



Impact of chlorination on the microbiological quality of drinking water in school area: case study of Central North Region in Burkina Faso

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ABSTRACT

In Burkina Faso, despite the realization of drilling, the consumption of safe drinking water remains a major concern in rural school area. To guarantee the consumption of safe drinking water, the project namely "koom-yilma" was opted for the chlorination of water with "Mini-WATA" in rural school area in Central-North region in Burkina Faso. This study aimed to evaluate the impact of this program in nine schools few months after its implementation. Thus, different water samples were analyzed following the membrane filtration method with specific culture media to identify and count fecal coliforms, *E. coli* and fecal streptococci. The results compared with those obtained before the program showed the efficiency of the intervention. Indeed, 40.45% of water samples from students was safe versus 5.05% before the intervention according to the WHO standard. For the 59.55% contaminated water, the number of fecal bacteria was low compared with untreated water. Despite this good results, the percentage of contaminated water still high in some schools because of lack of hygiene. Thus, the improvement of hygiene practices is necessary to ensure the microbiological quality of drinking water in addition to chlorination.

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INTRODUCTION

The lack of access to clean water, improved sanitation and adequate hygiene (WASH) are major contributors to the burden of several infectious diseases (Strunz et al., 2014; Stocks et al., 2014). These diseases, as they primarily persist in socially and economically deprived communities especially in rural area (Hotez et al., 2009; Utzinger et al., 2009). According to data from

the 2013 of Global Burden of Disease Study (GBD) and the World Health Organization/United Nations Children's Fund "joint monitoring program for water supply and sanitation", 7% of deaths in children aged 8-14 years in Burkina Faso was caused by diarrheal diseases, with over 96% attributed to inadequate WASH conditions as primary risk factor (WHO and UNICEF, 2012; Institute for Health Metrics and Evaluation, 2013). The

pathogenic agents associated with lack of WASH cause substantial gastrointestinal morbidity, malnutrition and mortality (Stanley, 2003; Feng *et al.*, 2011).

In Burkina Faso, the drinking water supply policy is essentially based on the realization of drillings in rural area without taking into account the quality of water consumed by populations (PN-AEPA, 2006). Indeed, in this area, the populations are confronted with optimal management of water supply points and traditional water sources attendance (Aouba, 2012). That's a one of causes of contaminated water consumption. Several studies showed a significant microbiological pollution of water in both domestic and schools areas (Dianou *et al.*, (2002; 2004); Mbawala *et al.*, 2010; Nkurunziza, 2013; Souny *et al.*, 2015; Gnazou *et al.*, 2015; Tamungang *et al.*, 2016; Sokegbe *et al.*, 2017; Kaboré *et al.*, 2017). That's essentially related to bad hygiene practices, the lack of sanitation and appropriate disinfection methods in house and school levels. In school area, the assessment of water quality stored in classrooms and those from children's drinking water cups revealed a high contamination with fecal coliforms, *E. coli* and fecal streptococci (Erismann *et al.*, 2016a; 2016b; Kaboré *et al.*, 2017). In view of this situation, the project namely "koom yilma" was opted for the disinfection of drinking water with sodium hypochlorite (bleach) in rural schools located in Central-North region in Burkina Faso. This method recognized by the WHO is sure, effective and cheapest for water purification (WHO, 2006). Moreover, the persistent action of sodium hypochlorite preserves the quality of water against microbial contamination.

This study aimed at evaluating the effectiveness of this program to improve the quality of drinking water in school area in order to consider a large scale implementation in Burkina Faso.

MATERIALS AND METHODS

Study area

The North-Central region is located in the central zone of Burkina Faso between parallels 12 ° 40'1; 14 ° North (N) and

meridians 0 ° 15; 25 ° West longitude (W). It occupies 18.212 km² and it's subdivided into three (3) provinces namely Bam, Namentenga and Sanmatenga (Regional Council of North Central, 2014). In this region, 42% of schools don't have drillings and education rate is low (71.3%) compared to national rate (80.3%) (MAH, 2012).

This program concerned 10 of 107 schools which participate at the first step of project "koom-yilma". Among the ten (10) primary schools selected, nine (9) schools have actually participated in this program (Kaboré *et al.*, 2017). These are the primary schools of Kinkirgo, Ouedsé, Loagha Catholic, Loada, Gabou, Sirgui, Mane Mossi, Zana, and Barkana. Figure 1 shows the location of these schools in North Central. Figure 1 presents the localization of these schools in Central North region in Burkina Faso.

Presentation of "Mini-WATA"

To implement the program, "koom yilam" provided all the schools with "Mini-WATA" to produce chlorine and treat drinking water. "Mini-WATA" is a simple device which produce a sodium hypochlorite from salt water. With 25 g/L of salt water it produce 6 g/L of active chlorine (Antenna Technology, 2017). This chlorine can disinfect 4,000 liters of water, ensuring the daily consumption of approximately 1,000 people.

Production and treatment of water with sodium hypochlorite produced with "Mini-WATA" in school area

In the schools, teachers and parents were trained to produce sodium hypochlorite and treat water according to "Mini-WATA" manual instructions (Antenna Technology, 2017). The project recommended to treat water from drillings each morning and store treated water in appropriate reservoirs in classrooms for students' consumption.

Water sampling and analysis

Few months after the implementation of the program, the microbiological quality of drinking water was assessed in these schools.

Water sampling consisted in taking of 100 ml of water from the storage containers in the classrooms and from children's drinking water cups, with sterile glass bottles. Water samples were stored at 4 °C in a cool box and carried to the laboratory for microbiological analysis according to French standard EN ISO 19458 (2006).

Three (3) bacterial indicators of fecal pollution namely *Escherichia coli*, fecal coliforms, fecal streptococcus were isolated and counted by the membrane filtration technique according to the European standard NF IN ISO 9308-1 (2000). Bacterial cells were concentrated on a 0.2 µm millipore membrane filter followed by culture on the chromogenic Rapid*E. coli* 2 agar (BIO RAD) medium which contains 2 substrates specific to the β-D-Glucuronidase (Gluc) and β-D-

Galactosidase (Gal) enzymes, respectively. Incubation was performed at 44.5 °C for 24 h. Colonies of *E. coli* (Gal+/Gluc+) appear at purple to pink while other coliforms colonies stain at blue. On the Bile Esculine Azide medium, Gram positive cells able to reduce Esculine as fecal streptococci stained black after 24 h incubation period at 37 °C, while Gram negative and other Gram positive cells are inhibited by sodium Azide.

Statistical analysis

Data were analyzed with statistical software R. The analysis of variance (ANOVA) permitted to compare mean bacteria concentrations with those obtained before the implementation of the program in schools.



Figure 1: Location of the nine (9) study schools.

RESULTS

Effect of treatment on the microbiological quality of water stored in the classrooms

For water samples stored in classrooms, the treatment with sodium hypochlorite showed a significant decrease of fecal coliforms ($p < 2.29 \times 10^{-5}$), *E. coli* ($p < 3.659 \times 10^{-6}$) and fecal streptococci ($p < 0.0001541$) in all the schools. Figures 2a, 2b, 2c present respectively the effect of treatment (T1) on fecal coliforms, *E. coli* and fecal streptococci. It appears a significantly decrease of fecal bacteria in drinking water in all the schools except those of Sirgui, Gabou, Loagha Catholic and Mané Mossi (Figures 2a, 2c). Indeed, during the intervention, 25%, 100%, 100%, 80%, 66.66%, 30% of water stored in classrooms respectively from Kinkirgo, Ouedsé, Loada, Barkana and Zana were safe versus 0%, 33.33%, 66.66%, 30%, 0% without any treatment. That shows an improvement of water quality stored in classrooms in these schools. However, for water samples from Sirgui, Gabou, Mané Mossi and Loagha Catholic, the proportion of contaminated water increased of 67%, 60% and 33.33% respectively during the intervention. In these schools, the chlorination wasn't applied regularly according the recommendation.

Effect of treatment on the microbiological quality of water from children's cups

Concerning water samples from children's drinking cups, the results showed a significant decrease of fecal coliforms ($p < 8.65 \times 10^{-7}$), *E. coli* ($p < 0.0002484$) and fecal streptococci ($p < 0.007820$). The effect of treatment (T1) is presented in figures 3a, 3b and 3c respectively for fecal coliforms, *E. coli*, fecal streptococci. For all water samples, the results showed a significant decrease of fecal bacteria in water samples from children's drinking water cups except those from Mané Mossi (Figures 3a, 3b and 3c). Indeed, according to the schools, the percentage of safe water during the program was 18%, 16%, 25%, 70%, 27.27%, 27%, 55.55%, 66.6% respectively for Loagha Catholic, Sirgui, Gabou, Kinkirgo, Ouedsé, Loada, Barkana, Zana versus 0% without any treatment for all these schools except Loagha Catholic (18%). For water samples from Mané Mossi, the percentage of contamination remained unchanged. Globally, the treatment improved the quality of children's drinking water.

However, despite the significant reduction of fecal bacteria, the proportion of water contaminated is still high because of lack of water equipment maintenance, bad hygiene practices and the irregularity of treatment.

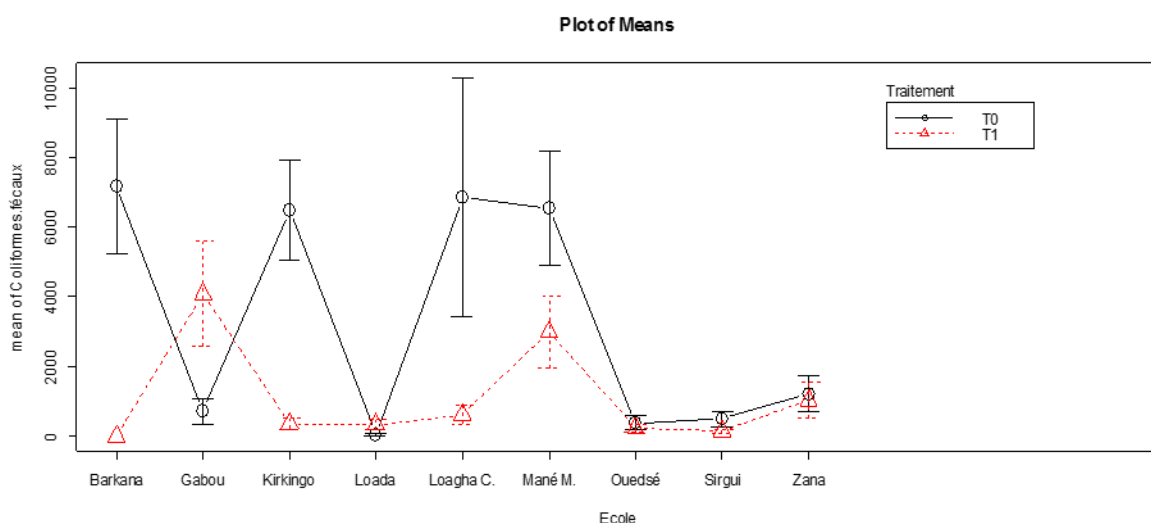


Figure 2a: Effect of chlorination (T1) on fecal coliforms in water samples stored in classrooms.

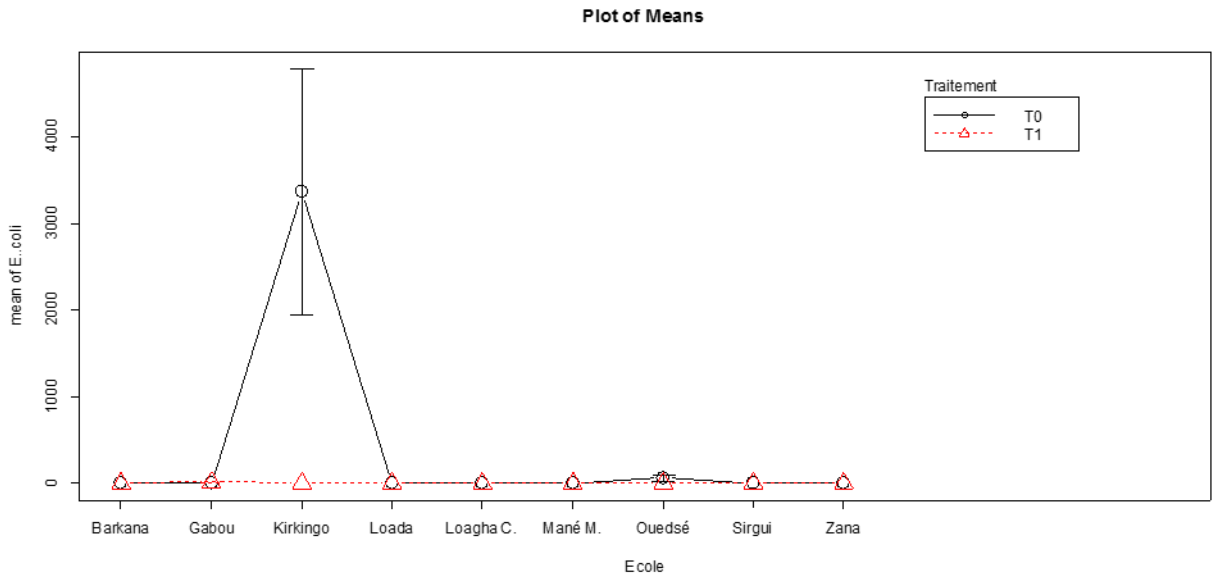


Figure 2b: Effect of chlorination (T1) on *E. coli* in water samples stored in classrooms.

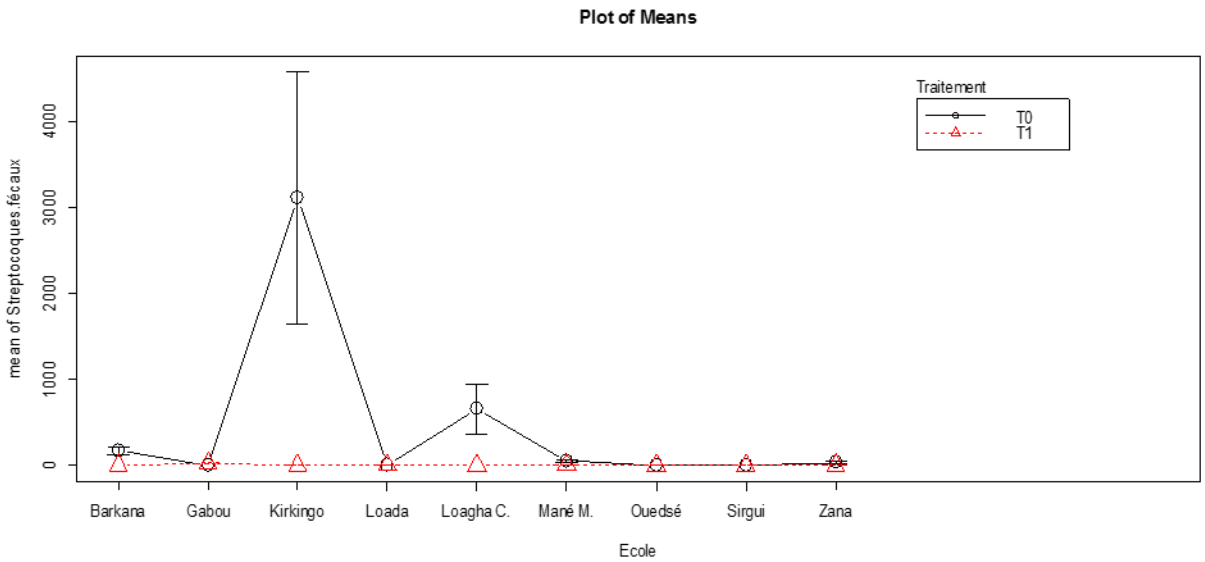


Figure 2c: Effect of chlorination (T1) on fecal streptococci in water samples stored in classrooms.

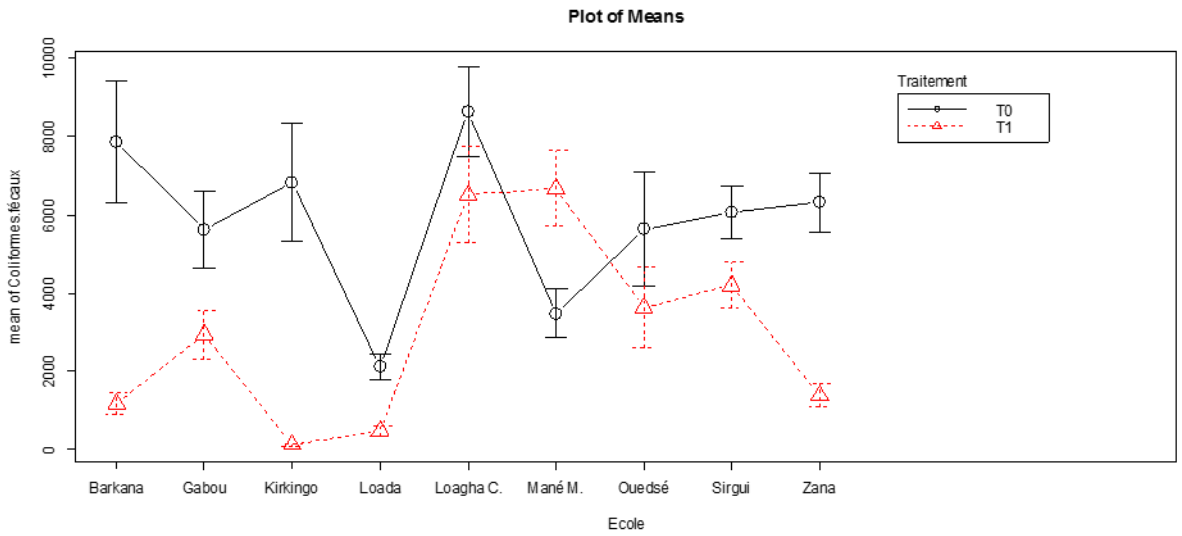


Figure 3a: Effect of chlorination (T1) on fecal coliforms in water samples from children's drinking water cups.

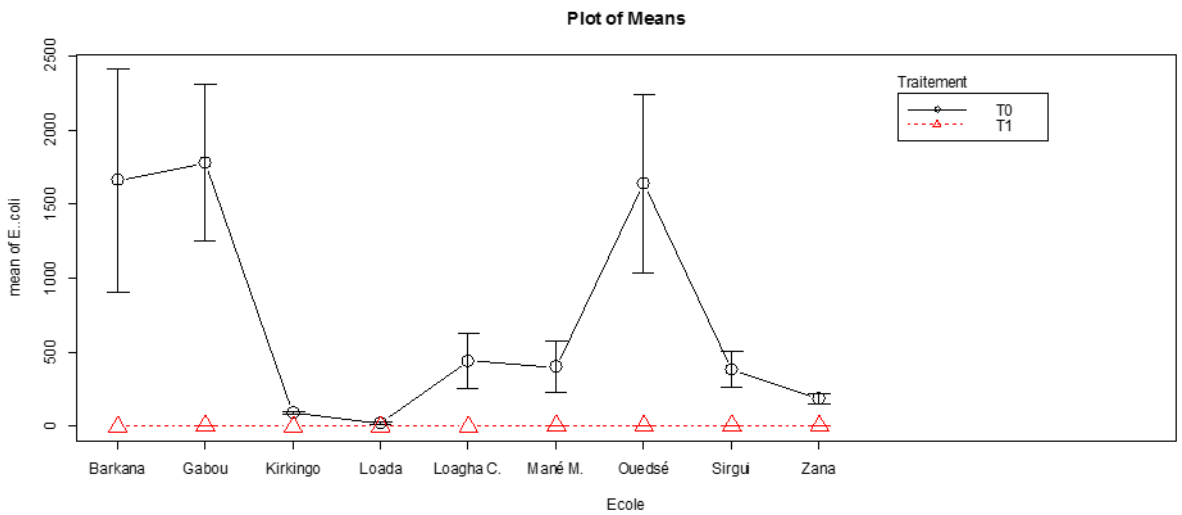


Figure 3b: Effect of chlorination (T1) on *E. coli* in water samples from children's drinking water cups.

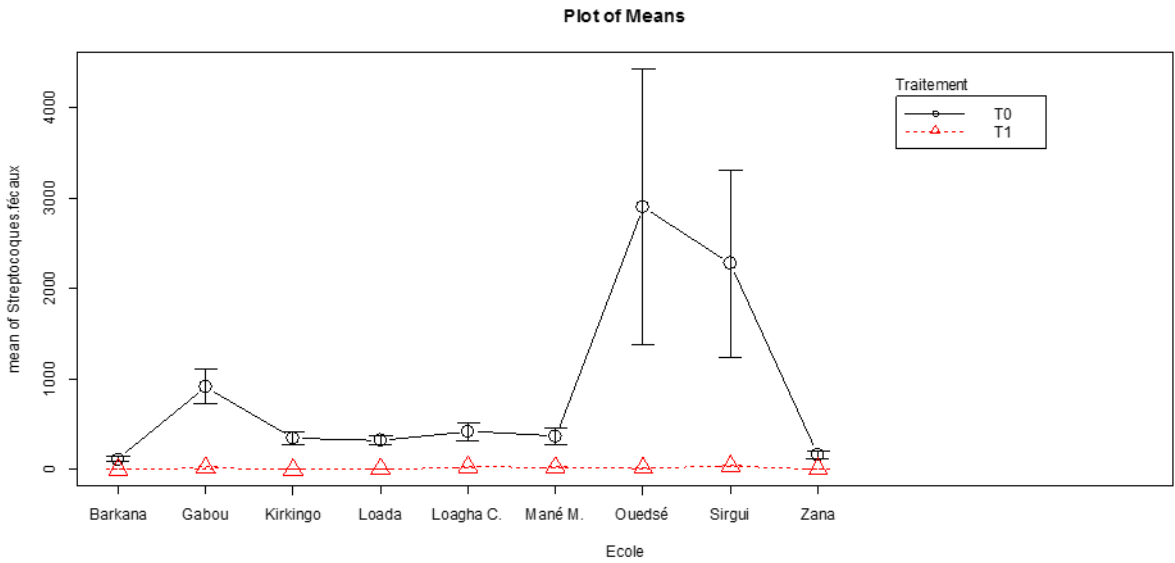


Figure 3c: Effect of chlorination (T1) on fecal streptococci in water samples from children's drinking water cups.

DISCUSSION

With all the schools combined, the results showed that 40.45% of students drank safe water during the program versus 5.05% before the intervention according to WHO standards. In addition, the number of bacteria in water contaminated were low compared to untreated water. This result shows the efficiency of treatment in rural schools. However, during water sampling, we observed a little involvement of teachers at the program. In Gabou, Mané Mossi and Loada, drinking water was not regularly treated according to the program recommendation. This situation explains the increase of fecal bacteria in water stored in some classrooms (Figures 2, 3, 4). Moreover, in the other classrooms, the treatment wasn't repeated when treated water finished before the end of courses. In these cases, the storage reservoirs still empty or filled by children with unappropriated hygiene practices. In addition, water storage reservoirs and cups were not regularly washed. All these factors contribute to explain the contamination of water stored in classrooms.

Concerning water samples from children's drinking cups, the results showed a decrease of all fecal bacteria (Figures 3a, 3b,

3c) during the program. But, many children still bring untreated water from their houses or other sources. Therefore they didn't consummate treated water from schools. Additional, student's cups used to consummate water are not washed regularly. That's explains the high number of fecal bacteria in their drinking water.

In view of these findings, it is necessary to revise the process in schools. Indeed, for treated water storage in classrooms, it will be more judicious to use big capacity containers to provide safe water away. Teachers must regularly treat water and make sure the container is washed before putting drinking water. The students must be train to produce and treat water and hygiene practices must be improve in schools. Thus, according to UNICEF, interventions including education on hygiene and hands washing can reduce by 45% the number of diarrheal diseases cases (UNICEF, 2006). Thereby, it will be important to implement school health clubs to sensitize and train children and make sure that hygiene practices are good in the schools (Erismann *et al.*, 2016b).

Conclusion

The chlorination improve drinking water quality and reduce the risks of waterborne diseases such as cholera, typhoid fever and gastro-enteritis in schools. The disinfection of water with Mini-WATA is a good approach to ensure safe drinking water in rural school area in Burkina Faso. Its easy use and the low cost of production of hypochlorite sodium make this technology suitable for rural area. However, its implementation requires a rigorous training and the involvement of teachers and students.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHORS' CONTRIBUTIONS

AK and BS designed the research proposal, analyzed the water samples and wrote the manuscript. WPS, JS and AKO performed the statistical analysis and contributed to write the manuscript. IBK, ZPLN implemented activities in schools. DD supervised the study.

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