Study of the physicochemical quality of water in the Sebi-Ponty basin at Diamniadio (Senegal)

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***Abstract*— The Sebi-Ponty dam has a basin that is widely used by the population for agro-pastoral activities (animal watering, agriculture, etc.). This basin covers an average area of 106,000 m2 and an average depth of 7 m or about a volume of 435,000 m3. The origin of the water is rainfall (runoff and direct descent). The availability of water is estimated to eight months taking into account the water being drawn, infiltration and evaporation. A qualitative knowledge of the contents of this pool will be a great benefit to those activities of the population. It's in this context that this study was carried out by this group of researchers, following physic-chemical compositions were targeted: turbidity, color, temperature, conductivity, pH, hardness; alkalinity, nitrite, iron, phosphate, boron, and chlorine concentrations.**

The physico-chemical results obtained on samples taken in the basin between October and December showed that the concentrations of boron, iron and nitrite exceeded the levels recommended by the standard for agro pastoral needs. While turbidity, color, temperature, conductivity, pH, hardness, alkalinity, phosphate and chlorine are at acceptable levels.

***Index Terms*— Sebi-Ponty, water quality, alkalinity, pH, nitrite, iron, boron, animal drinking, agriculture, household needs..**

I. INTRODUCTION

In order to facilitate the supply of drinking water and watering the gardens of the former William Ponty School, dam Sebi-Ponty was built in 1937 by the State of Senegal.

This dam is now actively used by the populations of Diamniadio and Sébikhotane for agro-pastoral and fish farming activities. On the other hand, although it is very useful for the population, this basin is confronted with problems of filling (or drying) **[1, 2]**, and above all to control the positive or negative impact of water quality on the activities of the population.

It's in this context that this study was designed to give some answers to this problem.

In this study, we will conduct an analysis of the physico-chemical composition of water from the dam after presentation of the study area. The target parameters are turbidity, color, temperature, conductivity, pH, hardness, alkalinity, nitrite, iron, phosphate, boron and chlorine.

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II. PRESENTATION OF THE STUDIED AREA

1.1 Location

Dam Sebi-Ponty is located in the municipality of Diamniadio under the administrative authority of Rufisque department in Dakar region.

The dam is located at a distance of thirty-five (35) kilometers from the city of Dakar and between the turnpike and the N ° 1 in particular in the industrial area Diamniadio, 17 ° 11 longitude West and 14 ° 43 North latitude.

The following figure 1 gives an overview of the position of the basin.

Figure1: Sebi-Ponty basin Site

1.2 History

Dam Sebi-Ponty was built in 1937 to facilitate drinking water supply and watering the gardens of the former William Ponty School. It had been ceded in 1952 and was rehabilitated by the Ministry of Justice for the exploitation of a 20-ha perimeter as part of the social reintegration policy for juvenile delinquents.

1.3 Study area climate

The study area is characterized by a tropical climate marked by the alternation of two seasons: - a rainy seasons of three (3) months from June to October. During this period, the Alize and Mousson winds from Sainte Helene, enter the country with an important moisture load;

- a dry season of nine (9) months; this period is swept by the Harmattan and Alize continental hot dry wind.

The average annual rainfall for Dakar region between 1985 and 2014 is 401.30 mm, with a large variation over the last ten (10) years. The days of precipitation per year are very low with an average of 25 days.

This confirms that the water potential of the area is similar to that of the country (Senegal) greatly reduced in recent decades. Intervals between 5 and 100 years are sufficient for determining the annual rainfall **[3, 4]**.

The thermal regime of the zone is characterized by relatively low temperatures with two (2) seasons. The cold season from December to March and the hot season between April and November.

III. Quality of water

In this section, we will study some physico-chemical properties of the sebi-ponty basin.

An analysis of some important parameters considered for agriculture or harmful to agricultural development, pastoral and fisheries will be made, in order to judge the quality of the water.Water stored in a basin with the soil composition is dominated as a whole, by fine sand and clay.

1.1 Materials used

The samples and tests were carried out with a material made of a water analysis briefcase including a conductivity meter with a built-in thermometer, a cooler for storing samples, a HANNA pH meter, water samplers for sampling in depth and 500 ml bottles with labels to mention the origin, location, date and time of sampling.

In the laboratory, we used an AL 800 spectrophotometer, reagents for different dosages, bowls, agitators, beakers, flasks and pipettes.

1.2 Methodology

Different locations were identified in the basin for sampling at different times in order to make the results as representative as possible. Three sampling campaigns were conducted between October and December. All samples were held between 11am and 1 pm in October, November and December, at different depths through the water samplers.

The cooler was used to keep the samples in the vials, and this to avoid a temperature change that would result in chemical reactions that may change the chemical composition of water. Some parameters such as pH, conductivity and temperature were measured on site, and the other analyzes were done in laboratory.

1.3 Presentation and interpretation of results

In this section, we present the results of the different quality analysis. Results will be compared to standards of agro-pastoral used and analysis of the positive or negative consequences will be done. The target parameters are: turbidity, color, temperature, conductivity, pH, hardness, alkalinity, iron, phosphate, boron, chlorine and nitrite.

1.3.1 Turbidity

Turbidity is one of the most important properties of natural waters; it is defined as the inverse of the clarity or transparency. Turbid water is more or less disorder. In limnology (physicochemical and biological study of lakes), the transparency of a water is measured according to the maximum depth at which a submerged object can be perceived distinctly **[5, 6]**. Table 1 below shows the turbidity results.

Table1 : Turbidity in "fau" of Sebi-Ponty Lake between October and December

Depth	**October**	**November**	**December**
above	> 500	> 500	> 500
0,5 m	> 500	> 500	> 500
1 m	> 500	> 500	> 500

The results show that the Sebi-Ponty basin has a turbidity that exceeds 500 FAU.This high turbidity is caused by the presence of suspended matter in the water. These materials may include clay, silt, plankton, fine particles of organic and inorganic matter, and microscopic organisms from the erosion of bare soil through runoff and the multiple avian species at the edge of the basin.

1.3.2 Color

Natural waters are always more or less colorful. Their colors range from straw yellow to barely perceptible to reddish brown, depending on the nature and concentration of coloring matter. These materials are often naturally or come from the degradation of plant materials: wood, lignin, bark, tannin **[6]**. In Table 2 below, we present the results of color measurement of samples in the Sébi-Ponty basin.

Table2 : Colors in pt-co of Sebi-Ponty Lake between October and December

Depth	**October**	**November**	**December**
above	56	46	49
0,5 m	42	42	48
1 m	47	47	48

We observe that the interval of the coloration observed varies from one month to another. It is strong as a whole with a minimum of 42 (pt-Co) and a maximum of 56 (pt-Co).The acceptable potable limit value of water is 15 (pt-Co) **[6,7]**, values that we exceed by far in our pool. Colored water is suspect for consumption regardless of its qualities.

1.3.3 Temperature

Key physical parameter, temperature acts strongly on chemical and biological processes within a lake. In Table 3 below, we present the results of measuring the temperature at the time of the samples taken in the Sebi-Ponty basin.

Table3 : Temperatures in °C of Sebi-Ponty Lake between October and December

Depth	**October**	**November**	**December**
above	31,4	32,5	25,3
0,5 m	31,4	31,9	25,7
1 m	30,9	33,3	25,2

The analysis of these results shows an average of 32 ° C between the months of October and November.This average decreases slightly during the month of December to 25.4 ° C coinciding with the onset of cold in Senegal.These variations in the thermal water regime strongly affect the distribution of living species. But they have no particular effect on agro-pastoral use.

1.3.4 Conductivity

Conductivity is an indicator of the content of dissolved salts in water **[6]**. It is greatly influenced by the geochemical nature of the rocks that make up the watershed. Substances from rock alteration often affect pond water and cause variation in conductivity. The water hardness (calcium, bicarbonates, magnesium) is also one of the conductivity variables. In Table 4 below, we present the results of measuring the conductivity of samples Sebi-Ponty basin.

Table 4 : Conductivity in µs / cm of Sebi-Ponty lake between October and December

Depth	October	November	December
above	481	501	543
0,5 m	484	500	541
1 m	484	492	540

The results show an increasing trend in the conductivity rate between October and December.

In the same way as pH, conductivity is strongly influenced by temperature, the biological processes of the basin, but also by the calco-carbonic equilibrium **[6, 8, 9]**. This explains the weakness of our conductivity values during the rainy season due to dilution by rain. During the dry season, this value has a growing trend due to evaporation and strong biological activity in December due to the more favorable climate.

The conductivity can't be directly proportional to the mineralization; it is also a function of the chemical composition of the water and the mobility of the ions

1.3.5 pH

pH measures the concentration of H + ions. The pure natural water is neutral (when the pH is equal to 7). The pH of a water represents its acidity or alkalinity, it varies between 0 - 14 and is an important indicator of the quality of a water. In Table 5 below, are presented pH measurement results Sebi-Ponty basin between October and December.

Table5 : Ph of Sebi-Ponty basin between October and December

Depth	October	November	December
above	7,9	9,4	9,00
0,5 m	8,47	9,27	9
1 m	8,42	9,22	9,01

The results in Table 5 show a variation of the increasing pH between October and November with a slight decline in December.

Temperature variation as well as certain biological processes such as organic matter decomposition and photosynthesis can be the causes of this pH variation. The rise in temperature is a decreasing factor of the solubility of CO_2 and consequently, decreases the pH value. By cons, CO_2 and HCO_3- ions are used in the plant photosynthesis process, resulting in a pH increase during this period **[10]**.

Water with a pH of less than 5 may cause excessive concentrations of toxic substances such as metabolic acidosis that is bad for cattle and goats.

For fish use, it is not advisable to be in an acid pH of about 4.5, very dangerous for most fish **[11]**. The pH upper limit is about 9.2 for trout **[11]**.

The values obtained in this study show that our basin is not acidic, so the risks associated with agro-pastoral use are zero. By cons, a very basic water (pH greater than 9) may promote dissociation of ammonium ions in favor of ammonia ions. However, the basins waters may be toxic to eggs and fish fry at ammonia concentrations greater than 0.008 mg / l, the upper tolerable limit being 0.02 mg / l **[10]**. We are generally within the acceptable limit of basicity except in November which has a pH slightly above the tolerance limit.

Nevertheless, since the standard pH for drinking animals requires values between 6.5 and 9.5 **[12]**, the practice of this activity in our basin is without problem.

1.3.6 Hardness

Natural waters are rich in mineral salts, and much of the chemical analysis of these waters consists of determining the most abundant cations and anions. In natural waters, these cations are calcium and magnesium then sodium Na^+ and finally potassium K^+. These are basically the Ca^{2+} and Mg^{2+} which are responsible for the hardness.

These magnesium and calcium ions come from the alteration of the bedrock. The use of hard water for watering plants can cause the drip of clog system **[13]**.Table 6 below presents the water hardness measurement results from October to December.

Table6 : Hardness in mg/L ($CaCO_3$) of Sebi-Ponty basin between October and December

Depth	October	November	December
above	48	50	50
0,5 m	48	49	50
1 m	49	49	49

The precipitation of magnesium and calcium bicarbonate in the form of sequins after evaporation of the water from the drip tends to clog the holes. But it will have the advantage of protecting the pipe against corrosion if the deposit is uniform. By cons, if the deposit is not uniform, there may be an acceleration of corrosion at some point in the piping.

The same phenomenon is observed in the industrial pipelines of water, especially in the pipes of transport **[14].**

Our basin contains fresh water as a whole (between 48 and 50 mg / L $CaCO_3$) up to 1 m deep.

1.3.7 Alkalinity

Alkalinity is a measure of the power of water to neutralize acids. In other words, alkalinity measures the water resistance according to variation of pH. This water neutralizing power is strongly linked to the presence of calcium bicarbonate and magnesium dissolved in water. In Table 7 below, results are presented on the alkalinity of water from October to December.

Table7 : Alkalinity in mg / l of Sebi-Ponty basin between October and December

Depth	October	November	December
above	253	14	16
0,5 m	237	17	15
1 m	253	14	18

In irrigation water, it is advisable to have an alkalinity level of less than 200 mg/l **[15, 16].** But aquatic animals can live and reproduce easily in alkalinities up rates of 400 mg/l **[17]**.

In our basin, we sometimes see peaks that exceed the limit of tolerance in irrigation, especially in October. But overall, the November and December we are well below the limit values of tolerance.

Nevertheless, alkalinity is an important parameter in fish farming, it buffers the pH and contributes to its stability. It's this direct connection between alkalinity and pH that the limits of tolerance of alkalinity are often fixed as a function of the pH of the water. If the water pH is less than 6.5, it is advisable to have an alkalinity of between 15 and 20 mg/l for fish production **[18]**. For cons, the range of alkalinity concentration recommended for breeding fish is between 75 and 200 mg/l **[19]**.

1.3.8 Iron

Iron is a parameter naturally found in water either in soluble form such as ferrous iron (bivalent iron existing in dissolved form Fe^{2+} or $Fe(OH)^{+}$), either in complex form such as ferric iron (trivalent iron: Fe^{3+} met the condition precipitate $Fe(OH)_3$). In Table 8 below, is presented the measurement results on the level of iron in the water from October to December.

Table8 :Iron content (mg / l) of Sebi-Ponty basin between October and December

Depth	October	November	December
above	> 3	> 3	> 3
0,5 m	0,5	> 3	> 3
1 m	0,15	> 3	> 3

In small quantities, iron is useful for plants; but in excess, it clogs the transmitters. An iron content of between 1 and 2 mg/l in irrigation water is considered optimal for plant nutrition **[14,20]**.On the other hand, for fish reproduction, the iron content in water must be less than 0.3 mg/l for small fish, and 0.5 mg/l for large fish **[20]**. This tolerance for fish farming is almost of the same order as for the watering of animals, which is also of the order of 0.3 mg /l **[21]**. A high concentration of iron causes an unpleasant taste to animal consumption.

In our case the average concentration being greater than 3, a solution is necessary to bring this concentration to an acceptable value.

1.3.9 Phosphate

Phosphate is involved in energy transfer (ATP), transmission of hereditary characteristics (nucleic acids) photosynthesis and carbohydrate degradation. This is essential for flowering, fruit setting, early maturity, fruit growth and seed maturation. The phosphate has no specific toxicity; it is its presence in excess and especially in the aquatic environment that can be the cause of the eutrophication of the environment. The eutrophication of aquatic environments leads to the proliferation of aquatic plants, algae and cyanobacteria. In Table 9 below, the results of measurement of phosphate levels in water from October to December are presented.

Table9 : Phosphate (mg/l) content of Sebi-Ponty basin between October and December

Depth	October	November	December
above	> 80	> 80	> 80
0,5 m	> 80	> 80	> 80
1 m	> 80	> 80	> 80

Indispensable to plant growth and development, phosphate plays an essential role in the root system, in photosynthesis and in plant reproduction **[22].**

The analysis of our results in the table above shows a high phosphate level in all the basin samplings and this is a great advantage for the plants.

Generally, this high value of the phosphate concentration does not pose problems in the biological activity of the basins. Its presence has no particularly detrimental effects, but it is an indicator of anthropogenic pollution **[10]**.

1.3.10 Boron

Boron is a trace element necessary for growth of plant but at a low concentration in irrigation water. It participates in the translocation of sugars into sugars-boron which allows it to cross the membranes and end up at the root in order to allow breathing. Boron is essential in protein synthesis, plant flowering and nitrogen metabolism.

It is a very toxic element for plants with different degrees of concentration depending on the plant. For example, a study by a US organization **[23]** established tolerance limits for individual plant families, the results of which are shown in Table 10 below:

Table 10 : Classification of boron tolerance limit for plants **[23]**

< 0,5 mg/l	Satisfactory for all species
0,5 à 1 mg/l	Satisfactory for most of the crops (however sensitive plants may have their affected leaves)
1 à 2 mg/l	Also suitable for certain species: production of sensitive species is reduced
> 2 mg/l	Only very tolerant plants give satisfactory productions

Table 11 below presents the results of measurements of boron in water from November to December in our Sebi-Ponty basin.

Table11 : Boron content (mg/l) of Sebi-ponty basin between November and December

Depth	November	December
above	> 2	> 2
0,5 m	> 2	> 2
1 m	> 2	> 2

The results obtained during these measurement campaigns in the basin Sebi-Ponty show a boron concetration in water greater than the tolerance limit (greater than 2 mg/l rate).
In general, it is advisable not to exceed 0.8 mg/l of boron in irrigation water in order to avoid toxic accumulation with sensitive crops such as garlic, beans, citrus fruit, cherry, orange tree, wheat, sesame, avocado, etc. **[15]**.
On the animal side, excess boron can affect their health. Absorbed, boron disperses in the body before it is rapidly excreted in part, the other part, incorporated into the bones, will take longer to be eliminated. Boron can also in some cases disrupt the development and reproduction of fetus. However, some species such as algae, bacteria, adult fish and invertebrates are more tolerant to boron excess.
Unfortunately there is not yet an economical solution to eliminate the boron contained in the irrigation water and even less of an amendment capable of eliminating its toxic effects.
The solution we propose to prevent boron risks is to give priority to crops of more tolerant species such as cabbage, celery, turnip, corn, artichoke, tomato, alfalfa, parsley, asparagus, red pepper, carrot , radish, potato, cucumber **[23]**.

1.3.11 Chloride

Chlorine is an ubiquitous element in nature and available in aqueous solution as an anion of chloride (Cl^-) and it is in this form that it is absorbed by plants. Table 12 below presents the measurement results for chloride in water from November to December.

Table12 : Chloride (mg/l) content of Sebi-Ponty Lake between November and December

Depth	**November**	**December**
above	0,19	0,12
0,5 m	0,19	0,13
1 m	0,21	0,13

As a regulator, chloride contributes to the regulation of nitrite levels in water, is involved in cellular elongation, the opening of stomata but also maintains hydration and turgor.
It’s advisable to have water with a chloride content is between 0 and 100 mg/l for plant irrigation **[6, 13]**.
The chloride contents obtained in our basin vary between 0.12 and 0.21 mg/l. They are very good compared to the maximum value of 100 mg/l defined by the tolerance of irrigation water. This allows us to conclude that the waters of Sebi-Ponty pool is safe for agricultural activities but also for the development of dependent species, especially aquatic species whose proliferation is blocked by this parameter.

1.3.12 Nitrite

Nitrites are unstable chemical elements because they are intermediate to nitrification, (biologically oxidizing ammonium to nitrate) **[24, 25].** They are toxic to plants and animals. In the blood of animals, nitrites react with hemoglobin and form a component called methemoglobin which has the properties of reducing the ability of the blood to carry oxygen.
Indeed, they are powerful oxidants which, in the organism of animals, have the capacity to transform hemoglobin into methemoglobin.
Nitrites are considered to be very harmful pollutants to human health and to animals (the normal nitrite level is set by World Health Organization at 0.1mg/l).
Table 13 below shows the measurement results on the nitrite levels in water from October to December.

Table13 : Nitrite content (mg/l) of Sebi-Ponty Lake between October and December

Depth	**October**	**November**	**December**
above	> 0,5	> 0,5	> 0,5
0,5 m	> 0,5	> 0,5	> 0,5
1 m	> 0,5	> 0,5	> 0,5

Often the nitrite tolerance limits are given as a function of the chloride concentration in the water, because being intimately related. Table 14 below proposes an assessment of the nitrite content correlated with that of the chloride **[10]**:

Table14 : Tolerance threshold for nitrite in fish-bearing waters in relation to the presence of chloride

Chloride content (mg/l)	**Nitrite tolerance threshold (mg/l)**
< 10	0,02
10 – 20	0,05
>20	0,10

It should be noted that the limit of tolerance for animal potability of water is much greater; it is of the order of 3 mg/l **[6, 26]**.
In our lake, we have a chloride concentration less than 10 mg/l (between 0.12 and 0.21 mg/l see Table 12). Thus, according to Table 14, the nitrite tolerance threshold is 0.02 mg/l for better use in fish farming.
This tolerance threshold is largely exceeded on all samples taken in Sebi-Ponty between October and December because they have nitrite contents above 0.5 mg/l (limit value of our measuring device).
This means that fish farming is risky in this basin if solutions are not found beforehand.

1.4 Conclusion

This study allowed us to assess the physicochemical quality of the waters of Sebi-Ponty, used for a long time by the population for animal drinking, off-season agriculture and often even household needs. Today, in light of our results, it is established that this water is therefore not drinking unfit for domestic consumption. Moreover, its agricultural and pastoral use require prior to treatment in order to increase yield. This is due to the presence in excess of certain components such as boron, iron and nitrites.

Pending resolution of this problem, operator’s awareness campaign is needed to help this population to better use.
For example, to prevent boron risks, it is important to cultivate tolerant species such as cabbage, celery, turnip, maize, artichoke, tomato, alfalfa, parsley, asparagus, bell pepper red, carrot, radish, potato, cucumber **[23]**.
This study is not exhaustive as not taking into account other elements that can be as harmful to agricultural use, such as

chromium, nickel, mercury and selenium **[15]**. We intend to extend this study on these components as well as on the bacteriology of water.

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