

Household Water Treatment in Benin: Current/Local Practices

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Abstract

In Benin, many families struggle to ensure the safety of the drinking water. This problem is common to most of developing countries. Even the water is clean, at source, it can be contaminated during transport and storage. Then, household water treatment technologies as emerged as an approach people can rely to treat water at home. Several methods of household water treatment are known and in use in Benin. Some from ancestral knowledge, others from initiative of NGOs. A very few households treat their water to prevent waterborne diseases, even if the source is not improved. And most of the time, they do not use these methods according to the recommended operating procedures. To address today the problem of the safety of water quality at household level in Benin, the need of the efficiency of the household water treatment in local area has to be proved. Moreover, populations have to be involved in all the aspect of the implementation of these methods. Communication and local NGOs outreach are also essential.

Keywords: Household water treatment, Benin, Water demand

1. Introduction

Water means life- this truth is so often repeated, that its significance often becomes lost. All natural organism need water for their survival. Therefore water is a right, such as clean air, soil and whole biosphere. People in developed world have access to excellent quality of drinking water. This access is obvious, and the tap water price is affordable. Population in developed world are protected in this way

from waterborne disease in better way, than their peers in developing world. In sub-saharan Africa, nearly half of the population (about 331.5 million) still using unimproved water sources (PNUD, 2015). As the other sub-saharan Africa countries, Benin is facing the challenge of safe drinking water. Water supply does not meet the actual demand due to institutional, physical, and economic reasons (PNE, 2009). As in most of the developing countries, centralized management systems for the supply of drinking water gets to cover a small part of the population (Sorenson et al., 2011). Rural areas are mostly not served. People often have to travel long distances to access water (Sorenson et al., 2011). This resource may be contaminated at the source or during collection, transport or storage (Onabolu et al., 2011). Even in urban areas, access to clean water is a real problem because of the high population growth, which is accompanied by an anarchic space development outside the control of public authorities (Agassounon et al., 2012). So in order to compensate the need, wells traditionally dug and surface waters become the main source of water supply of the population.

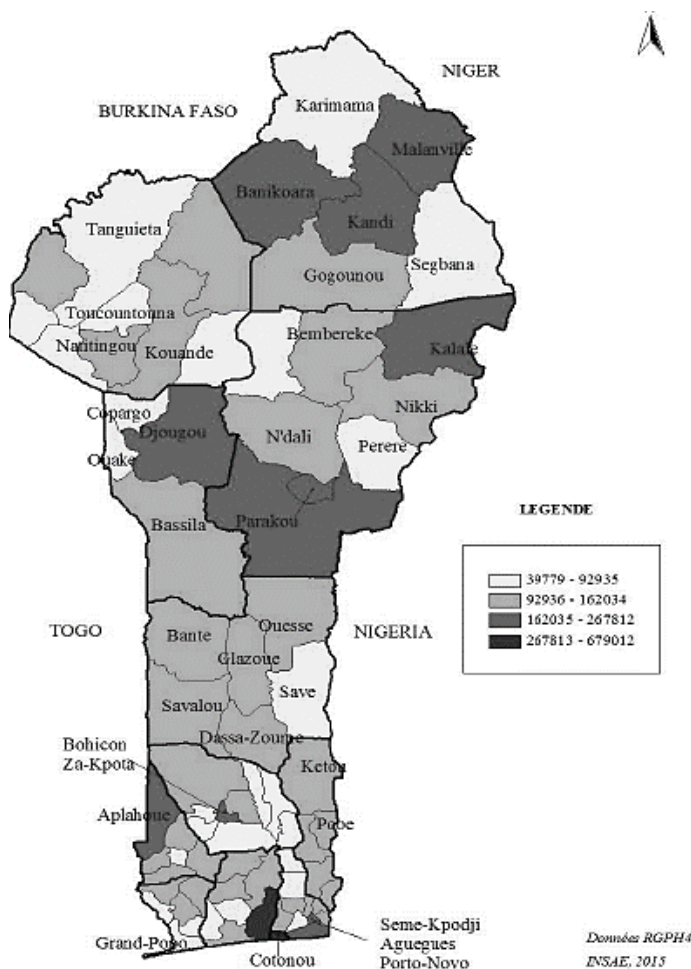
In that conditions, household water treatment methods (HWTM) are required to improve the quality and safety of water for drinking of course, the most appropriate technology will depend on technological aspects (such as the quality of raw water, the availability of the required materials or equipment, the availability of personnel to provide training and monitoring) and also on the social aspect (the education levels of the local population and the willing of local communities to use this method). In the country, several local practices inherited from ancestral habit and new implemented methods by several NGOs are used for household water treatment. This paper aims to present the practice of household water treatment in Benin.

2. Context

2.1 Overview of Benin

Benin, officially Republic of Benin, (in French « République du Bénin »), is a West African nation. It consists of a narrow wedge of territory extending northward for about 420 miles (675 km) from the Gulf of Guinea in the Atlantic Ocean, on which it has a 75-mile seacoast, to the Niger River, which forms part of Benin's northern border with Niger. Benin is bordered to the northwest by Burkina Faso, to the east by Nigeria, and to the west by Togo. Benin was a French colony from the late 19th century until 1960. The country covers an area of 114 763 km² and is divided in to twelve departments/provinces and 77 municipalities (INSAE, 2015). The provinces are: Alibori, Atacora, Atlantique, Borgou, Couffo, Collines, Donga, Littoral, Mono, Ouémé, Plateau, and Zou. The total population is about 10 000 000 in 2013 (INSAE, 2015). However, higher growth rates, especially due to inland migration are noticed in the cities, where most of the urban population is found (Figure 1). With a fairly good rain fall and characterized by spatial and temporal variability, the country receives on average between 700mm and 1300mm of rain per year in height, spread over 70-100 days from the extreme North to Southeast (PNE, 2009). The hydrographic network is dense, consisting of several streams with seasonal flow regime. Water is abundant but poorly distributed on the territorial space. It is estimated the pressure on Benin's water resources will increase, leading to greater competition for surface water (Höllermann et al., 2010). And also, financial and technological constraints hinder a satisfactory development and exploration of ground water and reservoir resources (Höllermann et al., 2010).

Figure 5: Population size per municipality in Benin
Adapted from (INSAE, 2015)



2.2 Water Supply Sector

In Benin, responsibility for the water supply relies on the «Ministère des Mines, de l'Énergie et de l'Eau» (MME, Ministry of Mines, Energy and Water Resources). Its responsibility is to develop and ensure the implementation of government policy in the mining, Energy and Water. This ministry is helped by the «Ministère de la Santé (MS, Health Ministry)» in term of water quality assessment and maintain. Below the «Ministère des Mines, de l'Énergie et de l'Eau» Benin's water supply to meet domestic demand can be distinguished as different water sources:

- The Société Nationale des Eaux du Bénin (SONEB, National Water Supply Company) is the public drinking water utility in urban areas. SONEB currently supply 70 of the 77 municipalities of the country. The water supplied by SONEB is not only consumed by those households with a house connection but also by the surrounding (unconnected neighborhood) (Agassounon et al., 2012). According to the «SONEB» in 2013, 67% of the population, in urban and rural area were supplied in drinking water (SONEB, 2014). It is a common practice in the country to resell water (Hadjer et al., 2005). Moreover, Wells (both protected and unprotected), rivers, *marigôts* (back waters)(Agassounon et al., 2012) are others sources of water for households.
- The Direction Générale de l'Eau (DG Eau, General Directorate of Water): this directorate is responsible for water supply coordination and overseeing in rural areas of the country. DG Eau is also responsible for cities and urban districts not served by SONEB. While DG Eau plans and

implements construction projects in these areas, at the provincial level, it is represented by 11 provincial water divisions which play important role. At local level in rural municipalities, user associations also play an important role. They are generally involved in the daily management of small facilities such as piped networks, hand pumps....

Several NGOs and Associations are also involved in water and sanitation sector such as: "Eau et Assainissement pour l'Afrique" (EAA, Water and Sanitation for Africa), Partenariat National de l'Eau (PNE, National Water Partnership, HELVETAS, PROTO. These actors are a big support for government institutions in water supply to populations. They mainly play a social intermediation role through advocacy, information education communication (IEC) training, and support for funding research.

2.3 Water Demand Satisfaction

In general, four types of water users are identified in the country: households, industry, irrigation and live stock. The domestic demand and satisfaction depends strongly on the water source being used (Hadjer et al., 2005). The principal water sources are: water supplied by SONEB, water supplied by DGE au (protected wells, boreholes...) and water from unprotected wells and rivers, The 2013 census data (INSAE, 2013) provide a valuable source of information concerning the population of each province and the frequency per household using these specific water sources. In urban areas, 86% of households have access to improved sources, against 72.1% in rural areas (Table 1). The improved sources in urban areas are mainly taps installed with in houses, while in rural area it is the public tap/fountain and the well pump/drilling. In rural areas, unimproved sources of water are used by 27.9% of households, against 13.4% of urban households. 20% of households (against 6.7% in urban areas) have to spend more than 30 min in terms of travel time to have drinking water. These results are based on the proportion of the population that has access to drinking water source. It does not include the level of satisfaction. Moreover, the qualitative aspect of water provision is not taken into account. For, it is important to consider the various forms of contamination that can occur between the water supply points and households (Onabolu et al., 2011). Population growth and economic development are the major determinants for future water demand at household level in the country.

Table 1: Access to drinking water in Benin in 2013
Adapted from (INSAE, 2013)

Service level setting	Household (%)		
	Urban	Rural	Total (for the Country)
Improved drinking water	86.4	72.1	78.4
Supply of water through multiple taps within the house	38.7	5.1	19.9
Public tap /fountain	26.6	29.6	28.3
Borehole	12.6	25.6	19.9
Protected well	7.5	9.6	8.7
Protected water source	0.6	1.6	1.1
Rain water	0.2	0.6	0.4
Bottled Water	0.1	0.0	0.1
Unimproved drinking water	13.4	27.9	21.5
Unprotected wells	11.6	17.9	15.1
Unprotected water sources	1.1	3.6	2.5
Water tanker	0.1	0.4	0.3
Surface water	0.6	6.0	3.6
Others	0.2	0.0	0.1
Total	100.0	100.0	100.0
Round trip time to fetch water			
Good access (Water provide through taps within house or on-plot trough at least one tap)	56.4	24.4	38.6
Less than 30 min round trip	33.3	50.5	42.9
30 min or more than 30 min round trip	6.7	20.0	14.1
nd	3.6	5.0	4.4
Total	100.0	100.0	100.0

3. Household Water Treatment in Benin

Household water treatment technologies as emerged as an approach people can rely on to have safe water by treating it in home (Clasen et al., 2005; Lantagne et al., 2006; Mohamed Farook et al., 2012). These technologies are used to improve the quality of drinking water, where there is no centralized system for the treatment and distribution of drinking water or when the available water quality is compromised (Sobsey et al., 2008). By preventing disease they can contribute to poverty alleviation and development. There are several technologies such as chlorination, Solar Disinfection, Bios and Filtration etc... They are advocated as a means to reduce substantially the risk of diarrhea in populations.

3.1 Household Water Treatment Practices

Household water treatment practices are almost the same in the entire country. The main practices are chlorination, boiling, solar disinfection, filtration (through ceramic filters or others filters)(Table 2).

Chlorination is one of the most widely used for water disinfection methods. It consists in performing a chlorine treatment in order to eliminate the micro organisms contained in the water to consume. The reagents used are supplied as liquids or tablets (5-10 ml or 1 tablet to 20l of water to be treated), allowing the user to process a large amount of water at a time. The principals treatment product used are: Calcium hypochlorite and bleach (sodium hypochlorite) and Aqua tabs (INSAE, 2013). "Aqua tabs" is an effervescent tablet containing sodium dichloro isocyanurate or troclosene (DCCNa). This product can be substitute to bleach for being less toxic and more active. A tablet for Aqua tabs can treat 20l of water in 30 min (Stevenson, 2008). However the dose of disinfectant to be added to water should normally be dependent on raw water quality. This practice, as well as the use of other forms of bleach or calcium hypochlorite is therefore questionable as regards to the right use by populations and the impact on the health of users. Solar disinfection consist on the exposition plastic bottles filled with water to the sun. The disinfection is carried out by both UV radiation and the heat treatment to which is subjected the water (Hunter, 2009).The effectiveness of this method depends on the solar radiation, and location. As solar disinfection, boiling allow the disinfection of drinking water by heat treatment. However, it does not affect the turbidity of the water. Filtration is a method based on the use of porous material for filtering the water (Mohamed Farook et al., 2012). Ceramic filters are in the form of "candle" or "pot" (Bielefeldt et al., 2009; van Halem et al., 2009). Candles or ceramic pots are manufactured locally-based organic matter clay mixture (sawdust, rice husks ...). The effectiveness of the ceramic filter is closely related to the quality of manufacture, and the pore size (Brown and Sobsey, 2010; van der Laan et al., 2014). The filters are adapted for relatively clear water treatment because pore filters clog quickly by substances in suspension. In sand filtration, water is passed through a filter bed of sand. The filter be disable to retain a large number of solid particles and microorganisms. On the filter surface, is formed a thin organic layer (called bio film) which allow the development of micro-organisms responsible for biological treatment. A sand filter requires regular cleaning to maintain the purifying capacity of the filter. Clothes are also used for filtration. In that case, a white cloth is use to remove suspended particles from water. The efficiency depend on the size of the pore of the cloth and also the quality of raw water.

In addition to these methods, populations also use Potassium alum, also called "kalinite". It is a crystalline solid, powdery, white or transparent and odorless. It is used as a coagulant to remove particulate pollution (and associated microbiological) water (Khan et al., 1984). In the Mono/Couffo population use oil (petroleum), palm branch puree. In Borgou/Alibori and Atacora/Donga, they also use lemon (Table III).

The use of lemon, oil (petroleum) or the palm branch puree come from traditional knowledge. Households using lemon juice for the treatment of drinking water suppose that it has a bactericidal effect. Also according to them, the lemon juice makes pleasant taste and smell of the water and has therapeutic dressed. No specific evidence regarding the dose is provided. However, Amin and Han

(2011) showed that lemon can be used to improve disinfection in a solar disinfection treatment. It can then be assumed that lemon can be a way to improve water quality at household level. Palm branch puree using is based on the supposition that it is very effective in accelerating of decantation of suspended particles of water. The chemical characteristics of this plant that promote this effect should be studied. The following steps are observed when using that method: (1) Triturate young oil palm leaves, (2) put the min water (3) Stir, (4) leave for a period of 30 minutes to one(01) hours. Oil (petroleum) kills larvae developing in water. However, its use exposed to risks of intoxication.

3.2 Actors Involved and Initiatives

3.2.1. Actors Involved

Few actors are currently involved in household water treatment in Benin. The principals are:

- The « Ministère de la Santé (MS, Health Ministry) » through hygiene agent, carry out disinfection of wells (2 times a year) with calcium hypochlorite;
- Some municipalities that raise awareness about the treatment of drinking water at household level;
- The «Eau et Assainissement pour l'Afrique, EAA» agency in collaboration with the NGO «Protos» to promote the chlorination in the treatment of rain water collected in rain water impluvium.
- The «Association Béninoise pour le Marketing Social et la communication pour la santé, ABMS», working closely with the «Population Services International, PSI» ABMS/ PSI promotes Aqua tabs since 2006 ;
- The NGO «Helvetas» promoting Solar Disinfection and
- The «Songhaï» involved in Ceramic water filters manufacturing

3.2.2. Some Initiatives Implemented

These are some initiatives from NGOs, in household water treatment in the country:

Initiative of ABMS/PSI

With funding from the United State Agency for International Development (USAID), the ABMS / PSI in partnership with Abt Associates promote since 2006 Aqua tabs for the treatment of water at point of use in households. In addition, communication activities for behavioral change are carried out through interpersonal communication and mass media at the location of households involved in the projects.

To assess the impact of its activities in connection with the use of Aqua tabs by the population, the ABMS / PSI initiated a study in 2009 and another in 2011(USAID, 2012). The survey, in 2011, was conducted among:

- 2256 women in charge of children under five years who did not know any of the promotional activities initiated by the ABMS/PSI trough the radio, television, billboards, flyers or interpersonal communication (not exposed women);
- and 940 women in charge of children under five who have been affected by one or more activities of mass media and interpersonal communication in the 12 months preceding the survey (exposed women).

The results of these surveys showed that 6.6% of women "Not exposed" and 21.9% of women "exposed" use the water treatment product Aqua tabs to treat water, against 6% in general in the 2009 survey. Regarding the knowledge of the use of Aqua tabs, only 8.6% of women "Not exposed" and 30.4% women "exposed" against 4.3% for 2009 knew how to use efficiently the product. Also, knowledge of water treatment time (30 minutes) by Aqua tabs was evaluated. Only 6.5% of women "Not exposed" and 28.6% of women "exposed" knew that information, against 2.7% of the 2009 respondents. Aqua tabs is a very effective product but not well known by the population. ABMS evaluates the coverage to 58% in 2012. Currently, perceptions related to the product are often negative. Some people believe that the taste of the water changes negatively after treatment. Others take or

confuse the product with a drug that can hurt. Aqua tabs demand is largely institutional part (UNICEF and other NGOs that promote the treatment of water).

Initiative of Helvetas

The Swiss NGO HELVETAS initiative was related to the promotion of solar disinfection method (SODIS). The project was initiated and tested in the department/province of Atacora, in the northern part of the country and will expand over time to other municipalities (DNSP, 2015). During the pilot phase, the constraints identified are in relation to this method:

- The difficulty for households to buy bottles;
- People are not always doubt about the possibility to treat water using the sun;
- And at least 6 hours of sunlight exposure was necessary to have a positive effect, and that was to long for populations

Helvetas also tested ceramic filters manufactured by “Songhai” in the municipality of Nikki.

Lessons learned are:

- The volume of water treated is low and do not fit the requirement of households
- The pores clog quickly requiring regular maintenance

Ceramic water filters from “Songhai”

“Songhai” has designed and promoted for over ten years ceramic water filters. These filters are made from clay and saw dust. These kind of filters can produce 1 to 3l per hour (van Halem et al., 2009). The entire device of Songhai’s filters is made of the ceramic pot, a plastic bucket and a tap. With a capacity of 10 liters, theses filters, according to a recent test, are capable to produce up to 2.5 liters of water in three (3) hours, depending of the quality of raw water (Johnson et al., 2015).

The factors limiting the promotion of theses filters are:

- The relatively non affordable price of the filters (14 000 fcfa or 28\$);
- The amount of produced water that is relatively low;
- And maintenance requirements

Initiative of “EAA”

“EAA” conducted between 2002 and 2008 school-based impluviums in the implementation of is program related to the improvement of access to clean water(Attakin et al., 2008). The chlorination drop by drop was used to treat the collected water. However, this project was only for schools and was not sustainable.

Apart from this initiative, “EAA” promotes improved equipment for water storage at home. In collaboration with the University of Zurich, improved jars have been developed by “EAA” to reduce microbiological contamination related to poor water storage consumption. However, after two years of experimentation, the improved devices utilization seriously decrease. Several targeted households have not renewed the devices. The reported common problems were related to the fragile clay jars, the taste of water, or the high temperature of the water when stored in plastic containers. EAA also promotes solar disinfection method.

Table 2: Household water treatment practices in Benin
Adapted from (INSAE, 2013)

Practices	Households (%)		
	Urban	Rural	Total (for the country)
Boiling	0.3	0.3	0.3
Chlorine/bleach	3.6	4.4	4.0
Filtration using a cloth	0.5	0.3	0.4
Ceramic filtration, Sand filtration and others kind of filtration	0.2	0.1	0.1
Solar disinfection	0.1	0.2	0.1

Practices	Households (%)		
	Urban	Rural	Total (for the country)
Others	0.9	1.7	1.3
Total	4.4	5.2	4.9

Table 3: Advantages and constraints of household water treatment practices founds in Benin

Treatment methods	Advantages	Use constraints
Boiling	Disinfection of water	<ul style="list-style-type: none"> Requires wood or other combustible fuels Requires time
Decantation	Removes suspended particles <ul style="list-style-type: none"> Significant reduction of turbidity Reduction of pathogens (low) 	long waiting time
Filtration with cloth	Removes suspended particles <ul style="list-style-type: none"> Significant reduction of turbidity Reduction of pathogens (low) 	<ul style="list-style-type: none"> Requires thin cloth Cleaning the cloth continuously or intermittently
Ceramic / sand filtration	<ul style="list-style-type: none"> Elimination of particles in the water Elimination of pathogenic germs 	<ul style="list-style-type: none"> maintenance required waiting time
Solar disinfection	<ul style="list-style-type: none"> Reduction of pathogens 	<ul style="list-style-type: none"> Low volume of water treated The long waiting time (6 hours of sun exposure)
Disinfection (chlorine, bleach...)	<ul style="list-style-type: none"> Reduction of pathogens 	<ul style="list-style-type: none"> Risks of mishandling Substantial cost
Lemon	<ul style="list-style-type: none"> Remove odor 	<ul style="list-style-type: none"> Taste change
Potassium Alum	<ul style="list-style-type: none"> Destabilized particles to facilitate coagulation Reduction of turbidity Reduction of some pathogens 	<ul style="list-style-type: none"> Cause of diarrhea in some children Unpleasant taste for some people
Palm branch puree	<ul style="list-style-type: none"> Reduction of turbidity 	<ul style="list-style-type: none"> Fermented Taste Water be comes slimy

4. Recommendations and Implications for Research

In Benin, demographic Health Survey have revealed that until 2012, only 5% of households rely on household water treatment for safe water, in a context where 21.5% of households use unimproved sources. In urban areas 4.4% of the population using an appropriate method of treatment against 5.2% in rural areas (INSAE, 2013). People are not always aware of the risk related to transportation practices, storage and handling of drinking water. However, household water treatment implementation has enjoyed numerous successes in some developing countries such as Nepal, Haiti, Dominican republic, Nicaragua, Cambodia, Bangladesh....(Baffrey, 2005; Clasen et al., 2005; Lantagne et al., 2006; Prüss-Ustün et al., 2014). Factors that contributed to the success of this programs include:

- The availability of implementation materials and technical assistance to support on-the-ground implementers;
- Large scale communications and social marketing, focusing on behavior change;
- The ability to obtain quality household water treatment option components and replacement parts locally

Based on these experiences, to overcome the difficulties in providing safe water in Benin, relying on household water treatment, effective implementation strategies are important. The first step will be to focus on the factors that contributed to the success in others developing countries. Secondly, much research has to be done in some specific fields such as:

- Health impact study: an effective health improvement related to the use of household water treatment method can be a good way to convince population ;
- Investigations of the economic demand considerations;

- Long term sustainability;
- Include community specific needs and preferences;
- Determine the impact of household water treatment on other water, sanitation and hygiene (WASH) interventions, and determine the optimal combination of their combine interventions
- Moreover, important operational research questions need to be solved, including:
- What is/are the current use/sustainable use of household water treatment method(s) in our demographic, socio-economic, and cultural context?
- How to motivate users to rely on household water treatment in Benin context?
- What are the most sustainable and cost-effective ways to reach rural areas?, knowing that these areas are the most exposed to unsafe water;
- What is the health impact of routine versus sporadic use of a household water treatment method in the country?

To address these questions, multi actors research need to be done, based on a collaborative work between publics institutions, NGOs, local communities and universities.

5. Conclusion

Household water treatment are proved low-cost and effective to provide safe water to those who will not have access to safe water. In Benin, several methods of household water treatment are known and in use. The use of one or another method vary with the provinces. However, only a few part of the population rely on these methods. NGOs play an important role in implementation of household water treatment methods in Benin. But it was notice that a large part of the population do not know how to use them correctly. Also, a long term use of implemented methods by populations was not effective because of use requirements or the investment cost.

In Benin, Household water treatment need to be implemented, in conjunction with others water and sanitation programs, in order to help to reduce waterborne diseases and alleviate poverty.

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