RAD U ZBORNIKU

# ENGINEERING SOLUTIONS AGAINST POLLUTIONS OF BOREHOLE FOR WATER SUPPLY CLOSE FROM ATLANTIC OCEAN IN SOUTHERN TOGO. CASE STUDY: BÈ AND BOKA BOREHOLES

# INŽENJERSKA REŠENJA PROTIV ZAGAĐENJA BUNARA ZA VODOSNABDEVANJE U BLIZINI ATLANTSKOG OKEANA NA JUGU TOGOA. PRIMER: BÈ I BOKA

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**ABSTRACT**: *The coastal areas of Bè and Kodjoviakopé are experiencing difficulties in accessing drinking water, caused by pollution of the surface shallow aquifers and surrounding lagoons. This led to the installation of telescopic isolation boreholes. A project has therefore been drawn up to install two deep boreholes on the two sites, with the aim of exploiting the totally confined deep aquifers, whose water quality is irreproachable for consumption, while isolating the highly polluted upper aquifers. These two facilities will supply the Bè and Boka castles for sharing domestic taps. The boreholes were successfully completed in their configuration, enabling the two deep aquifers to be tapped at the Bè site. However, at the Boka site, only the Paleocene aquifer was tapped, due to an error during the final drilling operations. Some of the drilling equipment fell into the borehole. This led the decision-makers to isolate the deeper Maeschtrichian aquifer down. The results have been satisfactory, since the flow rates from the boreholes during the pumping tests were high enough to cover the capacities of both chateaux.*
**Key words**: *Telescopic borehole, Coastal areas from Togo, Sea water intrusion, Isolation, confined aquifers*

**APSTRAKT:** *Obalska područja Togoa, a posebno grad Lome, imaju poteškoća u pristupu pijaćoj vodi, uzrokovanih zagađenjem površinskih plitkih vodonosnih slojeva i okolnih laguna. Ova oblast ima konfiguraciju nadređenih višeslojnih vodonosnih slojeva, što je dovelo do postavljanja teleskopskih izolacionih bušotina kako bi se izbegli svi problemi zagađenja. Zbog toga je urađen projekat postavljanja dve duboke bušotine u gradu, sa ciljem eksploatacije potpuno zatvorenih dubokih vodonosnih slojeva, čiji je kvalitet vode besprekoran za potrošnju, uz izolaciju visoko zagađenih gornjih vodonosnih slojeva. Ova dva objekta će snabdevati vodotornjeve Be i Boka a oni dalje domaćinstva. Bušotine su uspešno završene, što je omogućilo korišćenje dve duboke izdani na lokaciji Be. Međutim, na lokalitetu Boka nabušena je samo paleocenska izdan, zbog greške tokom završnih radova bušenja. Deo opreme za bušenje ostao je u bušotini. Ovo je navelo donosioce odluka da izoluju dublji vodonosni sloj Mastrihta. Rezultati su bili zadovoljavajući, jer su protoci iz bušotina tokom testova crpenja bili dovoljno visoki da pokriju kapacitete oba vodotornja.*
**Ključne reči**: *Teleskopska bušotina, obalska oblast Togoa, intruzija morske vode, izolacija, izdan pod pritiskom*

## INTRODUCTION

Coastlines are often subject to excessive pollution of their groundwater and surface water due to the intrusion of saline water and poor management of sewage from agricultural, mining and industrial activities (Belgium 2017; Abdelfattah et al. 2023). The Togolese coastal zone as a whole is experiencing these effects, with the salinisation of free intergranular subterranean aquifers and the surrounding lagoons. In the capital Lomé, people living in the neighbourhoods of Bè, Kodjoviakopé and Baguida are facing problems accessing drinking water as a result of this problem. The 3,000 $m^3$ Bè water tower, built to serve the area and supposed to be supplied from the Kakaveli Wellfield via pipes, has been empty for a long time due to the lack of an adequate supply source and a reliable pipe system. Bearing this in mind, in January 2020, the Ministry of Water and Villagers Hydraulics, with the support of the Togolese Republic presidency, undertook the construction of two deep wells at Bè and Boka to supply the Bè water tower and the newly-built Boka a water tower. The aim of the project is to isolate the free surface aquifers, which are highly polluted by landfill and the intrusion of saline sea water, in order to capture the deep aquifers whose hydrogeochemical water analysis meets international drinking water consumption standards, and to find a significant flow rate that can meet the capacities of both castles. The aim of this work is to present the configuration of these two structures, the different methods adopted for their construction and the different results obtained.

## 1-Framework of the study

In order to supply drinking water to the neighbourhoods of Bè and the surrounding area, as well as Kodjoviakopé, where the population is more concentrated in the city of Lomé (Fig 1, a), it is worth giving some thought. For this purpose, a project has been undertaken to rehabilitate and resupply the Bè water tower by drilling a borehole and building the new Boka water tower, as well as drilling a borehole to supply it. The project was proposed by the Ministry of Water and Villagers Hydraulics with the support of the Presidency of the Togolese Republic. The two areas are located in the capital, along Togo's Atlantic Coast, and are home to at least 1/3 of the capital's population. The area is packed with infrastructure such as factories and hotels that consume a lot of water. The volume of the two reservoirs is estimated at 3,500 m$^3$, broken down as follows: 3000 m$^3$ for the Bè reservoir and 500 m$^3$ for the Boka reservoir, (Fig 1 b and c).

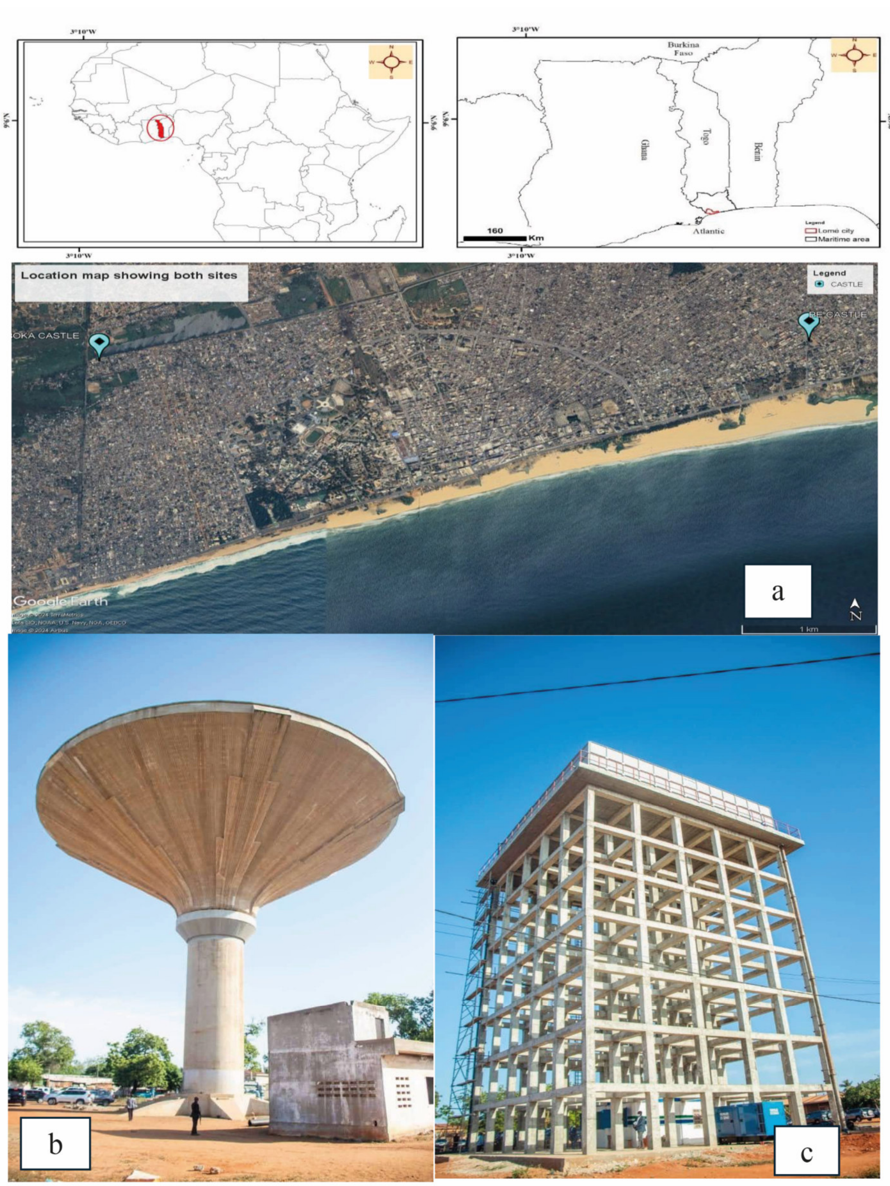


***Figure 1.*** *Location of both site (source: Google Earth) (a), Bè castle (b): X: 1º 1 4’57.01’’E; Y: 6º 8’9.57’’N and Boka castle (c): X: 1º 12’1.55’’ E; Y: 6º 8’2.84’’N*

## 2-General geological and hydrogeological settings

Geologically, the area is made up of coastal sedimentary basin formations consisting of sand, claystone's, limestone and phosphates with a monoclonal slope of layers in a north-west and south-east direction, as well as the thickness of the layers increasing in this direction. These deposits are recent in the history of Togolese geology and vary in age from the Tertiary to the Quaternary (Da Costa et al. 2013). Thanks to the permeability of some of their layers, they offer a potential reservoir for storing fluids such as water. (Fig. 2).

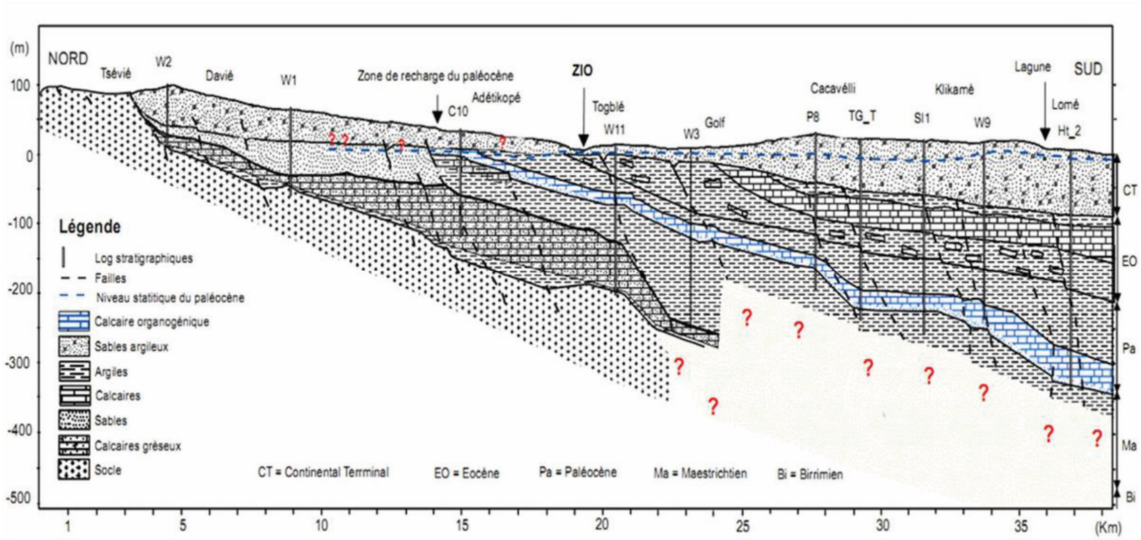


***Figure 2**. Geological cross section N-S showing the monoclinal structure of the layers in the Basin and their thickness (according Padaro et al. 2021, modified).*

Hydrogeologically, the area is made up of four superimposed aquifers; from the most recent to the oldest: The unconfined aquifer of sea sands, totally salted due to marine intrusion, which runs along the coast and is made up of recent deposits. The free aquifer of Quaternary-age Terminal Continental sands, which is continuous and covers the entire basin. It is also polluted due to the poor management of sewage from agricultural and industrial activities and landfill sites. Then there is the pseudokarstified and confined Paleocene limestone aquifer with an average conductivity of around 800 µS/cm. The confined Maeschtrichian sand aquifer, has an average conductivity of around 400 µS/cm. There are also discontinuous aquifers such as the Eocene, which is only present in the northern part of the basin (Gnazou et al. 2015; Gnazou et al. 2018). Hydrogeochemical analyses of water from the Paleocene and Maeschtrichian aquifers show chemical and bacteriological elements values that meet international standards for good quality water and good mineralisation.

## 3-Description of the configuration and method used

One of the main objectives of these boreholes was to tap the deepest aquifers, which include the confined Paleocene limestone aquifer, located between 150 m and 200 m depending on the location, and the Maestrichian sand aquifer, which is more than 380 m deep in the area, then to isolate the surface aquifers, which are unconfined and highly exposed to pollution from human activities and marine intrusion. Given the scale of the problem, the head of the engineering firme « Ingenierie Geotechnique et Assenissement » (IGA) in charge of the control, Mr Sama Dao, put forward a proposal for telescoped boreholes on the two sites to achieve the desired objectives (Guide technique de realisation, de protection, de gestion et abandon, des forage d'eau, 2015) (Fig. 3, a and b). This method involves varying the drilling diameter while isolating the exore by cementing of each diameter drilled after equipment. The diameter of the borehole varies as drilling progresses to greater depths. This method generally avoids contamination of deep aquifers by those located higher up. The principle in this case consisted of drilling to a depth of 20 m to a diameter of 609 mm and then installing a steel casing 550 mm in diameter. The drilling method used was rotary method with circulation of bentonite mud as the fluid. The rest of the operation consisted of reducing the diameter of the borehole and continuing the drilling process according to the different cases below.

In the case of Bè, located to the south-east of the town, where the aquifers to be tapped are deeper due to the slope of the geological strata, a 508 mm diameter borehole was drilled in the casing to a depth of 190 m with installation of a temporary 400 mm PVC casing and cementing of the exore. This was followed by a further reduction in the diameter of the borehole to 304 mm to a depth of 290 m, the depth of the roof of the Paleocene aquifer, followed by the installation of 280 mm PVC casing with cementing of the exore. The final phase consists of reducing the diameter of the borehole to 239.4 mm and drilling to a depth of 450 m in order to cross the two deep aquifers, then installing stainless steel pipes. The solid stainless-steel tubes are installed at the aquitards and the strainer tubes of the same diameter are installed at the aquifers (Fig. 3, a).

In the case of the Boka borehole at Kodjoviakopé, much further to the west, the same configuration was proposed, but the second telescoping operation was not planned because the depths of the aquifers in the area are shallower (Fig. 3, b).

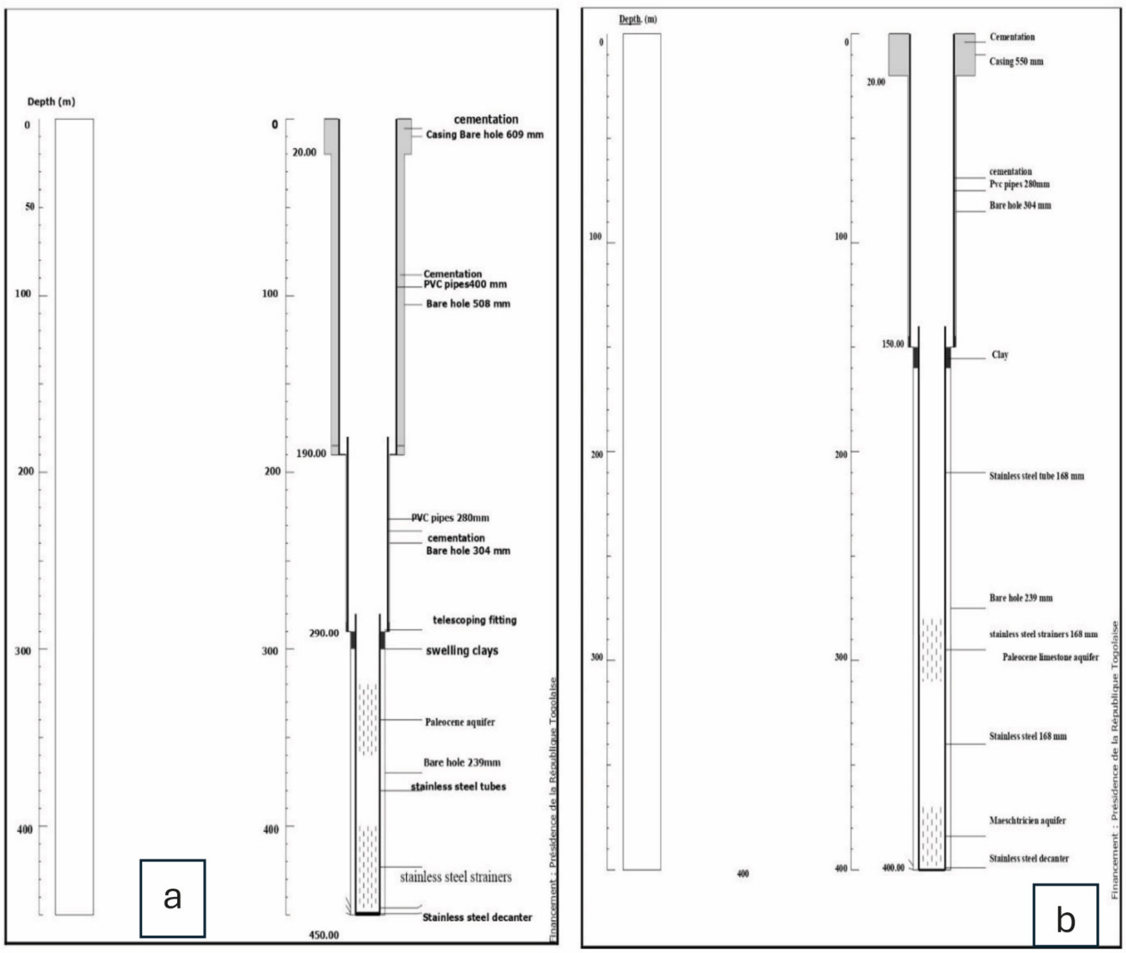


***Figure 3.*** *Technical cross-section of the Bè borehole (a) and Boka borehole (b)*

## RESULTS

After nine months of work (September 2020 to May 2021), the two boreholes have been set up and operational. As a result:

At Bè, a total depth of 432.45 m was drilled to tap the two deep aquifers (Paleocene and Maeschtrician) while respecting the various telescoping's and isolations provided for in the provisional cross-section. The planned equipment was adapted to the depths of the aquifer formations without any incident (Fig 4. a).

At Boka, the entire depth drilled (403 m) was not equipped due to a technical problem that occurred during the last drilling operations. Due to a handling error and the presence of a cavern in the limestone at

403 m, the drilling teams dropped the drilling tool (the tricone) plus 13 4.6 m drill rods into the hole. After several unsuccessful attempts at retrieval, the engineers in charge of the inspection, the project owner and the drilling team decided to fill in the depth of the dropped equipment and to equip the upper aquifer (Paleocene aquifer) after isolating the Maeschtrichian containing the dropped equipment by cementing it in place. For this reason, at Boka, only 310 m corresponding to the depth of the Paleocene was tapped and equipped while isolating those of the deeper Maeschtrichian and the free aquifers such as the terminal continental and the more polluted sea sands (Fig. 4, b).

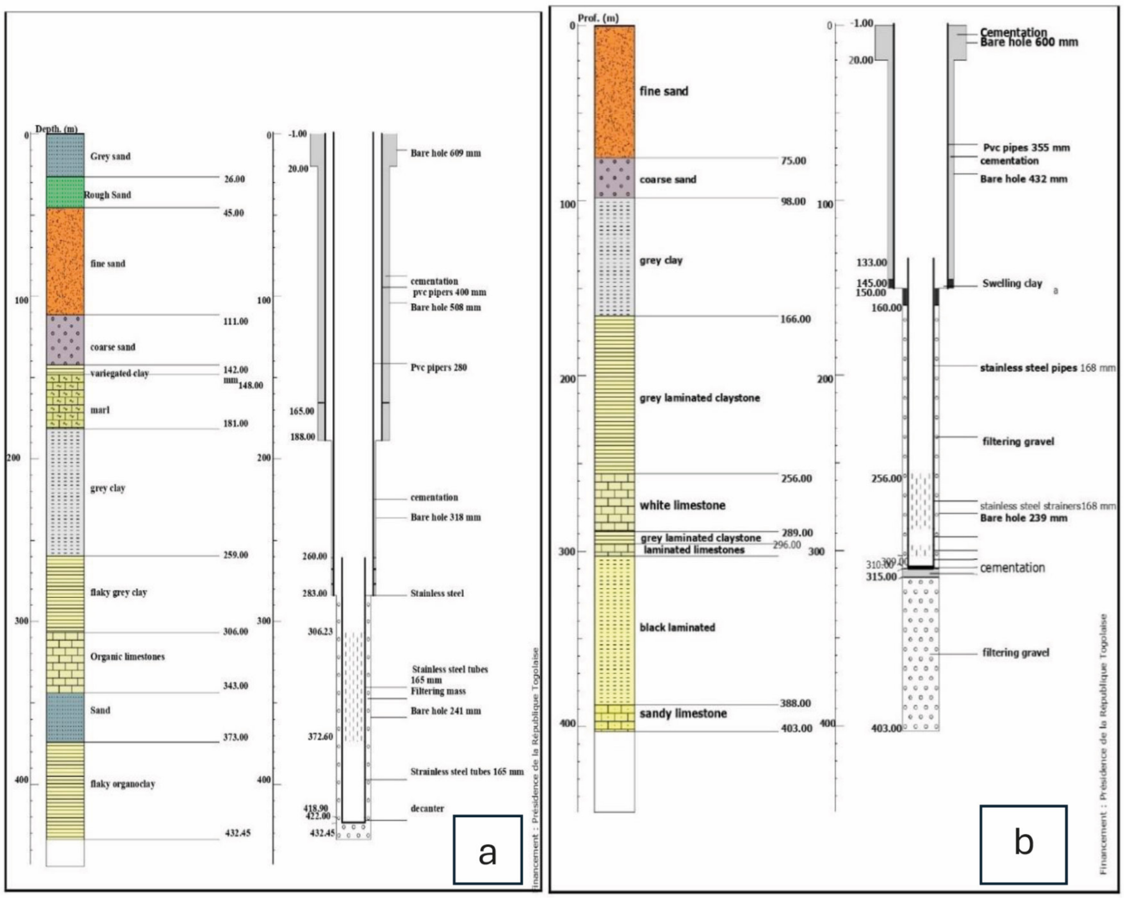


***Figure 4.*** *Final section of the Bè borehole showing the different telescopes with lithology (a) and Boka's* (b)

***Figure 5.*** *Videoendoscopic inspection (a) and pumping test (b) and (c) at Bè*

After the equipment had been installed on the two structures, a video endoscopic inspection was carried out to check the success and efficiency of the equipment installed, (Fig. 5 a). The pumping tests gave respective flow rates of 216 $m^3/h$ in the case of Bè and an average conductivity of 612 μS/cm, whereas in Boka the flow rate was 112 $m^3/h$ with a conductivity of 1065 μS/cm. The hydrogeochemical and bacteriological analysis results give chemical and bacteriological element values that meet international drinking water quality standards.

## CONCLUSION

Isolation boreholes are suitable for the Bè and Kodjoviakopé areas for the supply of drinking water. As these two areas are located on the Togolese coast within the capital, their exposure to marine and anthropogenic pollution is not negligible. The different configurations of these two structures in the area have made it possible to obtain water of appreciable quality and quantity for the supply of these two drinking infrastructures (the Bè and Boka castles) without any other costly treatment. We would like to see more of these types of facilities in the area and in other areas where the shallow waters are exposed to sources of pollution, to make it easier for people to access drinking water. A number of other questions remain unanswered, namely: Given that these two aquifers are totally confined and recharge is not direct, we need to know the actual reserve of these two reservoirs and, if possible, the net annual recharge, in order to be able to define a rational and forward-looking scale for exploiting this vital resource. There is also the question of whether, with these forges in place, aquifers will retain their ordinary physical and chemical properties?

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