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A REVIEW OF SELF SUPPLY OPTIONS TOWARDS MEETING DOMESTIC WATER NEEDS IN NIGERIA

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Self supply efforts in the provision of domestic water in Nigeria are primarily based on existing gaps in access to safe water sources. World Health Organization/ United Nations Children's Fund joint monitoring report estimated that 663 million people worldwide still use unimproved drinking water sources, nearly half of all people using unimproved drinking water sources live in sub-Saharan Africa and the vast majority of those who do not have access to improved drinking water sources live in rural areas. This research looked at self supply options for domestic water supply primarily by desk work, field visit and documentation of existing self supply facilities. Two options are considered adequate as self supply for use in urban areas: boreholes equipped with motorized schemes and self purification of available non municipal water. Technologies for semi urban and rural areas include the use of slow sand filters, use of cloth filters, boiling, protected hand dug wells, rainwater harvesting system for household supplies, boreholes equipped with hand-pumps and protected springs. It was concluded that the most effective way to consistently ensure the availability of safe domestic water supply is by the use of a comprehensive risk assessment and risk management approach termed the Water Safety Plans which is based on the principle of preventing contamination of source waters, purification of contaminated water for domestic use and prevention of re-contamination during storage, distribution and handling of drinking water.

INTRODUCTION

Many households in Nigeria depend on self supply options of sourcing domestic water to meet their needs. The lack of public water supply in many communities in the Country has forced the end users to resort to alternative sources for domestic water supply (Ohwoghere-Asuma et al, 2014). The use of unsafe drinking water sources negatively impacts on the health and productivity of any community resulting in the prevalence of water related diseases including diarrhoea, cholera, typhoid fever, malaria, guinea-worm, schistosomiasis, hepatitis and bacillary dysentery (Mcghee, 1991). Diarrhoea a leading killer of children, accounted for 9 per cent of all deaths among children under age 5 (U5) worldwide as at 2015, this translates to over 1,400 young children dying each day, which is more than 500,000 children a year, despite the availability of simple effective treatment (UNICEF, 2016). Research has shown that combined effort is required to combat water borne diseases such as diarrhoea (Skinner, 2009) as Water, Sanitation and Hygiene (WASH) interventions have been found to be more effective by the use of combined interventions than discrete water supply, water quality and hygiene interventions.

In order to meet international standards for drinking water quality, domestic water supply option used by households must be free from contaminants present in water, focusing specifically on the Physical, Chemical and Micro-biological parameters. The Physical Parameters include Colour, Taste, Odour, Turbidity and Solids. The Chemicals in water are usually from the soil, agricultural or industrial effluents, micro-biological parameters that must be removed from domestic water are mainly pathogenic micro-organisms, these parameters and requirement for meeting drinking water standards are presented in Tables 1 and 2 (WHO, 2008):

Table 1. Physical Parameters used in Monitoring Drinking Water Quality

Parameter	Unit	Maximum Levels	Remarks
Colour	TCU	15	TCU - True Colour Units
Odour	-	Unobjectionable	
Taste	-	Unobjectionable	
Turbidity	NTU	0.1	No health based guideline value proposed, for effective disinfection, 0.1NTU (NTU - Nephelometric Turbidity Units) is proposed.

Parameters including pH, Iron, Hardness and Potassium have shown ‘no health concerns at levels found in natural water samples’. Also, Total solids at high levels may be objectionable to consumers (some standards give 500mg/l). Total Coliform count should be absent immediately after treatment, Thermo Tolerant Coliform (E.coli)- 0cfu/100ml (WHO, 2011). Cadmium levels in water must be monitored for sources close to industries that engage in electroplating, production of cadmium-nickel batteries and alloy industries (Kaladar, 2014).

The Need for Self Supply Efforts in the Provision of Domestic Water Supply:

The World Health Organization/ United Nations Children’s Fund Joint Monitoring Report estimated that 663 million people worldwide still use unimproved drinking water sources, nearly half of all

Table 2. Chemical Parameters used in Monitoring Drinking Water Quality

Parameter	Unit	Maximum Levels	Remarks
Arsenic	mg/l	0.01	
Barium	mg/l	0.7	
Boron	mg/l	0.5	
Chromium	mg/l	0.05	
Cadmium	mg/l	0.003	
Chloride	mg/l	250	No health base guideline value proposed but values above 250mg/l gives rise to taste
Copper	mg/l	2	
Fluoride	mg/l	1.5	
Hardness	mg/l	200	No health base guideline value proposed but above 200mg/l will cause scale deposits
Iron	mg/l		No health base guideline value, 0.5 to 50mg/l found in natural waters
Manganese	mg/l	0.4	
Nitrate (NO_3^-)	mg/l	50	
Nitrite (NO_2^-)	mg/l	0.2	
Lead	mg/l	0.01	
Nickel	mg/l	0.07	

people using unimproved drinking water sources live in sub-Saharan Africa and the vast majority of those who do not have access to improved drinking water sources live in rural areas (WHO/UNICEF, 2015). Global water shortage impacts on a nations' economic growth (Palit, 2016), as a result many communities still depend on un-improved water sources for domestic water use in Nigeria as shown in Figure 1.

METHODOLOGY

This research was carried out primarily by desk work, field visit and documentation of existing self-supply facilities. The work is focused on documenting self-supply facilities that augments government efforts in the provision of domestic water to Nigerian communities. Focused areas in the research are areas classified into the urban, semi-urban and rural areas.

The Nigerian National Water Sanitation Policy (FMWR, 2005) defines the terms urban, semi-urban and rural in terms of domestic water supply as follows:

Figure 1: Unsafe Water source used in a Nigerian community (Source: Author)

Rural water supply is defined as guaranteed minimum level of service 30 litres per capita per day within 250 meters radius for the end user, each water point serving about 250 persons. A Rural community is defined as a community of up to 5,000 people.

Semi-urban (small towns) water supply represent a minimum supply of 60 litres per capita per day. A Semi-Urban community is a community with population of between 5,000-20,000 people.

Urban water supply is a minimum supply of 120 litres per capita per day to be served by full reticulation and consumer premises connection. An Urban area is an area with population greater than 20,000 inhabitants.

RESULTS

Available Safe Options for Domestic Water Self Supply:

The focus of this research is on 'Self Supply', therefore the use of the conventional water treatment and municipal water supply does not fall in this category. Self supply options are classified under use in Urban, Semi-Urban and Rural areas.

Options for Urban areas:

Two options are considered adequate as self supply for use in urban areas:

I. Boreholes equipped with motorized schemes in urban areas

II. Self purification of available non municipal water

Boreholes Equipped with Motorized Schemes:

The use of groundwater lifted to the surface using motorized schemes are commonly used by individual households in urban areas in Nigeria especially due to the availability of productive wells (Anomohanran and Iserhien-Emekeme, 2014); these are schemes using pumps which are powered by various sources of energy including petrol or diesel generators, electricity or solar energy (Burari, 2003). The quality of water abstracted from these sources usually meet the international standards for drinking water quality.

Self Purification of Domestic Water from non Municipal Sources:

Water supplied from sources that do not meet drinking water standards must be subjected to household treatment before use by:

- Aeration,
- Coagulation and Flocculation,
- Sedimentation,
- Filtration and
- Disinfection.

Aeration

Aeration processes are used to remove odour from water, to achieve removal of gases and volatile compounds by the transfer of air usually achieved using a simple cascade or diffusion of air into water, without the need for elaborate equipment, design requirements are between 1 and 3 m depth for effective aeration (McGhee, 1991).

Coagulation

Coagulation is used to remove flocculent particles from water that will refuse to settle out by plain sedimentation. Use of Chemical Coagulants is the most common approach for treatment of turbidity in surface waters; these are usually salts of aluminium (as shown in figure 2), to form an aluminium hydroxide floc (Agunwamba, 2008), typical coagulant doses are 2–5 mg/l as aluminium. The efficiency of the coagulation process depends on raw water quality; floc is removed from the treated water by subsequent solid–liquid separation processes such as sedimentation.

Figure 2. Aluminum Sulphate - A Coagulant

Filtration

In urban areas, water filters are commonly used at household level to remove solids, taste, odour and a wide range of organic compound from drinking water. Figure 3 shows a typical (commercial) household water filter while a range of different types of filters exist.

Figure 3. A unit household domestic water filter

Disinfection Methods

- Chlorination at the household level can be achieved by using:
  - i. Sodium hypochlorite solution
  - ii. Calcium hypochlorite granules
- Careful handling of chlorine must be ensured as the use of elemental chlorine impacts on receiving environments (Kaizar, 2015)'.
- Boiling of water before drinking is also an effective method for disinfecting unsafe water.

Self Supply Options for Semi Urban and Rural Areas:

Technologies for semi urban and rural areas include the use of slow sand filters, use of cloth filters, boiling, protected hand dug wells, rainwater catchment system for household supplies, boreholes equipped with hand-pumps and protected springs.

Use of Sand Filters:

Slow sand filter utilizes micro-biological organisms called *schmutzdecke* to operate, large area land is required for filtration with unit sizes of approximately 60m x40m, effective grain size of sand is between 0.25mm to 0.35mm, the uniformity coefficient is between 2 to 3. These filters must be used on a regular basis to maintain efficiency as clogging will occur between two to three months with head loss of up to 80 to 100cm (Rao, 2005), the filter will require maintenance based on the source of water and the level of turbidity, slow sand filter users must therefore store enough clean water for several days prior to cleaning the sand filter (Donison, 2004).

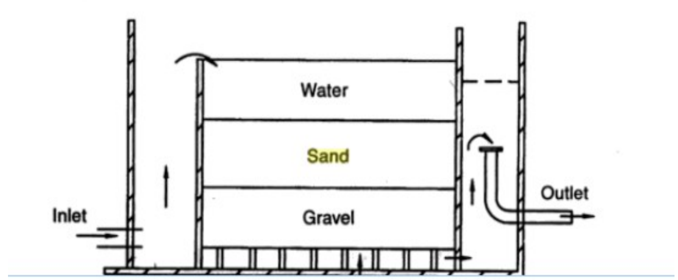

Figure 4. Schematic Diagram of a Slow-Sand Filter (Rao, 2005).

Cloth Filtration:

From more than 650,000 Guinea worm cases in 1988 to zero in 2013, Nigeria successfully stopped the transmission of guinea-worm disease, also known as dracunculiasis. A very simple water purification technology, figure 5 shows the cloth filter which was extensively used in Nigeria to combat Guinea worm infection; the cloth filter was used to break the reproductive cycle of the guinea worm. The World Health Organization (WHO) certified Nigeria as Guinea worm free country in December, 2013 (WHO, 2014). It is important to combine cloth filtration with disinfection to achieve acceptable domestic water quality, use of household disinfectants in form of tablets is also recommended.

Figure 5: Cloth filtration

Boiling:

Boiling is a very effective water purification technology which is ideal for small scale treatment as household water treatment. Boiling will remove disease causing micro-organism and make the water fit for drinking, however other parameters such as turbidity may not be removed.

Protected Hand Dug Wells:

There is no 'one single' technology for water purification suitable for small communities, it is important to protect naturally safe water sources from pollution (Cairncross and Feachem, 2005) as hand-dug wells are rarely more than 10m deep (Mustafa and Yusuf, 1999), the wells can easily be influenced by inter-seasonal variation in groundwater quality (Balogun and Adigun, 2013) giving rise to the need to prevent contaminants especially Nitrates from gaining access into water source (Kapoor, 1997). Figure 6 shows a protected hand dug well.

Figure 6. A Protected well (Sutton, 2010)

Simple key practices have been taught by promoting traditional improvement to wells on the principles of progressive risk reduction for suitability for drinking (Ojo, 2015) by:

- Protecting the top of the well and sealing it from surface inflow using drums or local material to raise the lid.
- A platform around the well to avoid ponding and seepage into the well.
- Use of lid to close the well opening.
- A single rope and bucket that is protected during storage from contamination by keeping off the ground as shown in figure 6.
- A roof to keep the rain out and the area around the well dry.
- A fence to keep out animals
- Drainage to take away spilled water

Rain Water Catchment System:

The rain water catchment system operates optimally when rain water allowed into the storage reservoir has been purified by diverting initial rainfall to runoff before allowing rain water into catchment reservoir. The technology requires that the water quality is monitored at the storage reservoir; further treatment can be achieved by the use of chlorine in monitored quantities. In small towns, proper construction of storage reservoir for Rain Water Catchment can supply water that meets requirements for domestic use (Smet, 2003)

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Figure 7. Roof catchment and storage **(**Source, Smet, 2003)

Boreholes equipped with hand pumps:

Handpumps are mainly used in rural communities in Nigeria (FMWR, UNICEF, 2012). Groundwater quality is usually affected by different mineral salts and chemical compounds such as iron, manganese, calcium, fluoride (Chowdhury, 2017), effective monitoring of water quality from domestic source especially by Hazard analysis promotes access to safe water (Ndububa, 2015).

Figure 8. School girls at a newly installed borehole equipped with hand-pump in a rural area of Nigeria (Source: Author)

Protected Springs:

Safe water can be obtained from protected springs as risk of contamination exists without spring protection, protection reduces vulnerability and presence of contaminants in water (Sharadqah, 2017).

Emerging Technologies:

Solar Powered Water Supply Schemes:

The use of solar energy to power water supply systems is on the increase, due to the initial capital investment, households have not individually keyed into the use of these systems even though solar energy is available in Africa with abundance of sunshine; also limited effort is required for the operation and maintenance of solar panels after installation.

Use of Moringa seeds as a Coagulant:

Turbidity in water is caused by suspended or colloidal matter which obstructs light transmission (Olaniyan, 2016), Crushed Moringa seeds have been used to clarify and reduce level of turbidity in water to meet standards for domestic use. It was shown that 70mg/l of crushed moringa seeds reduced turbidity of 183.7NTU to 8.2NTU in a particular raw water sample (Adejumo, 2013). This is a plant that grows in Africa and the use in water treatment can be promoted.

Figure 9. Moringa seeds (in and out of the pod)

Membrane treatment process:

Nano-filtration uses a membrane with properties between those of reverse osmosis and ultrafiltration membranes; pore sizes are typically 0.001–0.01 µm. Research is promoting the use of nano-filtration to remove chemicals in water on large scale basis as heavy metals can accumulate and persist in soils at levels above permissible limits (Obasi, 2017, Adeniyi et al, 2002)) which infiltrate into domestic water sources.

Water Safety Plans:

It has been shown that the most effective way to consistently ensure the availability of safe domestic water supply is by the use of a comprehensive risk assessment and risk management approach termed the Water Safety Plans (WSPs). Water quality tends to deteriorate gradually with human interventions (Ma, 2015) therefore the principles of WSPs are critical in domestic water supply which are:

- To prevent contamination of source waters
- To treat the water to reduce or remove contaminants that could be present to the extent necessary to meet the water quality targets

- To prevent re-contamination during storage, distribution and handling of drinking water (Skinner, 2009)

Research has shown that microbial presence in storage facilities can be higher than in the distribution system and treatment plant (Adam, 2010). This approach to risk management of the safety of drinking water involves:

- Knowledge of the catchment area
- Knowledge of the source water quality
- Water treatment/ Purification technologies
- Protection of the distribution system
- Safe water to end user (Deere, 2001).

Social and Ethical Considerations:

Social Considerations:

Deeply rooted social and economic inequities working against achieving success in gaining access to safe water sources has been a major challenge as much of the suffering from lack of access to safe drinking water and sanitation is borne by the poor, who do not benefit from education, health and other facilities (Bilgic, 2017) who live in degraded environments and impacts heavily on women and children (Samir, 2009).

The need to minimize these negative impacts can be achieved through strategic planning of actions in social, economic and environmental sectors (Eberson, 2015) by taking actions that reduce inequalities and improve health (Stewart et al, 2010). The bottom-up or community management approach has been found as a viable option to the sustainability of safe rural water supply schemes (Skinner, 2009). Water Supply Schemes must therefore be:

- Acceptable to the community in relation to convenience, traditional beliefs, practices and suitable for economic use as in construction which must be free from injurious amounts of deleterious materials (Afolayan, 2009).
- Feasible by taking into consideration factors that are based on financial, technological and user satisfaction as a crucial factor for evaluating service quality (Al-Nuaimi et al, 2016)
- Maintained, maintenance of system is required over time to achieve sustainability. (Asanza,et. Al, 2017).

Policy formulation to support Access to Safe Water Sources:

In order to develop public policies that will support increase in access to safe water sources as only 67% of the population in Nigeria have access to at least basic improved drinking water sources (WHO, 2017), there is need to understand the synergy between the development of public legislative processes and a country's national development choices. Key problems of the water environment originate from changes in water quality, which can in turn lead to potential ecological and health risks (Liu et al, 2016), Policies must ensure that:

- Resources are leveraged to achieve access to safe water sources for all citizens.
- Institutional capacity development is prioritized to support sustainability of water sources

- Institutions are strengthened for better social service delivery
- Strong coordination exist among actors in social service delivery
- Monitoring and Evaluation of programmes should lead to learning of lessons and knowledge sharing.

Policy actions should be focused on achieving the following objectives which should:

Increase service coverage for water supply to international water quality standards (Ndububa, 2016) using adequate water purification technologies (Ezeomo and Ifedili, 2007).

- Ensure affordability of water supply and sanitation services for the disadvantage and vulnerable group.
- Risk assessment should be used to identify, analyze, estimate and evaluate the potential hazards of a project (Agunwamba, 2001)
- Protect excessive groundwater extraction, which regardless of the ability of the aquifer would disrupt the environmental balance (Juandi, 2017)

CONCLUSION

The following conclusions are made:

1. Quality of water for purification is paramount in selecting water technology for domestic water self supply.
2. Simple purification technologies such as the use of slow sand filters are recommended for use in rural areas.
3. Purification of domestic water can be achieved by emphasizing hygienic methods of lifting groundwater to the surface, using hand-pumps or non contaminated rope and containers especially in rural areas.
4. Rain water for household use can be protected from contaminants by diverting initial rainfall to runoff before allowing rainfall into catchment reservoir.
5. Chemical disinfectants are recommended for use in rain water catchment reservoir in cases where water quality does not meet required standards.
6. To achieve sustainable domestic water sources in rural areas, participatory approaches must be employed in the selection processes of technological options proposed for use in communities.
7. Promotion of domestic water technologies must be technologies that are acceptable to the community in relation to convenience, traditional beliefs and practices by the use of various approaches including, inclusive and pro-poor approaches where the welfare of youths, disadvantaged and marginalized communities are taken into account.
8. Water safety plans should be used to achieve the catchment to consumer approach to risk management of safety for domestic water supply.
9. Public policy actions must ensure increase in service coverage for water supply to required international water quality standards. Supply must be affordable for the disadvantaged and vulnerable group with a guaranteed access.

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