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Water Quality and Hygiene Behavior in Burkina Faso: The Impact of Locally Produced Sodium Hypochlorite Solution in Schools

Qualité de l'eau et comportement hygiénique au Burkina Faso : impact du chlore produit localement dans les écoles

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Mots clés: Burkina Faso, maladies hydriques, appareil électro-chlorateur, WASH, chloration de l'eau, écoles.

ABSTRACT

Introduction. Sodium hypochlorite is a crucial element in the water treatment process. We aimed to verify if schools that lack adequate access to water and don't provide hygiene education courses would improve water quality after an intervention program. **Methods.** Twenty schools from the rural area of Burkina Faso were equipped with electro-chlorinator devices that produce sodium hypochlorite and received training to make water drinkable. Data related to behavioral change was collected. In addition, microbiological analysis of fecal coliforms, total coliforms, and fecal streptococci was performed in the drinking water from water stations or water storage containers. These indicators were measured before and two years after the program in six schools that participated, paired with three control schools from the same region. **Results.** Before the intervention, no schools practiced treating their water. After intervention, schools did it daily. WASH courses and water treatment training were also observed in intervention schools. Only the samples belonging to the control schools contained microorganisms in the drinking water after the intervention, particularly fecal coliforms and total coliforms. Fecal streptococci were not detected in any of the samples analyzed. Before the intervention, 50% of water samples from the intervention group and 66% from the control group were contaminated with fecal coliforms. **Conclusion.** Schools became independent of external disinfectant production after receiving electro-chlorinator devices and proper training to comply with WASH measures. Our findings might be useful to public health practitioners trying to implement sustainable programs.

RÉSUMÉ

Introduction. L'hypochlorite de sodium est un élément crucial dans le processus de traitement de l'eau. Nous avons cherché à vérifier si les écoles qui n'ont pas un accès adéquat à l'eau et ne dispensent pas de cours d'hygiène amélioreraient la qualité de l'eau après un programme. **Méthodes.** Vingt écoles de la zone rurale du Burkina Faso ont été équipées d'appareils d'électrochloration pour produire de l'hypochlorite de sodium et ont reçu une formation pour rendre l'eau potable. Des données relatives au changement de comportement ont été recueillies. De plus, une analyse microbiologique des coliformes fécaux, des coliformes totaux et des streptocoques fécaux a été effectuée dans l'eau potable des contenants de stockage. Ces indicateurs ont été mesurés avant et 2 ans après le programme dans six écoles participantes, jumelées à 3 écoles témoins de la même région. **Résultats.** Avant l'intervention, aucune école ne pratiquait le traitement de son eau. Après cela, les écoles d'intervention l'ont fait quotidiennement. Des cours WASH et des formations sur le traitement de l'eau ont également été observés dans les écoles d'intervention. Seuls les échantillons appartenant aux écoles témoins ont détecté des micro-organismes dans l'eau potable après l'intervention, notamment des coliformes fécaux et des coliformes totaux. Les streptocoques fécaux n'ont été détectés dans aucun des échantillons analysés. Avant l'intervention, 50% des échantillons d'eau du groupe d'intervention et 66% du groupe témoin étaient contaminés par des coliformes fécaux. **Conclusion.** Les écoles sont devenues indépendantes de la production de désinfectant pour se conformer aux mesures WASH.

INTRODUCTION

Access to safe drinking water is a fundamental human right and an essential component of adequate health protection and promotion (1). An estimated 2.5 billion people worldwide still lack access to adequate sanitation, resulting in many diseases stemming from unsafe water,

poor sanitation, and inadequate hygiene (2, 3). Unsanitary conditions and lack of access to safe drinking water are major contributors to morbidity and mortality rates, as illustrated by diarrheal diseases (4).
The sixth goal of the sustainable development goals (SDGs) brings attention to the issue of water availability and sanitation for all. More specifically, the targets described in this goal focus on access to safe and affordable drinking water and adequate and equitable hygiene and sanitation (5). One way to work towards these objectives is to provide drinking water, sanitary infrastructure, and hygiene education in schools. Schools in low-income countries often lack adequate access to water and sanitation facilities and do not provide hygiene promotion (6). WASH interventions, which simultaneously address water, sanitation, and hygiene issues, can therefore strategically use schools as an entry point for health promotion, infection control, and education, improving child health in addition to academic performance (7). The shortage of sodium hypochlorite is perceived as a significant barrier to water treatment and healthcare disinfection procedures in rural Africa. From hospitals in Burkina Faso (8), Mali (9), and Chad (10) to water treatment stations in Benin (11); the logistics, price fluctuations, and quality of the disinfectant acquired are challenges in the fight against waterborne and nosocomial diseases.
This intervention study aimed to determine whether installing electro-chlorinator devices and providing hygiene training in twenty schools in Oubritenga and Kadiogo provinces in Burkina Faso would effect behavioral change. The underlying theory of change is that if schools incorporate sodium hypochlorite production into their program alongside WASH courses, we would observe a change of behavior; sustainable use of this disinfectant leading to water quality improvement. Here, we report the results on the program impact.

METHODS

The project was conducted in 20 schools in the Oubritenga and Kadiogo provinces of Burkina Faso. Among them, six schools were selected to participate in the impact evaluation, and they were paired with three control schools in similar situations. Data were collected within the schools in each province. The schools were selected according to some inclusion criteria, which involved being a public school in a rural environment, having a borehole, and not having a power supply. These criteria ensured that the schools selected were as representative as possible of the conditions of an average school in Burkina Faso (Figure 1).

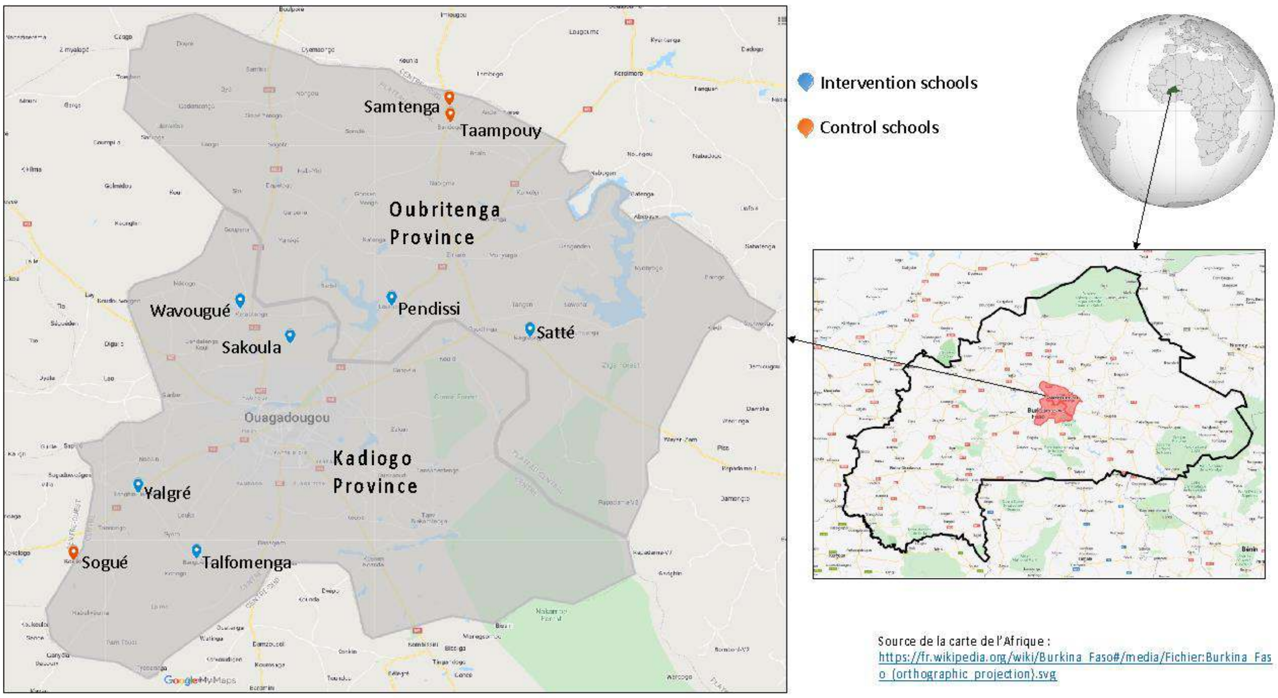

Figure 1- Location of intervention and control schools.

Study design

Pre-intervention indicators were assessed, in June 2017, in nine schools regarding the quality of the water used by communities and the knowledge of hygiene practices among students and their communities. The nine schools included in the project were divided as follows: six schools were allocated for intervention, and three schools were allocated for control where no intervention was done (Figure 2).

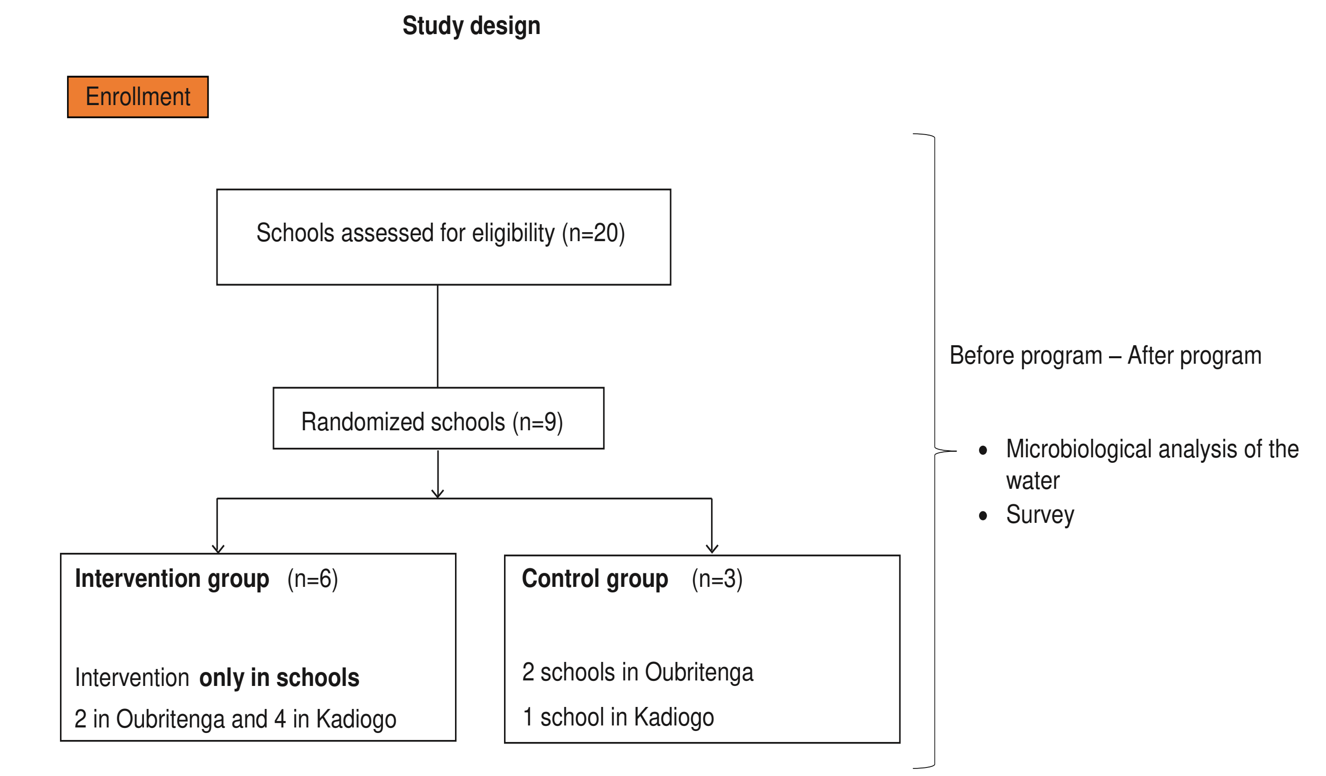

Figure 2- Study design

Two years after the project's initiation in June 2019, the survey was repeated in the selected intervention and control schools. The final evaluation measured the intervention impact of the water treatment project on schools and analyzed behavioral changes regarding chlorine-based water purification.

The intervention

The schools were provided with electro-chlorinator devices (Mini-WATA kit, developed by Antenna Foundation) to produce sodium hypochlorite, and received training on using chlorine to make water drinkable. A teacher's practical document, "Healthy Water in Schools: a teacher's guide," was developed to be implemented and available for download. This guide provides teachers with the necessary knowledge about home water treatment, which they can then pass on to their students. Topics covered include water contamination, hygiene and sanitation practices like handwash, and water chlorination including household water treatment.

The equipment and infrastructures provided for each school:

- 1 complete electro-chlorinator device (Mini-WATA kit).
- 1 solar module for powering the Mini-WATA
- 1 drinking water station per class
- 1 user kit consisting of cups, buckets, and cans in proportion to the number of students in each class
- Tippy-Tap model handwashing devices
- Supplies for the operation of Mini-WATA
- 1 liquid soap production kit

According to the manual's information and following the procedure described in Figure 3, sodium hypochlorite was produced in the class using the electro-chlorinator device and used for water treatment. Each Mini-WATA kit is able to produce 0,5 L of sodium hypochlorite in 3 hours (6g/L), potabilizing up to 2'000L of water. The target of active chlorine was 1.5 ppm and water turbidity inferior to 5 NTU.

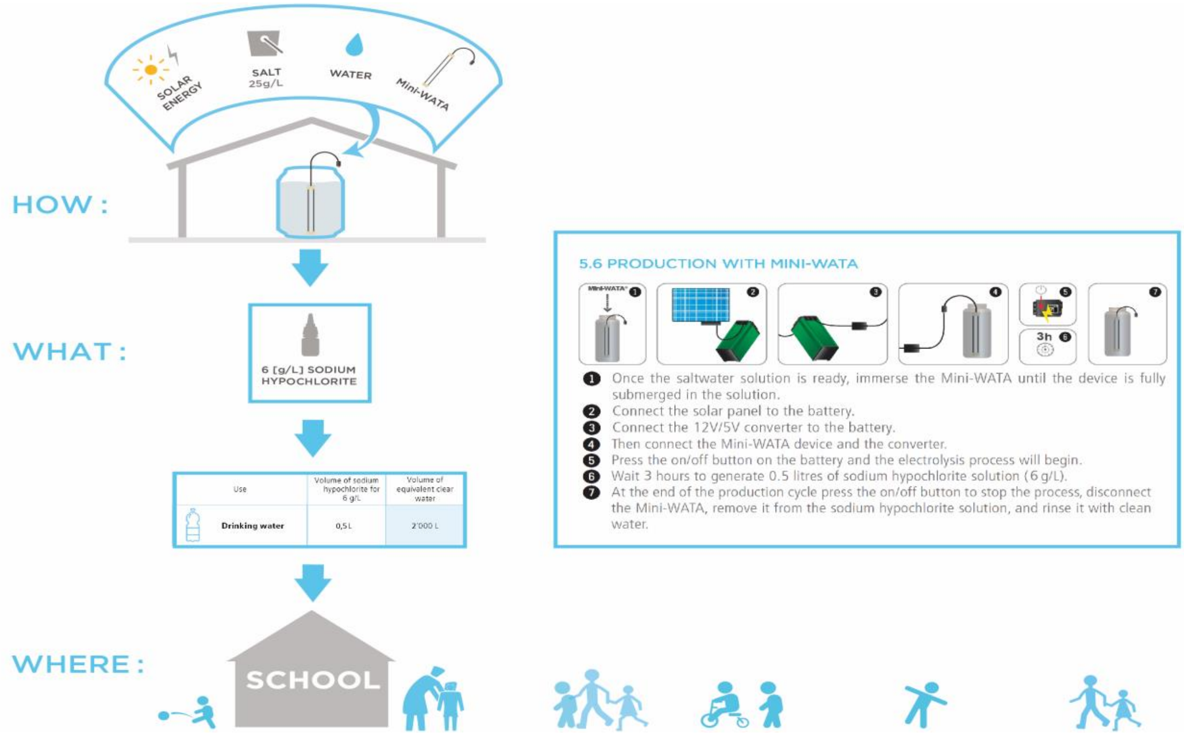

Figure 3 - Sodium hypochlorite production and its usage in schools.

Data collection and impact evaluation:

1- *Water treatment, hygiene, and sanitation knowledge.*

A cross-sectional study during which qualitative and quantitative data was collected a week before and two years after the intervention.

2- *Water quality*

Microbiological analysis of fecal coliforms, total coliforms, and fecal streptococci was performed in the drinking water from water stations or water storage containers for student consumption. Samples were aseptically collected, in the same way school members used water for drinking, to be analyzed by the National Public Health Laboratory (LNSP). Fecal and total coliforms were measured in 100 ml water samples. Briefly, the laboratory procedures involves membrane filtration followed by incubation of the membranes on selective media at 44–45 °C and colony counting after 24 hours. Results are expressed as CFU/100mL.

Data processing and analysis

For qualitative analysis, data was entered on Epi info V7 with data clearance, consistency control, and tabulation according to the analysis plan. Quantitative data was analyzed with the Statistical Package for Social Sciences (SPSS V2).

RESULTS

School demographics

The total sample consisted of one control school and four intervention schools in Kadiogo, two control schools, and two intervention schools in Oubritenga (Figure 1). A total of 1493 students were enrolled in the intervention schools and 293 students were enrolled in the control schools.

Adoption of new behavior

We evaluated water treatment practice and the adoption of new behavior in the control and intervention schools. Before the intervention, none of the schools practiced treating their water. After the intervention: training and with the mini-WATA equipment provided, the schools could produce sodium hypochlorite and perform water treatment for the students. After two years, all the intervention schools visited were practicing drinking water treatment on a daily basis. Evidence of changes in WASH knowledge, attitudes, and behaviors, such as hand-washing with soap after the Tippy-Tap model handwashing devices were installed was also observed in the schools. After two years, the adoption of WASH courses in the curriculum was observed in 5 schools in the intervention group (although two schools already had it before the intervention) and in one school in the control group. Students started being trained in household water treatment in the intervention group as described in the teacher's manual, but this was not observed in the control group during the follow-up visit. All schools from the control group were willing to purchase a commercial chlorine solution, while only 4 (67%) would pay for it in the intervention group (**Figure 4**).

Water quality

Finally, we evaluated the impact of water chlorination after using the Mini-WATA devices by assessing the quality of the water consumed by the students.

We performed microbiological analysis of water samples taken from the water stations or water storage containers for student consumption in the three control and six intervention schools. Analyses were performed to identify fecal coliforms, total coliforms, and fecal streptococci.

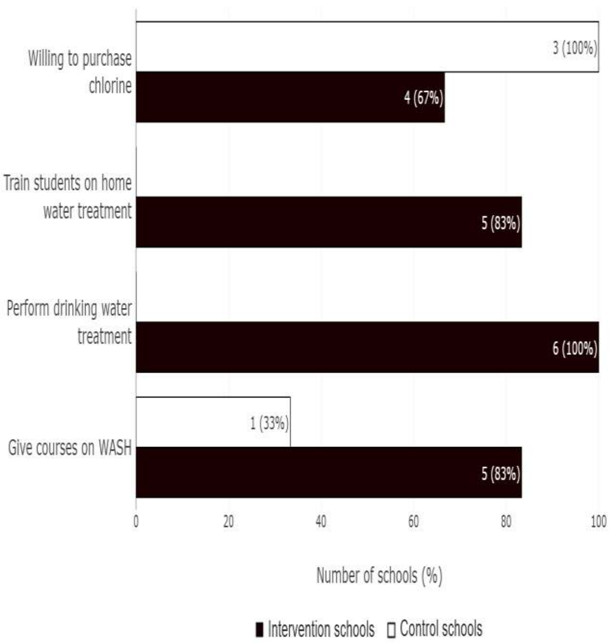

Figure 4: Comparison between intervention schools and control schools after the program.

The results showed that after the intervention only the samples belonging to the control schools contained microorganisms in the drinking water, particularly fecal coliforms and total coliforms. Fecal streptococci were not detected in any of the samples analyzed (neither in control nor in intervention schools). Results are reported by a number of coliforms in 100ml of water analyzed (**Table 1**).

Table 1- Water analysis before and after the intervention. Results given in (FC counts (cfu/100ml)).

Groups	Before intervention		After intervention	
	Total coliforms	Fecal coliforms	Total coliforms	Fecal coliforms
Control Schools				
Samtenga	100	0	100	15
Sogué	100	100	100	53
Tampouy	100	0	100	35
Intervention Schools				
Pendissi	100	0	0	0
Wavougué	100	15	0	0
Yalgré	100	35	0	0
Sakoula	0	0	0	0
Satté	100	0	0	0
Talofmenga	100	100	0	0

DISCUSSION

Water sanitation and hygiene are crucial for prevention and control of waterborne diseases. School-based WASH interventions aim to primarily reduce the incidence of diseases caused by contaminated water and lack of hygiene practices, and improve school enrolment, performance, and attendance. Those benefits might also go beyond the school, as children can act as agents of change in their households and communities, influencing hygiene practices around them (6). Our intervention evaluated a practical aspect linked to WASH interventions; the sustainable use of a device to provide sodium hypochlorite that is crucial for water treatment. Among the six schools selected for a close follow-up two years after the intervention, all of them still treated their drinking water, and four (67%) would be willing to purchase chlorine if something happened to the device. None of the control schools treated their water and this affected the quality of water collected in the schools. However, they were willing to purchase sodium hypochlorite. Perhaps this is due to communication between schools, children from the same family going to different schools or government interventions.

Fecal coliforms, also known as thermotolerant coliforms (TTC), are a subset of the total coliform group. Fecal coliforms are present in the gut and feces of warm-blooded animals. The WHO recommended guideline values for fecal and E. coli coliform bacteria are none detectable per 100 mL and total count not exceeding 500 CFU/100 mL (12). The levels of fecal and total coliforms in the water samples in the intervention group were not detectable, with a clear improvement on the situation before intervention. This was not observed in the control group. The access to electro-chlorinator devices, installation of tippy-taps (handwashing devices), and the training performed in the schools might have contributed to this scenario. Before the intervention, 50% (3/6) of water samples from the intervention group and 66% (1/3) from the control group were contaminated with fecal coliforms. These results are consistent with studies on water quality of stored drinking water in rural schools in Mozambique and Uganda (13).

Drinking water quality is an important indicator of WASH services and directly impacts students' health. An analysis of individual-level data from multiple studies found that for all ages, the risk of diarrhea increased by 21%, 35%, and 49% for those whose household water samples were from 11–100, 101–1,000, and > 1,000 TTC/100 mL respectively, compared to < 1 TTC/100 mL (14) indicating a clear link between fecal coliforms and diarrhea.

There are several studies on the effects of WASH interventions in schools on attendance and waterborne diseases among students (6) but very few on drinking water quality as an intermediate indicator of WASH interventions (13), and even fewer on long term sustainable actions to guarantee water treatment. Sodium hypochlorite is a key element in the water treatment process, and we aimed to measure the adequacy of an electro-chlorinator device in rural schools in Burkina Faso.

CONCLUSION

With this intervention, schools became independent of external disinfectant production after proper training on electro-chlorinator devices operation to comply with WASH measures; the drinking water quality was clearly improved. Our findings might be useful to public health practitioners trying to implement sustainable waterborne diseases control programs. This research provides important guidance for sustaining WASH in schools from low-income countries.

DECLARATIONS

Disclosure

This research was co-financed, conceptualized and analyzed by Antenna Foundation (a non-profit organization, based in Switzerland, that aims to disseminate innovations that improve the essential needs of the world's most vulnerable populations). The data collection was made possible thanks to the support of the Ministry of Education and was performed by Doctor Pascal Korgo. The project itself was co-financed by Charitable Foundation Symphasis.

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Authors contributions

PG Duvernay and RC Nogueira were involved in design and research coordination, as well as data analysis and writing of the manuscript. L Pittet and MPV Passos were involved in data analysis and writing. O Guira and I Bamouni were involved in research execution and coordination. P Korgo coordinated the design and research execution.

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