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Contamination of drinking water sources during the rainy season in an urban post-conflict community in Guinea Bissau: implications for sanitation priority

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Summary

Since the 1998 civil war cholera outbreaks and water-borne infections have been a major cause of morbidity and mortality during the rainy season in Guinea Bissau. Our survey aims at: 1.describing the distribution, characteristics and use of water sources and sewage facilities in a central area of the capital city of Bissau; 2. determining the microbiological quality of drinking water during the rainy season. After mapping of the Cuntum 3 study area, water sources' and latrines' location, characteristics and use were determined by visual inspection and interviews with householders. Microbiological analyses were performed from water sources for evaluation of *total Coliforms, E.coli, Enterococcus faecalis.* Twelve water sources (9 wells, 3 taps) and 15 latrines were identified and used by 444 inhabitants. Water sources and latrines were at less than 5 meters distance apart. Wells were self-built, hand-dug, shallow (4-6 meters), unprotected. Taps were located outdoor. Latrines were self-built, open air, unprotected. None of the houses had a bathroom. Maintenance of wells, taps and latrines is not performed on regular basis and well's handling habits are not safe. Well and tap water showed heavy faecal contamination with more than 1000 CFU/100 ml. The contamination of drinking water in Bissau due to poor construction, maintenance and improper use ten years after the civil war, demonstrates the need to allocate resources after conflicts in the area of water and sanitation. Both should be included as a priority in post-conflict reconstruction programs in order to reduce cholera outbreaks and diarrhoea related mortality.

Keywords: *Drinking water, fecal contamination, rainy-season, post-conflict, Bissau*

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Résumé

Depuis la guerre civile de 1998, l'épidémie de choléra et les infections d'eau souillée ont été les causes majeures de morbidité et de mortalité durant la saison pluvieuse en Guinée Bissau. Notre but d'étude était de décrire la distribution, les caractéristiques et l'usage des sources d eau et les facilites de vidange dans la région centrale de la cité capitale de Bissau et de déterminer les qualités microbiologiques de l'eau a boire durant la saison pluvieuse. Après avoir cartographie la zone d'étude, trois domaines d études, location des sources d'eau et latrines, les caractéristiques et l'utilisation étaient déterminées par des inspections visuelles et interviews avec les chefs de familles. Les analyses microbiologiques étaient réalisées des sources d'eau pour une évaluation du total de *coliformes, E. coli, Entérocoque fécale.* Douze sources d'eau (9 puits, 3 robinets) et 15 latrines étaient identifiées et utilisées par les in habitants. Les sources d'eau et les latrines étaient à moins de cinq mètres de distance les unes des autres. Les puits étaient construit individuellement, a main lever, petit (4-6 mètres) et non protégés. Les robinets étaient localises a l'extérieur. Les latrines étaient construites individuellement, à l'air libre, non protégées. Aucune des maisons n'avait de salles de bains. La maintenance des puits robinets et latrines n'est pas faite sur des bases régulière et la gestion habituelle des puits n'est pas sécurisée. Les puits et robinets d'eau ont montres une forte contamination fécale avec plus de 1000 CFU /100ml. La contamination de l'eau à boire en Bissau due à la mauvaise construction, la maintenance et l'usage malpropre 10ans après la guerre civile, démontrent le besoin d'allouer les ressources après les conflits dans les domaines et sanitaires. L'ensemble doit être inclus comme priorité du programme de reconstruction post-conflit en vue de réduire l'épidémie du choléra et de la diarrhée conduisant à la mortalité.

Introduction

Drinking water supply is one of the greatest problems in developing countries. Large urban centres as well as rural villages suffer from a chronic shortage of drinking water supply across Africa [1]. Only 62% of Africa's inhabitants gets access to drinking water

sources [2]. Properly monitored aqueducts are infrequent and water supply often comes from surface wells that are dug with not suitable modalities. The seriousness of the situation is confirmed by the health burden of water-borne infections (diarrhoeal diseases and cholera), particularly in the pediatric population. More than 2.2 million diarrhoea-related deaths occur every year in children aged less than five [2-3] and it is estimated that lack of access to improved sanitation (connection to public sewer or septic tank) contributes to about 1.5 million of child deaths per year and around 88% of deaths from diarrhoea. Moreover, cholera cases continue to steadily increase worldwide, mainly in Africa [4].

Guinea Bissau, in West Africa, is one of the poorest countries in the world [5]. During 1998–9 it suffered from a civil war with heavy fighting in the urban area. Wells, electric grids, hospitals and health centres were destroyed. Seasonal climate variations worsen these effects, causing an increase in morbidity and mortality during the rainy season (June–October), especially among children [6-7].

In the past decade various cholera outbreaks occurred [8-10], with 25111 cases and 399 deaths in 2005, 3242 cases and 219 deaths in 2006, 153 cases and 8 deaths in 2007, with a case fatality rate (CFR) ranging from 1.6% in 2005, to 6.76% in 2006 and to 5.23% in 2007 respectively. Until November 2008, 13781 cases and 221 deaths have been reported, with the majority always occurring in the urban area of Bissau [11]. Many studies have been carried out to determine the origin and the diffusion of similar water-borne diseases in the rural part of the country [12-13]. Several social and behavioural factors, like poor funeral practices, have been taken into account [12-14].

A study conducted in the rural Bijagos Islands demonstrated poor water quality during the rainy season as a cause of the increase of diarrhoea cases in that area [15]. Indeed drinking water supply is a crucial issue for the country: only 59% of the population has access to drinking water sources and only 35% has improved sanitary services available [5]. The drinking water distribution system of the city of Bissau, the main urban centre of the country with its 250000 inhabitants, has been built before independence from Portugal in 1974. It reaches only some suburbs and neither structural conditions nor the management look optimal. Pipe borne water is supplied by the Electricity and Water Company of Guinea Bissau (EAGB). Water supply to households more frequently comes from low-depth wells, therefore from the superficial aquifer. The city lacks municipal sewage facilities, thus the majority of people shares outdoor latrines often placed close to houses and wells.

A recent study on children accessing a Pediatric Outpatient Clinic in the capital city of Bissau, demonstrated that 70.7% used water from unprotected wells dug near the house and 15.7% from unprotected wells located in the road of residence. Only 2.7% had a bathroom at home, while 97.3% used outdoor latrines in common with other families [7].

The above data, albeit coming from heterogeneous researches, show a quite lower percentage of the population with sustainable access to improved sanitation and safe drinking water sources than expected, according to previous reports [5]. It could reflect the difficulty of re-organizing basic health services and making them accessible to the main part of the population after the war.

The aim of the present study is to describe the condition of water supply and sanitation for the population living in the central area of the capital city of Bissau. We thought that by describing the distribution, location, use and quality of water sources and sanitation facilities of a main suburb of the capital city, targeted interventions could be developed to reduce the heavy burden of cholera and diarrhoeal disease during the rainy season.

Materials and methods

Setting and study area

The capital city of Bissau is the main urban centre of the country, hosting 25% of the entire population of Guinea Bissau. Contum 3 is a central suburb of the capital city (Fig.1), situated just behind the National Reference Hospital for Tuberculosis and lung diseases. Thirty-one houses, a mosque, a school and two stores characterize the suburb. Buildings within the suburb are not served by paved roads and houses are separated from each other by soil covered backyards. Houses are built with mud bricks and covered by roofs made of corrugated iron sheets; windows are without glass or mosquito nets. The majority of them consist of 3 or 4 rooms. The composition of the population of the area is heterogeneous, with mainly medium-income families.

The study was conducted during the rainy season of 2006 (month of July). The study consisting of an epidemiologist, a pediatrician and a technician with previous experience of water collection and analysis.

Fig. 1: Google map of Bissau City, Guinea Bissau with the central suburb of Cuntum 3.

Phases of the study

Demarcation and mapping of the area

Due to the lack of maps of the municipality of Bissau, the study area was delimitated and mapped by visual inspection with the necessary measurements (Fig.2). The map was then compared with the Google Earth satellite map of Bissau for confirmation. Each house hosted one single household as verified before the beginning of the study. Interviews with the 31 household heads were conducted at the time of inspection to determine the number of inhabitants per house; the number and type of water sources, sanitation facilities and their use were also determined through the interviews. The site and type of water sources and latrines were then documented by visual inspection. The depth of the wells was measured using a graduated plumb-line while information on latrine's holes depth was obtained from the household heads who dug the latrines. The interviews were conducted in Portuguese-creole, the official language of the country.

Water sampling and bacterial analyses

Three samples of 125 ml each were collected from each water source. Water samples from water taps were collected directly in sterile glass bottles. Water samples from wells were collected through sterile plastic buckets: water retrieved from the bucket was immediately poured into the sterile glass bottle. Bacteriological analyses were performed in the laboratory of the National Reference Centre for Tuberculosis to determine the presence of *total*

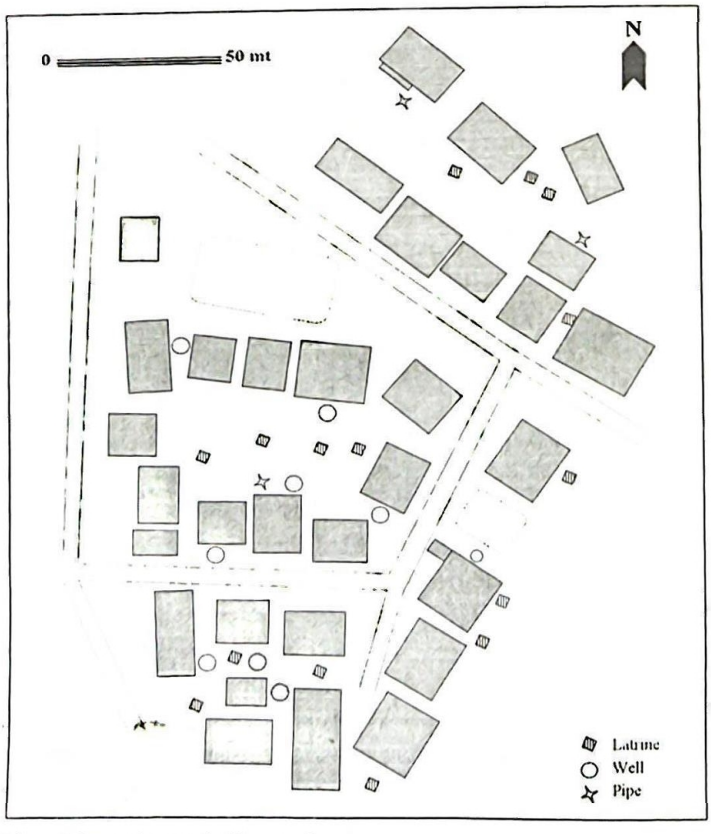

Fig. 2: Map of the study area in Cuntum 3

Coliforms (TC), *E.coli* (EC) and *Enterococcus faecalis* (SF) in collected water samples.

The membrane filter method has been used [16]: water samples (100 ml for each source) were filtered with air-pump onto 0.45 µm membrane filters and filters have been inoculated in Petri dishes supplied with specific recommended mediums [16-17] within 60 minutes from collection. Mac Conkey Agar was used for *total Coliforms* (with incubation at 35°C for 24 h), m-FC-Agar was used for *E.coli* (with incubation at 44°C for 24 h) and KF-Streptococcus-Agar for *Enterococcus faecalis* (with incubation at 35°C for 48 h). Incubation was performed in a mini-incubator (Elettrofor).

Counted colonies are reported as CFU/100 ml. A blank (100 ml sterile water) was routinely examined to control for contamination of the equipment.

Results

All household heads accepted to be interviewed and to have their water sources and latrines assessed. Four hundred and forty-four inhabitants lived in the Cuntum 3 area of the study, with a median of 13 inhabitants per house (range: 1-33 inhabitants).

Water sources characteristics and use

Twelve water sources have been found: 9 surface wells and 3 pipe borne water taps (Fig.2). Only 12/31 households (38.6%) have a water source (29% owns a well and 9.6% utilizes pipe water paying a rent for it to the EAGB). Two more wells were shown, but were contaminated with salt water and had not been used for the previous 3 years.

The nine wells in use at the time of inspection were all shallow with a depth ranging from 4 to 6 meters (Fig. 3). All were hand-dug bucket wells and were surrounded by a mud brick wall (or a metal sheet, in one case) with no cover. The wall bricks were prone to erosion. Water was up-taken with plastic buckets without a pulley. Buckets are generally held aside of the well and not protected from soil. Cooking, domestic washing (dishes and clothes) and personal washing take place beside the well. All wells were owned by the 9 households and had been built with dwellers' funding.

Households with taps reported lack of full day water supply and common water supply failures >12 hours per day, and therefore admitted using well water. None of the houses had showers.

Latrine Characteristics and use

Only one family had an indoor bathroom with a septic tank, but it was without running water. Fifteen latrines were identified (Fig.2), therefore only 15/31 households (48.3%) have a toilet facility, with a rate of 0.48 latrines per household (0,033 latrines per inhabitant).

Visual inspection revealed 15 open air latrines. All were completed and used at time of inspection. All had a simple similar structure (Fig. 4): a corrugated iron sheet surrounding, a béton slab without a concrete lining. No cover or superstructure was available in anyone. They were 2-3 meters deep. Latrines were also self-built (with dwellers' funding) and owned by the 15 households.

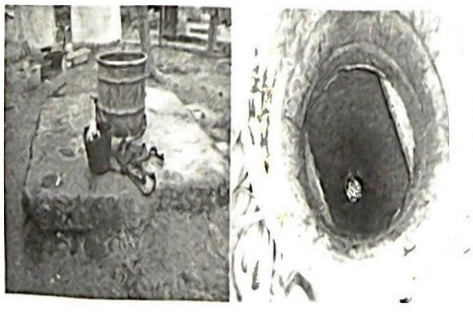

Fig. 3: Well, Contum 3, Bissau

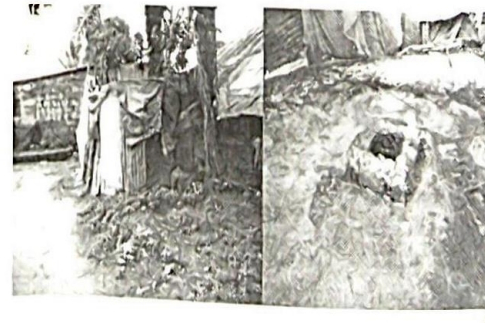

Fig. 4: Latrine, Contum 3, Bissau

Space distribution of wells and latrines demonstrates a location of both in the backyards of the houses and a wide proximity between the two: the majority of the latrines (90%) are less than 5 meters apart from the wells and some are also located upstream of wells and water taps.

Wells and latrines were shared and neighbouring residents had free access to them. Every inhabitant had access to water and latrines within a distance of 100 meters from home (less than 15 minutes walk). Maintenance and quality monitoring of wells, taps or latrines is not performed by owners or by a central authority.

Microbiological Analysis

All water sources showed high degree of fecal contamination according to international standards [17-18]. More than $1x10^3$ CFU/100 ml of *E.coli, total Coliforms, Enterococcus faecalis* were observed. No difference was observed between well water and pipe water regarding number of CFU/100 ml, demonstrating equal fecal contamination of public and private water, at least during the rainy season. The key results of our study are summarized in Table 1.

Table 1: Key results of the study

Well construction	none was built in a way to ensure a safe water supply
Latrine construction	- none was built in a way to minimize fecal leakage; - all were located close to the wells thereby easing fecal contamination of the superficial aquifer
Well and latrine use	- none of the well's buckets were used according to the rules for the prevention of water contamination - wells, water taps and latrines were shared by several families - wells, water taps and latrines did not have current or extraordinary maintenance
Fecal contamination	microbiological analyses showed a similar high contamination of the water up taken from the wells and the water streaming from the aqueduct

Discussion

The study confirms the difficult situation of safe drinking water supply in West Africa, particularly in Guinea Bissau. Such a difficulty was well known in rural areas [12-15], but is indeed demonstrated in urban areas as well. Ten years after the civil war, the capital city of Bissau shows percentages of safe water use and basic sanitation distribution that are below data available before and immediately after the war: 42% of safe drinking water in 1991 vs 79% in 2000 and 30% of basic sanitation in 1991 vs 95% in 2000, respectively [19]. Post conflict countries see a relative higher amount of funding being allocated in the immediate emergency and post-conflict period for health facilities rehabilitation and implementation of basic health services [20-23]. Reconstruction of a public water system and improvement of a tap water program as well as expansion of the sewage system are seldom included as a priority, despite the fact that increased access to safe water is directly related to a diminution of diarrhoea episodes and mortality at 5 years [1;24]. Inadequate water and sanitation systems and lack of basic health knowledge were among the major health problems pointed out in other post-conflict situations, like in post-conflict Northern Province of Sri Lanka [25]. It is well known that any progress towards increasing the proportion of people with sustainable access to safe drinking water and improved sanitation contributes significantly to the reduction of both major infectious diseases and child mortality [24; 26-30].

Despite the positive fact that 100% of the population has access to water sources and latrines within 100 meters from home, both water sources and latrines are far from being safe. The key results of our study (Table 1) clearly justify the high prevalence of gastrointestinal diseases in both adults and children as well as the high recurrence of cholera outbreaks in Guinea Bissau. Several epidemiological studies have confirmed the central role of water-borne transmission for such epidemic [1,26]. Other causes have been found in the setting of Guinea Bissau [12-14], but water contamination, poor water facilities and poor sanitation have to be confirmed as a leading cause of it. Between 2000 and 2005 the mean incidence of cholera in Guinea Bissau was much above the sub-region mean incidence (140 vs. 27 per million) and the third one amongst West African countries. In the same period, CFR was also amongst the highest of the region [8-10]. Moreover, Guinea Bissau has one of the highest rates of infant mortality at 5 years in West Africa and in the continent as a whole [5].

Our study demonstrates that an ever-increasing proportion of vulnerable people is still lacking access to safe water and improved sanitation ten years after the war. Unlike other urban communities, where the use of unimproved water and sanitation is limited to the poor [24,26,29], in Bissau this seems to be the average situation of the middle income class, as the one living in the Contum 3 area.

In order to reduce water contamination and the consequent spread of oral-fecal transmission diseases, it would be important to decrease the number of people using wells for drinking water supply and to increase the number of those having access to municipalized pipe water. The expansion, improvement and maintenance of an existing network, as the small one that is present in Bissau, even if apparently expensive compared to other measures as water chlorination, yields better and permanent positive effects [26-30] in the long run. It must be stressed that aqueducts management requires a continuous monitoring of water quality and specific competences with specialized operators in order to distribute safe water. As our paper shows, a pipe grid is not enough if it is not properly managed to ensure an acceptable water quality. Nevertheless, investment in the expansion and monitoring of a municipal pipe is the best option in the long run.

In our study, all the latrines were unimproved. The structure of latrines should be carefully studied, as well as their layout when water sources are in the area. The construction of latrines should not be self-organized (as in our setting), but should be monitored by a central authority in order to ensure the respect of rules and avoid any contamination of the aquifer. Lack of funding was reported by the household heads as the main reason for the lack of maintenance or for improvement of latrine's structure from unimproved to improved. In any case, the construction of a centralized sewage system itself would be the most efficient way to prevent aquifer contamination and gastrointestinal diseases as some experiences in Latin America have showed [4, 26, 29].

Poor handling habits of water sources by the owners suggest the need for intensive health education to acquire knowledge about preventive measures and modification of risky practices [26].

We conclude that interventions willing to definitively control water-borne infections and to reduce cholera outbreaks in Guinea Bissau should include a programmatic and co-ordinated approach that strengthens sustained health development. Unavoidable measures in the setting of Guinea Bissau must include:

- Allocation of resources to develop water pipe-lines or safe water wells
- Development of a Maintenance Program for water grids and wells as well as a Water Quality Monitoring Program
- Development of adequate sewage facilities
- Strengthening health education for forth coming high risk seasons as the rainy season.

Without these interventions, every year the rainy season will burst both diarrhoea and cholera cases and mortality, over-burning the already fragile health system. Moreover, the above interventions should be considered a priority in post conflict countries.

Conclusion

The contamination of drinking water in the urban post-conflict community of Bissau due to poor construction, maintenance and improper use of wells, taps and latrines ten years after the civil war, demonstrates the need to allocate resources after conflicts in the area of water and sanitation. Both should be included as a priority in post-conflict reconstruction programs in order to reduce cholera outbreaks and diarrhoea related mortality.

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