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QUALITY OF WATER AND SOURCES OF POLLUTION OF CHENAL COTONOU

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ABSTRACT

The assessment of the quality of the waters of the Cotonou Channel was made to see the degree of contamination of this ecosystem subjected today to various forms of pollution.

The methodology used in this study consisted of taking water samples, the necessary treatments of which were made at the Water Quality Laboratory of the Directorate-General for Water (DG-Eau). For this purpose, certain physical and chemical parameters (turbidity, color, pH, temperature, conductivity, chlorides, ammonium, sulphates, nitrates, nitrites and phosphates) were measured in situ and others have been assayed by atomic absorption spectrophotometry.

The results obtained for the analyzes of the physicochemical parameters reveal that the temperatures recorded are within the range tolerated by the hot water species (25 to 30 ° C.). The pH values varying between (7.58-7.95) express a slight basicity of the medium; the dissolved oxygen varies between (3.75-4.49), which explains a strong presence of organic matter in this medium. The conductivity is between (270-476 µS / cm), the salinity is zero, suspended solids vary between (20-40mg / l), sulfate (05-11mg / l), chloride (77- 152 mg / l), nitrite (< 0.001 mg / l), nitrate (0.1-0.3), ammonium (0.23-0.42 mg / l) and phosphorus (0.50- 3.59 mg / l).

Key Words: Channel of Cotonou, waters, pollution, physical and chemical parameters, cadmium

1. INTRODUCTION

Contamination of natural environments, particularly soil and water by heavy metals, has become an increasingly serious problem. The high concentration of these metals in the human body is detrimental to health (Ahmad, 2010). This is not only due to rapid population growth, increased urbanization, but also the expansion of industrial activities, exploration, the exploitation of natural resources and the spread of other modern agricultural practices (Calamari et al. 1994).

The Cotonou Channel, is an environment with strong economic potential for the region of southern Benin (Tossou, 2000). Like all other lagoons, it is an environment of high biological productivity (Pombo et al., 2002) and has a high potential for fish production, which gives it great economic importance.

Thus, in the perspective of sustainable development in the study area, the diversity, abundance and yield of fish resources depend on the quality of fish habitat, which in turn depends on natural and biological phenomena. human activities that affect the physicochemical regimes of water bodies, water quality and the biocenosis (Roche International, 2000).

This research aims to analyze the degree of pollution of the waters of the Cotonou Channel. It made it possible to determine certain physico-chemical characteristics of the channel waters to see the consequences of the pollution of the channel waters on its fishing resources.

2. STUDY ENVIRONMENT

The Cotonou lagoon is located between 6 ° 21 'and 6 ° 23'30' 'north latitude and 2 ° 25'30' 'and 2 ° 27' 'east longitude. It is a north-south channel, 4500 m long with an average width of 300 m. It is a deep corridor 5 to 10 m connected to Lake Nokoué by a funnel that distributes the flow of the channel in the lake at will of the jusques (Roche International, 2000).

The Cotonou Channel is an artificial outlet dug out (from 3m wide) in 1855 by French settlers in order to evacuate excess rainwater to the ocean and thus avoid flooding in Cotonou.

With an area of about 192 km², the Nokoué-Chenal Lake complex in Cotonou is located in the lower valley of the Ouémé River and the Sô River. This fluvio-lacustrine complex is the reservoir of the vast deltaic plain of the Ouémé River and the Sô River. It is bordered to the west by the Abomey-Calavi bar ground plateau and to the east by that of Porto-Novo (Tossou, 2000). To the south, the complex opens onto the Atlantic Ocean via the Cotonou Channel as shown in Figure 1.

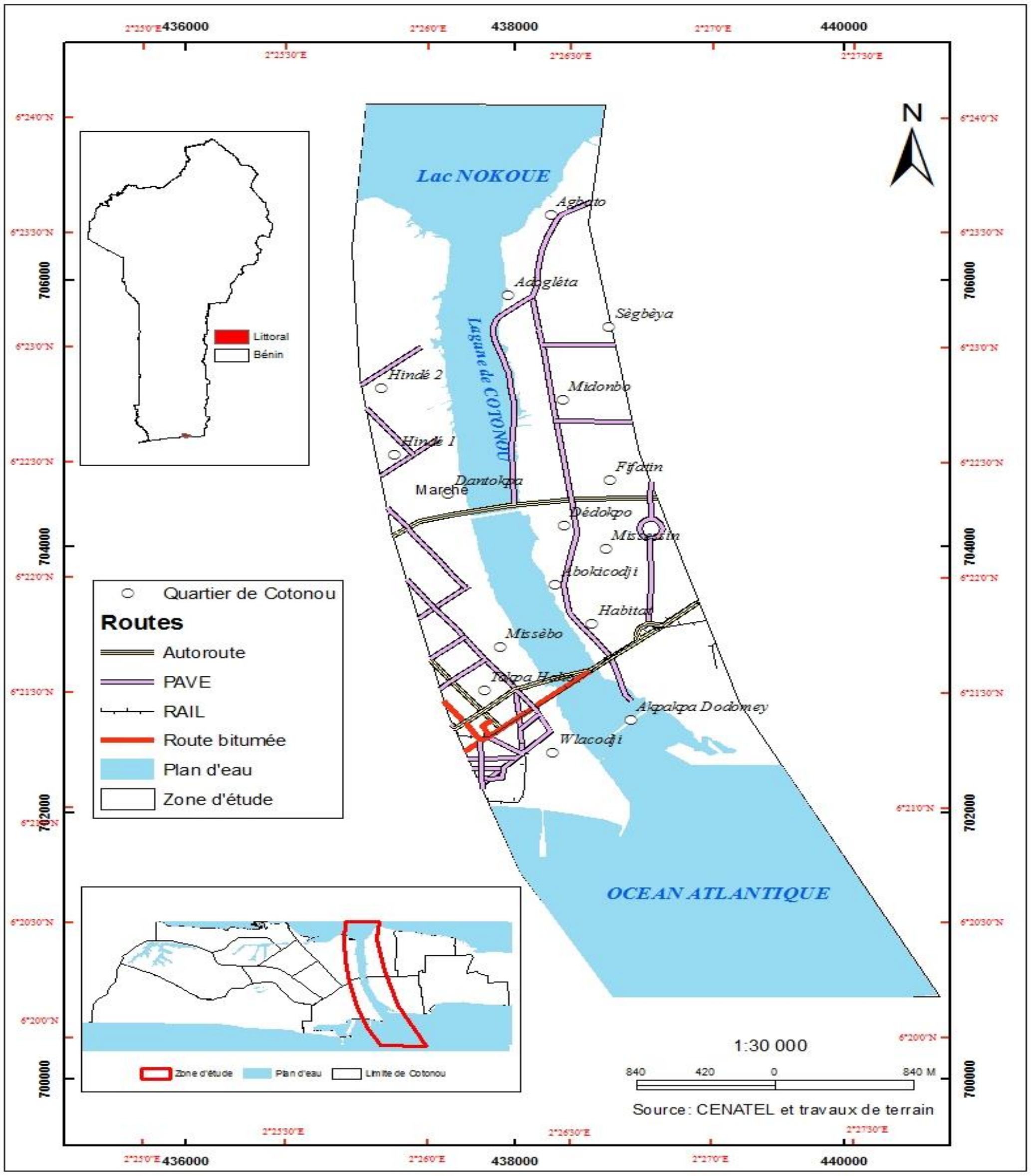

Figure 1: Geographical location of the study area

3. METHODOLOGICAL APPROACH

3. Methodological approach

The methodological approach used in this study consisted of data collection, data processing and results analysis.

3.1. Data

The data used for this study consist of qualitative and quantitative information obtained during the investigations in real environment and making it possible to take water samples from the lake and the channel at various sites identified for this purpose.

3.2. Data collection tools and techniques

Several tools and techniques were used to collect the data for this study.

3.2.1. Data collection tools

The collection tools used for field data collection include the Global Positioning System (GPS), which has taken geographic coordinates of the sampling stations, the multi-parameter PCE-PHD1 has been used for temperature, conductivity and pH, turbidity was measured using a HACH brand turbidimeter. A WTH OXY 730 brand oximeter that was used to measure dissolved oxygen, sample coolers, a motorized boat carried water, 1 liter plastic cans and 0.5 samples for sampling. of water, a net for catching fish, a digital camera for taking photos, a map of the city of Cotonou at a scale of 1: 60 000 for the location of sampling stations.

Laboratory equipment and materials include: a digester, an electronic scale, a laboratory mortar, a desiccator, 50 ml, 100 ml flasks and 25ml and 10 ml tubes, beakers, a magnetic stirrer and a magnetic bar, pipettes, a tuve, ceramic crucibles, reagents.

3.2.2. Data collection techniques

To achieve the objectives set for this work, the collection techniques adopted can be summed up in three sections: field surveys; field observations and samples.

- **Field investigations**

In the case of this study and with regard to the objectives set, the surveys were carried out with the aim of identifying not only the different sources of pollution and the factors responsible for the degradation of the banks.

- **Field observations**

Field observations were also carried out using an observation guide, which made it possible to identify the different sources of pollution as well as the state of pollution in the study area.

- **Samples**

The water and fish samples were taken in the field on the morning of October 24, 2015. The water was collected using 1 and 0.5 liter plastic bottles at each station at a shallow depth of 10 to About 20 cm. The vials are filled until they overflow before being sealed in order to prevent the entry of air bubbles. Part of the sample water samples (1 liter flasks) are acidified with 2 ml of concentrated sulfuric acid for storage for subsequent cadmium analysis. The addition of sulfuric acid made it possible to stabilize the samples by stopping the oxidation reactions. The samples in the 0.5-liter non-acidified flasks are kept cold at -20 ° C.

A total of 12 water samples were taken (6 acidified and 6 non-acidified) at 2 samples per station. The search for cadmium and the determination of physicochemical parameters (phosphorus, chloride, nitrite, nitrate, ammonium, etc.) were carried out at the Water and Food Quality Control Laboratory of the Department of Hygiene and Health. Basic Sanitation.

Six (06) stations were selected for water sampling and three (03) stations for fish sampling as shown in Figures 2.

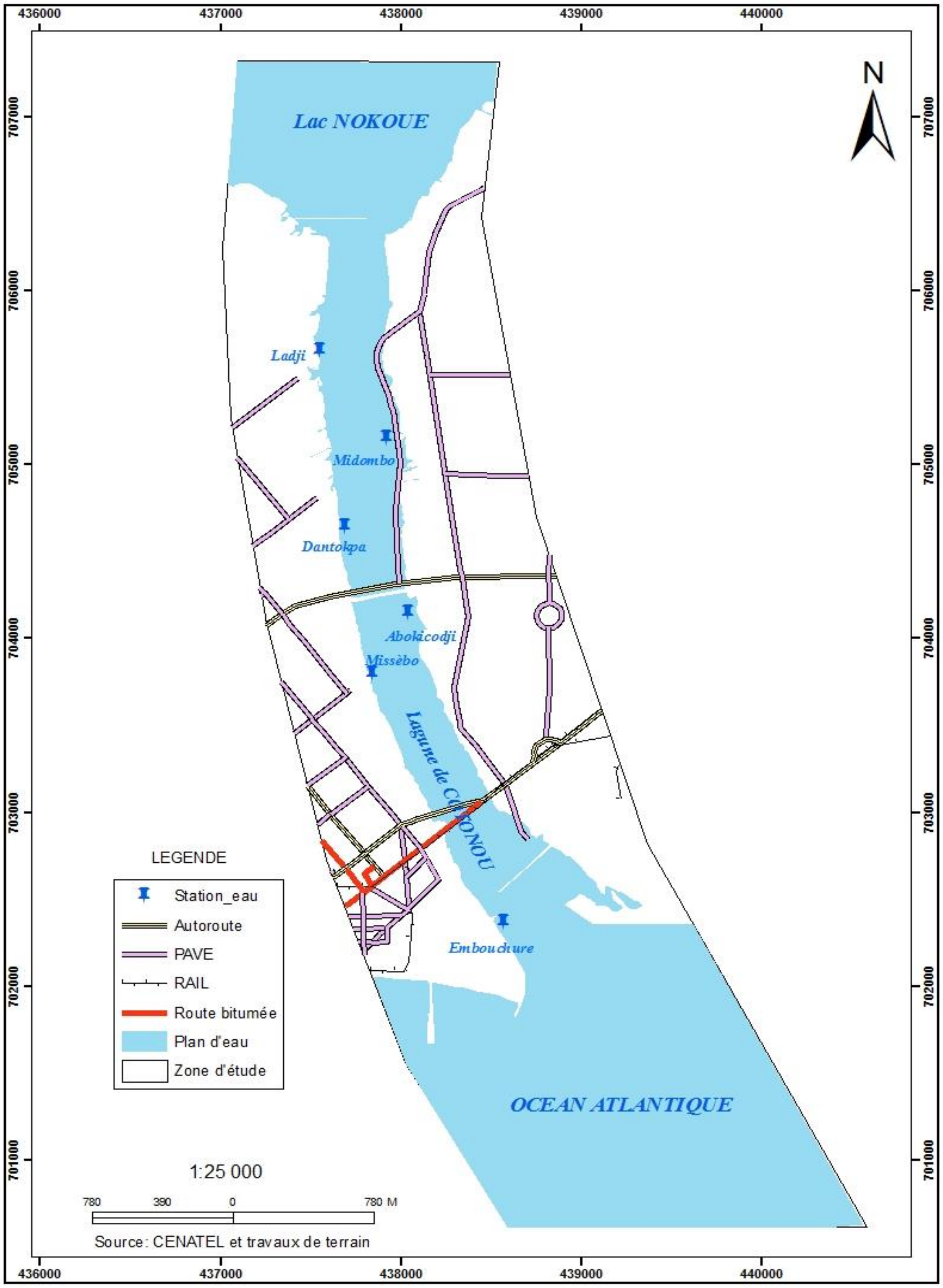

Figure 2: Spatial distribution of water sampling stations / sites

3.3. Method of processing the collected data

3.3.1. Data processing method

The processing of the collected data was done using computer tools, the SPSS statistical software version 16.0 for the comparison of the concentrations obtained with the standards in force. Apart from the collection of the data and their treatments, it was necessary to proceed also to laboratory analyzes to reach the objectives previously fixed.

- Study of the physicochemical quality of water

The water samples for the physico-chemical analysis were made in 1.5-liter plastic bottles. Samples are made between 08h 00 mn and 11h 00 mn. Water was collected at each site, in the immediate vicinity of the bank, at a shallow depth of about 20 to 30 cm. Once filled, the vials are sealed in the water to prevent oxygen from entering. They are then cleaned and labeled. The labels bear the following information: date, place and time of sampling. These flasks are finally sent to the laboratory for analysis (photo 1).

Photo 1: 1.5 L plastic bottles used to collect water for physico-chemical analysis.

Shooting: Akognongbé, 2015

The determination of physicochemical parameters in water was carried out at the Water Quality Laboratory of the General Directorate of Water (DG-Water). The physico-chemical parameters measured in water are: turbidity, color, pH, temperature, conductivity, chlorides, ammonium, sulphates, nitrates, nitrites and phosphates.

- **Bacteriological study of water**

Water samples for bacteriological analysis were taken in 250 ml sterilized glass jars (Photo 2).

Photo 2: 250 ml sterilized glass vials coated with aluminum foil to collect water

Shooting: Akognongbé, 2015

The samples are taken at the same times as those of the physico-chemical analysis under the same conditions. The aim is to study the indicator parameters of faecal pollution in samples of water taken and to evaluate their impact on the health of populations.

In addition, the levels of these waters in total coliforms and faecal coliforms were also studied. The search for bacteria in the water was carried out at the Water Quality Laboratory of the General Directorate of Water (DG-Water).

3.3.2. Analytical methods

3.3.2.1. Protocol for analyzes of the physicochemical quality of water

The physico-chemical parameters measured in water are: temperature, conductivity, pH, turbidity, color, chlorides, ammonium, sulphates, nitrates, nitrites and phosphates.

- Color

10 ml of the sample of water to be analyzed are added to 10 ml of distilled water as a control. The mixture is introduced into the spectrophotometer previously set to zero (0), and the result is read.

- Chloride

The chloride determination is done by titrimetry method using burettes. To 10 ml of water to be analyzed, two (2) drops of potassium dichromate indicator K2CRO4 are added. The mixture is carried out with 0.1 molar agent nitrate and a brick red color is obtained and then the concentration is read on the spectrophotometer. To obtain the concentration of chlorine (Cl) in the sample, the reading of the result on the spectrophotometer is multiplied by the molar mass of chlorine.

- Determination of ammonium by the sodium salicylate method

• Principle of the method

Ammonia compounds combine with chlorine to form monochloramine. This reacts with salicylate to form 5-aminosalicylate. This compound is oxidized in the presence of a nitroprusside catalyst to form a blue colored complex. The blue color is masked by the yellow coloring of the excess reagent to give a green final solution.

• Operating mode

To 10 ml of water to be analyzed, a kit of ammonia salicylate is added and then the solution is stirred to homogenize it. After a reaction for 3 minutes, a cyanurate kit is then added. After homogenization, and reaction for 15 minutes, the spectrophotometer is read the concentration of ammonium contained in the water. A blank (10 ml of distilled water + a kit of ammonia salicylate + a cyanurate kit) is first introduced into the spectrophotometer as a control.

- **Determination of sulfate**

• Principle of the method

The sulphate ions react with the barium of the sulphate reagent 4 and produce a precipitate of insoluble barium sulphate. The amount of turbidity is proportional to the concentration of the sulphate. The sulfaver4 reagent also contains a stabilizer to maintain the precipitate in suspension.

• Operating mode

To 10 ml of water to be analyzed, one (1) sulphate capsule is added. After homogenization of the solution thus obtained and a reaction for 5 minutes, the concentration of sulfate contained in the sample is read on the spectrophotometer. A blank consisting of 10 ml of the sample to be analyzed is first introduced into the spectrophotometer as a control.

- **Determination of nitrite**

• Principle of the method

The nitrite in the water sample reacts with sulfanilic acid to form a diazonium salt that reacts with chromo tropic acid to produce a pink colored complex whose color is proportional to the quality of nitrite present.

• Operating mode

To 25 ml of water to be analyzed, one (1) capsule of nitriver is added. After homogenization, and reaction for 20 minutes, the reading is made on the spectrophotometer. A 25 ml blank of the sample to be analyzed is first introduced into the spectrophotometer as a control.

- Determination of nitrates

• Principle of the method

Metal cadmium reduces nitrate to nitrite. The nitrite ion reacts in acidic medium with sulfanilic acid to form an intermediate diazonium salt. This salt reacts with gentisic acid to form an amber-colored solution.

• Operating mode

To 25 ml of water to be analyzed, one (1) nitrate gel capsule is added. After homogenization for one (1) minute, allowed to stand for 5 minutes and then read on the spectrophotometer. A blank consisting of 25 ml of the sample to be analyzed is first introduced into the spectrophotometer as a control.

- Determination of phosphate

• Principle of the method

Orthophosphate reacts molybdate in an acid medium to produce a phosphomolybdate complex. Ascorbic acid reacts with the complex and gives an intense coloration of molybdenum blue.

• Operating mode

To 25 ml of the sample to be analyzed, one (1) phosver capsule is added. It is mixed and allowed to stand for 2 minutes then the reading is the concentration of the phosphate contained in the water made spectrophotometer. A 25 ml blank of the sample to be analyzed is first introduced into the spectrophotometer as a control.

3.3.2.2. Bacteriological analyzes

The method adopted is that of the search algorithm for sprouts in water. This involves a presumptive search for total and faecal coliforms on Mac Conkey broth and a colony count per millimeter after 24 to 48 hours incubation in an oven at 37 ° C for total coliforms and at 44, 5 ° C for faecal coliforms in lactose agar medium TTC and TERGITOL7 (base according to AFNOR) for research of common germs. The identification of germs is done by the classical gallery or the gallery API 20 E, the gallery API ST APH.

- **Membrane filtration**

The membrane filtration method directly provides the number of total coliforms and fecal coliforms contained in a given water sample. The method consists in filtering a known volume of water through a membrane consisting of a cellulose derivative having pores of uniform diameter equal to 0.45 µm. This membrane is seeded in Petri dishes containing a selective culture medium and incubated at 37 ° C for total coliforms and 44.5 ° C for fecal coliforms. The examination of the petri dishes incubated for 24 to 48 hours is followed by a colony count with a magnifying glass. Total and faecal coliforms appear as yellow colony on the membrane.

3.3.2.3. Multipurpose grid of global assessment criteria for water quality

Table I presents the grid that makes it possible to assess the physicochemical parameters of the channel waters.

Table I: Multipurpose grid of global assessment criteria for water quality

Decreasing quality	Excellent	Good	Fair	Poor	Pollution
Quality class	1A	1B	2	3	4
Temperature (° C)	< 20	de 20 à 22	de 22 à 25	de 25 à 30	> 30
Conductivity (us / cm)	< 400	400 à 750	750 à 1500	1500 à 3000	-
pH	6,5-8,5	6,5-8,5	6,5-8,5	5,5-9,5	<5,5 ou > 9,5
Dissolved O2 (mg / L)	> 7	5 à7	3 à 5	< 3	-
Suspended matter (mg / L)	0	< 30	-	30 à 70	< 70
Nitrates (mg / L)	0	< 44	-	44 à 100	> 100
Ammonium (mg / L)	< 0,1	de 0,1 à 0,5	de 0,5 à 2	de 2 à 8	> 8

Source: Fine, 1998

4. RESULTS

Physico-chemical analyzes

The analysis of the physicochemical parameters mainly takes into account parameters that make it possible to assess the quality of the water or its degree of organic pollution.

• **Temperature**

Temperature affects most of the chemical and biological processes taking place in the water. Figure 3 shows the variations in water temperature at the different stations.

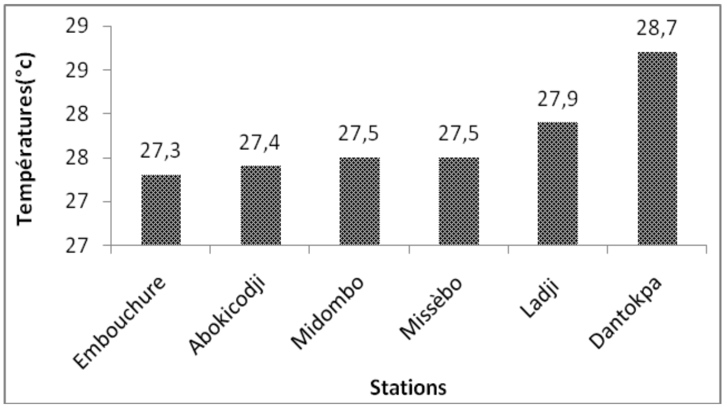

Figure 3: Water temperature at the different stations (October 2015)

At all sites, the various temperatures recorded vary between 27.3 and 28.7 ° C and are within the range tolerated by aquatic species of hot water (25 to 30 ° C). The temperature of the waters of the channel is favorable to the life of the different species which it shelters especially tilapia guineensis seen its preference and its thermal tolerance14 ° -33 ° C.

• Hydrogen potential (pH)

The pH expresses the concentration of H + ion and measures the acidity or alkalinity of a water read on a scale from 0 to 14. Figure 4 shows the variations of the pH of the water at the different stations.

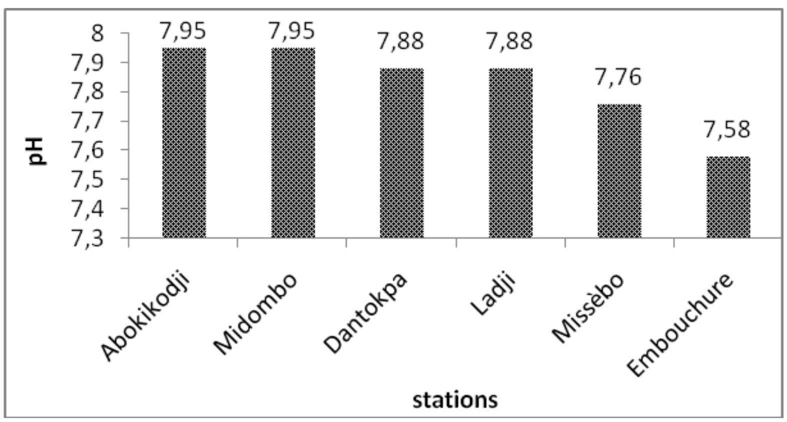

Figure 4: pH of water at different stations (October 2015)

The pH values obtained are between 7.58 and 7.95 with an average of 7.83. These values fall within the range of the accepted quality standard (6.5-8.5) and are favorable to the development of aquatic species.

• dissolved oxygen

The presence of dissolved oxygen in the water is essential for aquatic life. It promotes the process of self-purification of watercourses with the help of micro-organisms (PIMPEC, 2002). Figure 5 shows the changes in the dissolved oxygen of the water at the different stations.

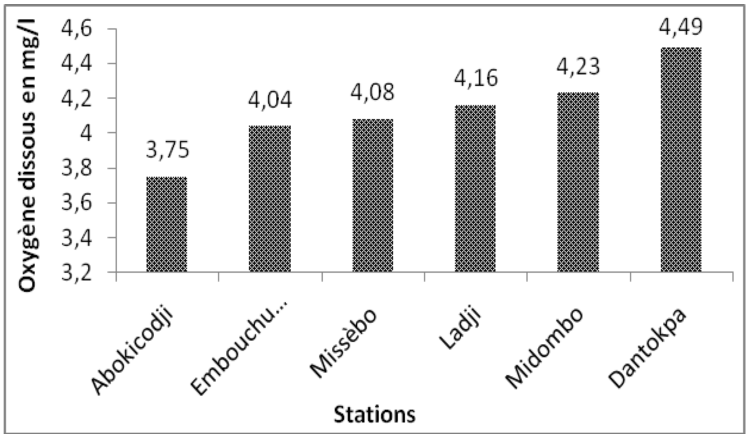

Figure 5: Dissolved Oxygen Concentrations of Water at Different Stations (October 2015)

The results show that there is a shortage of oxygen in the lagoon. The dissolved oxygen values observed at all sites are below the accepted quality standard of 7 mg / L and vary between 3.75 and 4.49 mg / L.

This is explained by a strong presence of organic matter in this environment. In fact, so-called aerobic bacteria consume the oxygen of water to degrade organic matter.

• Conductivity

The conductivity of a water indicates its ability to conduct the current, which depends on the content of water in mineral salts. Figure 6 shows the variations in the conductivity of the water at the different stations.

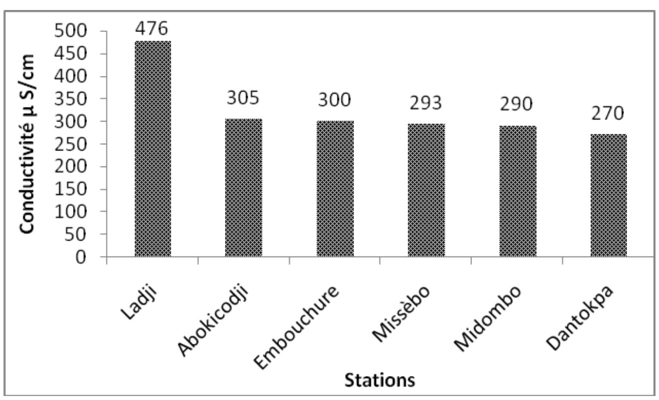

Figure 6: Conductivity of water samples taken (October 2015)

The values obtained vary between 270 and 476 µS / cm with an average of 322 µS / cm on all the stations. Of all the stations, the Ladji station recorded a high conductivity (476 µS / cm) higher than the accepted quality standard of 400 µS / cm, this can be explained by the presence of pockets of salinity and a high pollution of the lagoon at this station.

- **Suspended matter**

The high presence of suspended matter gives the water a cloudy appearance. Turbidity varies with these suspended solids and can be explained by the inputs of runoff and the transport of plant debris, animals, etc. Figure 7 shows the concentration of suspended solids at each station.

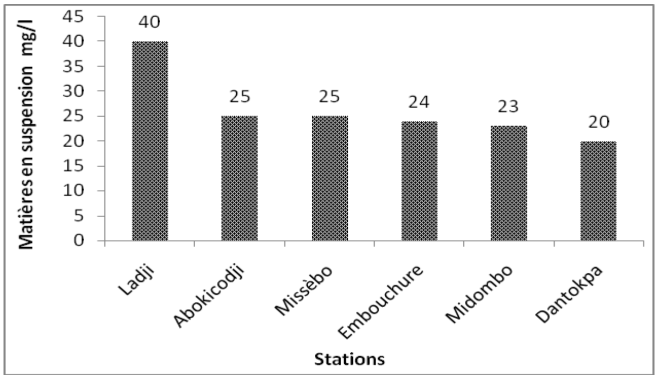

Figure 7: Suspended matter of water samples taken (October 2015)

The concentrations of suspended solids obtained vary between 20 and 40 mg / l. On all the stations, that of Ladji is the strongest and exceeds the accepted quality standard which is 30 mg / l. This shows the pollution of the lagoon at this station by human activities. The presence of suspended solids at all stations shows the poor quality of the channel water as good quality water should not contain suspended solids. Biodegradable suspended solids contribute significantly to the oxygen demand and cause a decrease in the concentration of dissolved oxygen in the aquatic environment (Roche International, 2000).

- **Sulfates**

Sulphates are minerals composed of metals combined with the element sulfur, chromium, molybdenum or tungsten. Figure 8 shows the evolution of the sulphate concentration in the water samples taken.

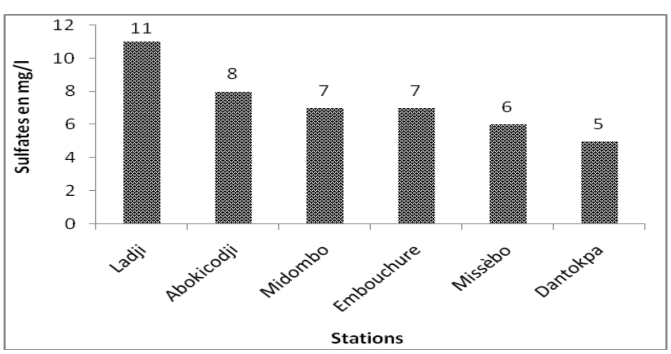

Figure 8: Sulphate concentration in water samples taken (October 2015)

The Ladji station recorded the highest concentration, 11 mg / l followed by Abokicodji 8 mg / l, Mouth and Midombo 7 mg / l, Missèbo 6 mg / l and Dantokpa 5 mg / l. The sulphate concentrations obtained at the stations are below the quality standard of WHO (2006) 500 mg / l. These values are therefore within the allowed margin for drinking water. These waters would therefore be safe for the health of most users.

• Chloride

Figure 9 shows that concentrations at all stations are quite high.

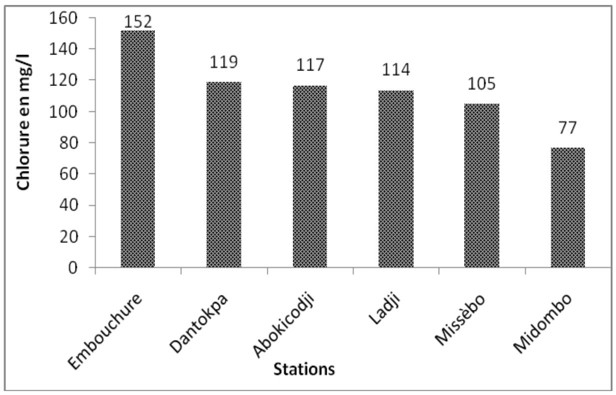

Figure 9: Chloride concentration of water samples taken (October 2015)

The analysis of Figure 9 reveals that the highest concentration of chloride was recorded at the mouth of the mouth (152 mg / l), followed by Dantokpa (119 mg / l), Abokicodji (117 mg / l), Ladji (114 mg / l), Missèbo (105 mg / l) and Midombo (77 mg / l). The chloride values of all the stations are above (20 mg / l) threshold limit of the levels recorded in natural waters in chlorides (Le Pimpec, 2002). The lake water would be unsuitable for most users and could pose a threat to public health and the environment. The high concentrations obtained here can be explained on the one hand by the intrusion of salt water due to the proximity of the ocean and on the other hand the presence of sodium chlorides in the solid and liquid wastes discharged on the bank and in Lake. These concentrations indicate an excess of chlorides in the waters of the Nokoué Lake-Cotonou Channel complex and could have negative effects on aquatic fauna and on public health. Indeed, according to tests by Cemagref (1979), there is a 50% inhibition of a population of daphnia (Daphnia Magna) in 24 hours for a concentration of sodium chlorides (NaCl) of 5240 mg / L.

This is explained by the intrusion of salt water due to the proximity of the ocean. It should be remembered that chlorides are not considered too toxic to aquatic life

• Nitrates

Nitrates are nitrogen compounds that undergo a real cycle of formation called nitrogen cycle. Figure 10 shows the nitrate concentrations at the different stations.

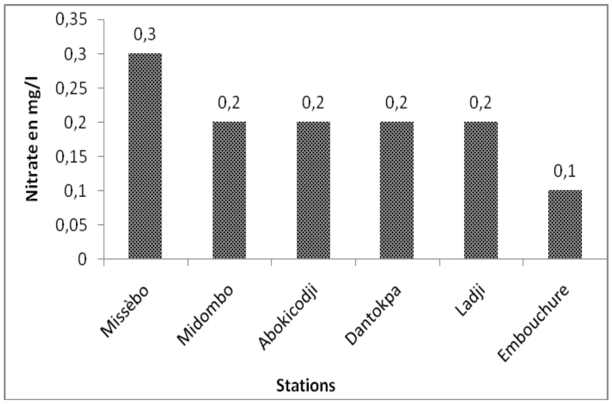

Figure 10: Nitrate concentration of water samples taken (October 2015)

The analysis in Figure 10 reveals that nitrate concentrations are generally low at all stations. The highest concentration was recorded at Missèbo (0.3 mg / l) and there is a consistency of 02 mg / l from Midombo to Ladji. Although these nitrate values are low, they are not safe for fish because water containing nitrate may be considered suspect or toxic to fish (Ahouantchédé, 2008).

The standard accepted by the World Health Organization (WHO) is 40 mg / L, the values obtained do not pose as much danger to the health of populations.

• Ammonium

Ammonium comes from the decomposition of nitrogenous wastes. The presence of ammoniacal nitrogen in water usually reflects a process of incomplete degradation of organic matter. Ammonium results from the first stage of the degradation of nitrogenous organic matter by ammonifying bacteria: we speak of ammonization. Figure 11 shows the ammonium content of the water taken at the different stations. Ammonium comes from the decomposition of nitrogenous wastes.

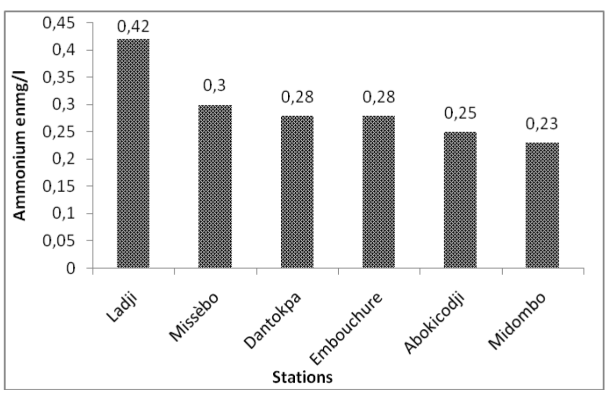

Figure 11: Ammonium concentration of water samples taken (October 2015)

The different concentrations obtained are generally low at all the stations. The Ladji station recorded the highest concentration (0.42 mg / l). The standard accepted by the European Union in 2006 being 0.5 mg / l, these ammonium values are found in the normal range.

• **Phosphates**

Phosphates are found in natural waters, in domestic and agricultural wastewater. They are formed as a result of the decomposition of organic matter. Figure 12 shows the phosphorus concentrations in the water taken at each station.

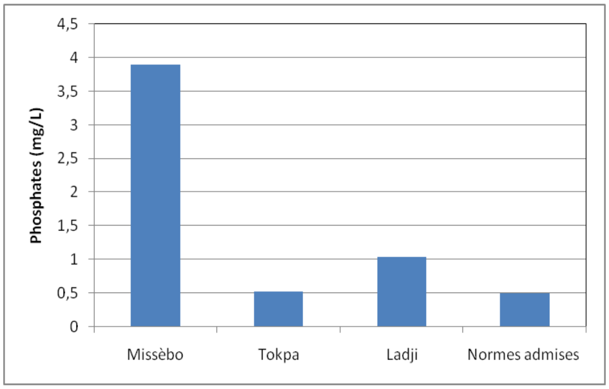

Figure 12: Phosphate concentrations in the water samples taken

The concentrations of phosphates obtained are higher than the allowable limit of 0.5 mg / L (Gaujous, 1995). This may later cause eutrophication problems for the lake. The Missèbo station recorded the highest concentration, 3.9 mg / L. A phosphate concentration greater than 0.5 mg / L of water is sufficient in the presence of nitrate and ammonium to trigger excessive growth of vegetation (Environment Agenda, 1999). It is the process of eutrophication of water that has mainly ecological, health and social consequences on the population. The nitrogenous compounds and phosphorus recovered from these analyzes in the form of nitrite, ammonium and phosphate salts would come from the discharge of untreated domestic and industrial wastewater as well as the leaching of the soil by the runoff water.

• **Determination of cadmium in the sampled waters.**

Cadmium is a naturally occurring trace element in the Earth's crust. It is found in batteries, solders, accumulators, paint pigments, photoengraving products, fertilizers and pesticides. It can also be found in food, and more particularly in seafood. Indeed, cadmium in water is retained by scallops, lobsters, lobsters and oysters, among other things that filter Seawater. Cadmium can also be found in fish, where it accumulates mainly in the viscera (intestine, liver and kidney) and very little in the muscle. In 2006, WHO defined a provisional tolerable weekly intake (PTWI) for cadmium, which is 7 µg / kg body weight / week (Montcho, 2005).

Figure 13 shows the concentration of cadmium expressed in µg / l in the water taken at each station.

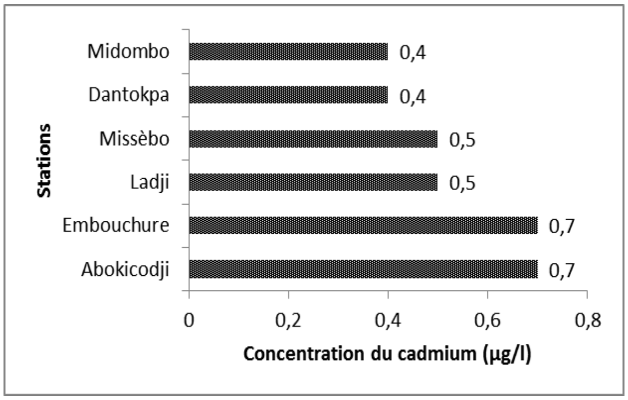

Figure 13: Concentrations of cadmium in the waters of the Cotonou Channel

From the mouth to Ladji, the cadmium content varies in places and from one station to another. The concentrations obtained are (0.7 µg / l) at Mouth and Abokicodji, (0.5 µg / l) at Missèbo and Ladji, (0.4 µg / l) at Midombo and Dantokpa. The average content of cadmium in water is 0.53 µg / l. This content is below the standard set for surface water 50 µg / l (Order of 1 March 1983 France). Since cadmium is a heavy metal (density > 5 g / cm3), it will be more likely to settle at the bottom of the water, that is to say in sediments. This explains the low concentration of cadmium generally obtained at all sampling stations. Moreover this study was carried out during high water period (October, 2012).

5. DISCUSSION

The channel water temperatures vary between 27.3 and 28.7 ° C with an average of 27.7 ° C on all sampling stations. This average value is lower than that obtained by Ahouantchédé in 2008 (28.06 ° C) and slightly exceed that obtained by Changotodé in 2010 (27.2 ° C). This variation is explained by the fact that the samples were taken at different times during the day.

The pH values obtained vary between 7.58 and 7.95 with an average of 7.83, the waters of the channel have a basic nature during high water periods. This state of affairs is not surprising because the studies of Changotodé in 2010 revealed the basic nature of water during periods of high water. Note that a pH that tends to be basic is not favorable for the development of fish that lose their flesh and become skeletal at maturity (Ahouantchédé, 2008).

The dissolved oxygen values observed at all the sites vary between 3.75 and 4.49 mg / l. The results show that there is a lack of oxygen in this environment. This oxygen deficiency is due to a strong growth of phosphate concentrations. Knowing that oxygen is essential to life, we must ask many questions about the future of this lagoon and the living species that it houses.

The values of the conductivity obtained vary between 476 and 270 µS / cm with an average of 322 µS / cm on all the stations. Of all the stations, the Ladji station recorded a high conductivity (476 µS / cm) above the accepted quality standard of 400 µS / cm. Thus, since the work done by Yèhouénou (2005), the conductivity of the Ladji station has greatly increased. It has increased from 70 to 476 µS / cm, which is explained by the fact that its work is carried out in low water period (May 2003) whereas the present work took place during high water (October 2012) . This same value recorded at Ladji is slightly below that obtained by Ahouantchédé (2008) 486 µS / cm. As the conductivity is closely related to the dissolved salts content of water (Le Pimpec, 2002), the very high value observed at the Ladji station can be explained by the high chloride content observed at this station, namely, 144 mg and the highest concentration of sulphate (11 mg / l), since a high sulphate content also induces a high conductivity (Le Pimpec, 2002).

The null salinity rates obtained are explained by the fact that these studies took place during high water periods (October, 2012). During this period we observe a descent of the waters which come inflated and diluted that of the lagoon. It should be noted that the decrease in salinity favors the proliferation of aquatic species, specifically water hyacinths which, when they develop, prevent the penetration of sunlight into the water and contribute to the scarcity of water aeration. a threat to fish (Dovonou, 2009).

Among the values of suspended solids obtained, that of Ladji is the highest and exceeds the accepted quality standard of 30 mg / l. This testifies to a pollution of the lagoon at this location by human activities. It should be noted that these waters should under no circumstances be consumed in view of the presence of suspended solids in the measured water.

The chloride values of these stations are above (20 mg / l) threshold limit of the levels recorded in natural waters in chlorides (Le Pimpec, 2002). Compared to Ahouantchede's 2008 work, only the chloride concentration of the Midombo station decreased from 102.95 mg / l to 77 mg / l. All other stations experienced an increase in their concentrations with an average of 93.83 to 114 mg / l.

In general, the concentrations of nitrogen compounds obtained are low and below 0.5 mg / l. The absence of nitrite and the low concentration of nitrate can be explained by a phenomenon of total or partial reduction of these elements in the medium. Nitrogen compounds and phosphorus recovered from these analyzes would come from the discharge of untreated domestic and industrial wastewater and the leaching of soils from runoff. It should be remembered that 1 kg of phosphorus in a lake allows the production of one ton of algae that will require 140 tons of oxygen to decompose in the depths (Servettazp, 2001). This is the process of eutrophication of water, characterized by a rapid growth of hyacinths and water lettuce. This phenomenon would not be possible because of the salinity of the water due to the proximity of the ocean. Water hyacinth and lettuce do not support salinity.

The cadmium concentrations obtained in the water have an average of 0.53 µg / l and are below the accepted norm of 50 µg / l. In comparison with the results obtained in the different works in Benin, they differ from those found by Agonkpahoun in 2006 (Cd: 0.0043 mg / l) in the Okpara River and in Lake Nokoué. And also results of the study carried out in the marine environment of Cotonou by Montcho in 2005 (Cd: 0.000073 mg / l); by Guédénon in 2009 in Lake Nokoué (Cd: 0.33 mg / l) and the Ouémé River (Cd: 0.47 mg / l). It should be noted that the low concentrations recorded in the water during this study are not necessarily true in the sediments since this research has not been conducted on the latter.

CONCLUSION

This study focused on the quality of the water and the sources of pollution of the Cotonou Channel. The hydrochemical study was conducted to characterize the quality of surface water on the one hand and to identify, on the other hand, the natural and anthropogenic factors that influence the quality of the lake's water. Several modes and tools of interpretation were used (cartography, diagrams, statistics, computer science, etc.). These showed that:

- From an environmental standpoint, investigations into the sources of pollution in the channel have shown that the riverbank is experiencing a very disturbing phase of pollution, which contributes to the deterioration of the quality of the water, thus modifying the physicochemical characteristics. waters of the Nokoué Lake-Cotonou Channel Complex and their contamination by toxic metals and certain bacteria. This situation is a threat to the equilibrium of the ecosystem and the health of the neighboring populations;

- In addition, the contamination of surface water is very high, which justifies the pollution of the aquifer by nitrogen at shallow depths. Thus, the possibility of contamination of deep waters can be seriously considered, especially with the current systematic exploitation of this channel.

The west bank of the Nokoué-Chenal Lake complex in Cotonou represents an important link in the aquatic ecosystem of southern Benin and represents an economic potential that should be highlighted. The protection and enhancement of this space would undoubtedly contribute to the take-off of Benin's economy, especially in terms of tourism, and would give the city of Cotonou an aesthetic appearance.

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