GREY WATER AS AN ALTERNATIVE SOURCE OF WATER IN LOKOJA TOWN, KOGI STATE, NIGERIA

By

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ABSTRACT

Grey water utilization, a means of water conservation which also offer an alternative water source is the focus of this study. There is increasing advocacy for water conservation in places with water deficit as well as those with abundant fresh water in view of diminishing global water resources. With rising urbanization, population growth and seasonality of rainfall, especially in Nigeria, strain is placed on the available freshwater. This study examined the level of laundry, bath and kitchen water re-use in households; as well as their degree of usage for non-potable applications. A multi-stage sampling technique was employed for the household survey in Lokoja town, where 524 respondents in both planned and unplanned neighbourhoods were interviewed using structured interview schedule. First, nine neighbourhoods were selected from the twenty-two neighbourhoods thereafter, individual households were selected. Amongst laundry water, bath water and kitchen water, the most substantial grey water which was utilized in Lokoja town was laundry water in all the sampled neighbourhoods. The most common non-potable application was toilet flushing, while grey water re-use for other non-potable applications like car or motor cycle washing, road or street wetting, and irrigation of garden was not widespread. To promote greater adoption of grey water reuse, water education which addresses the issue of water reuse advantages is needed, this can be achieved through public enlightenment using both formal and informal settings.

KEYWORDS: Grey water, Population growth, Non-potable application, Urbanization, Water conservation, Water resources

INTRODUCTION

Global fresh water withdrawal in 2030 would be 6,900 billion cubic metre, which is forty percent in excess of the existing 4,200 billion cubic metre accessible, reliable and sustainable water supply from surface and groundwater sources (2030 Water Resources Group, 2009). The forecast by the United Nations Population Fund (2003) is that by 2025, if the present rate of water

consumption continues, two-third of the world's population may be subjected to varying levels of water scarcity, ranging from moderate to high incidence of water scarcity.

With an estimated population of 162.5 million, in 2011, Nigeria was the seventh most populous country in the world (World Bank, 2013). As the country's population, urbanization and standard of living continues to rise, there is also an increasing demand for water to meet various needs in particular, domestic and agricultural amongst others. Thus, water resources have been placed under great stress (Federal Ministry of Water Resources, 2004; UNICEF, 2008).

Water demand in urban areas is high and these areas are experiencing great challenges in meeting their water needs, especially in developing countries where water services are inadequate (Butler and Memon, 2006). This claim was corroborated by the National Population Commission (2009) when its survey revealed that access to potable water supply in Nigeria was still a luxury, with only about 20 percent of urban dwellers having the experience of turning on taps and enjoying potable water flow. To reduce the gap between the water demand and what is supplied, two options were opined: demand-side options and supply-side options. The demand-side options encompass all the initiatives that promote efficient use of the available water while the supply-side options involve the development of new water supply projects. According to Abbey (2013), many developing countries have focused on the development of water infrastructure to bridge the gap between water supply and demand. On the other hand, Turner *et al.* (2008) and Ward (2010) observed that demand-side option approach and supply-side option approach are being used side by side in developed countries with more emphasis on demand management so that undue stress would not be placed on available freshwater.

The development of new water sources and infrastructure in Lokoja at a period when the available financial resources of Nigeria and States allocation is dwindling, will be a difficult endeavour. Also, continuous high withdrawal from groundwater sources as an alternative to potable water supply poses a challenge to water management as the water source is not renewable in the short term (Lawton *et al.*, 2008). A shift towards a more efficient use of available water resources, where people are encouraged to use the same water more than once, is therefore advocated in places with water deficit as well as those with abundant fresh water in view of diminishing global water resources (Abenu, 2016).

Wastewater re-use has been identified as one way of providing alternative water source in the face of increased pressure on traditional water sources. It is aimed at safeguarding water for future generations through efficient use of water (Marks, 2003; Esposito, 2004; Winward, 2007). Although water treatments plants have grown in number to meet the challenge of wastewater treatment, some areas do not have treatment plants (Asano, 2002), but its absence has not stopped people using wastewater for beneficial purposes (Le, 2005, Abbey, 2013).

The applications of wastewater is diverse, encompassing both potable and non-potable uses. In 1968, the first world's potable water reclamation plant with a capacity of 4,800 m^3/d was constructed in Windhoek, Namibia (Anderson, 2003; Lahnsteiner and Lempert, 2007). Asano (2002) argued that non-potable applications are more common, and potable re-use is still a distant possibility0 in most places and may never be implemented except under extreme conditions. A list of some of non-potable application was made by the National Academy of

Sciences (2012), ranging from applications in industrial processes, irrigation of crops and landscape, establishment and sustenance of receding wetlands, to numerous domestic purposes such as flushing of toilets, watering residential lawns, washing cars and streets and supply of water to decorative fountains.

In Nigeria, there is a growing use of grey water, a type of wastewater in homes in the Sudano-Sahelian region of Nigeria owing to the severity of water scarcity brought on by climate change (Ndabula and Jidauna, 2010). Grey water is distinct from black water. Grey water being all wastewater produced in houses with exception of toilet wastewater, which is termed black water (Winward, 2007). Grey water from laundry and bath tubs when re-used directly for non- potable uses is a good way of preserving fresh water supply (Le, 2005). The grey water from laundry and bath tubs is low load grey water because of the low level pollution while grey water generated from kitchen sinks is high load grey water (Khatun and Amin, 2011). Khatun and Amin (2011) claimed that water re-use for toilet flushing and gardening could save 31-54% of potable water in households.

This research therefore investigates the extent of re-use of laundry, bath and kitchen water in Lokoja town. In addition, the level of usage of the grey water for diverse non-potable applications was examined.

THE STUDY AREA

Lokoja town, the study area, has a landmass of 63.82 sq. km (Ifatimehin *et al*., 2010). It is located between Latitudes 7^0 45' and 7^0 52' North of the equator. Its Longitudes stretches from 6^0 39' to 6^0 49' East of the Greenwich meridian.

Two seasons, wet and dry, are noticeable in Lokoja town. The wet season largely commences in April and ends in October, with annual amount that ranges from 804.5mm to 1767.1mm. While the dry season is usually from November to March (Audu, 2012). The mean daily temperature in the town is 27.7^{o}C (Audu and Rizama, 2012).

Lokoja is a confluence town as a result of Rivers Niger and Benue, the largest rivers in Nigeria, converging in the area. There are also some small streams in the study area, prominent among them are Mmeme, Akpomoba and Donko.

The total population of the study area as at 2006 was 196,643 (National Population Commission, 2006). The male population was 101,145 while the female population was 95,498. With Nigeria's population growth pegged at 3.2% by the National Population Commission (2009), the population of Lokoja in 2014 was projected to be 254,014. In Lokoja town, there are many types of land use as evident by the functions that the inhabitants apply to the land available; these include: residential, agricultural, recreational, transportation, educational, administrative, commercial and industrial land use.

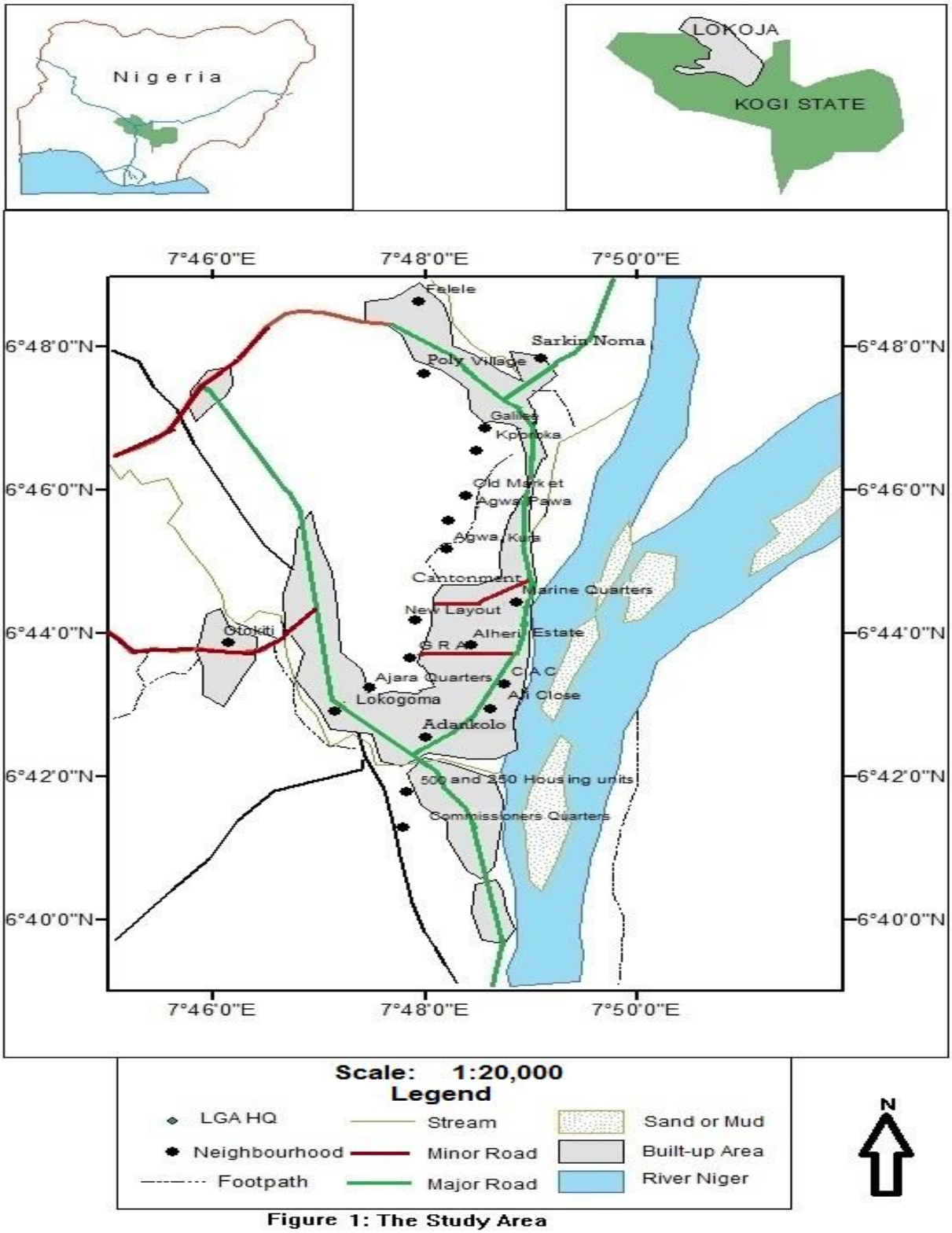

Figure 1: The Study Area

MATERIALS AND METHODS

Data for the study was obtained using structured interview schedule. This was administered to the heads of selected households, after verbal consent was solicited by the researcher and field assistants.

A multi-stage sampling technique was employed for the household survey. At the first stage of the sampling process, stratified random sampling was used in the selection of neighbourhoods. There are twenty-two neighbourhoods in Lokoja town, 14 of which are unplanned and 8 are planned. The number of the unplanned neighbourhoods is almost twice the number of the planned neighbourhoods. The number of selected neighbourhoods was proportional to the number of neighbourhoods in each stratum. While 6 out of the 9 sampled neighbourhoods were unplanned, the remaining 3 neighbourhoods were drawn from planned neighbourhoods. Subsequently, systematic sampling was used for the selection of households from the nine selected neighbourhoods at the second stage of the sampling process. Every tenth unit household from the selected neighbourhood was chosen for inclusion in the household survey at the second stage.

A total of 524 households were involved in the survey (Table 1). Most of the respondents, 372, were selected from unplanned neighbourhoods of the town and the remaining respondents, 152, were from the planned neighbourhoods.

Table 1: Structured interview schedule administered to sampled households in Lokoja

Neighbourhoods		**Number of Respondents**	
		Frequency	**Percent (%)**
Planned Neighbourhoods	Otokiti	32	6.1
	Ali Close	46	8.8
	Lokogoma Phase I	74	14.1
Unplanned Neighbourhoods	Sarkin Noma	68	13.0
	Old Market and environs	64	12.2
	Felele	124	23.7
	Adankolo	78	14.9
	Poly Village	24	4.5
	Galilee and Kporoka	14	2.7
	Total	**524**	**100%**

Source: Fieldwork, 2014

RESULTS AND DISCUSSION

Grey Water Utilization in Sampled Neighbourhoods

From the study carried out, about 39 percent (206 respondents) of the sampled households in Lokoja town utilized grey water. Utilization of grey water was practised across all the neighbourhoods studied, howbeit unevenly (Fig. 2). A much higher level of grey water re-use, 80 percent, was observed by Abbey (2013) in a study of four localities in Greater Accra

Metropolitan Area (GAMA). But the usage level in Perth, Australia, was comparatively lower as only 20 percent of the households utilized grey water (May-Le, 2004).

In the planned neighbourhoods, two out of the three sampled neighbourhoods, Lokogoma Phase I and Otokiti, presented a significantly low level of grey water re-use; with 17.6 and 25 percent usage respectively (Fig. 2). Most households (60.9 percent) in Ali Close adopted grey water. A result revealing that more access to potable water and better income made many respondents disinclined to adopt grey water utilization.

Two-third of the unplanned neighbourhoods in the survey, Old Market and environs, Poly Village, Sarkin-Noma, Galilee and Kporoka; had a relatively higher percentage of adoption of grey water re-use. More than 40 percent of the sampled households in the aforementioned neighbourhoods adopted grey water re-use. Old Market and environs, had the highest proportion of grey water re-use (65.6 percent). Adankolo and Felele both recorded less than 40 percent usage. The result indicates a moderate to high level of reliance on grey water in unplanned neighbourhoods, which are also areas with either communal stand taps or no access to potable water at all (Table 2).

Table 2: Tap Water Supply Use in Sampled Neighbourhoods

Neighbourhoods		**Tap Water Supplied By Government**		
		N	Yes	No
Planned Neighbourhoods	Ali Close	46	38 (83%)	8 (17%)
	Lokogoma Phase I	74	73(99%)	1(1%)
	Otokiti	32	30(94%)	2(6%)
Unplanned Neighbourhoods	Adankolo	78	61(78%)	17(22%)
	Felele	124	0(0%)	124(100%)
	Galilee and Kporoka	14	13(93%)	1(7%)
	Old Market and environs	64	47(73%)	17(27%)
	Poly Village	24	0(0%)	24(100%)
	Sarkin - Noma	68	28(41%)	40(59%)
Total		**524**	**290 (55%)**	**234(45%)**

Source: Fieldwork, 2014

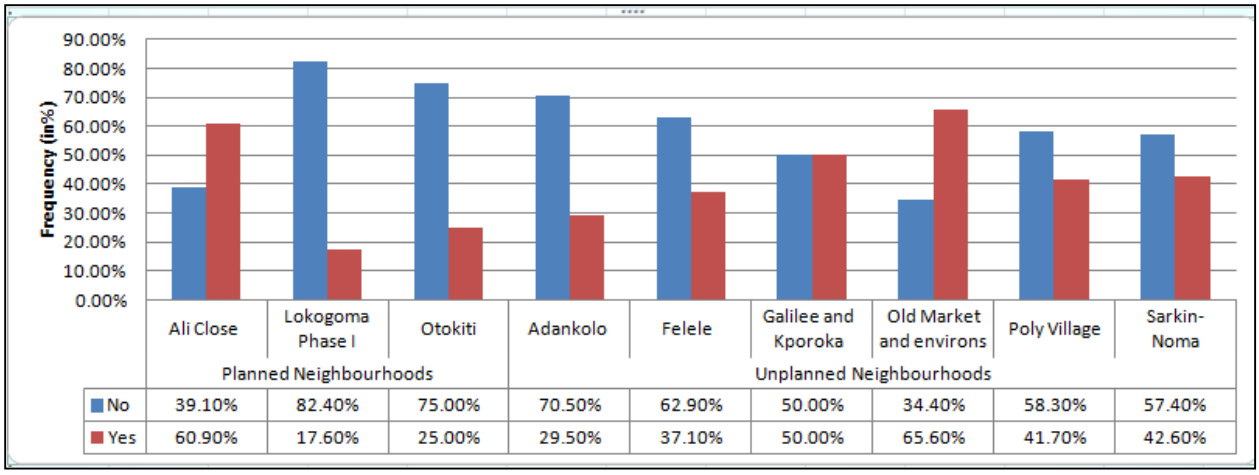

Figure 2: Level of Grey Water Utilization in Sampled Neighbourhoods
Source: Fieldwork, 2014

Sources of Grey Water in Lokoja.

Particular attention is given to the extent of utilization of laundry water, kitchen water and bath water, in the households that re-use grey water. Also included are the non-potable applications which grey water is used for in the sampled neighbourhoods.

Laundry Water Utilization
Every household where laundry is carried out produce grey water that could be utilized for beneficial purposes. Across all the sampled neighbourhoods, laundry water was a major source of grey water for re-use, with usage ranging from 54 to 100 percent (Fig. 3). Similar widespread preference for laundry water was observed in Greater Accra Metropolitan Area (GAMA), Ghana. According to Abbey (2013), 80 percent of the households that utilized grey water, re-used laundry water in GAMA.

Ali Close and Otokiti, both planned neighbourhoods, recorded 100 percent and 88 percent usage of laundry water respectively among households that re-use grey water. Lokogoma Phase I, where the least usage was recorded, had 54 percent usage. This is a clear indication that there is a marked preference for laundry water, among households that utilized grey water in areas served with potable water. In order to meet their unmet water demand, since water is rationed even in areas with potable water, many people embraced the use of laundry water as a strategy to diversify domestic water supply.

In the unplanned neighbourhoods, all but two of the neighbourhoods, Adankolo, and Galilee and Kporoka; had a percentage of laundry water utilization that was from 90 percent upward (Fig. 3). The high percentage of laundry water re-use among the households that utilized grey water in the sampled neighbourhoods is evidence that activities which did not require potable water in homes were carried out using laundry water that was believed to be well suited for them. The 'yuck' sensitivity which is generally related to water that has been used once was seen not to have deterred most people from using laundry water in most of the households that adopted grey water re-use.

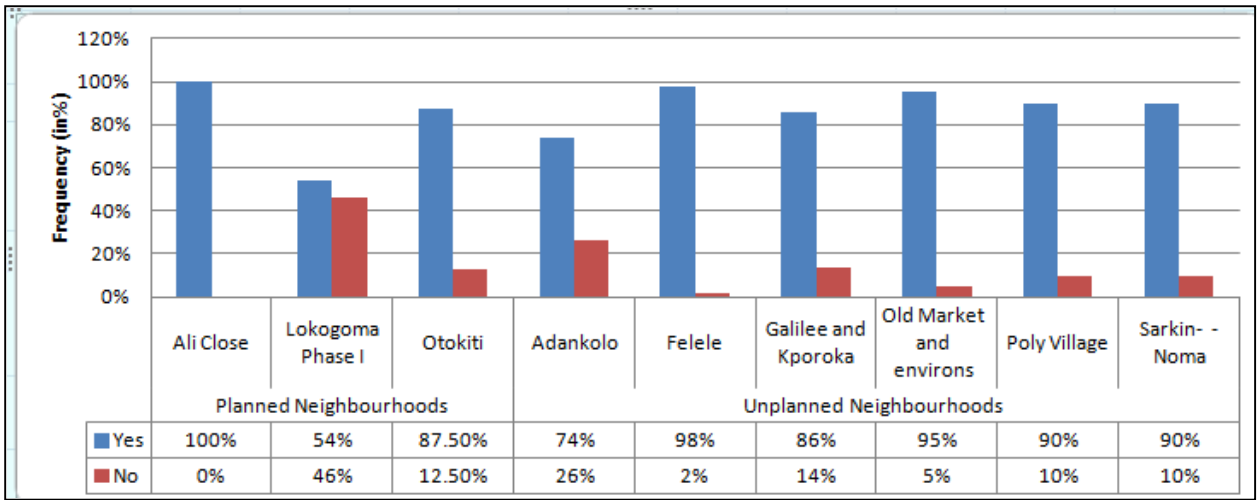

Figure 3: Laundry Water Utilization in Lokoja
Source: Fieldwork, 2014

Bath Water Utilization

The use of bath water as a source of grey water utilization did not account for much in the sampled neighbourhoods (Fig. 4). This is not unconnected to the fact that most of the bath water is usually lost to the drains. Households that used this particular grey water were places where infants or little children were bathed in big open basins or containers and the water retained for non-potable purposes. The highest usage of bath water in the sampled neighbourhoods was 3%. A much higher level of utilization was observed by Abbey (2013) in the Greater Accra Metropolitan Area, where 20.4% of the households that adopted grey water utilized bath water.

Out of the three planned neighbourhoods, Ali Close, Lokogoma Phase I and Otokiti, only Otokiti recorded the use of bath water in households where grey water was utilized for non-potable application. Its usage in Otokiti was very minimal, as only 3 percent of the households used it.

Old Market and environs as well as Felele, were the only two unplanned neighbourhoods where bath water was utilized. Adankolo, Poly Village, Sarkin-Noma and Galilee and Kporoka; did not have a single household that made use of bath water. The use was very negligible, accounting for 1 to 3 percent of the respondents interviewed in such neighbourhoods.

Bath water was not a significant source of grey water re-use in the sampled neighbourhoods. Its limited use shows that it was not the preferred choice in households that used grey water.

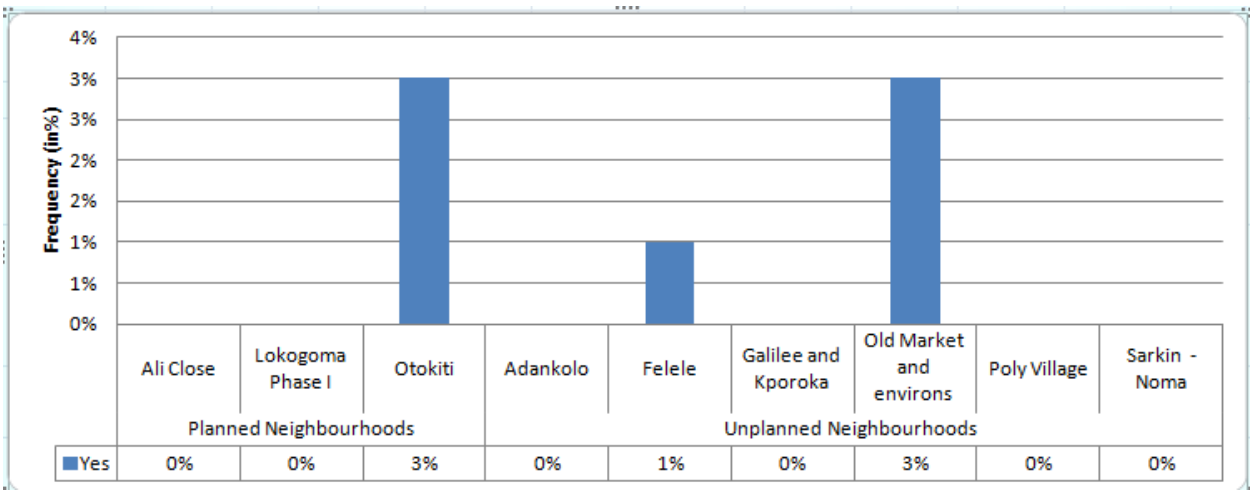

Figure 4: Bath Water Utilization
Source: Fieldwork, 2014

Kitchen Grey Water Utilization

Water from dish washing and the washing of vegetables and fruits, constituted the grey water gotten from kitchen in this study. Though its usage was not as widespread as laundry water, it was slightly higher than that of bath water, making it the second most preferred choice in the sampled neighbourhoods. A different result was observed by Abbey (2013) in Greater Accra Metropolitan Area, where kitchen water was the third highest grey water re-used, its usage coming behind that of laundry and bath water.

Kitchen water usage varied among the three sampled planned neighbourhoods. Lokogoma Phase I, with 46 percent usage among respondents that utilized grey water, was the highest user of kitchen water in the planned neighbourhoods (Fig. 5). Also it is remarkable to note that it had the greatest use of kitchen water across the nine neighbourhoods used in this study. Very minimal usage, 4 percent, was recorded in Ali Close while no single household in Otokiti considered re-using kitchen water.

Four out of the six unplanned neighbourhoods re-used kitchen water (Fig. 5). The level of usage among the four unplanned neighbourhoods varied from 10 to 17 percent, with Adankolo recording the highest. Galilee and Kporoka, and Sarkin-Noma recorded 14 percent usage. Poly Village was slightly lower with a record of 10 percent usage among households that re-used grey water. Not a single household in Old Market and environs as well as Felele re-used kitchen water among those who utilize grey water.

Although kitchen water, like laundry water, is generated consistent in homes, the willingness to use kitchen water is not as high as that of laundry water. This is probably due to the fact that grey water generated from the kitchen most often contains grease and bits and pieces of food in it.

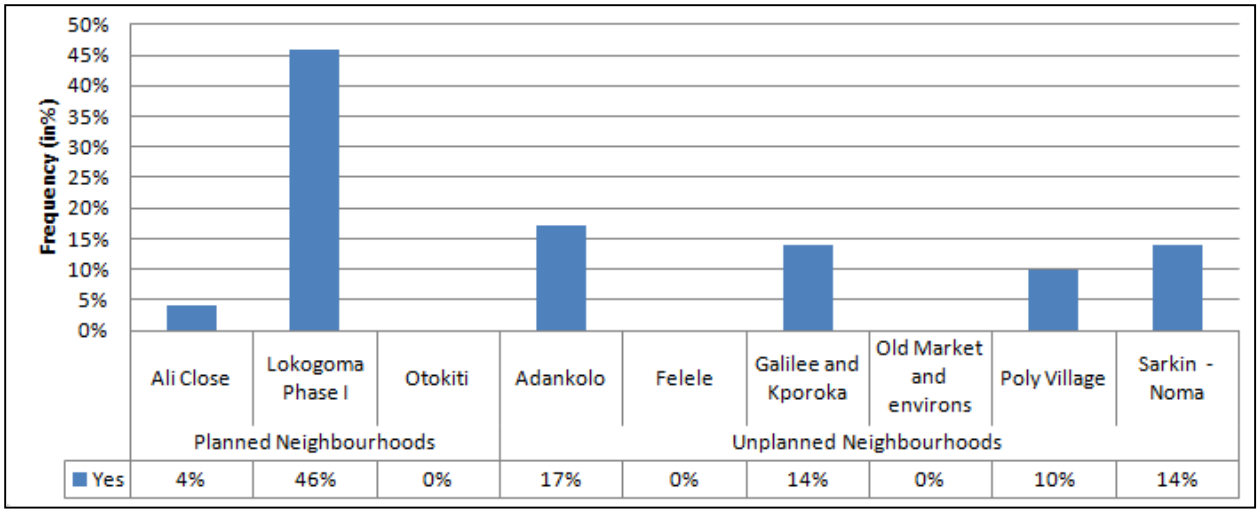

Figure 5: Kitchen Grey Water Utilization in Lokoja
Source: Fieldwork, 2014

Non-Potable Applications of Grey Water in Lokoja

The grey water generated in households was used for several non-potable uses. While its use for some non-potable needs were common, its use for other non-potable applications were at best insubstantial.

Grey water for toilet flushing

One of the non-potable uses to which grey water was applied daily in homes, in the sampled neighbourhoods, was toilet flushing where water system is used. This is an activity that requires much water. The use of grey water for toilet flushing was prevalent in all the sampled neighbourhoods (Fig. 6). Not less than 70 percent of respondents who utilized grey water in all the neighbourhoods applied it for this purpose.

The three planned neighbourhoods, Ali Close, Lokogoma Phase I and Otokiti, showed that 89 to 100 percent of households that utilized grey water, used it in toilet flushing. Otokiti, was at the highest end, with 100 percent utilization of grey water for the non-potable application.

With a figure of 100 percent, Poly Village had the highest value of grey water utilization for toilet flushing amongst the unplanned neighbourhoods (Fig. 6). The lowest usage amongst the unplanned neighbourhoods came from Galilee and Kporoka, with 71 percent of the respondents utilizing grey water for toilet flushing. Adankolo, Felele, Sarkin-Noma, and Old Market and environs, had values that varied from 74 to 97 percent. In Galilee and Kporoka, as well as Adankolo, the neighbhoods where a relatively lower percentage of respondents used grey water for toilet flushing, further investigations revealed that some of the households did not have water closets in their homes and a few practiced open defecation.

The result attests to the fact that a lot of people have come to see and even embrace the need to use grey water for some non-potable purposes. Also, since toilet flushing consumes quite a lot of

water, it is only prudent to allocate grey water to this activity in the home in order to conserve the available potable water for potable uses.

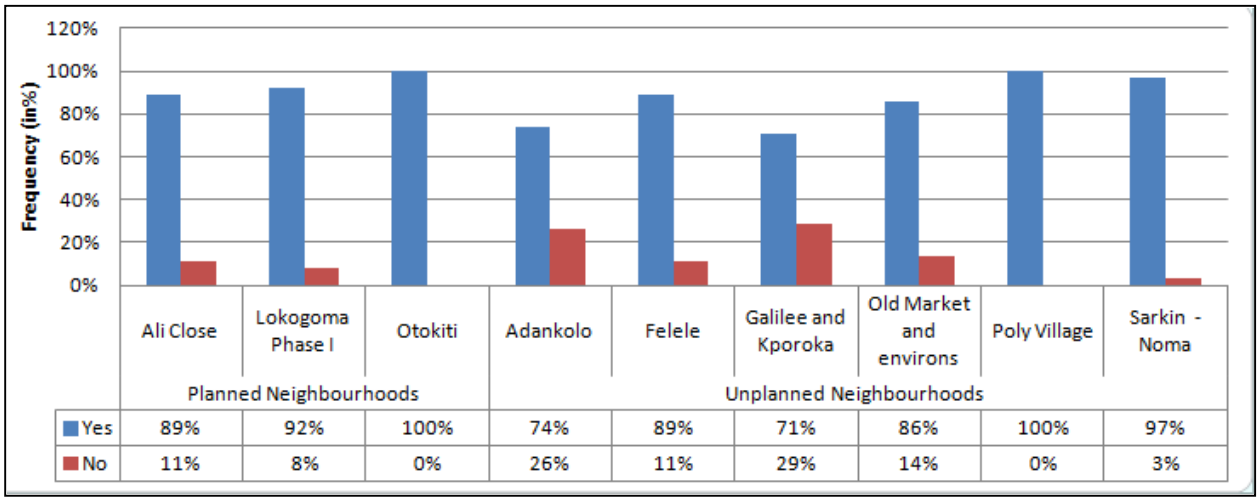

Figure 6: Grey Water Utilized for Toilet Flushing in Lokoja
Source: Fieldwork, 2014

Grey water utilized for car/motorcycle washing

The use of grey water for washing of cars or motorcycles did not cut across all the sampled neighbourhoods, as only five neighbourhoods out of the nine sampled neighbourhoods utilized grey water for this non-potable application (Fig. 7). The highest usage amongst the sampled neighbourhood was 38 percent. This was recorded in Old Market and environs. The outcome of a study conducted by Adewumi (2011) in Limpopo, South Africa, reveals a higher usage of grey water for car washing; with approximately 54 percent of the respondents utilizing it for that purpose.

Two planned neighbourhoods, Lokogoma Phase I and Otokiti, did not utlize grey water for the purpose of washing cars or motorcycles (Fig. 7). The use of grey water for washing of cars or motor cycles was only limited to Ali Close amongst the planned neighbourhoods, where 32 percent of the respondents washed cars or motorcycles with grey water.

Adankolo, Felele, Old Market and environ, and Sarkin-Noma, four unplanned neighbourhoods, re-used grey water for washing of cars or motorcycles, while Poly Village, Galilee and Kporoka; were the two that did not adopt grey water for the purpose (Fig. 7). The use of grey water for car or motorcycle washing varied from 3 percent to 38 percent in the unplanned neighbourhoods where this activity was carried out. Old Market and environs was the neighbourhoods with the highest percentage use, with a value of 38 percent, which was also the highest across all the sampled neighbourhoods. Comparatively the usage was slightly lower in Felele, 28 percent it was, among the households that utilized grey water. But in the remaining two unplanned neighbourhoods, Sarkin-Noma and Adankolo, where grey water was used to wash cars and motorcycles, the use was much lower as it accounted for 3 and 13 percent usage respectively.

Understandably, not all households used grey water for this purpose as not all of them owned automobiles. But even in households where these means of transportation was found, not all of them accepted the use of grey water in washing them. They preferred to use water that has not been used before.

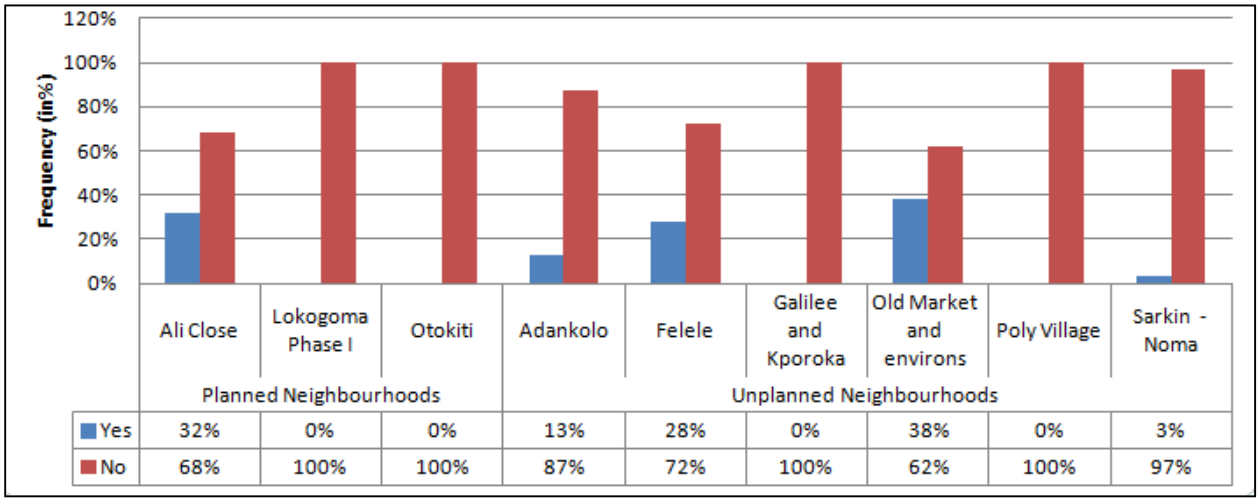

Figure 7: Grey Water Utilized for Car/Motorcycle Washing
Source: Fieldwork, 2014

Grey water utilized for road/street wetting

Dust from untarred roads or streets, especially when vehicles or other means of transportation are plying them, is not only a discomfort to people with respiratory problems, it discolours the paint on houses. Not all roads and streets in Lokoja are tarred. To keep the dust down and alleviate the discomfort of residents, as well as reduce the effect of dust on houses, some people use grey water to wet the streets (Fig. 8). This helps to prevent dust from clouding the atmosphere when vehicles speed past or when wind blows, especially during the dry season. Four out of the nine sampled neighbourhoods, found grey water useful for wetting streets or roads.

Ali Close was the only planned neighbourhood that re-used grey water for road or street wetting. 14 percent of the households in the neighbourhood utilized it for that purpose (Fig. 8). Lokogoma Phase I and Otokiti had no record of grey water utilization for road or street wetting. The minimal usage in the planned neighbourhoods can be traced to the fact that they have less untarred streets compared to the unplanned neighbourhoods.

The level of usage of grey water for wetting roads or streets varied from 5 percent to 17 percent amongst the sampled unplanned neighbourhoods (Fig. 8). Sarkin-Noma recorded the highest percentage of respondents using grey water for wetting roads and streets in unplanned neighbourholds and across all the sampled neighbourhoods. Adankolo, as well as Old Market and environs, were on record as re-using grey water for road or street wetting, having 9 and 5 percent of households respectively. It was found that Sarkin-Noma which recorded the highest had a large proportion of its roads untarred. Apart from the dual carriage way which passes

through this neighbhourhood, all other streets are untarred. In Felele, Galilee and Kporoka, and Poly Village respondents did not use grey water for road or street wetting.

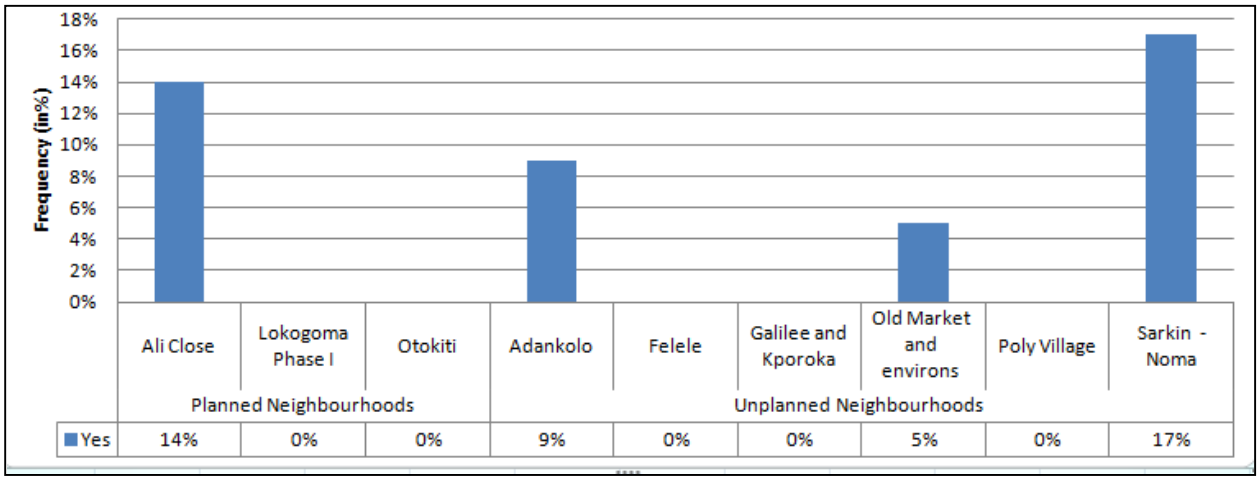

Figure 8: Grey Water Utilized for Road/Street Wetting
Source: Fieldwork, 2014

Grey water utilized for irrigation of gardens

The seasonality of rainfall in Lokoja hampers gardening activities in the dry season. However, some households which own gardens have been able to take advantage of the usefulness of grey water to continue to maintain and sustain their gardens, thus saving available potable water and groundwater sources for other important uses. In neighbourhoods that used grey water for irrigation, its use varied from 2 percent to 36 percent (Fig. 9). The results of a survey in Australia revealed a greater average usage, as 19 percent of the households used grey water on their gardens (May-Le, 2004).

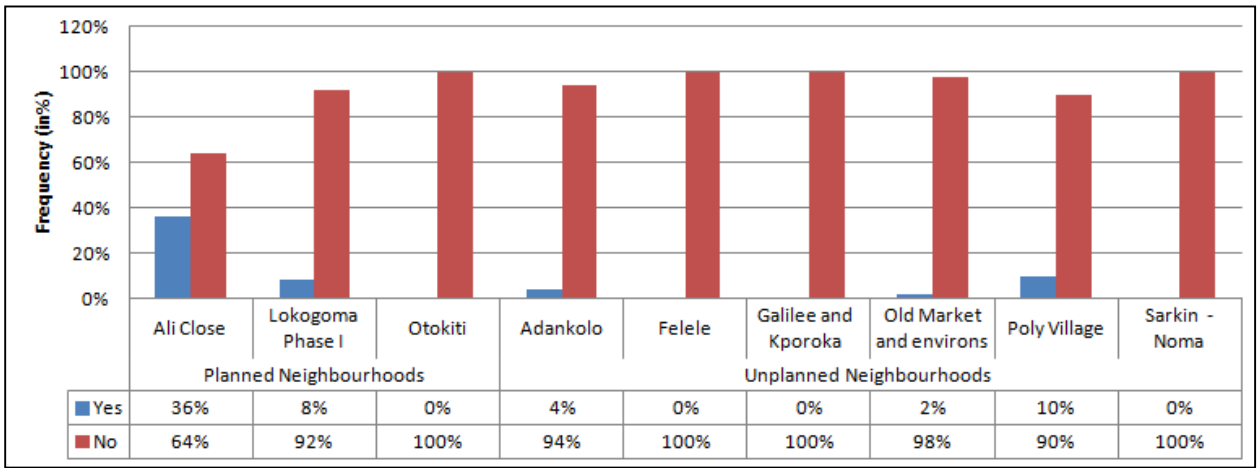

Figure 9: Grey Water Utilization for Irrigation of Garden
Source: Fieldwork, 2014

Ali close had the highest record of grey water adoption for backyard garden irrigation in planned neighbourhoods, with 36 percent of households that re-use grey water using it for this non-potable use (Fig. 9). The usage in Lokogoma Phase I, was far behind with 8 percent utlization. Otokiti on the other hand did not have any household making use of grey water for garden irrigation. In the planned neighbourhoods, though some households kept small gardens, it was observed that they used potable water or engaged in gardening only during the wet season.

In most of the unplanned neighbourhoods, the use of grey water for irrigating garden was minimal because some households which otherwise would have been interested in gardening lack the space. Poly Village and Old Market and environs, were the only unplanned neighbourhoods that utilized grey water for the irrigation of their gardens.

CONCLUSION

Across all the sampled neighbourhoods, laundry water formed the highest grey water that was utilized in Lokoja. Only one neighbourhood, Lokogoma Phase I, recorded a value less than 70 percent. The remaining eight neighbourhoods had greater usage, with values that ranged from 74 to 100 percent amongst households that utilized grey water. The use of kitchen water, among households that utilized grey way, was observed in two-third of the sampled neighbourhoods. Compared to laundry water, the use of kitchen water was relatively low as none of the neighbourhoods had up to 50 percent of their households using it. Bath water had the least usage. Only one-third of the sampled neighbourhoods re-used bath water. Its usage in the neighbourhoods where it was adopted was very insignificant, as it accounted for a mere 1 to 3 percent of households that utilized grey water.

Figures of 100 percent utilization of grey water for toilet flushing, amongst households that utilized grey water was found in two neighbourhoods- Otokiti and Poly Village. The lowest record of usage were observed in Adankolo, and Galilee and Kporoka; two neighbourhoods where open defecation was practised by some households. Car and motor cycle washing was practised in five out of the nine sampled neighbourhoods. All these were unplanned neighbourhoods with the exception of Ali Close, a planned neighbourhood. Comparatively, the use of grey water for car or motorcycle washing was far less than grey water usage for toilet flushing. Its utilization was 3 to 38 percent among neighbourhoods that re-used grey water for car or motorcycle washing. The utilization of grey water for road or street wetting was very minimal, as only 5 to 17 percent of households used it in four out of the nine sampled neighbourhoods. Irrigation of gardens with grey water was embarked upon by only one-third of the sampled neighbourhoods. The highest usage was in a planned neighbourhood, Ali Close, with 36 percent usage.

There is need to educate people in both formal and informal settings, on the necessity of adopting grey water re-use as a means of conserving water for future use. Research on frequency of grey water utilization should be carried out, this would further inform on the extent of grey water usage. Technology that provides cheap decentralized treatment should be developed locally, as this would increase the quantity of grey water utilization and its applicability for non-potable uses.

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