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Assessment of the Potential Contribution of the Ceramic Filter "Songhai" in the Treatment of Drinking Water in Benin (West Africa)

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Abstract

Contamination of domestic water sources by the biological and physico-chemical pollutants remains a public health issue in Benin. The household water purification devices such as ceramic filters may be a solution. "Filtre Songhaï" is a ceramic filter, accessible and easy to use, marketed in Benin. The purpose of this study is to assess the contribution of the "Filtre Songhaï" in the treatment of water for domestic use in a peri-urban area in Porto-Novo (Benin). Water samples have been taken, from a collective well and from the lagoon in the 5th district of Porto-Novo. The physico-chemical and bacteriological parameters were measured before and after filtration. The results showed that the use of filters has allowed for a reduction of 97.5% for total coliform in the well water and 99.05% for water from the lagoon. The reduction is 100% for *Escherichia coli* and fecal streptococci in both cases. Given the low cost and the lifetime use of "filtre Songhai", this device can be recommended to households for drinking water, particularly for children below five years old the most vulnerable to water related diseases. Research is still necessary to improve the filtration time of this device.

Keywords

Drinking Water, "Filtre Songhai", Porto-Novo, Bénin

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1. Introduction

According to the WHO/UNICEF 2013 report on progress in sanitation and water supply, 768 million people live without access to an improved water source and 185 million people use the surface water for their daily needs mainly in Africa [1]. The water quality is largely influenced by human activities and water found in nature is often polluted. The improved water supply shortage affects health with negative consequences on productivity and personal hygiene [2]. In Benin, despite efforts in water supply, assessment to improved water is still difficult especially in rural and suburban areas and households resort to unimproved water such as surface water and well water. Several studies conducted in Benin showed that the wells are often contaminated in proportions exceeding the WHO standard by various pathogens such as *Escherichia coli*, *Klebsiella pneumoniae*, *Staphylococcus aureus*, *Salmonella* spp, *Clostridium perfringens*, etc. [3] [4]. According to the Ministry of Health of Benin, each year, 4300 children under five years old die of diarrhea [5]. Interventions aiming at the purification of water at point of use may then be offered to households to improve the quality of drinking water. Among these, ceramic filters marketed in Benin under the name "Filtre Songhaï" can be offered to households.

These filters are made locally with a mixture of clay, sawdust and water; modeled in custom molds (**Figure 1** and **Figure 2**). Once dried, baked in an oven of 900˚C and cooled, the filters having a good filtration rate are immersed in a solution of water and colloidal silver [5]. This treatment improves the filter efficiency [5]. The benefits of these filters are their ease of use, long service life and their relatively low cost.

The objective of this study is to assess the potential contribution of the "Filtre Songhaï" in improving the quality of water for domestic uses in the 5th district of Porto Novo, a suburban district of the political capital of Benin.

Figure 1. Filter.

Figure 2. Device of the filter.

1.1. Study Sites

Located at 30 km from Cotonou, the city of Porto-Novo is located between 6˚30' Latitude North and 3˚30' East Longitude. It covers an area of 52 km^2 with a population of 263,616 inhabitants [6]. Porto-Novo has five (5) districts. The 5th district covers an area of approximately 14.25 km^2 and a population estimated at 82,430 inhabitants. The sampling of the water of the lagoon was conducted at the landing to Djassin-Topka, a neighborhood of Porto-Novo. As for the well water, the sample was collected from a collective well located Djassin Zoumean outlying district of the 5th arrondissement.

1.2. Sampling

The water samples were collected in glass vials of 500 ml. These vials were previously washed, rinsed and dried in the laboratory. They were then sealed and wrapped in aluminum foil and sterilized at 121˚C for 30 minutes.

Transportation from the sampling point to the laboratory was made in a cooler at 4˚C. The physico-chemical and microbiological parameters were measured in samples taken at each source, before and after the experiment.

Two filters were selected and numbered 1 to filter well water and filter 2 for water of the lagoon.

1.3. Bacteriological and Physicochemical Analyzes

The pH and conductivity were measured in situ using a multi-parameter. The color measurement was obtained using a spectrophotometer. The turbidity meter was used to measure the turbidity. Nitrates have been detected by the cadmium reduction method on a molecular absorption spectrophotometer DR 2800. Nitrites have been identified by the diazotization method. Phosphates were measured through the molecular absorption spectrophotometer DR 2800. The microbiological analyzes were carried out within twelve hours of the sample collection. Fecal coliforms, total coliforms and fecal streptococci were detected by routine methods (NF V08-051 February 1999).

2. Results

2.1. Physico-Chemical Parameters of Well Water and Water of the Lagoon

Table 1 and **Table 2** show the results of physico-chemical parameters before and after filtration of well water samples (**Table 1**) and Lagoon (**Table 2**).

2.2. Microbiological Parameters of Well Water and Water of the Lagoon

Table 3 and **Table 4** show the results of bacteriological parameters before and after filtration of well water samples (**Table 3**) and lagoon (**Table 4**). There is a significant reduction of microbiological contaminants both for well water and water from the lagoon.

Table 1. Results of the physicochemical parameters of well water before and after filtration.

Parameters	Before filtration	After filtration	WHO standards
pH	4.38	7.54	$6.5 \le pH \le 8.5$
Temperature (˚C)	25.3	25.9	-
Conductivity (µ/cm)	122.6	265	≤1000
Color (UCV)	22	20	15
Turbidity (NTU)	4.4	4	≤5
Nitrate (mg/l)	33.44	33.44	≤50
Nitrite (mg/l)	0.0627	0.0363	≤3
Ammonium (mg/l)	2.01	0.03	-
Phosphate (mg/l)	1.99	44.13	-

Source: result of the analyses DGEAU, 2014.

Table 2. Results of the physicochemical parameters of water from the lagoon before and after filtration.

Parameters	Before filtration	After filtration	WHO standards
pH	6.58	6.97	$6.5 \leq pH \leq 8.5$
Temperature (˚C)	25.2	25.3	-
Conductivity (μ/cm)	8390	6670	≤1000
Color (UCV)	40	13	15
Turbidity(NTU)	8	2.6	≤5
Nitrate (mg/l)	1.76	11	≤50
Nitrite (mg/l)	0	0.1	≤3
Ammonium (mg/l)	0.86	0.02	-
Phosphate (mg/l)	2.93	24.91	-

Source: result of the analyses DGEAU, 2014.

Table 3. Results of the bacteriological parameters of well water before and after filtration.

Parameters	Before filtration	After filtration	WHO standards
Total coliforms	9600/100 ml	240/100 ml	0/100 ml
E. coli	160/100 ml	0/100 ml	0/100 ml
Fecal streptococci	65/100 ml	0/100 ml	0/100 ml

Source: result of the analyses DGEAU, 2014.

Table 4. Results of the bacteriological parameters of water from the lagoon before and after filtration.

Parameters	Before filtration	After filtration	WHO standards
Total coliforms	5260/100 ml	50/100 ml	0/100 ml
E. coli	360/100 ml	0/100 ml	0/100 ml
Fecal streptococci	2720/100 ml	0/100 ml	0/100 ml

Source: result of the analyses DGEAU, 2014.

2.3. Debit

During filtration we found that for well water, the flow rate was 2.5 liter in 3 hours and for water from lagoon of 2.5 liter in 9 hours.

3. Discussion

The physico-chemical and microbiological analyzes were conducted in the laboratory of water quality control in the General Directorate of Water in Benin; an authorized laboratory for the monitoring of the quality of drinking water in the country.

The results have shown the effectiveness of the "filtre Songhai" for the well water as well as water from the lagoon, on the microbiological parameters and some physico-chemical parameters.

As regards to physico-chemical parameters such as pH, conductivity, nitrates and nitrites, a difference of values is observed. This could be explained by the properties of clay used in the manufacture of this material. Some physicochemical parameters also differ from the standards prescribed by WHO: in the case of the conductivity (lagoon water), and ammonium, which in the presence of high pH becomes highly toxic for human. The presence of ammonium, nitrates, nitrites and phosphates in the water indicate chemical contamination caused by discharges of sewage and garbage dumps on the edge of the lagoon. The low level of nitrates observed at the lagoon despite the heavy pollution could be explained by the presence of aquatic plants that require nitrates for growth and acting as a biological treatment.

As for microbiological parameters, the use of filter has decreased remarkably concentrations of total coliforms (99.05% for water of the lagoon and 97.5% for well water) as well as coliforms and fecal streptococci (100%). In general, the quality of water used by people, both well water as well as surface water is far from satisfactory. The concentrations of microbiological parameters observed were far beyond the standards set by the WHO. The microbiological parameters are influenced by factors such as distance and position between the wells and latrines, especially when the technologies used for latrines do not meet the sealing standards to prevent contamination of the groundwater [3]. This probably explains the high concentration of fecal coliforms, fecal streptococci as well as the total coliform, found in the well water.

Well water was taken from a place where households do not have access to water supplied by the national water company. This source is also shared with other households in the neighborhood who use the well water for domestic purposes. Our results demonstrate that these water sources are unsuitable for consumption and are consistent with results of Akodogbo [7] which reveal the presence of a large number of fecal coliforms, *Salmonella*, *Shigella*, *Escherichia coli* in well water as well as surface water which communicate with the lagoon of Porto Novo.

After filtering, the microbiological quality of the effluent obtained is much better. These results are comparable to the study by Moubokounou [8]. It therefore appears that the use of "filtre Songhai" is relatively effective for microbiological treatment, which considerably reduces the health risk to populations. The "filtre Songhai" is easy to use, have a long life and are affordable (30 euro) to all households. However, their effectiveness against the virus has not been proven [5].

The main limitation to their use is the low speed of the filtration rate. In our experiment, the observed rate 2.5 liters in 3 hours for well water is less than 1 L/hour; 2.5 liters in 9 hours for water in the lagoon, or 0.25 L/hour. These flow rates are very low compared with the filtration rate of 1 to 2 liters per hour suggested by Vinka *et al.* [5]. This major drawback makes using "Filtre Songhai" limited to households whose size is often important in Benin [6]. However, in keeping the efficiency demonstrated by our results, we recommend the use of these filters for drinking water mainly for children under 5 years, the most vulnerable group to water-related health risks. It appears important to continue research in order to improve the filtration rate of filter ceramics manufactured locally.

4. Conclusion

At the end of this study, it arises that the use of the "Filtre Songhaï" allows a significant improvement of the microbiological properties of water. Later research is needed to improve the speed of filtration of the "Filtre Songhaï".

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