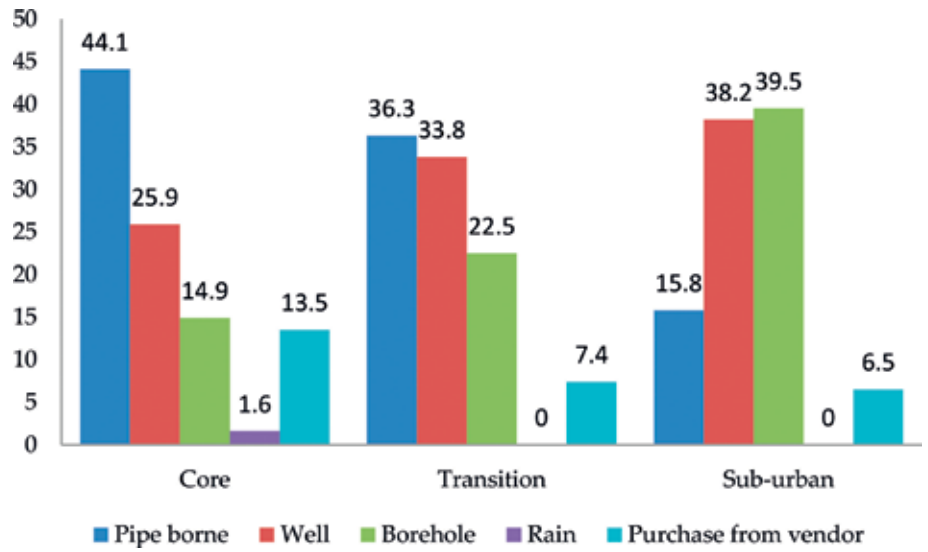

Figure 1.
Sources of water supply to households within Ile-Ife.

Location of water source	Core frequency (%)	Transition frequency (%)	Sub-urban frequency (%)	Total (%)
Within building	30 (23.6)	33 (41.2)	52 (68.4)	115 (40.6)
In neighborhood	42 (37.0)	21 (26.3)	26 (34.2)	79 (27.9)
Outside				
Neighborhood	55 (63.0)	26 (32.5)	50 (65.8)	89 (31.5)
Total	**127 (100.0)**	**80 (100.0)**	**76 (100.0)**	**283 (100.0)**

Table 2.
Location of water source in different residential areas of Ile-Ife.

These were within respondent's residential building, outside the residential building in the neighborhood and outside the neighborhood. Only 115 (40.6%) of households have a water source within their building. Of the 115 households with water source within the building, 52 (45.2%) were in the sub-urban. Households that sourced water from outside their neighborhoods in the study area were 89 (31.5%). Analysis of this figure revealed that 61.8, 29.2, and 9.0% were respectively from the core, transition, and the sub-urban areas. Further investigation revealed that it takes residents a minimum distance range of about 250 m–500 m to travel and source water outside their place of residence. It is thus established that while a considerable proportion of households in the sub-urban area do not travel a long-distance before getting water, result suggests that large proportion of households in the core travel as far as half of a kilometer to source water. It could also be established that households' distances to water source varied with the residential area.

Households' access to toilet facilities was also investigated. In residential areas selected for study, 190 (67.1%) households have toilet facilities. The distribution of responses, however, showed that 51.2% of households in the core, 67.5% in the transition, and 93.4% in the sub-urban residential areas have access to toilet facilities. In other words, the proportion of residents in the study area without access to toilet facilities will employ other methods of defecating such as the use of the open area, near-by bush, and other unfriendly environmental practices. The use of each of these environmentally unfriendly methods has implications for healthy living. These methods are capable of breeding flies and vermin. In areas where the methods are used, an outbreak of diseases and epidemic cannot be negotiated.

In the 190 households where residents have access to toilet facilities, types of toilet used were the flush (62.6%), ventilated improved pit (8.4%), and pit latrine with slab (28.9%). Types of toilet used in the study area also varied with the residential area. The use of flush toilet increased with distance increase from the core to the sub-urban. On the other hand, however, the use of pit latrine was inversely proportional to increase in distance from the core to the sub-urban. Indeed, in the core residential area only, households, where pit latrines were used, accounted for 69.1% of all households that used pit latrine in the study area. In contrast, 88.7% of households that used flush toilet were located in the sub-urban residential area of Ile-Ife. Looking at this information, it could be suggested among other things that a household's choice of type of toilet is influenced by age, educational status, and income of household head, as well as the location of residence in the city.

Across residential areas of Ile-Ife, different methods of solid waste storage and disposal were employed by respondents' households. Among the materials used for storing waste were polythene bag, sack, paper carton, local basket, and bucket with cover as well as without cover. Households also employed different methods for the disposal of waste generated. Dumping inside the drain, along the road,

uncompleted building, burying, burning, and the use of designated point in the residential area where the various methods employed in the disposal of solid waste in Ile-Ife. The investigation also revealed that residents dispose waste into skip-eater provided by the government. Although this arrangement is not evident in the sub-urban area of the city, many of the facilities for disposal provided by the government were concentrated in the core and transition residential areas. The initiative of the paramount ruler of the town is also noticed in solid waste management. Respondent gave an account of the emergence of *gba'fe mo* (Sweep Ife Clean) that was launched by the *Ooni of Ife* in the year 2016. Across the different residential area of the city, there was a disparity in households' accessibility to facilities provided.

4. Conclusions

This study established among other things that there were significant differences in respondents' socio-economic characteristics across the different residential areas of Ile-Ife. Similarly, there were differences in household's access to water and toilet facilities. These differences have impacted greatly households' sanitation practices. Inequalities in households' income and access to education identified in this study are a potential clogs in the wheel of attaining the SDGs in a typical developing nation's city. There is need, therefore, to develop policies that create an opportunity for all. This is irrespective of who you are, where you reside or come from. There is a need for an improved financial institution, regulation, and market to cater for identified inequalities. Disparities in households' sanitation practices across different residential areas also call for support and development aid where they are most needed, especially among the low-income earners in developing nations. The old direction of households' sanitation must be improved, if developing nations will keep track with the post-2015 development agenda.

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Chapter 4

Understanding the Hygiene Needs of People Living with HIV and AIDs in Southern African Developing Community (SADC) Countries

Ephias M. Makaudze

Abstract

This paper seeks to draw attention to the significance of integrating hygiene practices to HIV and AIDs programs in Southern African Developing Countries (SADC)—a region severely burdened by the disease. Integrating hygiene, in particular the habit of handwashing with soap and water, can reduce mortality rates and improve the livelihoods of people living with HIV and AIDS (PLWHA)—akin to Florence Nightingale's moment (1850s). The paper uses survey data attained from PLWHA (South Africa) as case point to provide empirical views by PLWHA regarding their views and perceptions about hygiene practices and significance. Key observations are that: PLWHA lack sufficient knowledge on handwashing practices and apparently ignorant about their exposure and extent of vulnerability to opportunistic infections. This paper concludes by making a call for integration of hygiene (especially handwashing with soap and water) as part and parcel of HIV and AIDS programs as this will positively impact livelihoods of PLWHA in SADC. The paper ends continuous monitoring of WASH programs across SADC new 90-90-90 water-sanitation-hygiene indicator scoreboard necessary for continuous monitoring of WASH programs across SADC and equally other developing countries.

Keywords: hygiene practices, HIV and AIDS, PLWHA (people living with HIV and AIDS), WASH (water sanitation and hygiene), southern African Development Community (SADC)

1. Introduction

Is Southern African Development Community (SADC) region winning the 'war' against HIV and AIDs? Maybe not. Most of the SADC countries remain heavily burdened with HIV and AIDS epidemic. Statistics at a glance indicate the region is fighting a losing battle as it continues to endure the highest HIV and AIDs prevalence (11.7%) in the world [15]. An estimated 15.3 million people are infected with the virus including 1.4 million children (**Table 1**). The prevalence is higher in women (53.1%) within the reproductive age group of 15–49 years. New infections, though showing a declining trend, remain high with more than 600,000 people

People living with HIV	15.3 million
Adults HIV prevalence	12.9%
Women HIV prevalence	53.1%
New HIV infections	620,000
AIDs-related deaths	530,000
Adults on antiretroviral treatment	8.6 million

Source: UNAIDS [15].

Table 1.
SADC HIV and AIDs statistics at a glance 2016.

infected with HIV virus and more than 500,000 people having died due to HIV in 2016. About 7.6 million children have been orphaned by disease and this in turn feeds into other socio-economic problems such as, the observed increase in the number of street kids, drug abuse, prostitution, gangs and gun violence, etc. In addition access to antiretroviral treatment (ART) remains limited in the region with only 48.2% receiving treatment.

A number of factors can be attributed to the high prevalence of HIV and AIDS in SADC region and key among them include: acute poverty especially in urban slums and associated problems of high crime rate, rampant prostitution, sexual violence, sexually transmitted diseases and infections; high mobility and influx of migrants particularly from neighbouring countries to South Africa; social depravation and high inequality within the region; limited and uneven access to quality medical care.

UN-Habitat [13] predicts that by 2020 a majority of people (>60%) in Africa would be living in major cities in search for employment and better life. The trend is equally observed in SADC countries, where most of the major cities are currently experiencing a boom in urban population. Correlated with increasing urban population is the proliferation of urban slum settlements and the resultant intensification of poverty as most of the new urbanites are not formally employed. Slum settlements generally consists of haphazardly scattered and overcrowded dwelling units characterised by lack of reliable supply of clean water, safe sanitation, hygienic living, reliable electricity, law enforcement and other basic services.

A number of studies indicate that the highest proportion of PLWHA reside in slum settlements [10, 12] (AIDS Foundation 2010). For instance **Table 2** indicates the settlement pattern of PLWHA in South Africa. As observed, a majority of PLWHA within 15–49 years age group predominantly dwell in poor urban slum settlements (25.8%), followed by rural slums (17.3%). In general, these settlement patterns have direct implications on WASH (water, sanitation and hygiene) provision.

This remainder of this paper is structured as follows: Section 2 provides an overview of WASH in SADC including links between HIV/AIDS and WASH; Section 3 discusses how hygiene matters for PLWHA; Section 4 showcases anecdotal evidence

Type of settlement	HIV+ (whole sample)	HIV prevalence (15–49)
Urban formal	9.1%	13.9%
Urban slum	17.6%	25.8%
Rural formal	9.9%	13.9%
Rural slum	11.6%	17.3%

Source: Tomlison [12].

Table 2.
Distribution of PLWHA in urban and rural settlements in South Africa.

based on empirical views, knowledge, perceptions and understanding of hygiene needs by PLWHA in South Africa and Section 5 concludes.

2. Overview of WASH in SADC

Hygiene practice has long been recognised as a critical component of public health programs associated with WASH. Yet despite its critical importance, hygiene has not received much priority in WASH policy programs. Under MDG (2000–2015) water and sanitation received global focus including high research priority with well-defined targets. However, under the new SDGs, significance of hygiene is recognised and explicitly included as part and parcel of WASH. Specifically, SDG target 6.2 represents the increasing recognition and role of hygiene and its close links with sanitation. Hygiene is multifaceted as it can comprise many aspects (e.g. handwashing, menstrual hygiene and food hygiene, etc.) and this makes it difficult to integrate measure and/or monitor performance WaterAID [16].

WASH practitioners have until recently identified handwashing with soap and water as a top priority in all hygiene settings, and a suitable indicator for national and global monitoring [18]. This new global SDG indicator for handwashing is defined as the '*proportion of population with handwashing facilities with soap and water at home*'. Handwashing facilities consist an array of devices such as, sink with tap water, buckets with taps, tippy-taps and portable basins, etc. Bar soap, liquid soap, powder detergent and soapy water all count as soap for monitoring purposes. In other cases, ashes, soil, sand and other materials are often used as handwashing soap substitutes, but these are less effective than soap and therefore counted as limited handwashing facilities.

The WHO/UNICEF's Joint Monitoring Program (JMP) has stepped up efforts to develop 'handwashing with soap and water' as primary indicator for global monitoring of hygiene under the SDGs. As a result JMP has recently developed a new 'ladder' intended to benchmark and compare progress in hygiene provision across countries. The new hygiene ladder is shown in **Table 3** illustrating three hygiene service levels: first, the *basic level* which is fulfilled when the household has a handwashing facility with soap and water available on premises; second, *limited level* which is met when the household has facility on premises but lacks water and soap; and third, *no facility* occurs when the household has no any form of handwashing available on his/her premises.

Using this approach, JMP (under WHO/UNICEF [18]) conducted baseline survey to assess hygiene provision worldwide. The results indicate that the least developing countries (SADC region included), 27% of the population had access to 'handwashing facilities with soap and water' on premises, while 26% had handwashing facilities but lacking soap or water, and the rest (47%) had no facility.

Services level	Level defined
Basic level	Availability of handwashing facility on premises with soap and water; soap devices include bar soap, powder detergents, soapy water
Limited level	Availability of handwashing facility on premises without soap and water; non-soap devices like ashes, sand are used instead
No facility	No handwashing on premises

Source: WHO/UNICEF [18].

Table 3.
The new JMP ladder for hygiene.

The graphic results are shown in **Figure 1**, showing the proportion of people with handwashing facilities including soap and water at home across different countries. It's striking to observe that across all SADC countries less than 50% of population have handwashing facilities with soap and water at their premises. The result imply dire implications especially for PLWHA. It is reasonable to infer that because of limited access to safe sanitation (see **Table 4**), many PLWHA are succumbing to communicable diseases predominantly due to lack of hygienic living.

2.1 HIV/AIDS link with WASH

Where is the link between HIV/AIDS and WASH issues? HIV and AIDS is not a waterborne disease nor is it spread via poor hygiene-related diseases like diarrhoea, typhoid and cholera [6, 7]. On one hand HIV and AIDS is principally a sexually transmitted disease, while on the other hand, water is a renewable resource whose availability depends on a variety of natural geographic and climatic factors. Likewise, sanitation and hygiene practices appear completely unrelated to HIV. Ostensibly, on face value, HIV and WASH issues appear distantly unrelated.

To the contrary, there are important links between HIV/AIDs and water/sanitation/hygiene with strong bearing on efficient provision and delivery of WASH services by municipalities [1].

First, AIDS kills by destroying the immune system of the body—rendering the body highly susceptible to common diseases. As a result AIDS victims die after succumbing to one or more of "opportunistic diseases" especially waterborne diseases such as diarrhoea, cholera, dysentery, typhoid, etc. For example, diarrhoea rates are estimated to be 2–6 times higher in PLWHA than in non-infected and rates of acute and persistent diarrhoea are twice as high in PLWHA compared to the non-infected ([5] in [17]).

Second, as PLWHA become frail, bed-ridden and increasingly incapacitated their demand for WASH (Makaudze & Gelles, 2015) services drastically increases [9]. For instance, they would require regular bathing, frequent washing of soiled linen and clothes, clean hygiene living environment with well-managed solid waste disposal. Safe sanitation involves proper handling and disposal of human excreta (faeces, urine, menstrual blood, and sweat), proper management of wastes (including trash, wastewater, sewage and hazardous wastes) and proper control of disease vectors such as mosquitoes and flies [14, 17]. However providing such essential WASH services for PLWHA in slum and rural settlements is a formidable challenge.

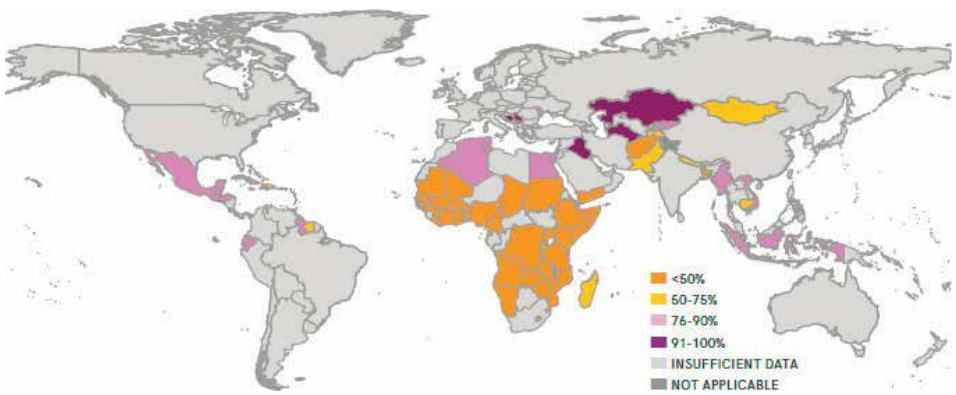

Figure 1.
Proportion of national population with handwashing facilities including soap and water at home, 2015. Source: WHO/UNICEF [15].

Country	Access to clean water (%)	Access to safe sanitation (%)	% hygiene
Angola	48	52	–
Botswana	95	65	–
Lesotho	82	30	–
Malawi	90	41	–
Madagascar	52	12	–
Mauritius	100	94	–
Mozambique	51	20	–
Namibia	90	35	–
South Africa	92	68	–
Swaziland	75	58	–
Tanzania	56	15	–
Zambia	66	44	–
Zimbabwe	78	38	–
Average	78	44	–

Source: UNAIDS Data Compilation [15].

Table 4.
WASH provision across SADC countries.

Third, hygiene practice that predominantly involves handwashing with soap and water is not a common practice among PLWHA. If the practice is routinely conducted at critical times, handwashing can effectively reduce diarrhoea instances. Some studies conducted in developing countries concluded that handwashing practices with soap can lower the risk of diarrhoea by 42–44% [2, 3].

Menstruation management for women living with HIV and AIDs is another important aspect that requires shrewd hygiene standards. Menstrual blood of HIV positive women contains the virus and can be hazardous risk to family members, caregivers and other people if not properly handled and managed.

Despite the potential benefits of WASH practices, meeting the special needs of PLWHA remains an enormous challenge in many SADC countries. While significant progress has been achieved in water and sanitation provision, it is hygiene component of WASH that has not received much policy attention and priority (see **Table 4**). Hygiene practice cuts across water and sanitation sectors and its efficient provision will benefit everyone, and incorporating hygiene into HIV programmes will provide additional opportunities to improve overall public health outcomes in SADC region.

The paper seeks to draw attention to the essence of integrating hygiene practices to HIV and AIDs programs in SADC and other developing countries equally burdened by the disease. Integrating hygiene practices could have a profound impact on reducing mortality and improving the livelihoods of PLWHA.

3. Hygiene is critical for PLWHA

A small but growing body of literature is emerging recognising the need to integrate hygiene practices in HIV and AIDs programmes in SADC and equally other developing countries. To gain better understanding of hygiene practices, the following questions are interrogated: first, what is hygiene and how can it be integrated as

part of WASH programs? Second, which hygiene practices are critical to PLWHAs? Third, what are perceptions and understanding of hygiene practices by PLWHA?

Hygiene can be defined as a set of deliberate actions undertaken to preserve health, prevent sickness and enhance individual or community's safety and health security. Simply defined, it is the "deliberate act and habit of preserving health security". The actions may be instituted and/or enforced by the government in the interest of preserving individual or public health security. The World Health Organisation [17] defines hygiene practices as conditions that "help maintain health and prevent the spread of diseases". Personal characteristics, socio-economic and cultural factors play a role in the adoption of hygiene practices.

The term hygiene originated from the ancient Greek and basically means "that which is healthy". Its name is coined from the Greek "god of health" called Hygeia. Today the term is widely applied particularly in WASH where its meaning has been expanded to include issues such as; personal hygiene, water hygiene, sanitation hygiene, food hygiene, public hygiene, environmental hygiene, etc.

Florence Nightingale (1820–1910), regarded as the godmother of hygiene, was the "first" to apply hygiene practices to the wounded combatants during the Crimean War (1853–1856). Nightingale's approach included providing proper ventilation, heating, light, clean environment, clean beds and bedding, personal hygiene, food and nutrition hygiene. What underlies the significance of Nightingale's approach was to facilitate and provide a conducive environment that resulted in lowering mortality rates by two-thirds. Her work provoked such profound effect that sparked worldwide healthcare reforms. It is the Nightingale's moment that we seek to apply by facilitating and promoting hygiene practices with the potential to reduce mortality rates of PLWHA. Because a majority of PLWHA dwell in rural and urban slum settlements (as discussed earlier) where they face deplorable living conditions marked by serious lack of safe sanitation, improvement in hygiene practices is critical for the sustenance of livelihoods of PLWHA.

3.1 Essential hygiene practices for PLWHA

This section provides a brief overview of the essential hygiene practices critical for PLWHA in SADC. The main hygiene components that need to be integrated in HIV and AIDS programs include (but not limited to) water hygiene, sanitation hygiene and personal hygiene and these are discussed below (see [17] for detailed discussion).

3.1.1 Water hygiene

Quality water is unavailable in many slum and rural settlements across SADC countries. In some cases water may be available but often untreated or contaminated—posing a high risk to PLWHA. Several affordable technologies are available for treating water and these include water chlorination, filtration, proper boiling, solar disinfection and ultraviolet radiation [17]. Such low-cost strategies for water treatment at the household level can greatly improve the microbial quality of water and can reduce diarrhoeal instance by 30–40%, achieving outcomes [11, 14, 17].

Ideal water hygiene can be regarded as water that has been subjected to such treatment as boiling, chlorination, filtration, solar disinfection including safe storage facilities. Water boiling is perhaps the most commonly popular and convenient approach especially for rural households where there is a general lack of electricity. Besides water boiling, chlorination is another widely practised water treatment especially at community level. Chlorinated water can be safe for drinking up to 7 days. A variety of different chemical substances can be used for water chlorination,

e.g. sodium hypochlorite, (a bleaching powder), calcium hypochlorite or sodium dichloroisocyanurate (NaDCC) [17].

NaDCC tablets are increasingly being used for routine drinking water treatment in especially in urban areas. The tablets provide cheap alternative chlorine source for use in the safe water system. In comparison to the chlorine solution, the tablets have benefits such as low cost, long shelf life, resistance to sunlight degradation, single-use package easy to distribute due to low weight [17].

Solar disinfection (SODIS) is another water hygiene practise gaining popularity in developing countries. SODIS uses UV-A radiation from the sun for treating water. Because solar energy is easily available across SADC countries, SODIS can be used as a cheaply available water treatment approach. Unlike chlorination methods (discussed above), SODIS does not affect the colour, taste, or odour of the water. However the approach has distinct disadvantages; can only be used when the water is clear (and not turbid water); requires small transparent plastic bottles (e.g. 1–2 l); requires long periods for effective treatment (6 hours in bright sun or 2 days in cloudy weather) and treating large quantities of water is problematic as this would require large plastic containers.

3.1.2 Sanitation hygiene

Ideal hygiene sanitation for PLWHA can be defined as a facility with infrastructure which is safe, reliable, private, protected from the weather, well-ventilated, minimum smells, easily accessible, access clean, minimises the risk of spreading sanitation-related diseases. In particular, hygiene sanitation requires proper handling and disposal of human excreta (faeces, urine, menstrual blood, and sweat), proper management of wastes (including trash, wastewater, sewage and hazardous wastes) and proper control of disease vectors such as flies and pests.

HIV/AIDS policy programs in many SADC countries have not prioritised the provision of hygienic sanitation particularly in slum settlements that are essentially convenient for PLWHA. For instance, a significant proportion (>20%) of households in slum settlements in South Africa still use the condemned bucket system or bushes and open space for defecation [4, 8].

4. Empirical views on hygiene by PLWA: case of South Africa

The results presented below are intended to showcase the views and understanding of hygiene practices by PLWHA in South Africa. The results are drawn from a research grant conducted by the author as one of the principal researchers and supported by Water Research Commission (WRC, 2009–2011). The study was based on 485 HIV and AIDs individuals drawn from three different types of settlements (rural, peri-urban and urban slums) and sampled from three selected municipal districts of Khayelitsha (Western Cape Province), Ukhahlamba (Eastern Cape Province) and Groblersdal (Limpopo Province). The district of Khayelitsha typically represents urban slum type of settlements, while on the other hand, the districts of Ukhahlamba and Grobersdal represent rural and peri-urban type of settlements respectively. The results are reproduced in this paper (courtesy of WRC) to provide empirical anecdotal evidence on hygiene practices and interpretation in the lens of PLWHA in South Africa. In other words, the results seek to demonstrate perceptions by PLWHA regarding: their understanding of hygiene practices, views on effectiveness of hygiene campaigns by local municipalities and how hygiene improvement is likely to impact their livelihoods.

	All	Khayelitsha	Ukhahlamba	Groblersdal
Type of settlement		Urban slum	Rural	Peri-urban
N=	485	198	175	112
Wash hands before eating	32.2%	42.9%	38.9%	2.7%
Wash hands after toilet use	7.0%	12.8%	4.6%	1.0%
Wash hands with soap	3.7%	8.1%	1.1%	0.0%
Wash your body regularly	34.0%	29.3%	24.0%	58.1%
Clean toilet with detergents	1.4%	2.5%	1.1%	0.0%
Other	9.7%	2.5%	0.6%	36.6%

Source: Water Research Commission [8].

Table 5.
Understanding hygienic practices by PLWHA in South Africa.

The results in **Table 5** indicate "hygiene practices" undertaken by PLWHA across the three sampled areas. Results show most interviewees indicating '*wash your body regularly*' (34%) as the most dominant hygiene practice, followed by '*wash hands before eating*' (32.2%). A rather surprising result is the practice of 'w*ash hands after toilet use*', with less than 10% indicating this practice. The smallest proportion was in Groblersdal and the highest in Khayelitsha. Some differences exist between the three areas with those in Khayelitsha being much more focused on washing regularly (than in the other two areas) and having a much lower percentage regarding *washing hands before eating* as important. The result suggest serious lack of knowledge by PLWHA of crucial hygiene practices of handwashing during critical times.

In recent years, local municipalities have mounted several campaigns aimed at improving provision of general public health and security. **Table 6** shows that more than half of the all interviewees were aware of any such campaigns. Khayelitsha had the least awareness (31.3%) and Groblersdal the highest (>90%). Overall, for those individuals who indicated awareness of such campaigns, there was the general perception the campaigns were not effective.

	All	Khayelitsha	Ukhahlamba	Groblersdal
Type of settlement		Urban slum	Rural	Peri-urban
N=	485	198	175	112
Aware of campaigns? (Yes)	54.4%	31.3%	57.1%	91.1%
Very effective	19.2%	3.5%	22.3%	42.0%
Effective	25.4%	12.6%	27.4%	44.6%
Not effective	5.1%	7.1%	0.6%	3.6%
Should they target people living with HIV/AIDS? (Yes)	87.4%	88.4%	81.1%	95.5%
How to keep body clean	1.9%	1.5%	3.4%	0.0%
Education on water & sanitation	47.8%	46.4%	56.0%	37.5%
How to avoid opportunistic infection	1.0%	1.5%	1.1%	0.0%
Other	18.8%	3.0%	11.4%	58.0%

Source: Water Research Commission [8].

Table 6.
Awareness of hygiene campaigns and perceptions on effectiveness by PLWHA.

	All	Khayelitsha	Ukhahlamba	Groblersdal
Type of settlement		Urban slum	Rural	Peri-urban
Will improve health status	31.1%	38.4%	22.9%	42.0%
Will reduce opportunistic infection	9.4%	9.6%	9.1%	18.8%
Will reduce vulnerability to water-borne diseases	12.5%	9.5%	16.0%	17.9%
Likely to live longer	24.4%	15.2%	34.9%	8.9%
Enhances my dignity	16.1%	17.7%	15.4%	10.7%
Other	2.4%	3.0%	1.7%	0.0%

Source: Water Research Commission [8].

Table 7.
Perceptions by PLWHA on likely impact of improved hygiene practices.

Overall, more than 80% of interviewees thought the campaigns should target PLWHA. Of these, the overwhelming view was that such campaigns should target educating people on water and sanitation.

The results in **Table 7** indicate perceptions by PLWHA on the potential impact of improved provision of hygiene practices. The interviewees' dominant view was that improvement in hygiene practices will improve their health status—Nightingale's moment. Results also indicate that interviewees think they are likely to live longer (24.4%) with improvements in hygiene practices and in addition this could also enhance dignity (16.1%). A low proportion (<10%) of interviewees expressed the view that improved hygiene practices could reduce opportunistic infection or reduce vulnerability to water-borne diseases (12.5%). This result imply the lack of knowledge by PLWHA on how vulnerable they are to unhygienic practices.

5. Implications of empirical results

The empirical results discussed above help to highlight some important implications regarding perceptions on hygiene practices by PLWHA in general. Although hard and fast statements may not be drawn, the results nonetheless underlie important insights:

a. *lack of sufficient knowledge on handwashing practices*

- The results point to serious lack of sufficient knowledge on how "handwashing" as a hygiene practice, can have such a profound effect on the health status of PLWHA. Handwashing is one of the interventions that promote hygiene, since it can stop the transmission of pathogens that cause various diseases (e.g. diarrhoea, cholera, etc.). If done properly and at critical times, handwashing with soap and water (basic level) or even abrasive material such as ashes (limited level) is effective in preventing the spread of communicable diseases (e.g. diarrhoea, cholera). Studies conducted in developing countries have concluded that handwashing can significantly reduce the mortality of PLWHA.

b. *health campaigns on HIV/AIDS must integrate WASH*

- The approach by most governments in SADC has been to treat HIV and AIDS as a purely health issue and completely divorced from non-health yet complementary sectors (e.g. WASH). Most HIV and AIDS campaign programs rolled out by governments are predominantly focussed on preventive efforts and measures particularly aimed at changing sexual behaviour; e.g. the ABC (**a**bstain-**b**e-faithful-**c**ondom) campaigns. Such approaches have downplayed the complementary role other essential non-health sectors can play in reducing the impact of HIV and AIDS. The government Departments of Health and Water and Sanitation need to work hand-in-hand in coordinating or developing joint national programs that integrate WASH as part and parcel of HIV and AIDS programs targeting PLWHA.

c. *lack of knowledge on extent of vulnerability to opportunistic infections by PLWHA*

- PLWHA seem to be ignorant about how vulnerable they are to opportunistic infections especially waterborne and skin diseases because of compromised immuno-system. Diarrhoea in particular is the number one killer. This result emphasises the need to raise awareness and educational campaigns among PLWHA about vulnerability to opportunistic infections and significant role hygiene practices especially the role handwashing with soap and water can play in reducing morbidity and mortality rates.

d. *improvement in hygiene practices will provide "Nightingale's moment" to PLWHA*

- Perhaps the most important result by PLWHA is that improvement in hygiene practices will improve health status. This calls upon all stakeholders in health and WASH sectors across SADC countries to integrate hygiene practices particularly handwashing as part and parcel of national HIV and AIDS policy programs. The desired outcome is that such approach will provide 'Nightingale's moment' to PLWHA.

e. *implement new 90-90-90 water-sanitation-hygiene indicator scoreboard*

- The 90-90-90 is an ambitious treatment program initiated by UNAIDS working to end the AIDS epidemic by 2020. The program stipulates that by 2020, 90% of all PLWHA will know their HIV status; by 2020, 90% of all PLWHA will receive sustained antiretroviral therapy and by 2020, 90% of all people receiving antiretroviral therapy will have viral suppression. Following a similar approach, it could be prudent to launch 90-90-90 water-sanitation-hygiene indicator scoreboard by 2020. This could interpreted as by 2020, across all SADC countries (and/or developing countries) 90% of population must have access to clean water; 90% of population must use safe sanitation and 90% of population must have handwashing facilities with soap and water on the premises. With many SADC countries lagging behind in sanitation provision, special emphasis can be devoted to promote 'handwashing with water and soap' campaigns targeting PLWHA.

6. Conclusion

There is overwhelming evidence that improvement in hygiene practices will reduce opportunistic infection especially water borne diseases. Hygiene practices particularly handwashing with soap and water have the potential to reduce

morbidity and mortality rates among PLWHA. However despite the potential benefits of hygiene practices, full implementation and meeting the special needs of PLWHA remains an enormous challenge in SADC. While significant progress has been achieved in water and sanitation provision it is hygiene component of WASH that has not received much policy attention and/or priority. This paper has made a case calling for the integration of hygiene practices (particularly handwashing with soap and water) in HIV and AIDS programs as this will provide additional opportunities to improve health outcomes and reduce mortality of PLWHA akin to Nightangle's moment across SADC countries.

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Section 3

Water Handling Challenges Affecting Hygiene and Health

Chapter 5

Drinking Water Treatment and Challenges in Developing Countries

Josephine Treacy

Abstract

Safe drinking water remains inaccessible to many humans in the developing countries. Research continuously innovates to develop efficient and cheap methods to sustain clean water for developing countries. Developing nations are a broad term that includes countries that are less industrialised and have lower per capita income levels than developed countries. This chapter will discuss clean water for drinking water purposes. Pollution concerns of water in developing countries will be categorised in terms of physical, chemical and biological pollutants such as turbidity, organic matter and bacteria. Natural and anthropogenic pollution concerns linking with seasonal factors will be outlined. The multi-barrier approach to drinking water treatment will be discussed. Abstraction points used will be researched. Water treatment systems, medium- to small-scale approaches, will be discussed. The processes involved in removing the contaminants including physical processes such as sedimentation, filtration such as slow-sand filtration, coagulation and flocculation, and disinfectant processes such as chlorination will be reviewed. Other important methods including solar disinfection, hybrid filtration methods and arsenic removal technologies using innovative solid phase materials will be included in this chapter. Rainwater harvesting technologies are reviewed. Safe storage options for treated water are outlined. Challenges of water treatment in rural and urban areas will be outlined.

Keywords: drinking water, water source treatment pollution

1. Introduction

Drinking water remains inaccessible to 1.1 million people globally. Safe and readily available drinking water is important for public health. Drinking water can be used for many purposes including cooking, drinking, washing, personal hygiene, irrigation, recreational and industrial use. Water can be classified aided by the 'environmental quality objective' for what it is used for and the 'environmental quality standard' for what is the quality of water for its purpose. Improved water supply, sanitation and better management of water resources can boost countries' economic growth and can contribute greatly to poverty reduction. The sources of drinking water in developing countries can range from surface water, groundwater, spring water, saline water, bottled water and harvested rainwater [1]. Access to drinking water is monitored by the World Health Organization (WHO), the United

Nations Children's Fund (UNICEF) and the Joint Monitoring Programme for water supply and sanitation (JMP) [2].

Efforts to develop efficient, economical and technologically sound methods to produce clean drinking water for developing countries have increased worldwide [3].

Figures 1 and **2** highlight the importance of scientists to develop and sustain technologies to improve drinking water quality due to the percentage of society lacking suitable drinking water [4]. Water is a key variable within sustainable development goals in terms of environmental, social and economic initiatives as highlighted by the United Nations in 2014 [5]. The discussion on the role of water

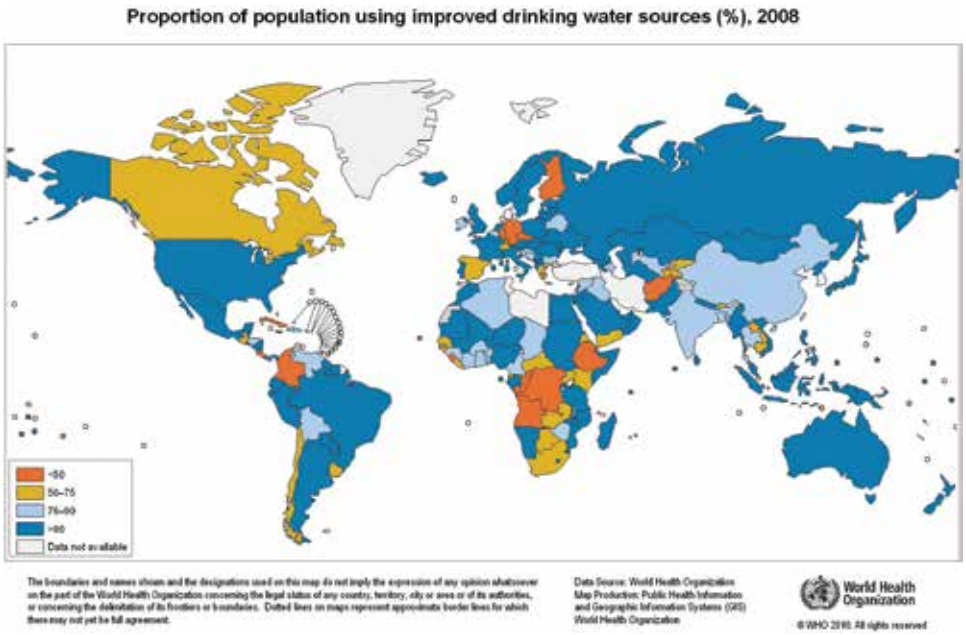

Figure 1.
Proportion of population using an improved drinking water source (WHO 2010) [4].

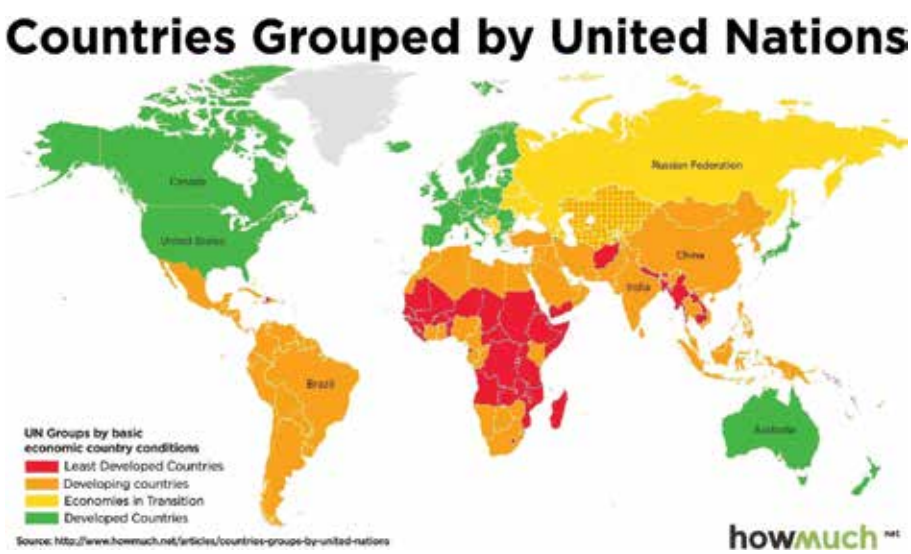

Figure 2.
Global representation of developing countries (WHO/UNICEF Joint Monitoring Programme [4]).

for sanitation and hygiene in the 'water development report 2015' emphasises cost as one of the key challenges for future water needs [6].

2. The importance of treating water

As well as accounting for the lack of physical water accessibility due to drought, 'distance from a water supply' and polluted water can all affect drinking water accessibility. Water quality issues due to anthropogenic and natural pollution can affect the amount of water available for use. Both surface and groundwater can be contaminated by both anthropogenic and natural contaminations. Microbiology and chemical contaminants in drinking water can cause acute and chronic health effects. Contamination can also affect the aesthetic properties of water systems. The contaminants include:

- Pathogens—disease-causing organisms that include bacteria, amoebas, viruses and eggs and larvae of parasitic worms [6].
- Harmful chemicals from human activities and industrial wastes such as pesticides and fertilisers [7].
- Chemicals and minerals from the natural environment, such as arsenic, common salts and fluorides. In Bangladesh, for example, 1.4 million tube wells have high levels of naturally occurring arsenic [8].
- Some non-harmful contaminants may influence the taste, smell, colour and turbidity of water and make it unacceptable to the consumer; its examples include zinc, iron, particulate matter and humic material [9].

The physiochemical properties of contaminants of water that can impact its toxicology in water include size, density compared to water, charge, solubility, volatility, polarity, hydrophobic, hydrophilic, boiling point, chemical reactivity and biodegradability [10].

2.1 From source to consumer and the multi-barrier approach

When deciding on the water supply for drinking water purposes an understanding of the stresses on the water source is important. Seasonal variation of the water source is also important to understand in areas such as water level and water table levels and sanitation contamination trends [11]. Throughout this chapter emphasis on the multi-barrier approach to maintain clean water will be described. All parts of the multi-barrier approach, including source selection, treatment type, transport to consumer and storage if necessary are all important to control, to minimise the risk of contamination. The water safety plans (WSPs) manual published in 2009 by the World Health Organization (WHO) guides the multi-barrier approach for the maintenance of good quality drinking water [12, 13]. When deciding on the drinking water supply and subsequence treatment, the WHO safety plan manual encourages people to think of the best treatment taking into consideration local factors. In the International Water Association (IWA), Bonn Charter emphasises the 'provision of clean safe drinking water which has the trust of consumers' as a focal point [14] (**Figure 3**).

The multi-barrier approach examines water in detail from source to tap and aids in maintaining the quality of water at each stage. The lesser the number of steps in treatment, the cleaner the water source and the nearer the consumer is to the source are challenges in drinking water management. Other variables to consider include

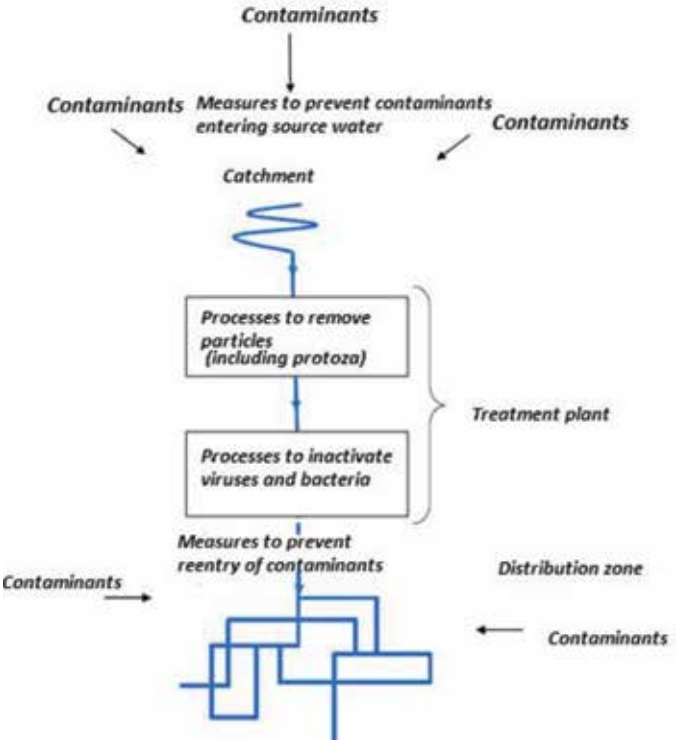

Figure 3.
The multi-barrier approach [15].

prevention of reentering of contaminants at storage and distribution stages of the process [16]. Indicator parameter studies of facial coliforms have been used in Rangoon Burma of Southeast Asia for storage and distribution control management [16].

2.2 Abstraction points

The source supply is known as the abstraction point. A large priority of water management in developing countries is to supply water from a source that requires little or no treatment rather than a source that requires treatment. Risk management to ensure that the source is protected from pollution is also a priority [17]. The baseline of the water source physiochemical, organic and inorganic composition and its monitoring is a challenge [18]. Supply provision of water source under different conditions such as seasonal factors is important to understand. The types of water abstraction points consist of boreholes, open wells, surface water river and lakes, saline waters and brackish waters. An example of the range of drinking water abstraction types utilised in developing countries can be seen in **Table 1** [19].

Abstraction water point in certain areas will change at different times of the year corresponding with the dry season and the wet season. Boreholes where citizens dig down to find water would be popular in dry seasons and river water sampling, and the use would be popular in wet season. This is common in areas such as Francistown, Botswana, in South Africa. The Shashe river is used readily in the wet season as stated by a sister of the Cross and Passion order working in the Francistown area. Another source of water for future investigation would be bottled water; bottled water can be bought in from other countries. Bottled water can be classified as natural mineral water, and water source bottled from an underground aquifer still or aerated protected from pollution has no treatment [20]. Issues with

Source type	Drinking water % use	Domestic water % use	Irrigation % use
Shallow well	68.6	75.4	82.3
Borehole	11.0	4.3	6.5
River	0.7	0.7	1.6
Spring	0.7	0.7	1.6
Wetlands	0	0	1.6
A combinations of above Due to seasonal factors	9.7	9.4	1.6

Table 1.
Abstraction drinking water supply and % use from case study Ndola [19].

confidence in quality, shelf life, storage including refrigeration and transportation to consumer can be a challenge. The cost of transporting bottled water can be costly.

2.3 Rainwater (water harvesting)

Rainwater harvesting can be considered a free source of water. Rainwater precipitation can be very large in certain parts of the globe. Global precipitation climatology, for the period 1979–2017 in millimetres/day, can be visually seen in **Figure 4** [21]. This data represents the precipitation estimate from version 2.3 global precipitation climatology project (GPCP) SSAI/NASA GSFC project data [21].

Different technologies can be used for rainwater harvesting such as roof water which can be collected through gutters and pipes into storage tanks [22]. Other water harvesting systems that have been developed include farm ponds, community ponds, wells, recharge pits micro-irrigation sprinklers and check dams' low cost water harvest systems [23]. The advantage of farm ponds and check dams is that water can be stored in the rainy season which can be utilized during the dry season. Recharge pit systems can be used to recharge groundwater aquifers in the rainy season. The Vidarbha region of India has successfully deployed farm pond and pit macro-irrigation systems. Positive outcomes of these technologies include crop irrigation improvements and raised water tables, subsequently increasing the availability of drinking water sources. [23].

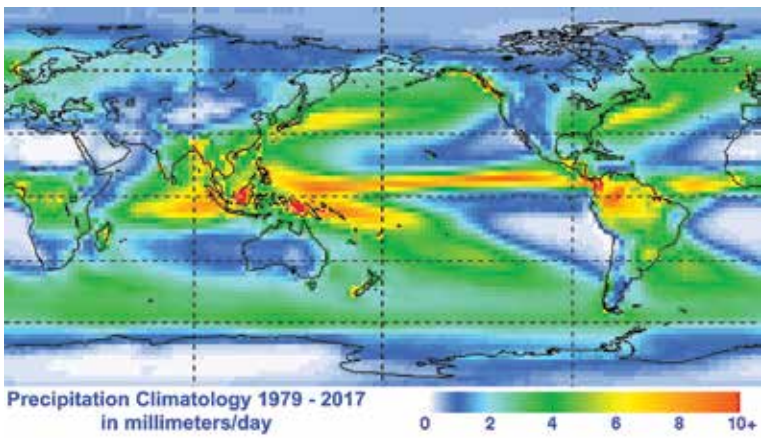

Figure 4.
Global precipitation image provided by David Bolvin (SSAI/NASA GSFA [21]).

From **Figure 4**, one can see that the estimated rainfall in Africa, Asia and South America is in the range of 4–10 millimetres/day, which can be utilised for water harvesting for the purpose of drinking water, irrigation and washing and cooking. The data in **Figure 4** is based on a combination of passive microwave and active radar sensors.

Rainwater can be a significant source of water for an individual, a family or a community. Rainwater harvesting is widely practised in Maldives, India and Sri Lanka [24]. It is very beneficial for tsunami-affected regions where piped water infrastructures are severely damaged [25].

Other areas where rainwater harvesting has been developed include Bhutan and Bangladesh as an alternative source due to the high levels of naturally occurring arsenic in groundwaters [26]. The advantage of using rainwater as a water source is a great benefit to a community if distance from a water supply in rural areas makes water inaccessible.

Rainwater harvesting can levitate issues with storm water and minimise diffuse sources of pollution due to storm water. Harvested rainwater is a water source during the drought season if stored correctly. The treatment of the rainwater if needed would involve point-of-use (POU) treatment technologies which will be discussed later in this chapter.

Globally, sub-Saharan Africa has the largest number of water-scarce countries [27]. Unfortunately, these countries also do not have a large availability of clean drinking water due to urbanisation and industrialisation impact on water quality [27]. Most of the African continent relies on rainfall and surface water for their drinking water supply. Experts estimate that between 75 and 250 million people will live in water-stressed areas of Africa by 2030 [28]. Pollution of rainwater can be due to the transboundary pollution and anthropogenic and naturally occurring pollution such as bird droppings [29]. The key benefits of using rainwater include local water security and reduced central treatment infrastructure needs for water supplies.

2.4 Desalination

Processes such as distillation and evaporation can be used as a means of desalination [30]. Other processes include freeze distillation and reverse osmosis. Freezing salt makes crystals of fresh water form and grow leaving a concentrated brine solution behind [31]. Reverse osmosis involves movement of water from a high concentration to a low concentration. Membrane systems can also be used [32]. The major advantage of desalination is that when chlorination is used as a disinfectant, there is a lower risk of forming disinfectant by-products as the water has a lower organic content [32]. Many developing countries have coastal areas which enable sea water and brackish water following desalination to be used as a drinking water source. The largest challenge to the use of desalination technologies is the cost of the technologies used [33]. Research has shown that cost of desalination can be minimised by using solar and wind energy as an energy supply for reverse osmosis [34].

3. Pollution and abstraction point

The minimising of pollution must be linked with point and diffuse sources of pollution. Categories of pollution risk include point sources and diffuse sources of pollution. Diffuse source of pollution is harder to control and monitor. Diffuse sources of pollution include dry and wet atmospheric deposition. Storm water infiltration from waste storage and septic tanks is also a major concern [35].

Watershed protection refers to the activities preformed on a topographical and hydrological water area in order to protect water quality within a catchment. As an example for drinking water the topography of the watershed basin is studied linking with surface water runoff entering a river or stream. Soil types should be investigated in terms of soil characteristics and water permeability and sand silt and clay composition [36]. Water-permeable soil can impact on the movement of surface water downwards to groundwater causing a transfer of pollution (**Figure 5**).

Aquifer protection groundwater quality is dependent on the geology of the subsurface material of which water is drawn. Also, understanding the transport and fate of contaminants requires a study of groundwater geology if any aquifer protection zone treatment is in place. Soil horizon characteristics should also be reviewed. Arsenic is a common naturally occurring metal problem in developing countries as can be seen in **Figure 6**. Hydraulic pump control to prevent intrusion of sea water is an important variable to control in coastal areas in terms of fresh water aquifer use [38].

Waste disposal and lack of proper sanitation practices can affect the quality of surface waters and groundwaters. The principle component analysis (PCA) and factor analysis (FA) can be used to minimise the risk of water pollution. The PCA and FA create an inventory of variables that can be an impact on water quality [39]. **Figure 7** shows the PCA and FA flow approach in relation to surface water management [40]. Point and diffuse sources and source-receptor mechanisms are also important to understand. Source-receptor mechanisms are important to control and understand, linking to the physical, chemical and biological characteristics of the pollutants that may be natural or anthropogenic [41].

The types of waste issues to monitor relate to the pharmaceutical and agricultural industries, oil refining, textile industry, leather industry, fine chemical manufacture, animal and human solid and liquid waste and sediment issues linked with floods and the construction industry.

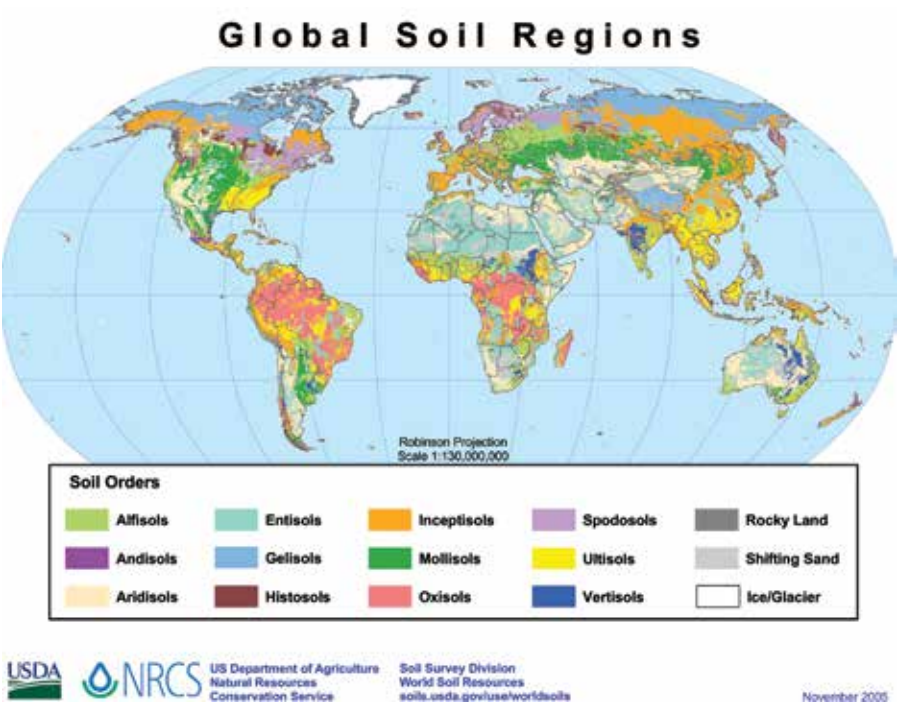

Figure 5.
Soil types globally [37].

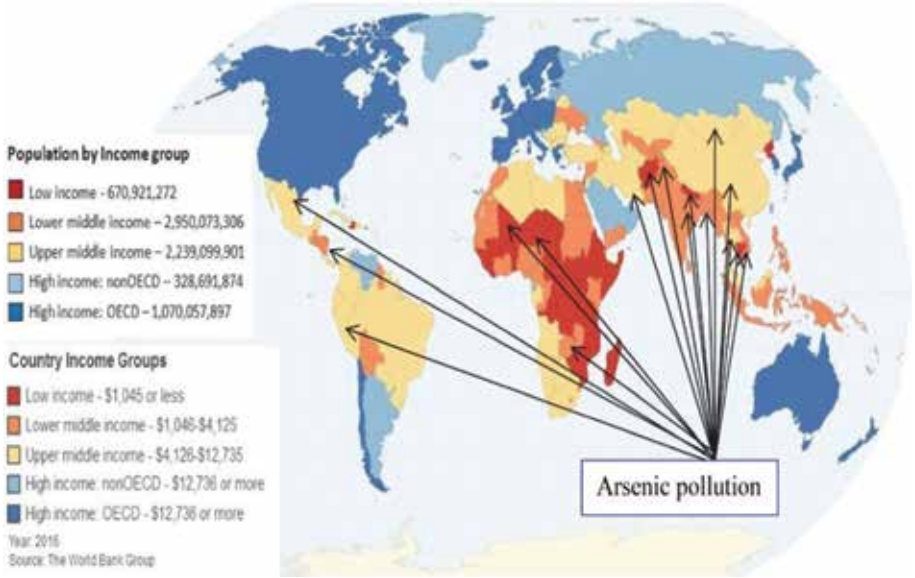

Figure 6.
Naturally occurring arsenic in a global perspective [1].

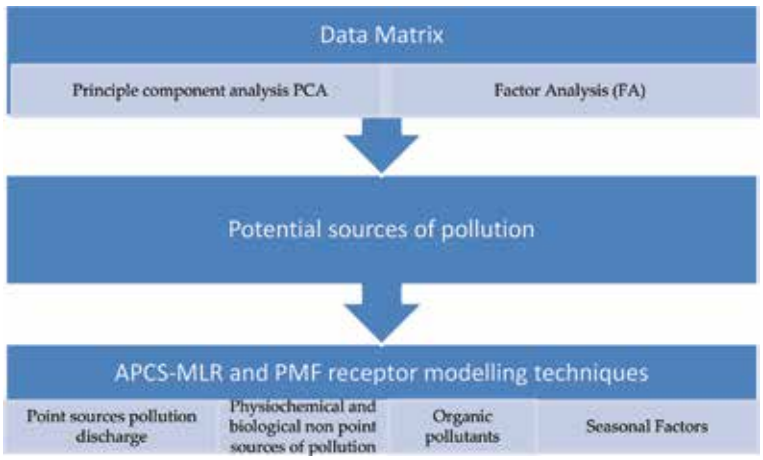

Figure 7.
Point and diffuse sources and seasonal factors and pollution control linking with PCA and FA [40].

4. Treatment technologies

Any drinking water treatment technology focuses on source supply, treatment type, storage and transportation to customers. Conventional treatment methods in developed countries can be applied to developing countries. The basic drinking water treatment steps can be seen in **Figure 8**.

The first stage of treatment to produce drinking water involves screening the abstraction point water and passing through coarse filters. The water can then be kept in a storage tank where natural sedimentation occurs and natural ultraviolet light can break down pathogens. The next stage is the pre-chemical stage which can involve aeration, use of activated carbon and use of aluminium salts or iron salts. Aluminium salts are the more commonly used. The simplest coagulant is aluminium

Figure 8.
Drinking water treatment [42].

sulphate $Al_2(SO_4)_3.14H_2O$ known as alum. Aluminium sulphate salt is converted to an aluminium hydroxide complex in the water which is known as a polynuclear species $Al_{13}O_4(OH)_{24}^{7+}$ and in the presence of polyelectrolytes aids in the coagulation process [43]. The traditional view of coagulation is that it facilitates agglomeration of small colloidal particles into large particles of a size that can be physically removed. Dirt, chemicals and pathogens in the water attach to the aluminium hydroxide during the coagulation process. Dual coagulants, a hydrolysed metal salt and a low concentration of polyelectrolyte, can be used. The most common polyelectrolytes in water treatment consist of polydiallydimethyl ammonium chloride (polyDADMAC) and epichlorohydrin dimethylamine (epiDMA) [43]. Coagulation/flocculation technologies can also remove total organic carbon (TOC). High-charge-density cationic polymers bridge particles of the primary coagulations to form a floc to initiate the flocculation process. Sedimentation and decanting of the water occur at this stage, and the floc can fall out of the water phase. The gravity sedimentation removal of particles from water follows the coagulation/flocculation process. High-rate gravity sedimentation involves blasting flocculation using polymers. This process is commercially known as ACTIFLO process, microsand 70–100 μm is dosed together with the polymer forming a lamella [44]. The lamella settles out of the water clarifying the water [45]. In the dissolved air flotation (DAF) technique, part of the treated water is recycled under pressure to dissolve air in the water as part of the aeration process. The floc attaches to the air bubbles, moves to the top of the water and can be removed [45].

The next stage of the treatment is sand filtration; enhanced filtration systems such as granular media filtration and disinfectant membranes are also readily used. The filtration process can remove excess pathogens and chemicals from the water [46].

The post-chemical stage involves disinfection of the water; disinfectants used include hypochlorous acid, ozone and chloride dioxide [47]. Many water utilities have moved to the use of multiple disinfectant rather than just chlorination. Advanced technology with the use of ultraviolet light to create free radicals which can break down pathogens can also be used.

The most common disinfectant used is chlorine (Cl_2) which reacts with water forming.

$$Cl_2 + H_2O = HCl + HOCl \quad (1)$$

Hypochlorous acid which is a weak acid can dissociate into hydrogen ion, H^+ and hypochlorite ion OCl^-:

$$HOCl \rightleftharpoons H^+ + OCl^- \qquad (2)$$

Both HOCl and OCl^- can act as disinfectants [47].

Chlorine dosing is the best disinfectant as it can leave a residual in the water to aid disinfection. Ozone and ultraviolet light do not give a residual disinfectant in the water. Post-chemical treatment can also involve pH control. Fluorination can also be used as a post-chemical treatment in certain countries such as Ireland [47].

The water is then stored in reservoirs before being used. Residual disinfection in the storage facility is important to prevent contamination of the storage space. The network management is also very important, and residual disinfection is important to maintain water safety. Microbial slimes in the distribution system pipes can cause the development of waterborne viruses and bacteria and invertebrate grazing in the pipe systems [48]. Lead piping is also an issue in the European countries [49]. Breaks in pipe systems are concerns in terms of society's water footprint and overall sustainability. Infiltration and leakages in pipe systems are other issues. Excessive particulate matter in pipe systems can also give rise to microorganism build-up [48]. Stagnation in the pipes can also give rise to microbial slimes [48].

Certain privately owned ground water supplies and group schemes incorporate treatments such as aeration and disinfectant using chlorination and ultraviolet light disinfectant [47].

For conventional drinking water treatment, sufficient time for each step of the process, maintenance and energy use is important to management in terms of moving in the direction of an eco-label for water treatment.

4.1 Water treatment in developing countries

In developing countries, the priority is to obtain biologically safe water. Waterborne diseases is a large issue globally especially in tropical countries with poor water supplies [17]. The chemical and physical characteristics of water should not be overlooked, but emphases on the biological quality treatment should be salient.

The treatment that is utilised in developing countries shall now be discussed.

The two treatment systems include:

a. Central source treatment systems

b. Point-of-use (POU) treatment

Central source systems involve water treatment in a central location followed by distribution to the consumer. This is known as medium- or large-scale treatment. The treatment is similar to conventional treatment used in developed countries. This type of treatment can be suitable for urban areas in developing countries. Challenges of network contamination and maintenance of the infrastructure are a large concern [48]. The treated water can be transported by tanker to rural areas, if piped networks are not present in a particular area.

Point-of-use (POU) treatment involves 'informal sources' treated at source which are also known as small-scale treatment. Risk management in terms of pollution of informal sources such as rainwater, shallow boreholes and small streams treated per household is a large concern [50]. When deciding on which type of POU treatment variables to consider, it should include ease of use, price, time for treatment and volume of water treated.

A selection of point-of-use (POU) treatment commercial systems and small-scale technologies that can be utilised can be seen in **Table 2**.

Some interesting point-of-use (POU) treatments will be discussed below.

4.1.1 Chlorination

Chlorination was initially used to disinfect public water supplies since the early 1900s, in cities in Europe and the United States of America. In developing countries, a common method for treating water at source involves using a sodium hypochlorite solution placed in a bottle with directions for use. The user adds one full bottle cap volume of the solution to clear water (or two cups volumes for turbid water) to a standard-sized storage container. The user shakes the container and then waits 30 minutes before drinking. The reason that chlorination is so popular is because it leaves a residual in the water matrix [57].

One of the large challenges of chlorination is the presence of high organic composition that can give rise to the formation of disinfectant-by-products which are considered carcinogenic.

4.1.2 Chlorination and flocculation

Hybrid water treatment technologies are commonly used such as a combination of chlorination and flocculation. An example of the combined technologies involves a small sachet containing both a powdered ferrous sulphate (a flocculant) and calcium hypochlorite (a disinfectant). A commercial design of this approach is known as Pu-R. To use Pu-R, users open the sachet and then add the contents to an open bucket containing 10 litres of water maximum. The bucket contents are stirred for 5 minutes, and the solids in the water will then settle to the bottom of the bucket [56, 57].

The water is then strained through a cotton cloth into a second container; the user then waits 20 minutes for the hypochlorite to inactivate the microorganisms. This technique has been shown to remove bacteria, viruses and protozoa, even in highly turbid waters [58].

Chlorination and flocculation can eliminate the formation of disinfectant by-products as the flocculation process can remove organics from the water.

4.1.3 Filtration

Filtration and innovations in filtration are a growing interest in the water industry. Basic filtration involved the use of porous stones, and a variety of other natural materials have been used to filter visible contaminants from the water for hundreds of years. Filters are an attractive option for household treatment [59]. A number of interrelated removal mechanisms within the filter media are relied upon to achieve

Commercial name	Information reference
Biosand filter and ceramic water purifier	[51]
Kanchan™ Arsenic filter (KAF)	[52]
AquaEst RainPC®	[53]
Solar disinfection (SODIS)	[54]
LifeStraw®	[55]
PUR Purifier of Water™	[56]

Table 2.
Selection of point-of-use (POU) treatments and small-scale treatment.

high removal efficiencies. These removal mechanisms include the following processes: (1) sedimentation on media (sieve effect), (2) adsorption, (3) absorption, (4) biological action, and (5) straining [60].

There are many porous materials which are locally available and inexpensive options for filtering water. They are simple and easy to use, and the filtering material has a long lifetime. However, filtration has its drawbacks due to maintenance issues such as back flushing of filters and lack of residual effects with regard to disinfection. Again, hybrid water treatment technologies involving basic filtration have been investigated. An interesting membrane hybrid system combining trickling filtration filter and a thin layer of biomass biosand to reduce organic matter can be seen in the literature [61]. Other membrane designs that can be utilised include disc and tubular design, microfiltration, ultrafiltration, nanofiltration and reverse osmosis. The scope for the removal of contaminants by filtration processes can be seen in **Figure 9**.

4.1.4 Filtration and biosolids

More advanced filtration methods using biosolids have been developed. The biosand filter (BSF) is a slow sand filter which can be adapted for use at home. When the water pours over the filter, a shallow water layer is formed which allows a bioactive layer to grow on top of the sand, which breaks down pathogens in the water. A plate protector prevents the water layer from being disturbed when more water is passed through the filter. In the literature it can be shown that the BSF has high efficiency to remove bacteria and protozoa from the water [63, 64].

An interesting study to remove arsenic from the water in the presence of iron can be seen in the literature in Nigeria using a sand filter. The filter immobilises arsenic (As) via co-oxidation with Fe(11) and sorption to or co-precipitation with the formed Fe(111) to the filter surface [65].

One of the problems with the prolonged use of filters is the potential build-up of biofouling on the surface of the filter [66].

4.1.5 Filtration and chlorination

A combination of filtration and chlorination systems is also regularly used [67]. Ceramic and slow sand filtration lack a residual disinfectant protection of water, to compensate for this filtration followed by chlorination can be used [68, 69].

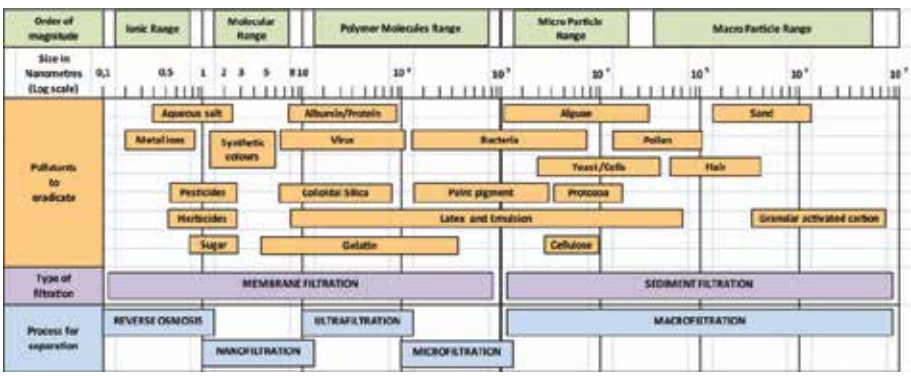

Figure 9.
Filter/membrane particle sizes and what contamination can be removed [62].

4.1.6 Innovative solid materials

To remove arsenic (As) metal and its metalloids from drinking water, metal absorption phases have been utilised including iron oxide-coated sand, ferrihydrite red mud, activated alumina, TiO_2, $FePO_4$ (amorphous), MnO_2, MnO_2-loaded resin, natural zeolites (such as clinoptilolite), iron oxide and iron-loaded chelating resin [70]. The use of the biosand iron oxide-coated sand filters to remove viruses from water can be seen in literature. The method consists of electrostatic adsorption of negatively charged virion to sand particles with positively charged iron oxides [71].

4.1.7 Solar disinfectant

The role of natural sunlight to disinfect water has much potential in developing countries. A common method in use is known as the solar disinfection (SODIS) method. Solar disinfection (SODIS) method was initially developed to inexpensively disinfect water used for oral rehydration solutions [72]. The SODIS method involves filling 0.3–2.0 litres of plastic soda bottles with low-turbidity water, followed by shaking to oxygenate the water. The bottles are left for 6 hours in sunny conditions and 2 days if weather is cloudy [73]. Studies have shown that the SODIS method inactivates bacteria and viruses; the protozoa cryptosporidium and giardia are also sensitive to solar irradiation [74]. Other innovations using ultraviolet light can be seen in the literature [75–78]. One of the major advantages of ultraviolet light technology is its cheapness. One of the challenges is designing the technology for max trapping of the ultraviolet light. Seasonal factors can affect the intensity of the ultraviolet light. Small volumes and length of time to treat the water can be a concern. If water has high turbidity, it is recommended to pretreat with flocculation or filtration before ultraviolet light treatment. Presently, the container type is plastic.

4.1.8 Innovative technologies and nanotechnologies

Photocatalysts based on nanocatalysts such as the TiO_2 catalyst harness ultraviolet radiation from the sunlight and use the energy to break down substances such as microbes, pesticides, dyes, crude oils and organic acids [79]. Pilot projects for drinking water purification in developing countries have only begun involving TiO_2 immobilised on plastic which is activated by ultraviolet light to disinfect the water [80]. Other nanotechnologies are at developing stage [81, 82].

5. Challenges

Challenges to the drinking water supply in developing countries include the natural scarcity of water source in certain areas. Floods can create more siltation problems in river systems as well as the contamination of rivers and large dams giving rise to source-receptor issues. Climate change and water scarcity are also some of the concerns [83, 84]. Stratification problems in lake abstraction points and aeration of abstraction point to break down the thermocline layer are needed which requires much energy.

Poor access to water and poor water resource management must be addressed. Poor water productivity in the agricultural sector can impact on water quality [85]. Water affordability issues and the challenges of investing in water infrastructure need to be addressed [86, 87]. Storage and confidence in storage facility container to prevent contamination entail education and awareness of cross-contamination [67].

Figure 10.
Variables to consider in integrated water management [88].

To maintain clean drinking water, an integrated approach is needed in developing countries. Proper management of solid waste and waste water can enhance the quality of our drinking waters [88, 89].

Private companies' management of water treatment systems is an interesting debate in developing countries [90]. Water conservation and future issues of water recycling have been discussed in developed countries and can also be applied to developing countries.

Large-scale and small-scale technologies are important to review in terms of maintenance and monitoring [91]. Energy and water treatment needs are a concern [92]. Most developing countries are located in regions of the world which have the most droughts and seasonal changes in precipitation and evaporation which challenges the source of the water at different times of the year [93] (**Figure 10**).

Natural disasters such as storms and earthquakes can affect infrastructure of large-scale system and small-scale systems; point-of-use (POU) treatments are needed to compensate for these issues. Education on the use of point-of-use (POU) treatment in local communities must be encouraged [76]. At different times of the year, the water source availability varies for examples rivers are used during the wet season and bore well water sources are used during the dry season.

6. Conclusion

Access to safe drinking water is also considered to be a human right, not a privilege, for every man, woman and child (World Bank, 2018).

The World Health Organization emphasizes that 'the introduction of water treatment technology without consideration of the socio-cultural aspects of the community and without behavioural, motivational, educational and participatory activities within the community, is unlikely to be successful or sustainable' [94]. Research, development and deployment (R&D&D) of clean water technologies for developing countries are important to nurture. All these initiatives can help move in the direction of the challenge by the Millennium Development Goals (MDGs) to halve the proportion of the people without access to safe water by 2015 [95]. Clean water is only as clean as waste water management and treatment linking with global waters and the practically closed loop [96]. Performance management framework surrounding drinking water must be nurtured [97]. Private companies organising treatment systems must be properly introduced [98].

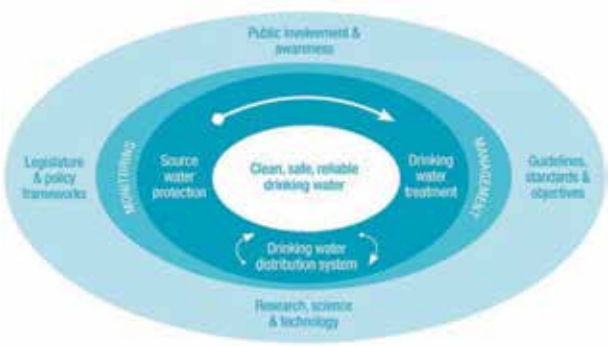

Figure 11.
Drinking water sustainability [113].

Certain water sources used for different applications challenge our water resources such as industrialisation needs of developing countries. Transport costs and informal sources are important to develop [99]. The human carrying capacity and population increase and water use are important to monitor [100].

Legislation and risk management audits and awareness in terms of water conservation issues and human behaviour towards water are important to address [101, 102].

Informal water supply involving point-of-use (POU) treatment will need to be continuously integrated with central supply systems (CSS) as CSS will not facilitate all water demands [50, 103–105]. Cost issues for integration need to be addressed [106].

Two key indicators highlighted by the World Bank are 'annual freshwater withdrawals' and 'improved water source' [107, 108]. Linked with these two key indicators are performance management, public awareness and conservation issues of central treatment systems and point-of-use (POU) treatment [109, 110].

Waterborne diseases will always be researched in the future [111]. Industrial regulation and waste management especially when industrialisation is occurring at a rapid rate in developing countries are important issues in the future. Good waste management practice will always be embedded in achieving clean drinking water supplies [112] (**Figure 11**).

The full multi-barrier approach from the source to the tap linking with policy should be a future strategy [113]. Network maintenance and provisions for same are salient within the strategy [114, 115]. A harmonisation approach to water sustainability should be embedded in future water planning [116, 117]. The harmonisation approach would involve common arrangements, simple procedures and sharing of information and standards [118]. Developing countries should nurture the opportunity to learn from developed countries about their successes and failures. Sustainability and water security will also be embedded in the future of water management. Informed education, information sharing and simplified production are important to ensure good water quality [119]. Health and water are fundamentally interlinked and need to be constantly researched in terms of global development [120–123].

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Conflict of interest

None.

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Chapter 6

Household Water Handling Practices in the Arid and Semi-Arid Lands in Kenya

Edith J. Kurui, George M. Ogendi, Wilkister N. Moturi and Dishon O. Nyawanga

Abstract

Utilisation of water from unimproved water sources coupled with inadequate access to sanitation can adversely affect human health. This study undertaken from November 2014 to March, 2015 sought to assess the household water handling practices and relate them to the prevalent diseases in Baringo Central and South, Kenya. A Household sanitary survey was conducted and questionnaires were administered to 100 household heads within the study area. The data was analysed using descriptive and inferential statistics. The results indicated that 72% of the households (n = 100) collected water for cooking and drinking from the water pans. Only 34% of the households treated water commonly using boiling (19%), filtration with cloth (2%), chlorine (11%) before using it for drinking. There was a positive correlation between methods used in accessing water from drinking water storage containers and water related diseases prevalent in the study area ($p < 0.05$). Household drinking water in the study area did not meet the WHO drinking water quality guidelines mainly due to poor handling practices at the household level. There is a need to promote water, sanitation and hygiene campaigns in the study area to prevent water related diseases at the household level.

Keywords: drinking water, sanitary survey, storage containers, water pan users, Baringo

1. Introduction

Despite numerous efforts and interventions by the private and government sectors, 1.3 billion people in the developing world lack adequate access to clean and safe drinking water [1]. Recent statistics indicate that approximately 770 million people still use unimproved water sources, whereas 36 per cent of the world's population lack improved sanitation facilities [2].

Kenya is considered chronically water scarce. The ASALs in Kenya are highly affected, with water scarcity leaving the majority of the inhabitants dependent on unimproved water sources. According to the 2014 Joint Monitoring Program (JMP) report, Kenya was ranked to be among countries with inadequate sanitation facilities in the rural areas, where some open defecation cases have been reported [3]. Water sources for most households in ASALs is drawn from water pans, dams, unprotected springs, unprotected wells, water vendors and rivers.

Like many other ASALs in Kenya, Central and South Baringo is characterised by inadequate access to water and sanitation. The main water sources in the region are unprotected water pans and dam. The existing high morbidity and mortality from communicable diseases in households in ASAL areas can partly be attributed to inadequate access to sanitation [4]. According to 2014 survey by the Ministry of Health (MoH) in Kenya, Baringo County was ranked 38 out of 47 on County sanitation. Twenty four percent of the Baringo County population uses improved water sources, whereas 39% uses improved sanitation facilities [5]. It is against this background that this study was conceived to assess the household water handling practices in relation to the prevalent water-related diseases in Central and South Baringo.

This study focussed on the arid and semi -arid lands of Eldama Ravine, Mogotio and Marigat sub-counties. Literature shows that the areas are water scarce and the major water sources that augment the river water are the excavated water pans [6]. WHO, in 2008 categorised open water sources without protection as unimproved water sources.

2. Methods

2.1 Study area

Central and South Baringo is located at the longitudes and latitudes of 35° 30" 0° E and 0° 30" 0° N (**Figure 1**). Geographically, Central and South Baringo is made up of; Marigat sub-county at the central point of Baringo county, to the south is Eldama Ravine and Mogotio sub-counties which form the Southern part of the County. The population size of the study area was estimated to be 239,405, distributed among the three sub- counties as follows; Mogotio sub county; 60,959, Eldama/Ravine; 105,273 and Marigat Sub-County; 73,173 [7]. The population dwelling in Eldama Ravine and parts of Mogotio Sub-Counties practice mixed farming and marginal mixed farming [7]. The climatic condition ranges from arid to semi-arid lands. The temperatures experienced ranges from a minimum of 10°C to a maximum of 35°C. Annual rainfall varies from 1000 to 1500 mm in the highlands of Eldama Ravine sub-county, and varies between 250 and 500 mm per annum in Mogotio and Marigat sub-county.

2.2 Research design

A cross sectional survey study was used in conducting this research. The study was conducted among the water pan users utilising the six randomly selected water pans in Central and South Baringo. The water pans used in the study were; protected (Cheraik) and unprotected (Kures, Kapchelukuny, Chepnyorgin, Kaptipsegem and Kinyach) water pans. Protected water pans as used in this study were those water pans that were fenced and had distinct water points for human access and livestock watering, whereas the unprotected water pans were those water pans that had no fence and there was free access for both humans and livestock to the water, increasing the level of contamination.

Nassiuma [8] formula was used to determine the household sample size that was used to administer the questionnaires and conducting the sanitary surveys. A preliminary survey was conducted prior the data collection to be able to identify the total number of households using the water pans. The total number of household were retrieved from the water pan committee members of the various water pans who verified the number of households using the water pans to be a total of 1130 households.

$$n = NC^2/C^2 + (N-1)e^2 \quad (1)$$

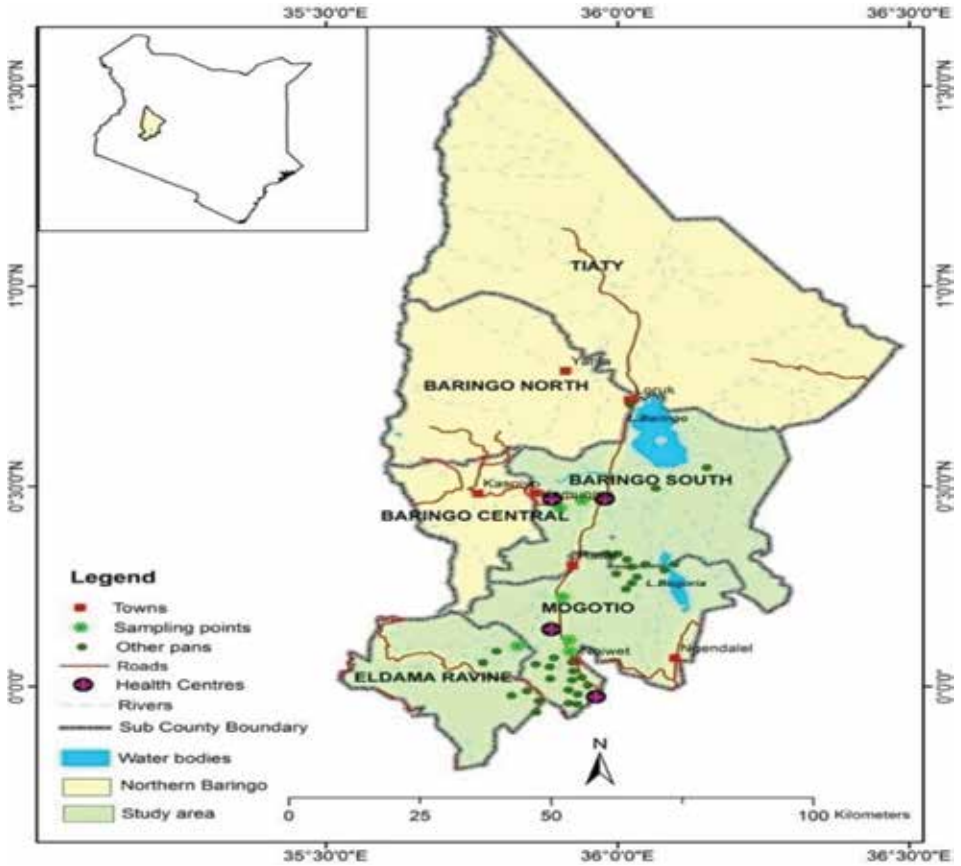

Figure 1.
Map showing the study area.

Where, N: represents the total number of households using the water pans (1130). n: represents the study sample size, C: coefficient of variation (30%) e: margin of error(2.9%).

Using the above formula;

$$n = 1133 \times 0.3^2/0.3^2 + (1133–1)0.02^2 \quad (2)$$

$$n = 98 \approx 100 \quad (3)$$

100 households were used in conducting the household survey and administration of the household questionnaires. They were proportionately selected from the water pan users using each water pan as shown in **Table 1**.

Primary data collection was done using observations and scheduled interviews of the selected households. Secondary data on the prevalence of water-related diseases in the study area was collected based on health records from health centres located in the study area.

2.3 Data analysis

Descriptive statistics were used to analyse the data on the demographic information. Pearson correlation was used in assessing the association of household water handling practices to the prevalence of water related diseases in the study area.

Name of the water pan (site)	N(n)
Cheraik	91(8%)
Kapchelukuny	396(35%)
Kures	46(4%)
Chepnyorgin	249(22%)
Kaptipsegem	57(5%)
Kinyach	294(26%)
Total	**1133(100%)**

Key: N is the total number of households using the water pans, whereas, n is the sample size selected from the water pan.

Table 1.
Showing the proportionate distribution of the sample size per water pan.

3. Results

3.1 Demographic information of the respondents

Out of the 100 respondents randomly selected for this study 35% (n = 35) were male whereas the rest (65%) were female. The majority of the respondents were in the age bracket of 31–40 (32%) and 21–30 (30%) years of age respectively while the rest of the respondents were below 20 years. The age bracket of the respondents depicts a younger and youthful age of most of the resident communities in the study area. This was slightly higher than the national age bracket of 21–30(18.1%) and 31–40(14.5%), respectively in Kenya. The education level of the respondents from the study area is shown below (**Table 2**).

3.2 Water sources in the study area

Water pans are open surface water and prone to contamination. Seventy-two percent of the households depended on water drawn from pans for cooking, drinking, bathing and livestock (**Figure 2**).

3.3 Time taken to and from the water sources

This study found out that water pans have eased the time spent by the water pan users within the study area in search of water for cooking and drinking with most of the respondents spending less than an hour on a round trip of water, some could spend as few as 10 minutes on a round trip due to the close proximity of the excavated water pans. (**Figure 3**).

Highest education level attained	Percentage (%)
University	3
Tertiary colleges	11
Secondary schools	35
Primary	45
Did not go to school	6
Total	100

Table 2.
Education level of the respondents.

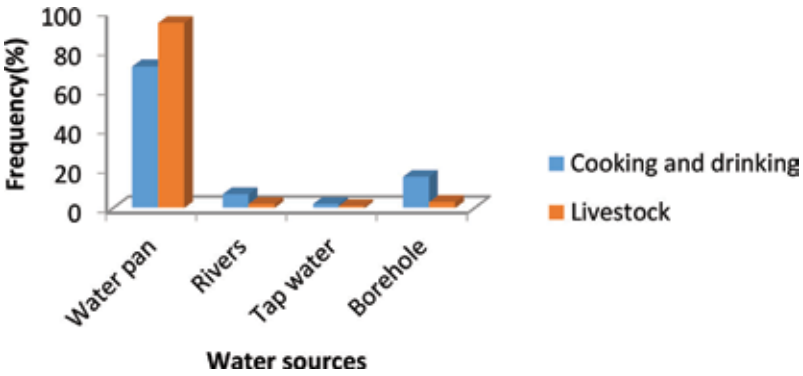

Figure 2.
A graph showing the water sources for cooking, drinking and livestock use.

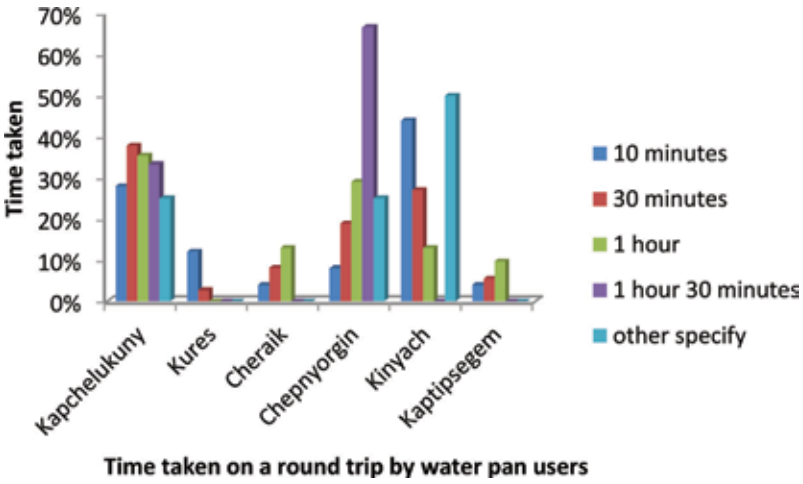

Figure 3.
A graph showing time taken on a round trip to nearby water sources.

3.4 Household knowledge and attitudes on drinking water

A Likert scale showed that 33% of the respondents perceived the water they drink from the water pans as good, 19% perceived them as bad since they were covered with algae and has a bad smell and 48% perceived the water they drink to be fair because they had never suffered from any disease while using the water pan water for drinking.

3.4.1 Household water handling practices

3.4.1.1 Drinking water storage containers

Approximately 71% of the respondents used plastic containers to store their drinking water. This was explained as easily affordable in the market and provided a good option for safe water storage at household level. Nineteen percent of the study population used jerry cans (**Figure 4**), this was explained by the respondents as easy to carry and readily available in the market. The jerry cans are available in various capacities that could also be carried by small children. Six percent used clay pots to store drinking water in their households, as it keeps water cold and reduces microbial contamination (**Figure 4**).

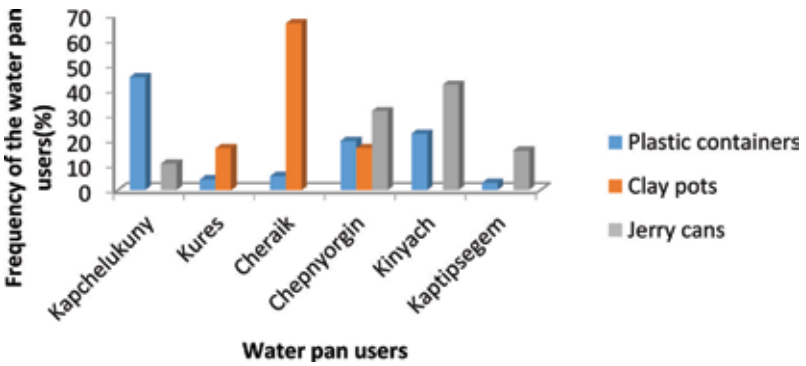

Figure 4.
A graph showing drinking water storage containers used by the water pan users.

3.4.1.2 Location of drinking water storage container in the house

The storage containers were located in different parts of the room. According to 57% of the respondents their drinking water storage containers were located in the corner of their living room. This was associated to protection of the drinking water storage container from contamination and damage. Seventeen percent of the respondents stored their drinking water storage containers in the kitchen, since it was easily accessed and also used for cooking. Fourteen percent of the respondents stored their drinking water storage containers at the door of the living room, since it was easily accessed and the living room was clean and safe from contaminants.

3.4.1.3 Water handling in the household

Ninety three percent of the respondents covered their drinking water storage containers. Eighty three percent used tight fitting lids of the containers, 3% covered them using a clean cloth and 4% did not cover their containers. According to this study, the drinking water storage containers were cleaned as per the following frequencies; daily (11%), after 2 days (16%), weekly (42%), and yearly (3%). The cleaning was conducted upon the presence of dirt in the drinking water storage container. Approximately 60% of the households in the study area cleaned their drinking water storage containers. On average 52% of the respondents used soap and water, 25% used sand and water whereas 13% used water only to clean their containers. This was believed to remove dirt in the storage container. Those using sand and water, believed that due to the abrasion nature of the sand, it was a good material that could remove the bio film formation in the drinking water storage container.

3.4.1.4 Mouth sizes of drinking water storage containers and mode of access

Mouth sizes of the drinking water storage containers varied from one household to another in the study area. The mouth sizes were categorised into narrow, small, wide and medium. The drinking water storage containers that were categorised as **Small** mouth size identified the 5 litre- 35 litre jerry cans that are used in the household for the purpose of storing drinking water in the household. **Medium** mouth sizes were those containers with a minimum volume of 50 litres to a maximum volume of 10,000 litres that had a tap fitted in it used in fetching water. **Wide** mouth sizes were used to identify the buckets that were used to store drinking water in the household.

Fifty-five percent of the respondents reported that adults fetched water for the young children; because children were likely to contaminate drinking water upon access. In 38% of the households children fetched their drinking water for themselves increasing the chances of fecally contaminating the household drinking water (**Figure 5**).

3.4.2 Household water treatment in the study area

Averagely, 34% respondents in the study area treated their drinking water. This was explained as a way of killing the pathogens in drinking water. On average 19% of the respondents boiled their water before drinking. This was attributed to the existing knowledge of killing the diseases causing pathogens in water before consumption. On average 11% of the respondents reported using chlorine and its constituents (5.25% NaOCl) to treat their drinking water, sodium hypochlorite was preferred by the respondents due to the residual effects they have in killing microbial contaminants.

3.4.3 Household solid wastes

Data from household questionnaires and observation schedules indicated that approximately 89% of the households disposed of their household solid waste through burning, thus there was no waste lying at the resident compounds at the time of visit. Eleven percent of the respondents reported throwing their solid wastes away in the open; it was observed that the latter had solid wastes lying within the proximity of their compounds.

3.4.4 Hand washing

Findings from this study indicated that 31% of the respondents washed their hands before eating, because of cultural beliefs and taboos. Seventeen percent washed their hands after visiting the toilet and reported to have been trained by the public health officers, after taking a sick child to the hospital. Other critical hand washing times identified in the study included; during cooking (4%) and after handling children faeces (9%).

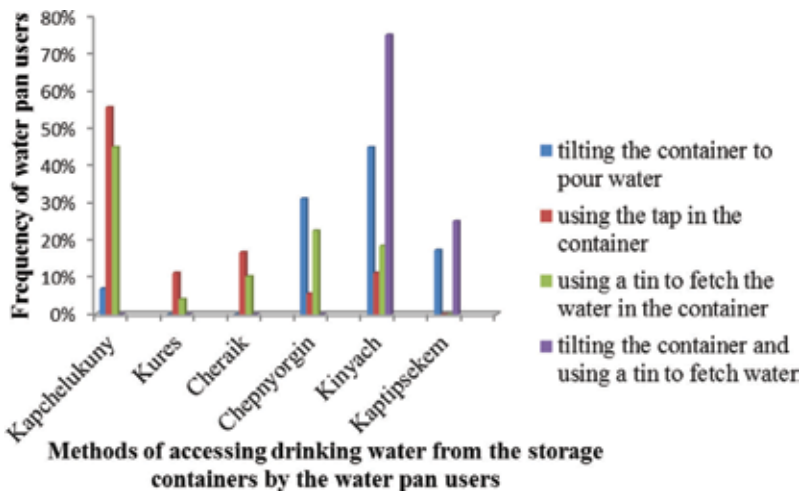

Figure 5.
Figure showing methods used to access drinking water from the storage containers.

Sources of hygiene advice	Percentage (%)
Public Health Officer	28
APHIA II	13
APHIA Plus	9
Clinics	3
School	2
SIDA	1
World Vision	1
WHO	1
Never heard	42
Total	100

Table 3.
The sources of information on personal hygiene in the study area.

The study results further indicated that respondents used the following materials to wash their hands; water only (13%), soap and water (86%) and mud and water (1%).

3.4.5 Sources of hygiene awareness

Fifty nine percent of the respondents had received information on personal and food hygiene, whereas, 27 and 13% indicated that they had received information on sanitation and hand washing. However, 12% of the respondents indicated that they had not received any hygiene awareness during the past 1 year (**Table 3**).

4. Discussion

The 2014 National Demographic and Health Survey showed that 5% of Kenyans had no education, 23.4% had primary level and 45.4% had secondary school education and above. From this survey, the level of education in Central and South Baringo was lower as compared to the national figures. The income level of the resident communities in the study area were far much below a dollar per day, and are categorised among the lowest wealth quintile in Kenya, reported to be at 14.8% [9].

Findings from related studies indicated that 51% of the respondents in Kakamega obtained their water from open sources that are prone to contamination [10], In Central and South Baringo resident communities reported using the water pans for sourcing their household water for use, since it was the only available water source within their reach. In Tanzania, a study documented that only 49.7% of the studied population had access to improved water sources [11], with the remaining portion dependent on unimproved water sources. Use of unimproved water sources for cooking and drinking at the household exposes the household members to consumption of fecally contaminated water causing water related diseases.

Findings from the current study indicated that respondents spent less time in accessing water compared to other studies. Afullo et al. [12] in their study found out that averagely 26.7% of the Kenyan households in ASALs spent under 30 minutes on a round walking trip to and from water sources. Another study by Mohammed et al. [6] found that 41.2% of the respondents in Dukem town Ethiopia spent less than 30 minutes in one round walking trip to obtain drinking water for their households.

Despite the efforts to increase water accessibility to the study population, some of the residents of Central and South Baringo are still spending a lot of time in search of this valuable resource. These study findings were in agreement with other study findings that found out that 42.8% of the households in Kenyan ASALs took more than 1 hour to fetch water in a one round trip. However, in this study majority spent 30 minutes and below on a round trip [12]. In Nakuru municipality 55.4% of the respondents were documented to spend more than 1 hour. in one round trip of fetching water, however, this study recorded 44% households spending 1 hour or more on a round trip of water accessibility [13]. Mohammed et al. [6] found that an average of 17.6% of the respondents took more than 30 minutes to obtain drinking water on a round trip.

With respect to the householder's perception towards water handling Our study findings showed similarities with those of Baig et al. [14] and Sibiya and Gambi [15]. A study in Northern Pakistan revealed that health was not a householder's areas of concern, since they had other pressing needs and that people were not concerned about the poor quality of drinking water as a result of floods [14]. Another study conducted in Nepal revealed that there was lack of knowledge and practices in rural areas regarding water source and sanitary facilities maintenance [16].

In terms of household water storage, the current study findings are similar to those of Mohammed et al. [6] who found out that most respondents (74.4%) in Dukem town used plastic jerry cans container to store drinking water. Safe water storage at the household level helps in preventing microbial water contamination causing water related diseases at the household level. This study finding contrasts with that of a study done in Kakamega that found out that respondents stored their water in different places in the house to make it cool for drinking [10]. Location of drinking water storage containers has not been of householder's concern in regard to microbial contamination of the drinking water, but in making the water cool for drinking. These findings were comparable to Mohammed et al. [6], who found out that 93.2% of the respondents covered their drinking water storage containers. Covering of drinking water storage containers provided a safer way of preventing household drinking water from the risk of microbial contamination.

Twenty nine percent of the households stored their drinking water in jerry cans with small mouth sizes. The containers were tilted to pour water, preventing contamination and was regarded a safer way of accessing drinking water. Forty nine percent of the households used a tin to fetch water from the drinking water storage container; this allowed the household members to place hands and or cups into the stored drinking water increasing the risk of faecal contamination of drinking water. Eighteen percent of the households used the tap fitted in the container to fetch drinking water from the containers, this was the safest way of accessing drinking water without contaminating the water in the storage container during water access. A study conducted in Nyakach in Kisumu found out that 4.8% of the respondents stored their water in a storage container which had a tap in it [17]. This study recorded the highest number of household using safe means of accessing drinking water from the containers. Point of use contamination of water has been perceived to be the leading microbial contamination of drinking water in the households among communities.

The findings of this study contrast greatly with those of Uwimphuwe et al. [18], in their study in Rwanda that showed 67% of the respondents treated their water. This study was comparable to other studies by Onyango and Angienda [5] in Western Kenya found out domestic water treatment practices to include boiling and use of sodium hypochlorite. Wasonga et al. [19] in their study found out that commonly used water treatment options in Nyakach, Kisumu County included use of chlorine. Household water treatment is significant in the reduction of water related diseases such as diarrhoea. Onyango and Angienda [5] study in Western

Kenya deduced that diarrhoea cases were significantly reduced as a result of domestic water treatment. A systematic review and Meta-analysis by Struntz et al. [16] revealed a reduced prevalence of soil transmitted helminths infection as a result of using treated water from a pre-intervention prevalence rates of 68.3% to the post intervention prevalence rates of 43.95%. Studies by Kipyegen et al. [20], revealed that high parasitic infections in Baringo County were associated with inadequate water availability, poor sanitation and lack of water treatment practices in the households.

Hand washing is important in the reduction of communicable diseases. This lack of basic hand washing hygiene adversely affects household water quality as the household members dip their hands in storage containers to access water for household tasks. This study finding contrasted greatly to observations made by Uwimphuwe et al. [18] in their study in Masaka Rwanda, in which they found that 97% of the respondents washed their hands before eating and 20% of the respondents washed their hands before preparing food and 31% of the respondents washed their hands after handling babies. The hand-washing practice is poorly observed in the study area. This study finding was comparable to a study conducted in Masaka Rwanda that indicated that the respondents used soap and water (87%), ash and water (1%) and water only (12%) to wash their hands [19]. Our findings were consistent with those of Wasonga et al. [19] that found out that only 7% of the respondents in Nyakach, Kisumu County reported using soap to wash their hands after visiting the toilets.

Despite the high level of household waste management observed in the study area, 11% of the unmanaged household solid waste can cause serious health problems during the rainy season, as the waste are carried off by run-off to the water pans, thus increasing the level of microbial contamination. Haphazard disposal of solid wastes provide breeding sites for disease vectors such as mosquitoes and flies. This study contrasted with that by Wasonga et al. [19] that observed that 37% of the respondents owned dumpsite within their homestead. Another study by Karija and Shihua [21] linked the high prevalence of typhoid, cholera and diarrhoea in Juba, South Sudan to solid wastes carried off by run-off during the rainy seasons.

Finally, our study findings were consistent with those of Wasonga et al. [19],who indicated that 41.5% of the respondents reported community health workers/clinics were their main source of information on hand washing, whereas 23.4, 20.2 and 9.6% indicated that media, schools and community gatherings, respectively, as their sources of information. Hygiene practices at home have been noted to provide a clean environment for children, thus reducing the threats to their health and provide the best chance of a prosperous living [19, 22–24].

5. Conclusions

The water, sanitation and hygiene (WASH) information received by the resident communities is inadequate in reducing the occurrences of water related diseases that occur as a result of improved household hygiene. Increasing the level of community awareness on adequate household, personal and behavioural hygiene is necessary in reducing the prevalent water related diseases in the study area.

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Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Ethical approval

The participants were asked for consent prior to gathering of information and anonymity as well as confidentiality was highly maintained while carrying out the study.

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Chapter 7

Water Quality Monitoring Infrastructure for Tackling Water-Borne Diseases in the State of Madhya Pradesh, India, and Its Implication on the Sustainable Development Goals (SDGs)

Abhishek Parsai and Varsha Rokade

Abstract

It is estimated that around 37.7 million Indians are affected by water-borne diseases annually, 1.5 million children are estimated to die of diarrhoea alone, and 73 million working days are lost due to water-borne disease each year. The resulting economic burden is estimated at $600 million a year. Owning the largest share, India has a significant role to play in achieving global Sustainable Development Goals. In such scenario, monitoring of drinking water quality and its improvement plays a significant role in ensuring public health and reducing economic burden. Taking cue from this, a study was designed to assess the efficiency of water quality laboratories established under the National Rural Drinking Water Programme in the State of Madhya Pradesh. In the state, which tops the list of states in the country with the highest infant mortality rate (IMR), the drinking water quality assessment infrastructure is not in a position to monitor the water quality in rural areas. The study assessed that none of the 56 laboratories was able to perform a minimum of 3000 tests per year (annual analysis load) in the state for monitoring water quality. This paper presents the findings of the statewide status of water quality in rural areas and also qualitative assessment of 56 water quality laboratories in 16 districts.

Keywords: water quality, water-borne diseases, water quality laboratories, field test kits, SDGs, MDGs

1. Introduction

Sources of good quality water for drinking and domestic use, whether surface or groundwater, are fundamental to human health. Water quality is naturally influenced by the climatological and geochemical location of the water body through temperature, rainfall, leaching and runoff of elements from the Earth's crust. Consumption of water containing pathogens or elements that are potentially toxic can lead to health impacts ranging from discomfort to death [1]. Though the global

Millennium Development Goals (MDGs) target for drinking water was met in 2010, 663 million people still lack improved drinking water sources. 96% of the global urban population uses improved drinking water sources, compared with 84% of the rural population. 84% of the people who don't have access to improved water lives in rural areas, where they live principally through subsistence agriculture. Eight of 10 people without improved drinking water sources still live in rural areas. In developing countries, as much as 80% of illnesses are linked to poor water and sanitation conditions [2]. Besides the current target (achieved) was based solely on access to an improved facility, the definition of "improved" does not take into account other important parameters such as drinking water quality, adequacy of quantities available for domestic or productive uses, distance to water source, time spent to access and use facilities, reliability and maintenance of services, affordability and social barriers to access and safe disposal and treatment of wastewater. Furthermore, any recalibration of targets and/or adoption of stricter definitions of improved would result in significantly higher estimates of population receiving services below a basic standard [2].

With 78.5 million people, India is at the top amongst countries with the largest number of people without access to safe water. Most of those people are living on around £3 a day. India is also amongst the top ten worst countries for household water access. Besides these distinctions, the country has the State of Madhya Pradesh with the highest infant mortality rate (IMR) (57 deaths of children less than one year of age per 1000 live births) [3], which is worse than some of the African countries often cited for poor health indices. According to the World Bank, the IMR for Rwanda for the same year was 33, Ethiopia 43 and Zambia 45. Increased access to improved water sources is significantly associated with decreased under-five mortality rate, decreased odds of under-five mortality due to diarrhoea, decreased IMR and decreased odds of MMR. Access to water and sanitation independently contributes to child and maternal mortality outcomes [4]. If the world is to seriously address the Sustainable Development Goals (SDGs) of reducing child and maternal mortality, then improved water and sanitation accesses are key strategies.

2. Policy framework governing water quality in rural India

The 12th Five-Year Plan (2012–2017) [5] has placed a greater thrust on coverage of the water quality-affected habitations, in order to address water quality issues in rural areas. As per the NRDWP guidelines (water quality) [6], 20% of the annual NRDWP funds are allocated for tackling water quality problems to enable rural communities to have access to potable drinking water. The NRDWP guidelines further stipulate that 3% of NRDWP funds on a 100% central share basis are to be used for water quality monitoring and surveillance activities at the field level and for setting up and operating water quality testing laboratories at the state, district and sub-district levels.

The Bureau of Indian Standards (BIS) has specified drinking water quality standards in India to provide safe drinking water to the people. As per the Bureau of Indian Standards, IS-10500-2012 [7], water is defined as unfit for drinking purpose if it is bacteriologically contaminated (presence of indicator bacteria particularly *E. coli*, viruses, etc.) or if chemical contamination exceeds maximum permissible limits (e.g. excess fluoride [>1.5 mg/l], total dissolved solids (TDS) [>2000 mg/l], iron [>0.3 mg/l], manganese [>0.3 mg/l], arsenic [>0.05 mg/l], nitrates [>45 mg/l], etc.).

The Uniform Drinking Water Quality Monitoring Protocol of the Government of India [8, 10, 11] describes specific requirements for monitoring drinking water

	Total no. of habitations	No. of habitations where all sources have been tested		No. of habitations where no source has been tested		No. of habitations where 75% of sources have been tested	
	Number	Number	%	Number	%	Number	%
India	1,692,133	113,781	6.72	1,088,514	64.33	155,583	9.19
Madhya Pradesh	127,169	22,924	18.03	69,918	54.98	32,052	25.20
16 districts	59,087	11,217	18.98	34,231	57.93	14,545	24.62

Source: www.indiawater.gov.in.

Table 1.
Habitation status based on lab testing. Madhya Pradesh state (as of 31 March 2014).

quality in rural areas. In addition, this document also includes requirements for setting up laboratories at state, district and sub-district levels and quality control for regular testing and surveillance of drinking water sources. The purpose of this document is to describe various elements of laboratory management practices.

Following the various provisions in the protocol and with funding provided by the Government of India, 51 district laboratories, 3 block laboratories and 106 sub-divisional laboratories have been established in 51 districts of the State of Madhya Pradesh. In the month of July 2014, an assessment of implementation of various provisions of the protocol with regard to (1) availability of space for analytical purpose; (2) availability of office equipment, instruments, glassware and chemicals; (3) availability of human resource; (4) sampling; (5) use of field test kits; and (6) safety measures was undertaken. The objective of the assessment was to find gaps in the above-mentioned six areas and also to suggest measures, so that each laboratory achieves the target of minimum 3000 water quality tests per year.

It is evident from **Table 1** that in the State of Madhya Pradesh there are only 22,924 (18.03%) habitations where all sources have been tested in laboratories, whereas in the case of 16 districts, it is 11,217 (18.98%). In the statewide number of habitations where no source has been tested in the laboratory, it is 69,918 (54.98%), whereas in the case of 16 districts, it is 57.93%. The number of habitations where 75% of sources have been tested in laboratories is 32,052 (25.20%) in the state and 14,545 (24.62%) in 16 districts. It is a point of concern that in 69,918 habitations (54.98%), quality of water and potential risks are not known either to nodal department or to common people, i.e. water users.

3. Methodology

The Uniform Drinking Water Quality Monitoring Protocol prescribes various provisions with regard to availability of space for analytical purpose, availability of office equipment, instruments, glassware and chemicals, availability of human resource, sampling, use of field test kits and safety measures for water quality laboratories. Based on various provisions of the protocol, a structured questionnaire was designed. The questionnaire was used to collect data from chief/head chemists of all 56 water quality laboratories in 16 districts (Annexure I). The data collected in each category was analysed against the respective provision in the protocol. For example, absence of separate analytical space for biological testing of water samples against space as prescribed in the protocol highlights a gap. Absence of office equipment such as computer and internet connectivity highlights a gap in data entry and so on.

4. Results and discussion

This section highlights data collected from 56 laboratories against prescribed provisions in the protocol. Column 1 depicts provision prescribed in the protocol, whereas Columns 2 and 3 show data collected from the laboratory staff on the respective provision of the protocol. The information has been analysed in five categories altogether (**Table 2**).

Categories ↓	**As prescribed in the protocol**	**Survey data (% of labs)**		**Figure**
	1	2		3
		Yes	**No**	
Space	Space for analysis (district level 60m^2 including 20m^2 for bio and block level 50m^2 including 20m^2 for bio)	26.79	73.21	1
	Separate space for biological testing	17.86	82.14	
	Space for storage (inm^2) (district—25 and block—20)	12.50	87.50	
	Space for office and library (inm^2) (district—15 and block—10)	12.50	87.50	
	Total space requirement (inm^2) (district—100 and block—80)	25.00	75.00	
Office equipment	No. of computers (district—1 and block—1)	41.07	58.93	2
	Internet	39.29	60.71	
	No. of UPS (at least 1)	30.36	69.64	
	Inverters (backup time = 3 hours) (district—2 and block—1)	16.07	83.93	
	Printer	37.50	62.50	
	Telephone facility	28.57	71.43	
	Fax	3.57	96.43	
Minimum requirement	Instruments	48.21	51.79	3
	Glassware	82.14	17.86	
	Chemicals	57.14	42.86	
	Air conditioner	10.71	89.29	
Human resource	Chemist/water analyst	75.00	25.00	4
	Microbiologist/bacteriologist	21.43	78.57	
	Laboratory assistant	51.79	48.21	
	Lab attendant	14.29	85.71	
	Data entry operator	17.86	82.14	
	Person engaged exclusively for sample collection	9.00	91.00	5
	Mobility allowance to sample collectors	8.93	91.07	
Sampling	Availability of written code/guidelines for sample collection in laboratories	52.00	48.00	6
	Retesting of positively tested samples for analysis validity and confirmation of results	66.07	33.93	7
	Maintaining record of test results	60.71	39.29	8

Categories ↓	As prescribed in the protocol	Survey data (% of labs)		Figure
	1	2		3
		Yes	**No**	
Field test kits	Purchase of FTKs in the last one year	26.79	73.21	9
	Distribution of FTKs to gram panchayats	25.00	75.00	10
	Checking FTKs for reliability and validity of testing	37.50	62.50	11
Safety measures	Staff awareness on precautions with hazardous chemicals	82.14	17.86	12
	Staff awareness on precautions with hazardous equipment	85.71	14.29	
	Availability of fire extinguisher	10.71	89.29	
	Availability of first-aid kit	26.79	73.21	
	Fume hood in the laboratory	7.14	92.86	

Source: Survey data.

Table 2.
Provision vs. survey data.

4.1 Availability

Out of 56 laboratories, 73.21% of laboratories do not conform to the space norms for analytical and related purposes as prescribed in the protocol. About 82.14% of laboratories do not have separate space for biological testing of water samples as prescribed. In 87.50% of laboratories, sufficient space is not available for storing necessary chemicals, instruments, office equipment and furniture. About 58.93% laboratories devoid of computer, and 60.71% laboratories don't have internet facility. About 71.43% laboratories don't have the telephone and fax facilities.

The minimum instruments, glassware and chemicals required for testing of 13 basic parameters are not available in 51.79, 17.86 and 42.86% of laboratories, respectively. About 89.29% of laboratories do not have sufficient resources for testing of parameters (other than 13 basic parameters) such as heavy metals.

4.2 Human resource

Though survey data show posting of a chemist/water analyst in 75.00% of laboratories, they are not the regular staff. About 78.57% of laboratories don't have a microbiologist/bacteriologist for bacteriological testing of samples and their interpretation. In 48.21% of laboratories, laboratory assistants are not posted to assist a chemist/water analyst in analytical work. About 85.71% laboratories don't have a lab attendant. The posts of data entry operators for entering analysis data are vacant in 82.14% of laboratories. A 91% of laboratories don't have sampling assistants for collection, transportation and coding of sample. In 91.07% of laboratories, sample collectors are not paid mobility allowance for meeting basic travel expenses in sample collection.

4.3 Sampling

A 48.21% of laboratories don't have written code/guidelines to be followed during collection of samples. A 66.07% of laboratories reported to have conducted retesting of positively tested samples for validation, but the lab staff failed to

produce any documentary evidence in support of their claim. In 39.29% of laboratories, though staffs maintain separate register for positively tested samples, it was not found updated in 62.50% of such cases (62.50% of 39.29%).

4.4 Field test kits (FTKs)

In the last one year (prior to survey), 73.21% laboratories did not purchase FTKs for distributions to Gram Panchayats. Though 26.79% laboratories reported to have purchased FTKs in the last year, out of that only 37.50% of laboratories distributed them to Gram Panchayats. In 71.43% of laboratories, FTKs are not tested for validity and reliability of testing.

4.5 Safety measures

The staff in 82.14 and 85.71% of laboratories were found aware on safety measures while dealing with hazardous chemicals and equipment, respectively, but requisite safety measure, viz. fire extinguishers, first-aid kits and fume hood, was not available in 89.29, 73.21 and 92.86% of laboratories, respectively).

5. Discussion

5.1 Space crunch putting laboratory's staff and performance at risk

The unavailability of exclusive space especially for biological testing makes samples vulnerable for contamination, which in turn decreases the reliability of test results. Unavailability of sufficient space for storing necessary chemicals, instruments, office equipment and furniture is creating difficulty for staff to perform and also posing threat to them (**Figure 1**).

5.2 Devoid of office equipment

Because of the unavailability of computer and internet facilities, the laboratory staff have to visit PHE division or subdivision offices, which simply wastes time and energy, and it is also responsible for delayed and poor data entry. The lack of

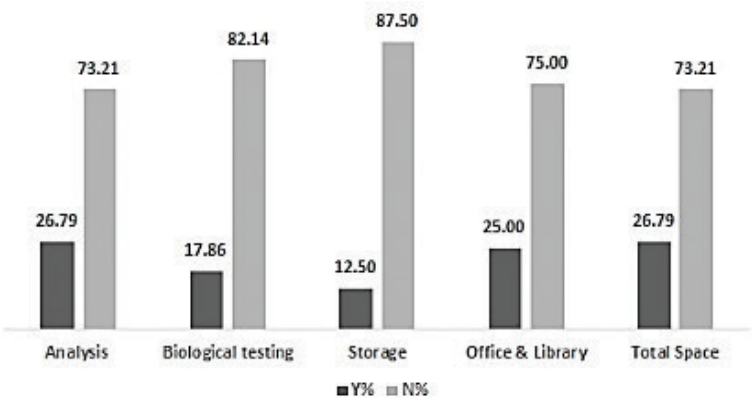

Figure 1.
Availability of space in laboratories.

telephone and fax facilities results in irregular and delayed communication among different stakeholders such as sample collectors in field, community water users and higher officers (**Figure 2**).

5.3 Insufficient instruments/glassware/chemicals for testing of 13 basic parameters and heavy metals

Unavailability of minimum instruments, glassware and chemicals required for testing of 13 basic parameters and heavy metals is causing laboratories to underperform. In the absence of air-conditioner or cooling facility, it is impossible to maintain optimum temperature for achieving accuracy in testing results. Because of the above gaps, none of 56 laboratories is able to achieve a minimum target of 3000 tests per year (**Figure 3**).

5.4 Dearth of qualified human resource

The lack of a regular chemist/water analyst in all 56 laboratories is making the undertaking of analytical work difficult. The absence of a microbiologist/bacteriologist is creating a problem in bacteriological testing of samples and their interpretation. It poses more threat in the case of drinking water sources, having damaged infrastructure like dilapidated hand pump apron, associated drainage systems and leaky distribution lines (**Figure 4**).

5.5 Faulty sample collection and record maintenance

Because of the unavailability of sampling assistants in laboratories, the work of sample collection, transportation and coding are severely affected. Not receiving payment for collecting and delivering samples even for meeting basic travel expenses is discouraging sample collectors. This ad hoc arrangement for sample collection has a negative effect on the performance of laboratories (**Figure 5**). The absence of written code/guidelines for sample collection is responsible for violation of sampling protocols, and it also raises serious questions on the accuracy of test results. Not retesting positively tested samples for validation raises doubts on the test results. Poor documentation especially of positively tested samples leaves no scope for future reference.

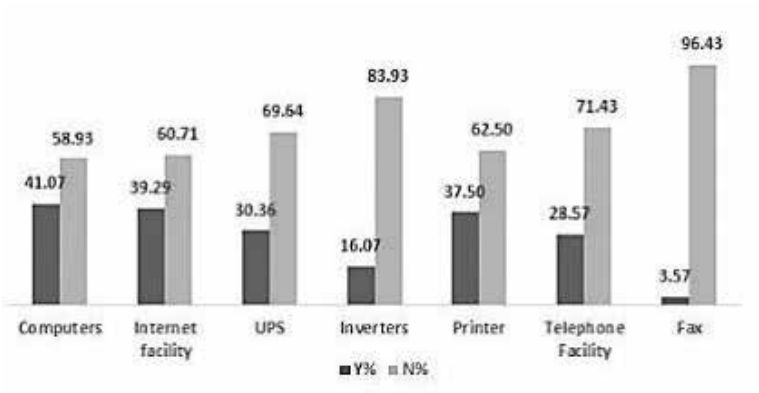

Figure 2.
Availability of office equipment in laboratories.

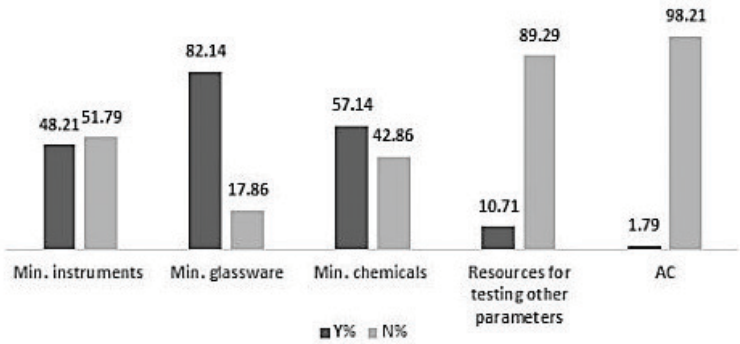

Figure 3.
Availability of instruments/glassware/chemicals.

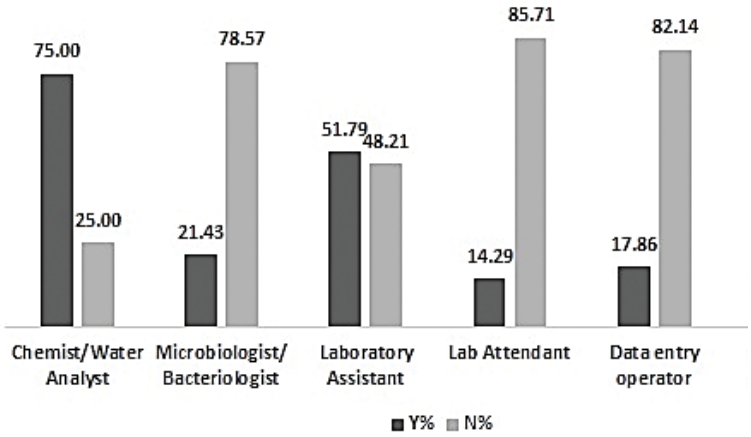

Figure 4.
Availability of human resource in laboratories.

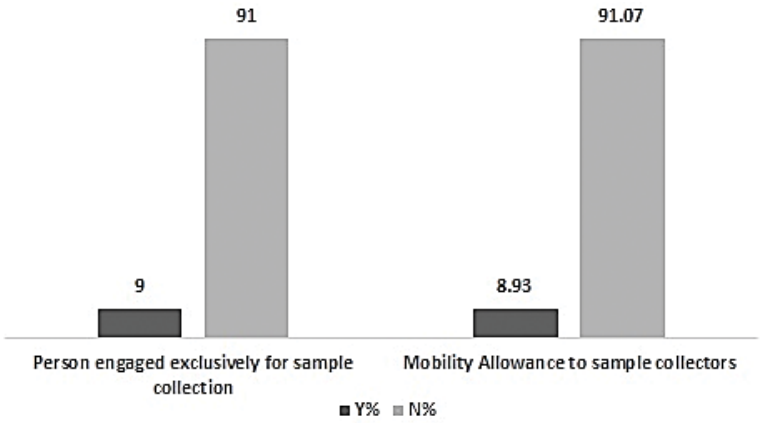

Figure 5.
Sample collectors and mobility allowance.

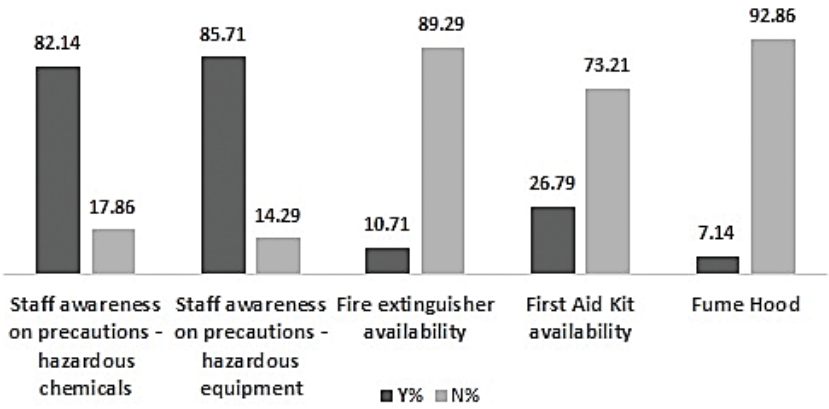

Figure 6.
Awareness on and availability of safety measures in laboratories.

5.6 Nonexisting community participation in water quality monitoring through field test kits (FTKs)

FTKs serve the purpose of initial screening of contamination, but they also are an effective tool for awareness generation amongst the community to consume only safe drinking water. Since majority of laboratories did not purchase FTKs in the last 1 year (prior to survey), it raises serious question on community participation in water quality monitoring through FTKs. Not testing FTKs in laboratories for checking their validity and reliability for water quality testing results in wastage of resources.

5.7 Insufficient safety measures

Though survey data indicate high level of awareness amongst the laboratory staff on the safety measures while dealing with hazardous chemicals and equipment, in majority of laboratories, the absence of safety measures such as fire extinguishers, first-aid kits and fume hood in laboratories is posing threat to the safety of the laboratory staff. It also puts psychological stress on the staff while working in laboratories (**Figure 6**).

Because of the above gaps, none of the 56 laboratories in 16 districts is able to perform a minimum of 3000 water quality tests per year (annual analysis load).

6. Conclusion

6.1 Interdepartmental coordination for space sharing or availability

Since most of the district and sub-district offices of the Public Health Engineering Department are not having their own lands except for offices, land may be availed on lease from the District Land Revenue Department.

6.2 Development of procurement system

Minimum chemicals, glassware, instruments and office equipment as prescribed in the protocol must be made available in laboratories. For this a procurement

system may be put in place. This system will help laboratories in periodic need assessment, product quantification and forecasting, budgeting and procurement planning. The procurement function may also be outsourced to an external specialised agency.

6.3 Recruitment of qualified human resource and their capacity building

In order to achieve efficiency in functioning of laboratories, qualified staff in sufficient number must be posted on a regular basis. If it is not possible for the entire state for the want of finances, it may be ensured at least for districts having more number of quality-affected sources. For capacity building of the laboratory staff and community water users, capacity building module based on the "Uniform Drinking Water Quality Monitoring Protocol" of the Government of India comprising salient features may be used.

6.4 Developing cadre of sample collectors and their capacity building

Amongst community members, a group of people especially the youth may be selected for developing them as a cadre of sample collectors. Their services may be incentivised through pecuniary or non-pecuniary measures. The capacity of this cadre may also be built on the use of FTKs for preliminary investigation of water samples. Ground staff of other departments such as ASHA, Anganwadi workers, school teachers, GP members, social workers, etc. may also be involved in collection of water samples from the field.

6.5 System development for random checking of positively tested samples

A separate register may be maintained for positively tested samples. From this register, samples may be chosen on random basis and may be retested. This random checking of samples should be made a routine activity for the laboratory staff. Results of positively tested samples need to be conveyed to the staff of the Public Health Engineering Department for taking remedial actions. Water users fetching water from such sources must be informed immediately, and necessary actions should be initiated.

6.6 Availability of safety measures in laboratories

Safety measures in sufficient quantity should be made available in laboratories for the safety of the laboratory staff. Standards operating procedures (SoPs) to be followed during emergency situations may also be developed, and staff should be oriented on the same.

6.7 Technological intervention for real time data and information management

Considering the dynamic nature of water sources and prevalence of water-borne diseases, it is very difficult for nodal department/agency to monitor and maintain the water resources and schemes spread over a large geographical area. This herculean task may be made simple and effective with the involvement of local water user communities. The use of FTKs by the local community provides an excellent opportunity for this kind of participation. But it has some limitations such as availability of FTKs, replenishment cost, frequency, etc. The modern Information and Communication Technology (ICT) for information sharing may also be applied in the field.

6.8 Upgradation of laboratories to national or global standards

The National Accreditation Board for Testing and Calibration Laboratories (NABL) is a constituent board of the Quality Council of India. NABL has been established with the objective to provide the government, industry associations and industry in general with a scheme for third-party assessment of the quality and technical competence of testing and calibration laboratories. Some of the laboratories of the state may be thought of upgrading to the NABL standards and may be used for exposure and training purposes.

There are certain risk factors that are associated with increased mortality and morbidity. The unsafe water and lack of sanitation are included in those preventable risk factors. Unsafe water supplies and inadequate levels of sanitation and hygiene increase the transmission of diarrhoeal diseases (including cholera), trachoma and hepatitis [9].

In such state, the infrastructure which is responsible for assessing and monitoring the water quality is in dismal condition. Though the world is on track to reach the drinking water target, it is projected to miss the sanitation target if trends remained unchanged; global rate of progress will be negatively influenced especially by poor progress in populous countries like China and India.

In order to reduce the rates of important health indicators such as IMR and MMR, strengthening of water quality monitoring infrastructure is of utmost important. If done properly, this would have a positive impact on global goals such as the SDGs, because India has a large share in these goals to be achieved by the year 2030.

Annexure I

List of districts and number of laboratories assessed.

S. no.	District	District laboratories	Subdivision laboratories
1	Alirajpur	1	2
2	Barwani	1	1
3	Chhatarpur	1	3
4	Damoh	1	2
5	Dhar	1	4
6	Dindori	1	2
7	Jabalpur	1	2
8	Jhabua	1	1
9	Mandla	1	4
10	Panna	1	1
11	Rewa	1	4
12	Sagar	1	4
13	Satna	1	3
14	Sehore	1	3
15	Sidhi	1	2
16	Tikamgarh	1	2
Total		**16**	**40**

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Edited by Natasha Potgieter and Afsatou Ndama Traore Hoffman

There are 17 comprehensive and detailed Sustainable Development Goals, which are all interlinked. Although access to water, sanitation, and hygiene is a human right, billions of people in developing countries are still faced with daily challenges accessing even the most basic of services, specifically the poor and vulnerable in communities. Hygiene is an important aspect for women/girls to access the economic, educational, and social opportunities they deserve. Proper hygiene removes disease as a barrier for equality, economic growth, and more. The role of hygiene in water, sanitation, and infections must be addressed from both scientific and social perspectives. This book provides the reader with an analysis of hygiene behaviors and practices and provides evidence-based examples in a number of developing countries.

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