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Period within Which Drinking Water Supply Should Be Restored in Malawi

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ABSTRACT

Supply of safe water is intermittent in some parts of the world. In Malawi, some of the water supply interruptions are long, and force consumers to fetch water from alternative sources. Most of the alternative sources, however, provide unsafe water which makes people to suffer from waterborne diseases. This situation can be avoided if the water supply interruptions are not long. However, the period beyond which safe water supply interruptions force consumers in Malawi to fetch water from other sources was not known. Therefore, the aim of this study was to establish this period. The study has established that people are forced to fetch water from other sources whenever safe water supply interruptions last for 1.4 days or longer. The paper, therefore, advises the water utilities in Malawi to ensure that safe water supply interruptions do not last for this long. Strategies for ensuring that safe water supply interruptions are not prolonged have been suggested in the paper.

KEYWORDS: drinking water supply, Malawi, prolonged water supply interruption, waterborne diseases

INTRODUCTION

In some parts of the world, safe water is supplied for only some hours per day or some days per week [1,2,3]. A study conducted in Malawi in 2013 in eight areas showed that, on average, safe water was available to the users for 13 hours per day [4]. In one of the eight areas, safe water was actually available for only 6 hours per day.

Prolonged water supply interruptions force people to use unsafe water [5,6]. Consumption of unsafe water, however, makes people to suffer from waterborne diseases [7,8,9]. This is the case even where the intermittency of the safe water supply is occasional [10]. For example, a study conducted between 2009 and 2014 in Uvira, South Kivu Province in the Democratic Republic of Congo found out that in the 12 days that followed a day without tap water, the cholera incidence rate increased by 155% on average [11]. Conversely, a study conducted in Hubli-Dharwad in India, established that prevalence rates of dysentery and typhoid fever were lower by 37% and 42% respectively in the households with continuous piped water supplies than the households with intermittent piped water supplies [12].

As regards Malawi, a study conducted by Ungwe [13] in eight areas situated in all parts of the country, found out that waterborne diseases accounted for an average of 2.2% of all illnesses. This prevalence rate signals a problem with the safety of the water used in those areas. Results from a worldwide study by Pruss-Ustun et al [14] show that waterborne diseases where 100% of the people use unsafe water account for an average of 3.5% of all illnesses.
Based on this finding, waterborne diseases in the eight areas, where about 80% of the people had access to improved water sources [15], should have accounted for 0.7% of all illnesses and not 2.2% (214% more than what it should have been). The high percentage of waterborne diseases suggests that despite living in the areas with piped safe water supplies, the people there sometimes use unsafe water. One reason for this is prolonged water supply interruptions [13].

Although it is well-documented that water supply intermittency forces people to use unsafe water; and that the people who consume unsafe water suffer from waterborne diseases [5,6,7,8,9], the period of water supply interruptions that force people to fetch and use unsafe water was not known. The aim of this study was, therefore, to establish the period within which drinking water supply should be restored in Malawi so that people are not forced to use unsafe water. The causes of the prolonged water supply interruptions were also studied and the solutions for improving the situation have been suggested.

RESEARCH METHODOLOGY

Water consumers who came to pay for water supply services at 5 water supply systems in Malawi, namely Chitipa, Mzuzu, Lilongwe, Zomba and Chiradzulu were requested to complete a questionnaire. In the questionnaire, the water consumers were asked to indicate the period that elapsed during water supply interruptions before they started looking for water from other sources. The consumers were also asked to indicate the average period of water supply interruptions at their premises. 483 consumers completed the questionnaire from a total of 86,000 water

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connections. The number of the respondents from each water supply system was proportional to the number of water connections in each water supply system i.e. 46 respondents from Chitipa, 82 from Mzuzu, 240 from Lilongwe, 71 from Zomba and 44 from Chiradzulu.

Selection of the water supply systems where the questionnaire was administered was purposive. The selected systems experienced different severity levels of water supply interruptions. The water consumers perceived that Chitipa, Lilongwe and Chiradzulu experienced quite prolonged water supply interruptions while water supply interruptions in Mzuzu and Zomba were not as prolonged.

The consumers who completed the questionnaire came from all parts of the selected water supply systems. This was achieved by administering the questionnaire at all the pay-points in the selected systems. The number of respondents from each area was proportional to the number of water consumers who dwelt in those areas.

After getting the responses on the two questions, in-depth study of ten water supply systems situated in all parts of Malawi (inclusive of 3 where the questionnaire was administered) was conducted. Senior managers of the institutions that managed the ten water supply systems were interviewed to find out the causes of the prolonged water supply interruptions. Purposive sampling was also used to select the ten water supply systems. The selection was done using the criteria that ensured that the selected water supply systems were representative of all the types of the piped water supply systems in Malawi. Among the selected 10 water supply systems, at least two abstracted raw water from each type of the four main water sources in Malawi (i.e. rivers, dams, lakes and boreholes); seven were managed by the Water Boards and three were managed by the communities; water supply was by gravity at four of the 10 case water supply systems and by pumping at the rest of the case water supply systems; five case water supply systems were located in the northern region of Malawi, three in the central region and two in the southern region. The above attributes of the case water supply systems are summarized in table 1.

Table 1: Overview of the case water supply systems for the current study

Case No.	Name of piped water supply system	Administrative region in Malawi	Type of managing institution	Type of water source	Means of water supply
1	Chintheche	North	Water Board	Lake	Pumping
2	Chipoka rural	Central	Community	River	Gravity
3	Chipoka town	Central	Water Board	Lake	Pumping
4	Chiradzulu	South	Water Board	River	Gravity
5	Chitipa	North	Water Board	Boreholes	Pumping
6	Ighembe	North	Community	River	Gravity
7	Mudi	South	Water Board	Dam	Pumping
8	Mzuzu	North	Water Board	Dam	Pumping
9	Nkhamanga-Lunyina	North	Community	River	Gravity
10	Salima	Central	Water Board	Boreholes	Pumping

To get a comprehensive and varied account of the key issues in the case water supply systems, at least three senior managers were interviewed from each of the five institutions that managed the ten water supply systems. A total of 17 respondents were interviewed. The five institutions that managed the case water supply systems were the Department of Water Supply Services, Blantyre Water Board, Central Region Water Board, Northern Region Water Board and Southern Region Water Board. Considering their positions, educational qualifications, work experience, and professional background, the senior managers were considered to be knowledgeable of the causes of the prolonged water supply interruptions in their organizations [16].

PERIOD BEYOND WHICH PEOPLE FETCHED WATER FROM OTHER SOURCES

The responses from the water consumers who completed the questionnaire are summarised in table 2.

Table 2: Period beyond which people fetched water from other sources

Name of water supply system	Average period of water supply interruptions (days)	Average period beyond which consumers fetched water from elsewhere (days)
Chitipa	3.1	1.0
Mzuzu	0.9	0.9
Lilongwe	1.9	1.4
Zomba	0.7	1.3
Chiradzulu	2.7	2.3
Average	1.9	1.4

Table 2 shows the average period of water supply interruptions at Chitipa, Mzuzu, Lilongwe, Zomba and Chiradzulu. The overall average period of water supply interruptions at the five water supply systems is 1.9 days. However, there was no data to which these findings could be compared. This was the case because the institutions that managed the studied water supply systems did not keep record of the periods of water supply interruptions.

Table 2 also shows the average period beyond which (whenever water supply interruption persisted) the water consumers at Chitipa, Mzuzu, Lilongwe, Zomba and Chiradzulu started fetching water from other sources. The overall average period beyond which the water consumers started fetching water from other sources is 1.4 days. Out of the 483 respondents, 114 respondents (24%) indicated that water supply interruptions at their premises lasted for 1.4 days or longer. Since each respondent indicated an average period of the water supply interruptions which they experienced, the response from each respondent has been considered to relate to one representative water supply interruption which they experienced. As such, the total number of responses has been taken as the total number of representative water supply interruptions that the water consumers experienced at the case water supply systems. Based on this logic, it is interpreted that water consumers experienced 483 water supply interruptions and 24% of these lasted longer than the period beyond which water consumers started fetching water from other sources. [As indicated above, the institutions that managed the studied water supply systems did not keep record of the periods of the water supply interruptions, hence there was no data to which these statistics could be compared]. This implies that during 24% of the water supply interruptions, people were forced to fetch water from other sources. The other sources from which water was fetched are wells, hand-pump boreholes, rivers, and lakes [17]. The water from these sources, however, was not treated and as such, it was not safe for human consumption [18,19]. This was the case because without treatment and not containing residual chlorine, the water easily got contaminated and caused waterborne diseases [7,8,9]. This explains the high percentage of waterborne diseases at 2.2% (of all illnesses) instead of 0.7% which would be in line with 80% people's access to improved water sources in the studied areas.

FACTORS THAT CONTRIBUTED TO THE PROLONGED INTERRUPTIONS OF WATER SUPPLY

Prolonged water supply interruptions were caused by the factors mentioned in the quotations in box 1.

Box 1: Factors that influenced prolonged water supply interruptions at the case water supply systems

"The source of water for this water supply system dries up completely during dry season due to catchment degradation and inadequate rains" (Respondent No. 14-7)

"... farmers divert water for irrigation from upstream of the river from which we abstract raw water. Last year, instead of taking water to their gardens through furrows, they blocked the whole river and there was no water at our abstraction point for a week" (Respondent No. 11-12)

"… power supply is erratic; making it impossible to pump water from the boreholes even though water might be available in the boreholes. As a result, days could pass without water supply" (Respondent No. 3-6)

"We are not able to provide continuous water supply because power supply is erratic … Power supply is available for 8 hours per day on average" (Respondent No. 12-6)

"The water supply system is no longer providing water to the users because materials for maintenance and cleaning of the tank are not available" (Respondent No. 14-7)

"In most cases, volunteers do not maintain breakdowns quickly. This is the case because they need time to work on activities from which they earn a living" (Respondent No. 21-7)

"Pipes that break frequently are those in shallow trenches and sometimes not backfilled" (Respondent No. 23)

"Raw water pumps for this water supply system break down frequently because impellers wear out often because the raw water contains small sand particles" (Respondent No. 11-4)

"This water supply system was commissioned in 1953. The pipes that were installed that time have not been replaced, rather the works that have been implemented over the years were for expanding the system. Such pipes burst a lot because of aging as well as high pressures which are exerted to pump water to high-lying areas where people are settling these days" (Respondent No. 1-1)

"When quality of raw water gets bad during floods in the rainy season, the treatment plant fails to handle the poor quality raw water, and the plant is stopped thereby affecting the quantity of water produced" (Respondent No. 8-12)

"There is intermittent water supply to some areas under this water supply system. However, this problem will no longer be there once the project for upgrading the distribution pipe network currently underway is completed" (Respondent No. 12-8)

"I remember one incident whereby we had run out of chemicals and we had to close the water treatment plant until we received the chemicals" (Respondent No. 11-12)

"One time, the volunteers were not available for some days to remove the leaves that had clogged the opening of the water intake pipeline and as such, there was no water supply in all those days" (Respondent No. 11-8)

The quotations in box 1 show that prolonged water supply interruptions at the case water supply systems were due to:

a. Limited available raw water;
b. Infrastructure that did not have sufficient capacity to produce and/or supply adequate water to satisfy the demand;
c. Limited capacity of water supply infrastructure to abstract and/or treat occasional poor quality raw water;
d. Lack of prerequisites for operating water supply infrastructure; and
e. Prolonged breakdown of water supply infrastructure.

The above factors caused prolonged water supply interruptions as follows:

i. Limited available raw water: The available raw water at some of the case water supply systems was sometimes less than the required quantity. The respondents explained that whenever the quantity of available raw water dropped below a certain level (due to various reasons), the amount of treated water produced was less than the demand. As such, the produced little water was rationed to the consumers. This was done by supplying water to the consumers only for some hours per day. This was the case at 4 of the 10 case water supply systems.

ii. Infrastructure that did not have sufficient capacity to produce and/or supply adequate water to satisfy the demand: Some of the water supply infrastructure did not have enough capacity to produce and supply adequate water to satisfy the demand. For example, the water treatment plant at one of the case water supply systems produced an amount of water which was less than the demand. In that case, the water utility was forced to ration the little water that was produced. As such, safe water was supplied to the consumers only for some hours per day. Similar situation prevailed at other 3 case water supply systems.

iii. Limited capacity of water supply infrastructure to abstract and/or treat occasional poor quality raw water: Some of the water supply infrastructure had limited capacity such that it was not able to abstract and/or treat occasional poor quality raw water. In some instances, occasional poor quality raw water could not be abstracted (during strong wave action in Lake Malawi) because the debris in the water choked the screen at the inlet of the pipeline. In other instances, occasional poor quality raw water (especially during floods) had to be diverted from the water treatment plant back into the rivers because the quality of the water was too poor to be treated by the existing plant. In addition, at one of the case water supply systems, during dry season, the raw water contained high concentration of calcium deposits. The calcium deposits clogged the pipelines, and there was no water supply to the areas which were served through the clogged pipelines. The situation remained like this until the pipelines were replaced. As a result, there were prolonged water supply interruptions.

iv. Lack of prerequisites for operating water supply infrastructure: Some of the prerequisites for operating the water supply infrastructure were not available sometimes. For example, there were either complete power outages or the provided power had low or high voltage, which if used, would have damaged the water supply plant and equipment. Therefore, the plant and the equipment was not operated during such situations. Further, while it was mandatory for some water supply systems to apply chemicals like chlorine to the water before it was supplied to the consumers, such chemicals were sometimes not available. The water treatment plant was stopped until the chemicals became available. The consequence of the unavailability of power supply and/or chemicals was that operation of the infrastructure was stopped. This resulted in prolonged water supply interruptions as sometimes it took long for the prerequisites to become available again. This was the case at 7 of the 10 case water supply systems where at least one of the prerequisites was not available at one time or the other.

v. Prolonged breakdown of water supply infrastructure: It took long to repair some of the broken-down water supply infrastructure at all the 10 case water supply systems. The breakdowns that took long to maintain were major breakdowns and/or a number of frequently-occurring minor breakdowns. It took long to maintain major breakdowns because such breakdowns needed to be maintained by experts and/or using special equipment. Mobilization of special equipment and experts, however, took long because the base for these were head offices situated far from the affected water supply systems. On the other hand, a number of frequently-occurring minor breakdowns took long to maintain cumulatively although individually such breakdowns were maintained within a short time.

The other reason for the delayed repair of breakdowns in the studied water supply systems was unavailability of the required spare parts and appropriate maintenance tools. As such, time was spent looking for spare parts or improvising them and/or taking a longer route of maintaining the infrastructure due to the unavailability of appropriate maintenance tools.

Another reason for the delayed repair of breakdowns was that some of the water supply systems were maintained by the volunteers who were not available sometimes. The volunteers were sometimes absent so that they could work on other activities from which they earned their income. This observation is supported by Carter et al [8] who state that voluntary roles are not sustainable in the long term. The consequence of all this was that there was no water supply throughout the periods that the infrastructure remained broken down.

The above findings are corroborated by Totsuka, Trifunovic and Vairavamoorthy [1] who state that prolonged water supply interruptions are normally due to scarce water resources and/or poor operation and maintenance practices. Table 3 shows the factors (out of the above five) that influenced prolonged water supply interruptions at each of the 10 case water supply systems.

Table 3: Causes of prolonged water supply interruptions at the case water supply systems

Case water supply system	**Cause of prolonged water supply interruptions**				
	Inadequate raw water	Insufficient capacity of infrastructure to produce and/or supply adequate water	Lack of prerequisites for operating infrastructure	Prolonged breakdown of infrastructure	Limited capacity of infrastructure to abstract and/or treat occasional poor quality raw water
Chintheche	X	X	√	√	√
Chipoka rural	X	√	X	√	√
Chipoka town	X	X	√	√	√
Chiradzulu	√	X	√	√	X
Chitipa	√	X	√	√	X
Ighembe	√	X	X	√	X
Mudi	√	√	√	√	X
Mzuzu	X	√	√	√	X
Nkhamanga-Lunyina	X	√	X	√	X
Salima	X	X	√	√	X

Key: √ ~ The cause influenced prolonged water supply interruptions at the system
X ~ The cause did not influence prolonged water supply interruptions at the system

ROPOSED STRATEGIES FOR SHORTENING WATER SUPPLY INTERRUPTIONS IN MALAWI

Based on the causes of the prolonged water supply interruptions discussed above, the following strategies (that correspond to the causes) are proposed to shorten the periods of water supply interruptions in Malawi:

a. *Ensuring that sufficient raw water is available to satisfy the demand*: As indicated above, prolonged water supply interruptions that occurred at 4 of the 10 case water supply systems were due to limited available raw water, among other factors. Yet for 6 of the 10 case water supply systems, prolonged water supply interruptions were due to other factors and not inadequate raw water. This was the case because raw water was adequate at the 6 case water supply systems. This means that availability of adequate raw water is one of the strategies for preventing prolonged water supply interruptions. Hodgkin [20], and Morita-Lou and Waters [21] support this strategy and state that water resources need to be sustained to achieve continuous water supply;

b. *Ensuring that water supply infrastructure has sufficient capacity to produce and supply adequate water that satisfies the demand*: Water supply infrastructure at 6 of the 10 case water supply systems produced and supplied adequate water that satisfied the demand. As such, prolonged water supply interruptions at the 6 case water supply systems were due to other factors and not insufficient capacity of infrastructure to produce and supply adequate water. While this was the case, insufficient capacity of infrastructure to produce and/or supply adequate water was one of the causes of prolonged water supply interruptions at 4 of the 10 case water supply systems. This implies that infrastructure that has sufficient capacity to produce and supply adequate water that satisfies the demand is one of the strategies for preventing prolonged water supply interruptions. Lockwood [22] supports this

strategy and advises that infrastructure should continue to produce and supply water of sufficient quantity if drinking water supply services are to be sustainable;

c. *Ensuring that water supply infrastructure has sufficient capacity to operate in all possible conditions*: The condition of the environment in which water supply infrastructure operates should be assessed regularly so that the infrastructure is upgraded and/or modified to operate under the new conditions. For example, where the quality of raw water sometimes gets bad (even where the inflow of the poor quality raw water is occasional), the infrastructure should be upgraded so that it is able to abstract and/or treat the occasional poor quality raw water;

d. *Ensuring that prerequisites for operating water supply infrastructure are always available*: All prerequisites for operating water supply infrastructure should always be available. For example, where water is produced and/or supplied by pumping, power supply should always be available. Where there are prolonged outages of the usual power supply, alternative standby power sources should be provided. RWSN [23] states that power should always be available in the appropriate measure if pumping water supply systems are to be operated continually. In addition, other prerequisites like chemicals should always be available. Lockwood [22] advises that the requirements necessary to operate the infrastructure should always be available in the required quantities and quality; and

e. *Preventing occurrence of major and/or frequent breakdowns, and quick maintenance of broken-down water supply infrastructure*: Water supply infrastructure should be designed and constructed in such a way that there should not be major and/or frequently-occurring breakdowns. However, where major and/or frequent breakdowns still occur, there is need to shorten the maintenance period. This can be achieved by putting in place measures for quick maintenance of the broken-down infrastructure. This strategy is supported by Carter et al [8] who state that breakdowns should be repaired as quickly as possible if drinking water supply services are to be sustained.

A follow-up study will be conducted to identify the specific tactics for implementing the above strategies.

CONCLUSIONS AND RECOMMENDATIONS

One of the key factors that force people in Malawi to fetch water from other sources other than the usual piped supplies is prolonged water supply interruptions. Water consumers at Chitipa, Mzuzu, Lilongwe, Zomba and Chiradzulu water supply systems in Malawi perceive that up to 24% of the water supply interruptions last for 1.4 days or longer. Yet the people in these areas can only wait for water from the piped systems for up to 1.4 days on average. This means that people are forced to fetch and use water from the other sources during 24% of the water supply interruptions. The water from the other sources, however, is not safe for human consumption [18,19]. Considering that use of unsafe water causes waterborne diseases [7,8,9], it is recommended that water supply interruptions should not last for more than 1.4 days (34 hours) (the time beyond which people start fetching water from other sources). It is, therefore, important that the water utilities in Malawi should deal with the 5 key causes of the prolonged water supply interruptions. The 5 key causes, identified in this study, are limited available raw water, infrastructure that does not have sufficient capacity to produce and/or supply adequate water to satisfy the demand, limited capacity of water supply infrastructure to abstract and/or treat occasional poor quality raw water, lack of prerequisites for operating water supply infrastructure, and prolonged breakdown of water supply infrastructure. These causes can be addressed by employing 5 corresponding strategies, which are: (a) ensuring that sufficient raw water is available to satisfy the demand, (b) ensuring that water supply infrastructure has sufficient capacity to produce and supply adequate water that satisfies the demand, (c) ensuring that water supply infrastructure has sufficient capacity to operate in all the possible conditions e.g. the infrastructure should still function even when the available raw water is sometimes of poor quality, (d) ensuring that prerequisites for operating water supply infrastructure are always available, and (e) preventing occurrence of major/frequent breakdowns of water supply infrastructure as well as putting in place measures for quick maintenance of the broken-down infrastructure. Since each of the above strategies prevents occurrence of prolonged water supply interruptions by addressing the corresponding cause, employment of all the five strategies will address all the 5 causes of prolonged water supply interruptions. This will ensure that prolonged water supply interruptions will not occur at all in Malawi. It is, therefore, recommended that the Government of Malawi should develop a policy that will require that the above strategies should be employed in the management of all piped safe water supply systems in Malawi. This will ensure

that, whenever there is water supply interruption, piped water supply will be restored before people start fetching water from the sources that provide unsafe water.

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