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A Model of Transforming Seawater into Drinking Water at Conakry, Republic of Guinea

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Abstract

In the Republic of Guinea, many populations still suffer of water shortages today, particularly in the capital Conakry. The reasons include the rapid increase in population and the lack of water supply infrastructure as well as the degradation of certain fresh water resources due to human activities. In this context, new water supply technologies must be considered. This paper propose a model for transforming seawater into drinking water. The method used is thermal distillation. To achieve this objective, seawater samples were collected in Banares beach to determine the physicochemical parameters before and after treatment using electrometric and nephelometric experimental technic. Ten (10) liters of seawater were treated and 1.5 liters obtained after thermal distillation process. The seawater physicochemical parameters were compared before and after treatment. The results shown dissolved salt rate went from 95g/l to 0.7g/l after treatment (thermal distillation). The pH varied from 5.56 to 6.89 respectively before and after treatment (thermal distillation) showing a decrease of the seawater acidity. The conductivity before and after treatment are respectively 174300 and 1402 µs/cm indicating a drastic reduction of the seawater conductivity. The turbidity varied from 92.7 to 1.11 UTN respectively before and after treatment

Keywords: Model; Desalination; Distillation; Seawater; Thermal; Transformation

Introduction

Water is abundant on earth, it represents 1380 million km3. However, this quantity is made up of sea water (97.2%) and ice (2.15%) which cannot be used directly for consumption. Fresh water, easily available (lakes, rivers, certain groundwater), represents only 0.07% of the total resource (approximately one million km3). It should be noted that the distribution of this water is very unequal. In fact, ten (10) countries share 60% of fresh water reserves and twenty-nine (29) others, mainly in Africa and the Middle East, are on the contrary faced with a chronic shortage of fresh water. In these countries, according to (the Water Resources Institute), 250 million people today don't have the minimum subsistence level of water defined at 1000 m3 per inhabitant and per year. 400 million people live under water stress, estimated at between 1000 and 2000 m3 per inhabitant and per year. And it is estimated that 2.5 billion people could suffer from a lack of water in 2050 because of demographics evolution and water consumption increase [1]. A recent report from UNICEF and the World Health Organization (WHO) indicates that 13% of the world's population does not have access to a satisfactory quality source of water.

Despite significant progress, the problem of drinking water still exists and represents a real global concern (economic and health issue).

Guinea, often nicknamed the water tower of West Africa because of its numerous river basins, faces major water supply challenges for populations. According to a UNICEF survey, in Guinea, several children under 5 years old die due to water-borne diseases or lack of water. According to the African Water Association [2], at the end of 2011, all sources of water production drinking water in Guinea provided approximately 165,000 m3 per day while the needs of the populations of Conakry are estimated at 280,000 m3 of water per day. The water resources management problem in Guinea is investigated in [3].

To deal with this predicted water shortage problem in Guinea, new techniques for producing drinking water must be implemented to satisfy the water needs of population. It is why we carried out this research entitled 'A Model of Transforming Seawater into drinking water at Conakry, Republic of Guinea. This paper proposes a model for seawater treating into drinking water by thermal distillation. The use of desalination is very old and started by Greek sailors [4].

Desalination of seawater issues have been addressed by several researchers. Seawater desalination an important option for addressing the world's water supply challenge [5]. Many desalination technics exists among which osmotic gradient [6-8], thermal distillation [9]. Opportunities for solar water desalination worldwide is addressed in [10].

Thermal desalination plant is installed in Malesia [11]. Seawater desalination is much advanced in Middle Eastern countries and reptsents 75% of total world capacity of desalinated water [12]. The effectiveness of desalination is measured by the dissolved salts rate which must be less than 500 mg/l [13]. Large-scale seawater desalination remains little developed in African exception of the Maghreb and South Africa [14].

This paper is organized as follows. After the introduction section above, a description of the study zone is made. Then the Materials and Methods section is presented in which the distillation technic and laboratory tests allowing seawater physico-chemical parameters determination before and after treatment are presented.

Materials and Methods

Materials

Study Area

Bénarès beach is located in the Yimbaya port district, southwest of Ahmed Sékou Touré International Airport, in the commune of Matoto which is one of the thirteen (13) communes Conakry city, according to an extrapolation of the 2014 census (RGPH3). It has a population estimated at 712,185 inhabitants in 2016. Benares beach extends over more than one kilometer of fine sand, lined with coconut palms, shells and mangroves. It has a dimension of 1.35 kilometers.

Tools

To carry out this research, we used certain materials and equipment of three types. In situ tests materials, laboratory tests materials and materials served to transportation of sea water (salt water). Table 1 gives the In situ tests materials and their function, while the table 2 gives the laboratory tests materials.

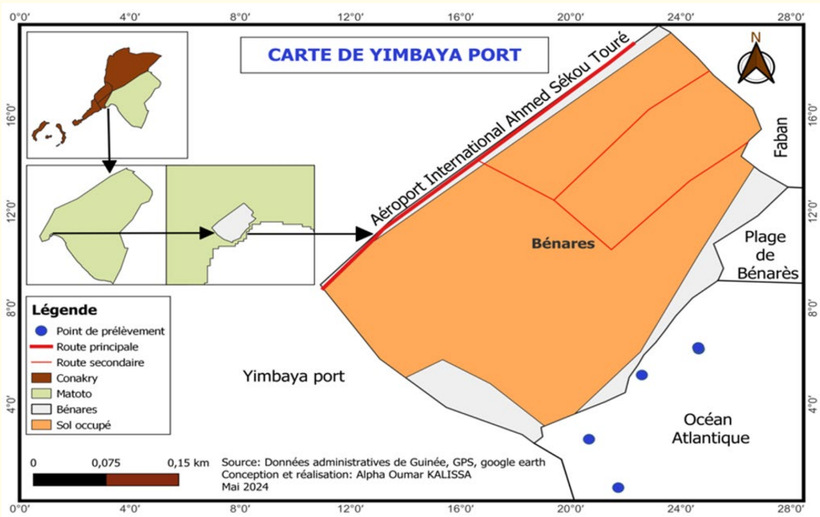


Figure 1: Map of the Yimbaya port district.

Materials	*Function*
GPS	To locate the geographical coordinates of Bénarès beach
Multimeter	To determine the parameters (Ph, Temperature, Conductivity) of sea water
Photometer 7500	To determine the turbidity of sea water
Pissette	To keep water distilled
Bottle	To take the seawater sample
Glacière Cooler	To preserve the seawater sample

Table 1: The In situ tests materials.

Divise	*Operating principle*	*Function*
Multimeter	Electrometric	pH Determination
Multimeter	Electrometric	Conductivity determination
Compact turbidimeter	Nephelometric	Turbidity determination
Multimeter	Electrométric	Temperature measurement
Pan	Thermal distillation	Distillation of sea water

Table 2: Laboratory tests materials.

The mains materials from table 1-2 are in Figure 2.

Figure 2: Mains materials used in this study.

Methods
Sampling and In-situ Tests

The first work consisted of taking sea water samples at Benares beach. Three samples were taken at three different times. The aim being to constitute a water sample representative of the state of sea water of Benares beach. Then we proceeded to their in-situ physico-chemical parameters determination. Figure 3 shows the Sea water sample collection in-situ physicochemical parameters determination.

Sample transport

Before leaving Conakry for the laboratory of University of N'Zérékoré for laboratory analyses, we purchased the cooler and bottles in order to transport the seawater sample in very good condition under a temperature of 4°C.

Figure 3: Sample collection and in-situ determination of physico-chemical parameters.

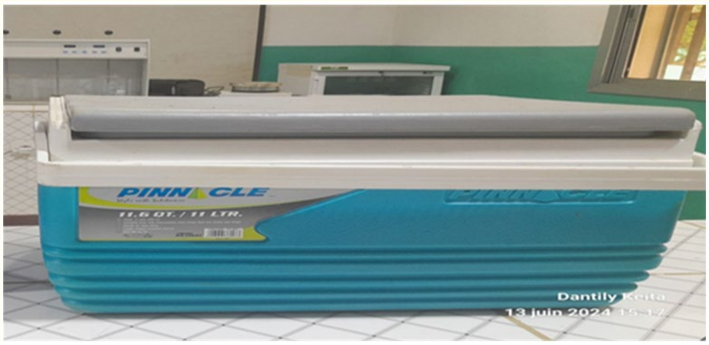


Figure 4: Conservation equipment used for samples transporting to the laboratory.

Physico-chemical analyzes in the laboratory

The analysis were carried out at the analytical chemistry laboratory of the University of Nzérékoré. The seawater sample analyzed is the mixture of the three samples taken at different times on the site (Benares beach).Thes analysis consisted of determining the same physicochemical parameters (pH, conductivity, turbidity and the level of dissolved salts) as the in-situ test performed on the beach. Figure 5 shows the experimental device and procedure for the laboratory analysis.

Desalination procedure

In this part, we explore innovative solutions that make seawater suitable for human consumption. Indeed, this method makes it possible to convert salt water, characterized by a high salt concentration, into potable fresh water.

The seawater desalination process can be carried out in several ways such as:

Inverse osmosis (membrane).

- Thermal distillation.
- Electrodialysis.
- Capacitive ionization.

Figure 5: Experimental device and procedure for the laboratory analysis.

In our study, we used the thermal distillation method which consists of heating sea water until evaporation at a temperature of 100°C through a heating plate and a saucepan which not only contains a small container but also constitutes a specific cover allowing the recovery of the water vapor in order to obtain water which contains a very small quantity of mineral salt. Figure 6 shows thermal distillation used.

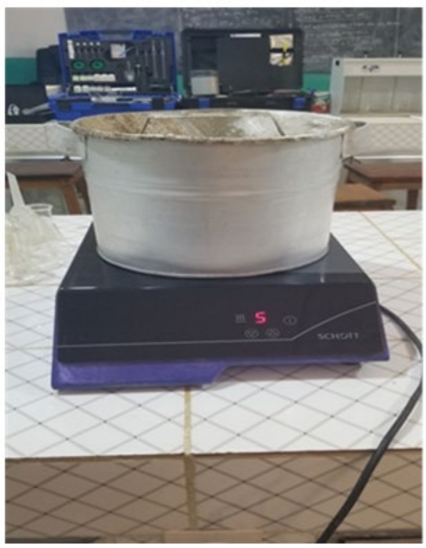


Figure 6: Thermal thermal distillation procedure.

Results and Discussions

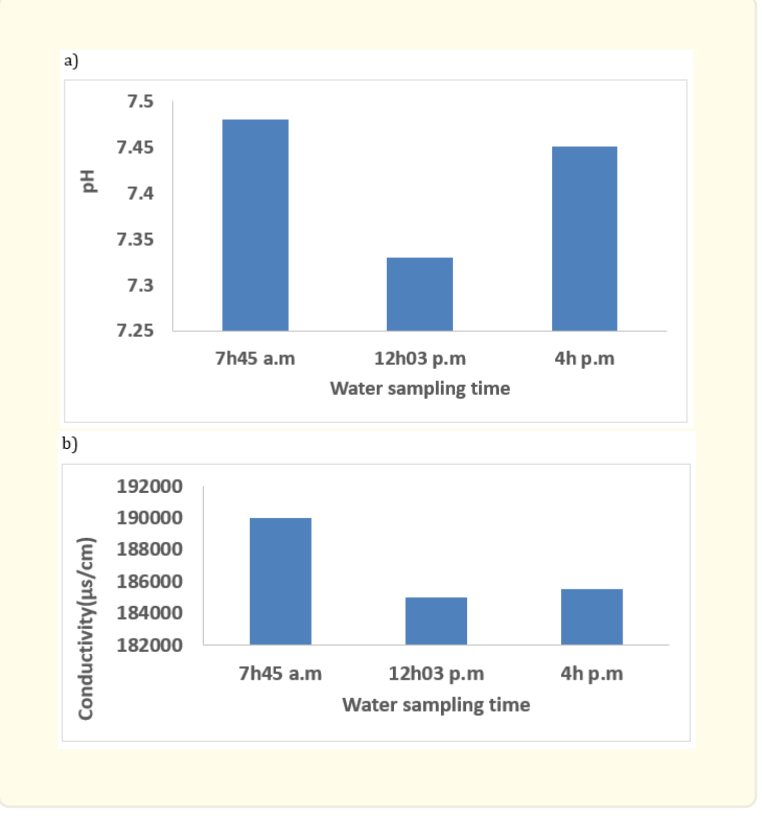
After thermal thermal distillation procedure, we further carried out laboratory analyzes to determine the physicochemical parameters in order to compare them to the same parameters before thermal thermal distillation and to compare, the parameters after thermal distillation to World Health Organization (WHO) standards parameters of water. The aim being to compare the parameters of sea water, in particular the rate of dissolved salts before and after thermal distillation and to the WHO recommended values. Table 5 below gives the comparison between the parameters on site, in the laboratory before thermal distillation, in the laboratory after thermal distillation and World Health Organization (WHO) standards parameters.

In-situ Physicochemical parameters analysis results

Table 3 gives in-situ physicochemical parameters values while Figure 3 illustrates the variation of these parameters in function of water sampling time.

Sample collection		***Physico-chemical parameters***				
Sample code	Time	pH	Turbudity	Conductivity	Dissolved salt rate	Temperature
E1	7h45 a.m	7,48	95,66 UTN	190000µs/cm	95000 mg/l	25°C
E2	12:03 p.m	7,33	293,66 UTN	185000µs/cm	92500mg /l	25°C
E3	4 p.m	7,45	278,99 UTN	185500 µs/cm	92750 mg/l	25°C

Table 3: Sea water in-situ physico-chemical parameters.



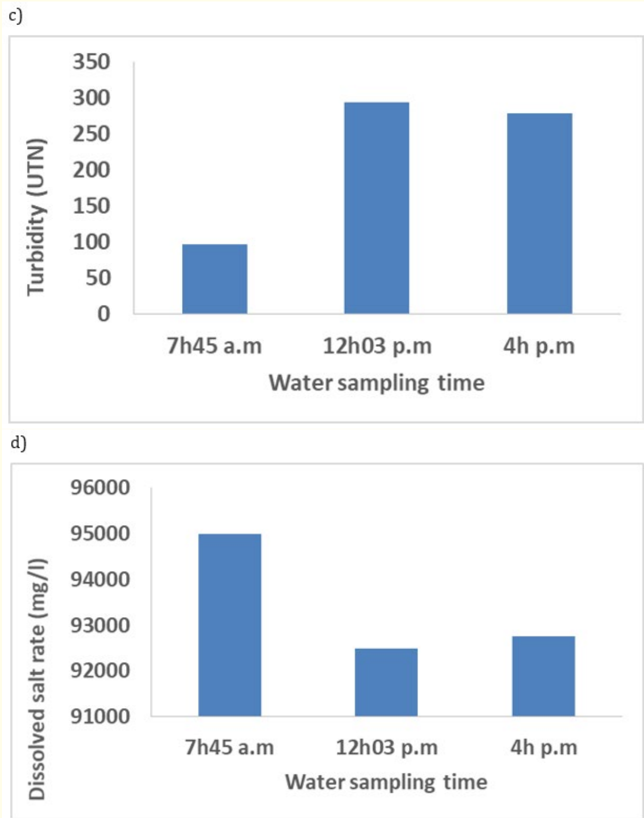


Figure 7: Seawater physico-chemical parameters in function of sampling time: a) pH, b) conductivity, c) turbidity, d) dissolved salt rate.

Physicochemical parameters analysis results in laboratory before thermal distillation process

After laboratory analysis before treatment (thermal distillation), the results are recorded in Table 4.

Physico-chemical paraters determined in the laboratory before thermal distillation				
pH	***Turbidity TB***	***Conductivity CD***	***Dissolved salt rate (DSR)***	***Temperature***
6,89	92,7 UTN	174300 µs/cm	87150 mg/l	25°C

Table 4: Sea water laboratory physico-chemical parameters before thermal distillation.

Physicochemical parameters analysis results in laboratory after thermal distillation process

After thermal thermal distillation procedure the physicochemical parameters analysis results are recorded in Table 5.

Physico-chemical parameters determined in the laboratory after thermal distillation				
pH	***Turbidity TB (UTN)***	***Conductivity CD (µs/cm)***	***Dissolved salt rate DSR (mg/l)***	***Temperature***
5,56	1,11	1402	701	25°C

Table 5: Sea water laboratory physico-chemical parameters after thermal distillation (treatment).

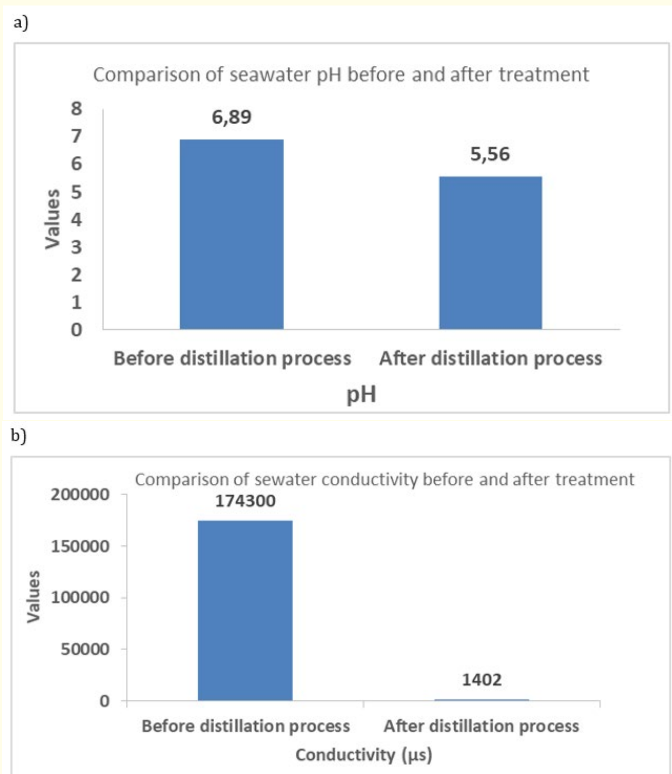
Comparison of the seawater physicochemical parameters after treatment (thermal thermal distillation process) to World Health Organization (WHO) standards parameters of water

To evaluate the effectiveness of the treatment carried out on seawater in this study, we compared the physicochemical parameters of the treated seawater to those before treatment (thermal distillation) and to standards recommended by the World Health Organization (WHO). The World Health Organization (WHO) standards parameters of water are shown in Table 6.

pH	*Turbudity TB (UTN)*	*Conductivity CD (µs/cm)*	*Dissolved salt rate DSR (mg/l)*
6,5-8,5	>5	1000	500

Table 6: The World Health Organization (WHO) standards parameters of water.

The following Figure 8 gives the comparison of physicochemical parameters of seawater before and after treatment (thermal thermal distillation process).



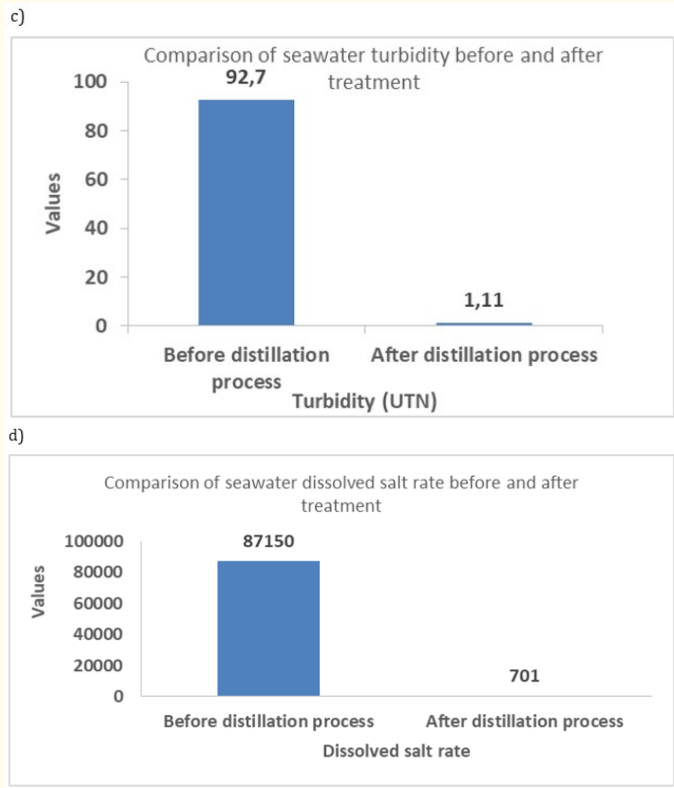


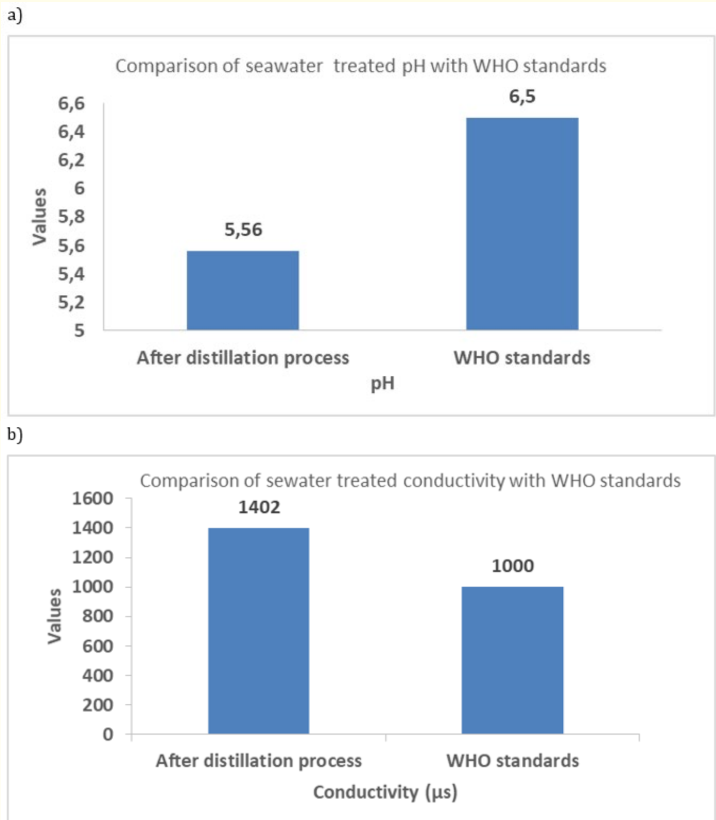
Figure 8: Comparison of seawater physicochemical parameters before and after treatment (thermal distillation): a) pH, b) conductivity, c) turbidity, d) dissolved salt rate.

From Figure 8 and Table 5, we can see, the pH values of seawater vary from 5.56 to 6.89 respectively before and after treatment (thermal thermal distillation). This indicates that treatment allowed to decrease seawater acidity. The conductivity before and after treatment are respectively 174300 and 1402 µs/cm indicating a drastic reduction of the seawater conductivity. The treatment had a very beneficial effect on turbidity reducing its value from 92.7- to 1.11 UTN. For total dissolved salts, the values are 87150 and 701- mg/l respectively before and after treatment (thermal thermal distillation). Figure 9 shows the state of seawater before and after treatment (thermal thermal distillation).

Figure 10 illustrates the comparison between the treated seawater (after thermal thermal distillation process) physicochemical parameters and with the World Health Organization (WHO) standards parameters of water.

From Table 5-6 and Figure 10, the pH value is 5.56 and is include in the WHO standards values (6.5-8.5). Turbidity value after thermal distillation is 1.11 UTN much better than what is required by WHO standards (5UTN). However, the total dissolved salts value is 701 mg/l, slightly exceeding the WHO standard value (500 mg/l) for human consumption. The conductivity value is 1402 µs/cm which slightly exceeds the WHO standard (1000 µs/cm).

Figure 9: State of seawater, a) before treatment (thermal thermal distillation), b) after treatment (thermal thermal distillation).



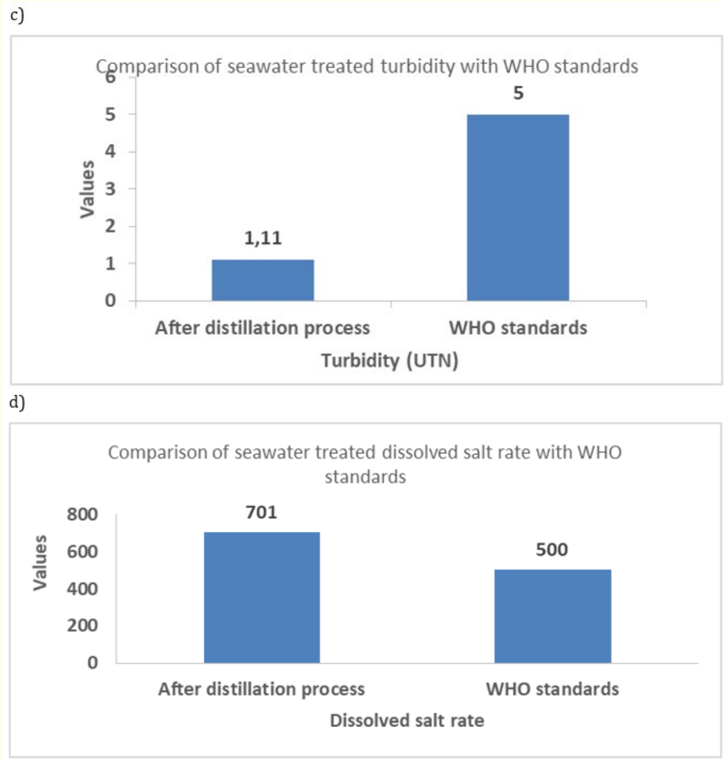


Figure 10: Comparison of seawater treated physicochemical parameters with World Health Organization (WHO) standards parameters: a) pH, b) conductivity, c) turbidity, d) dissolved salt rate.

Conclusion

This work allowed us to desalinate sea water from Bénares beach in the Yimbaya district in the urban commune of Conakry by thermal thermal distillation. Seawater samples were collected on site at different times and in-situ physicochemical parameters also determined. Transported in conditions to not affect its quality, the seawater samples were transported to the analytical chemical laboratory of Nzérékoré University. Ten (10) liters sample composed of a mixture of the three seawater samples collected on site at different times was constituted and analyzes carried out to determine the physico-chemical parameters. Then we carried out the thermal thermal distillation of this sample and again analyzed the physico-chemical parameters. Thus the physicochemical parameters were compared before and after treatment (thermal thermal distillation). The results shown the pH varied from 5.56 to 6.89 respectively before and after treatment (thermal thermal distillation). This indicates that treatment allowed to decrease seawater acidity.

The conductivity before and after treatment are respectively 174300 and 1402 µs/cm indicating a drastic reduction of the seawater conductivity. The treatment had a very beneficial effect on turbidity reducing its value from 92.7- to 1.11 UTN. For total dissolved salts, the values are 87150 and 701 mg/l respectively before and after treatment (thermal thermal distillation).

At the end the physicochemical parameters of the treated seawater were compared with the World Health Organization (WHO) standards parameters. The results illustrate that pH value is 5.56 and is include in the WHO standards values (6.5-8.5). Turbidity value after thermal distillation is 1.11 UTN much better than what is required by WHO standards (5UTN). However, the total dissolved salts value is 701 mg/l, slightly exceeding the WHO standard value (500 mg/l) for human consumption. The conductivity value is 1402 µs/cm which slightly exceeds the WHO standard (1000 µs/cm).

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