Evaluation of Chemical Pollution of Seawater in Donaten's Ecological and Biological Important Area

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Abstract Donaten's Ecological and Biological Important Area is subject to anthropogenic pressure; resulting in its pollution. This study has enabled the assessment of pollution of its maritime part with a view to its preservation. Thus, physico-chemical parameters such as color, temperature, pH, dissolved oxygen, oxygen saturation, salinity, TDS were recorded *in situ* in three different points on the coast, two of which showed evidence potential pollution. Water samples were taken in these points for determination of BOD_5 and COD, concentration of suspended solids, ammoniacal nitrogen, total nitrogen, nitrates, orthophosphate, total phosphorus, copper, zinc, lead and cadmium using standard methods. The results of physico-chemical characteristics recorded, namely temperature (29.8°C to 30.1°C), suspended solids (1.41 to 42.3 mg/L), pH (6.4 to 6.9), dissolved oxygen concentration (5.4 mg/L to 6.2 mg/L), oxygen saturation (80 to 94), salinity (29.8 to 32.1 g/L), TDS (29513 to 31533 mg/L), COD (<5 to 26 mg/L), BOD (< 1 to 18 mg/L), ammoniacal nitrogen (<0.05 to 2.89 mg/L), nitrates (0.27 to 0.32 mg/L), total kjedahl nitrogen (3.8 and 7.1 mg/L), ortho phosphate (0.002 to 0.47 mg/L), total phosphorus (0.73 to 2.2 mg/L), copper (0.01 to 1.13 mg/L), zinc (1.53 to 2.41 mg/L), lead (<0.001 at 0.022 mg/L) and cadmium (0.008 to 0.012 mg/L) revealed that Donaten's Ecological and Biological Important Area was not polluted with organic and metallic trace elements pollutants. This study could form a basis for further scientific studies.

Keywords: ecological and biological importance area, organic pollution, trace metal pollution

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1. Introduction

Benin currently has two Ecological and Biological Important Areas (EBIA) [1]. These are environments with ecological and biological potentiality. The first Ecological and Biological Important Zone is that of "Bouche du Roy" with 89.90 km[2] located in Ramsar 1017 site in west of Cotonou [1]. The second is that of Donaten with an area of 49 km[2], located in Ramsar 1018 site in east of Cotonou on maritime side [1]. Donaten's Ecological and Biological Important Area consists of a continental part (terrestrial) and a maritime part (73% of the EBIA). The maritime part of Ecological and Biological Important Area is subject to anthropogenic pressure. Some of the anthropogenic activities observed like contraband petroleum products transport, boats used to transport petroleum products washing, oil tankers deballasting, accidental hydrocarbon spills, domestic and industrial wastewater discharges

could have impact on sea water's quality of the Zone and on biodiversity.

Any Ecological and Biological Important areas was very important, it was necessary to investigate the state of maritime part of that of Donaten in a view to preserve coastal and maritime biodiversity.

Therefore, the main objective is to evaluate pollution of seawater in Donaten's EBIA. More specifically, to evaluate organic pollution and metal pollution of EBIA's water.

2. Materials and Methods

2.1. Choice of Sampling Points

Three sampling points were selected along Donaten's EBIA. Two of them were chosen in portions of strong anthropogenic activities and presenting potential signs of pollution. The first sampling point, with no visual evidence of pollution, is located behind El Dorado hotel.

The second sampling point is the discharge point of a sewer, draining domestic wastewater from villas of CEN-SAD (Community of Sahel-Saharan States for Development) towards the sea. Finally, the third Sampling point is the place where the city's faecal sludge treatment plant discharges into the sea, it is next to a garbage dump.

Geographical coordinates of sampling points, recorded using a GPS, are shown in Table 1.

Table 1. Sampling times and coordinates of sampling points

Parameters	Sampling points		
	Point 1	Point 2	Point 3
Sampling times	10h40	11h40	11h50
Geographical	2.46380 E	2.47262 E	2.32356 E
coordinates	6.35654 N	6.36060 N	6.214282 N

2.2. Sampling

1.5 liter bottles previously washed, rinsed with distilled water and rinsed again with sea water are immersed in the sea to a depth of about 20 cm. The bottles were filled to the brim, kept in coolers containing ice and then transported to laboratory, where they were kept at 4°C and analyzed within 24 hours.

2.3. Physico-chemical Parameters' Measurements

Some physico-chemical parameters were measured *in situ* immediately after each water sample. Measurements of dissolved oxygen, oxygen saturation, salinity, TDS (Total Dissolved Solids) and temperature were made using multiparameter (YSI Pro2030) and pH using a pH portable meter (HANNA HI991001).

Other parameters were determined in laboratory and include determination of concentrations of suspended solids, parameters indicating organic pollution (biochemical oxygen demand for 5 days, chemical oxygen demand, ammoniacal nitrogen, nitrates, total Kjedahl nitrogen, orthophosphate, total phosphate), and metallic trace elements (copper, zinc, lead, cadmium).

Suspended solids were quantified by spectrophotometry. Biochemical oxygen demand for 5 days, chemical oxygen demand was determined respectively using respirometric method and colorimetric method [2].

Total Kjedahl nitrogen and ammoniacal nitrogen were quantified using spectrophotometric method using Nessler's reagent [3]. Nitrates concentration is determined by colorometric method using spectrophotometer. Quantification of total phosphorus was carried out according to standard NF EN ISO 6878 [4]. Orthophosphate was quantified according to colorimetric method with ascorbic acid. Copper content was determined using bicynchroninate spectrophotometric method and that of zinc using spectrophotometric method, those of lead and cadmium using dithizone spectrophotometric method.

2.4. Statistical Analysis

The results obtained were presented in form mean ± standard error of mean. They are processed according to the Annova software with one factor, made using Minitab software. The differences between values of each site are statistically very significant with p < 0.05.

3. Results and Discussion

3.1. Colour

Donaten's Ecological and Biological Important Area as a whole has a large expanse of limpid water. This water is not turbid. However, there is greenish colored water pocket that revealed organic contamination.

3.2. Temperature

The values recorded vary between 29.8°C and 30.1°C (Table 2). These values, which relate to surface layer of water, are probably influenced by ambient air temperature.

Table 2. Water temperatures in Donaten's Ecological and Biological Importance Area

Parameter	Sampling points		
	Point 1	Point 2	Point 3
Temperatures (°C)	30.1	30	29.8

3.3. Suspended Solids

Suspended solids contents of the three sampling points are shown in Table 3. They are very low at sampling points 1 and 2. Sampling point 3 suspended solids content was very high and even higher than the quality standard for wastewater in Benin [9]. This could be as a result of the discharged sewage and the leaching of the garbage dump by runoff water.

3.4. pH

The pH are all below 7 (Table 3) and slightly acidic. They are also lower than sea water's normal pH (8.3) according to Aminot and Kerouel [5]. They are within tolerable limit (5 to 9) for most marine resources. This slight acidity should not have harmful effect on marine resources because according to Diagne *et al* [6], only pH values below 5 or above 9 are harmful to fish.

3.5. Dissolved Oxygen

Dissolved oxygen levels vary between 5.4 and 6.2 mg/L (Table 3). These values also indicate that dissolved oxygen is not deficit in EBIA sector. A decrease was noted in sampling points 2 and 3, which reflects the use of oxygen probably by microorganisms to degrade biodegradable pollutants of domestic wastewater (site 2), garbage and faecal sludge (site 3). This parameter, dissolved oxygen, is an important parameter for aquatic life [7].

3.6. Oxygen Saturation

Oxygen saturation values recorded show good oxygen availability for biodegradability and purification (Table 3).

Table 3. Physico-chemical parameters of Donaten's Ecological and Biological Importance Area

Parameters	Sampling points			Standard [9]
	Point 1	Point 2	Point 3	
Suspended solids (mg/L)	1.41 ± 0.01	1.8 ± 0.01	43.2 ± 0.01	35
pH	6.4 ± 0.01	6.63 ± 0.01	6.9 ± 0.01	
Dissolved oxygen (mg/L)	6.2 ± 0.01	5.4 ± 0.01	5.5 ± 0.01	
Oxygen saturation (%)	94 ± 0.01	80 ± 0.01	85 ± 0.01	
Salinity (g/L)	29.8 ± 0.01	30 ± 0.01	32.1± 0.01	
Total Dissolved Solids (mg/L)	29513 ± 0.01	29765 ± 0.01	31533 ± 0.01	

3.7. Salinity

Salinity of water samples varied between 29.8 g/L and 32.1 g/L for sampling point 1 and sampling point 3 respectively (Table 3). These values were lower than 34.7 mean sea water salinity value [8]. The difference between sampling points 1 with 29.8 g/L and 2 with 30 g/L, and sampling point 3 with 32.1 g/L could be explained by dilution of sea water by considerable inflow of Lake Nokoué's water. Sampling points 1 and 2 are closer from where the lake meets the sea than point 3.

3.8. Total Dissolved Solids (TDS)

TDS or total dissolved solids values 29513 mg/L to 31533 mg/L recorded showed that sea water is well concentrated in minerals, salts, ions (cations and anions) (Table 3). The values obtained showed that there was no significant difference between sample point 1 and sample point 2. Sample point 3 has a higher value than the other two. These differences indicate the importance of additional input of ions from domestic wastewater (point 2) faecal sludge and landfill (point 3).

3.9. Chemical Oxygen Demand (COD)

COD of sampling points 1 and 2 was less than 6 (Table 4). This showed that water from these sampling points contained low organic matters. Sampling point 3, has a higher COD of 26 mg/L though lower than Beninese standard [9] which is 125 mg/L (Table 4). The load of oxidizable organic matter in faecal sludge and garbage dumped there explains this COD. This organic matter's load is not sufficient to cause pollution.

3.10. Biochemical Oxygen Demand (BOD$_5$)

The results obtained (Table 4) showed almost no organic polluting load at sampling points 1 and 2. Sampling point 3, on the other hand, had a high BOD$_5$ of 18 mg/L. This value, though lower than Beninese standard (25 mg/L) [9], revealed contamination by faecal sludge and dumps dumped in the point. They are rich in organic matter and nutrients. Organic matter and nutrients degradation by microorganisms requires oxygen Table 4: COD and BOD$_5$ of Donaten's EBIA water.

Table 4. COD and BOD$_5$ of seaweater of Donaten's Ecological and Biological Importance Area

Parameters	Sampling points			Standard [9]
	Point 1	Point 2	Point 3	
COD (mg/L)	< 5	< 6	26 ± 0.1	125
BOD$_5$ (mg/L)	< 1	< 1	18 ± 0.1	25

3.11. Ammoniacal Nitrogen

The results of ammoniacal nitrogen in the three sampling points revealed a content of less than 0.05 mg/L for sampling point 1. The values obtained for the other two sampling points were relatively higher, 1.53 mg/L for sampling point 2 and 2.89 mg/L for sampling point 3 (Table 5). This difference could be explained by the release of ammonium from process of oxidation incomplete of organic matter present at these points. This is therefore evidence of contamination, the intensity of which is greater at sampling point 3 than at sampling point 2. Only sampling point 1 was not subject to ammonium contamination.

3.12. Nitrates

Nitrate contents in the 3 sampling points showed that there was significant difference between the values (Table 5). Sampling point 1 recorded 0.32 mg/L. It was 0.27 mg/L for sampling point 2 and 0.29 mg/L for sampling point 3. The waters studied are not subject to contamination or nitrate pollution.

3.13. Total Kjeldahl Nitrogen

Total Kjeldahl nitrogen contents provide information on all forms of nitrogen in solution. It is respectively 3.8 mg/L; 6.2mg/L; 7.1 mg/L for the first sampling point, the second and the third (Table 5). These values are lower than Beninese standard. Consequently, there is no pollution but rather there is nitrogen contamination, a low-level organic contamination. There will be pollution when the values obtained are higher than the standard.

Table 5. Chemical characteristics of seawater

Parameters	Sampling points			Standard [9]
	Point 1	Point 2	Point 3	
Ammoniacal nitrogen (mg/L)	<0.05	1.53 ± 0.01	2.89 ± 0.01	
Nitrates (mg/L)	0.32 ± 0.02	0.27 ± 0.02	0.29 ± 0.01	
Total Kjeldahl Nitrogen (mg/L)	3.8 ± 0.1	6.2 ± 0.00	7.1 ± 0.00	15
Ortho phosphates (mg/L)	0.002 ± 0.000	0.047 ± 0.01	0.44 ± 0.01	
Total phosphorus (mg/L)	0.53 ± 0.02	0.73 ± 0.03	2.2 ± 0.00	10

3.14. Phosphorus

The values of ortho phosphate obtained show that at sampling point 1 water contains practically no ortho phosphates (0.002 mg/L) and that at sampling points 2 and 3 there are in very small quantity (Table 5). It is 0.047 mg/L at sampling point 2 and 0.44 mg/L at sampling point 3. All values are below 1 mg/L The presence of ortho phosphate can only be attributed to the input of domestic sewage which does not contain as much of it as faecal sludge and garbage.

As for total phosphorus, sampling point 3 with a content of 2.2 mg/L is more concentrated than sampling points 1 and 2 which contain 0.53 mg/L and 0.73 mg/L respectively (Table 5). There was no significant difference between points 1 and 2. Discharged faecal sludge and garbage dump at sampling point 3 are the sources of this difference.

Nutrient concentrations obtained showed that there is no pollution or risk of eutrophication. Rather, there is contamination. Indeed, levels of nutrients obtained are all lower than the standards for wastewater in Republic of Benin [9].

3.15. Metallic Trace Elements

Copper contents obtained (Table 6) show that there is no copper contamination at sampling points 1 and 3.

Sampling point 2, on the other hand, shows contamination by domestic wastewater which contained more copper than the faecal sludge and landfill.

As for zinc, domestic wastewater (point 2), landfill and sewage (point 3) contain more zinc.

With regard to lead and cadmium, the three sampling points showed levels well below the standard (Table 6).

Table 6. Concentration of some metallic trace metals

Parameters	Sampling points			Standard [9]
	Point 1	Point 2	Point 3	
Copper (mg/L)	0.01 ± 0.001	1.13 ± 0.01	0.07 ± 0.01	2.5
Zinc (mg/L)	1.53 ± 0.01	2.05 ± 0.01	2.41 ± 0.01	5
Lead (mg/L)	<0.001	0.016 ± 0.000	0.022 ± 0.000	1
Cadmium (mg/L)	0.008 ± 0.000	0.008 ± 0.000	0.0121 ± 0.000	1

It appears from metal pollution's investigation of seawater in the Donaten EBIA that the area is not subject to metal pollution.

4. Conclusion

Every aquatic ecosystem is prone to pollution. The study showed that it is not polluted now but could be polluted in future if not proteged i.e. if it is not transformed into a marine protected area. The values of organic pollution parameters indicator, namely COD, BOD$_5$, total nitrogen content, phosphorus content; and those parameters indicator of heavy metals pollution such as copper, zinc, lead, cadmium are all below standards for quality of waste water in the Republic of Benin. The study also revealed that the portion of the EBIA located at the SIBEAU company wastewater treatment plant is subject to low-level organic contamination.

This study was the first to be carried out on Donaten's EBIA. No previous data on the physicochemical characteristics of Donaten's EBIA is available according to the literature consulted. This study could form a basis for further scientific studies.

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Conflicts of Interests

The authors declare no conflict of interest.

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