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Nutrients and Trace Elements Concentrations in Biétri Bay after its Volume Reduction, Côte d'Ivoire

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Abstract:*Dissolved inorganic nutrients, mainly nitrogen and phosphorus components are involved in marine ecosystems eutrophication. Trace elements are known as hazardous components in aquatic ecosystems. The study was undertaken in Biétri Bay, one of the most polluted bays of the Ebrié Lagoon in Côte d'Ivoire, to assess its waters' quality after its volume reduction due to some embankments for the extension of Abidjan Port activities. pH, temperature, salinity and Electric Conductivity (EC) were measured in situ at each of the sampling stations. Ammonium (NH_4^+), nitrite (NO_2^-), nitrate (NO_3^-), orthophosphate (PO_4^{3-}) and twelve (12) trace elements concentrations were determined in waters collected from four (4) selected stations. The measured values of pH, temperature, salinity and Electric Conductivity were in the respective ranges of 7.24-7.82; 20.99-28.77°C; 25.78-36.66; 40.32-55.46 mS/Cm. NH_4^+, NO_2^-, NO_3^- and PO_4^{3-} were in the respective ranges of 0.19-0.66, 0.013-0.038, 1.20-3.00 and 0.23-1.35 mg/L. Na and Mg concentrations ranged from 365.02 to 2033.0 mg/L and from 0.33 to 29.93 mg/L respectively. Waters were safe of Pb at the station closed to Port-Bouët fish market, and exhibited concentrations values that ranged from 0.01 to 0.67 mg/L elsewhere. Arsenic (As) was only detected in surface waters from the station closed to the Ivorian Refinery Society (SIR) with a high value of 0.86 mg/L. Salinity, Nitrate, orthophosphates, lead and arsenic values observed for the present study were higher than the values reported beforeBiétri Bay's volume reduction. The treatment of liquid effluents before their introduction in Biétri Bay is recommended for a best management of waters resources.*

Keywords: *Nitrogen, phosphorus, trace metals, water quality, Biétri Bay, Ebrié Lagoon, Côte d'Ivoire.*

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I. Introduction

Worldwide, water is known to be the source of life. In coastal areas, lagoons are among the most dynamic, diverse and productive ecosystems on Earth, and provide a wide range of goods and services of a great socio-economic value to local communities (Beer and Joyce, 2013; Newton et al., 2014; Rodellas et al, 2018). Unfortunately, coastal ecosystems are threatened by anthropogenic and climatic disturbances that lead to land reclamation loss of habitats and vegetation and significant pressure on biological and ecological resources (De Jonge et al., 2002; Jennerjahn and Mitchell, 2013). Development in costal watersheds has resulted in significant degradation of estuaries and coastal ecosystems through several interacting factors including habitat loss, nutrient pollution (Carpenter et al., 1998; Mallin et al., 2000; Foley, 2005; Lotze, 2006; Seitzinger et al., 2010; U.S. Environmental Protection Agency, 2016). Due to its key role for all forms of life, the water quality is of particular importance worldwide, specifically in coastal areas with changes in population, land use, and pollutants inputs from continental sources(Seitzinger et al., 2010; Kataria et al., 2011; Tuo et al., 2012; Bhuyan et al., 2017). Nutrients (phosphorus and nitrogen) are the essential components for marine ecosystem primary production and for biodiversity equilibrium when they occur in acceptable levels. Apart from nitrogen and phosphorus, silicate is also essential for diatom growth, but it is assumed that its input is not significantly influenced by human activity. In coastal areas, a part of nutrient is of natural origin involving the decomposition of plants and animal material, while the most important is from anthropogenic activities (atmospheric, synthetic fertilizer, soil, animals and septic wastes, residential development, domestic and agricultural practices, sewage discharges, harbor and industrial activities, etc.) (Tuo et al., 2020a). Coastal waters are particularly vulnerable due to their relative lack of major removal processes that can increase nutrients amounts in coastal environments (Slomp and Van Cappellen, 2004; Weinstein et al., 2011; Tovar-Sánchez et al., 2014; Tuo et al, 2020b). High amounts of nutrients in surface waters may conduce to several hazardous effects including eutrophication. Thus, concentrations, effects, trends and sources are studied in several coastal areas (Adesuyi et al, 2015; Rodellas et al, 2018; Oelsner and Stets, 2019, Tuo et al., 2020a). The widely documented hazardous effects of eutrophication are toxic algal blooms, increase growth of nuisance microalgae, increase in oxygen consumption leading to oxygen depletion in lower water layers and sometimes mortality of marine species such as benthic animals, fish, etc. (Cloern, 2001; Conley et al., 2002; 2004; Tuo et al., 2012). Trace metals, due to their wide societal use and applications, are among widespread environmental contaminants and hazardous to human and non-human biota in relation with their persistent, bio-accumulated and magnified through food web and finally reach to human, the final consumer, causing public health risks (Viana et al., 2005, Casado-Martinez et al, 2006; Botwe et al., 2018). Hazardous effects link to arsenic contamination are peripheral and central nervous changes (sensory changes, numbness, and tingling), muscle tenderness (Bronstein et al., 2011). Chronic exposure to cadmium presents a larger threat to human and non-human health (Thévenod and Lee, 2013). For lead exposure, birth defects, mental retardation, autism, psychosis, allergies, dyslexia, hyperactivity, weight loss, shaky hands, muscular weakness and paralysis, nausea, lack of concentration were reported (Kontoghiorghes et al., 2004; Crisponi et al., 2013). Hazardous effects reported for iron exposure are arrhythmia, heart failure, increased atherosclerosis risk, and increases in the risk of liver, breast, gastrointestinal, and hematologic cancers (Araujo et al., 1995; Nelson et al., 1995; Kallianpur et al., 2004; Sahinbegovic et al., 2010; Dongiovanni et al., 2011; Kremastinos and Farmakis, 2011; Ellervik et al., 2012). Prior the Biétri Bay surface (volume) reduction for Abidjan Port activities extension, the data of several studies conducted in Biétri Bay showed that both waters and sediments were contaminated in nutrients, organic matter and trace metals (Yao et al., 2009; Tuo et al, 2012; Tuo et al, 2013; Tuo et al, 2015). The aim of the present work was to assess the waters' quality after the area's reduction due to Abidjan Port activities extension, basing on physicochemical parameters, nutrients and trace metals data. Thus, hydrological parameters (pH, temperature, salinity, Electric Conductivity (EC), ammonium, nitrite, nitrate, orthophosphate and twelve trace elements were studied.

II. Material And Methods

2.1. Study area

The present work was undertaken in Biétri Bay, among the most polluted bays located in the urban area of the Ebrié Lagoon in Côte d'Ivoire (Table 1, Figure 1). The Biétri Bay is located in the Ebrié Lagoon that communicates with the Atlantic Ocean through Vridi Chanel, and has a low renewal rate of its waters (Figure 1). This urban bay is affected by several domestic and industrial activities, receiving liquid effluents that often contain several pollutants such as nutrients, organic matter, trace metals, etc. (Tuo et al., 2012).The Ebrié Lagoon has an area of 566 km^2 and stretches on 125 km along the coast of Côte d'Ivoire, between 3°40' and 4°50' West, at latitude 5°50' North. Ebrié Lagoon waters are simultaneously diluted with marine waters during dry seasons and with fresh waters (from coastal rivers, mainly Comoé River) during the rainy and flood seasons (Tuo et al., 2012).

The sampling stations and their respective locations and depths are presented in Table 1, while Figure 1 shows the location of Biétri Bay in Ebrié Lagoon and the sampling station's location in the studied area.

Table 1: Sampling stations codes and locations in Biétri Bay.

Station	Code	Location	Depth
Station A	A	Closed to Ivorian Refinery Society (SIR)	6m
Stations B	B	Closed the slaughterhouse of Port-Bouët	12m
Station C	C	Closed to a great gutter	3m
Station C	D	closed to the artisanal fish market of Port-Bouët	4m

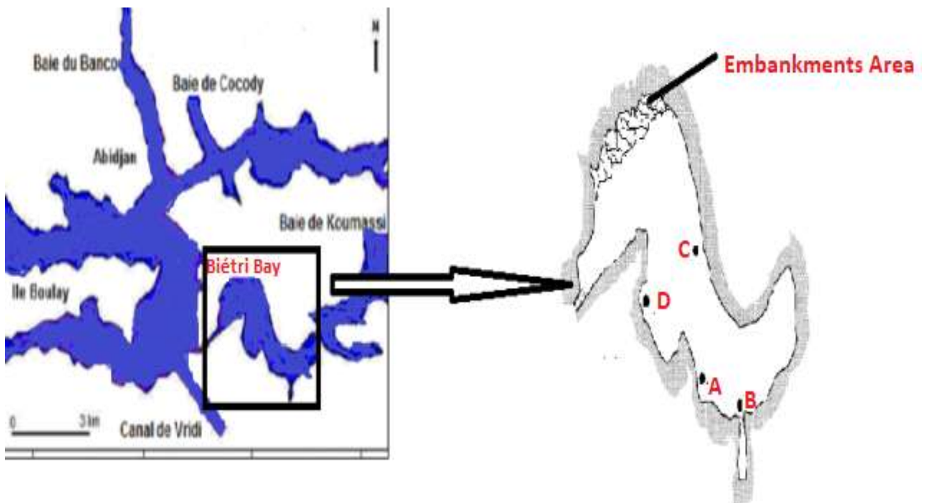

Figure 1: Map showing sampling stations in Biétri Bay.

2.2. Samples collection and treatment

The water samples were collected (in surface and bottom layers) at four (4) points (A, B; C and D) distributed along the Biétri Bay in Ebrié lagoon, the 23 April 2016, using a Niskin bottle, according to standards methods (APHA, 2005; Tuo et al., 2012). pH, temperature, salinity and Electric Conductivity (EC) were measured *in situ*, using a multi-parameter (Type HI 9828 pH/ORP/EC/DO). Immediately after collection, water samples were stored in a cooler and transferred to the lab for further nutrients and trace elements analyses.

2.3. Nutrients analysis

Dissolved inorganic nutrients (nitrate, nitrite, ammonium and orthophosphate) were measured by standard colorimetric method using UV–Vis spectrophotometer (Rodier, 2006; Tuo et al., 2012; Tuo et al., 2020a). Ammonium ions (NH_4^+) are treated in an alkaline pH, with sodium hypochlorite and phenol giving indophenol which is of blue coloration. This reaction is catalyzed by nitroprusside. Ammonium was measured colorimetry on 630 nm (Rodier; 2006). Nitrite (NO_2^-) was determined by complexation with the diazotization of sulfanilamide and with N-(1-naphthyl) ethylenediamine in acidic pH, which gave a purple-colored complex. Nitrite was measured colorimetry on 540nm (Rodier, 2006). Nitrate (NO_3^-) was measured colorimetry on 420 nm. Sulfosalicylic acid forms with nitrate in anhydrous environment and releases in basic environment a nitrosalicylate complex which is of yellow color. A colorimetric determination of this ion allows to determine the concentration of nitrate ions in a solution (Rodier, 2006). Orthophosphates react in the presence of antimony molybdate to give phosphomolybdic acid compounds that were reduced by ascorbic acid, giving a blue coloration. Ortho-P was finally measured colorimetry on 885 nm (Rodier, 2006).

2.4. Trace elements analysis

Trace elements concentrations in water samples were analyzed using and ICP-MS Instrument after specific treatment according to the following description. The sample pre-concentration was done by evaporating 100 mL of the water to 5 mL on a hot plate. The digestion of the water sample was then achieved by adding 5 mL of concentrated nitric acid (HNO_3) and heating on a hot plate for 30 min. Some 10 mL of concentrated hydrochloric acid (HCl) was added and digestion continued until the solution remained light brown or colorless. The volume was then adjusted to 25 mL with distilled water (Tuo et al., 2012).

2.5. Statistical analysis

The averages, standards deviations and graphs were performed using Microsoft Excel and/or STATISTICA software (2005, 7.1 Version).

III. Results

3.1. Physicochemical properties (pH, temperature, salinity and Electric conductivity)

Physicochemical properties are important parameters used in environmental studies in general, and particularly for coastal waters studies. pH, temperature, salinity and Electric conductivity measured in the four selected stations are presented in Table 2 and their spatial distributions are presented in Figure 2.

pH values observed in waters from Biétri Bay ranged from 7.24 to 7.82 and from 7.61 to 7.69 in surface and bottom waters respectively (Figure 2a, Table 2). An average value of 7.61±0.26 was observed in surface waters, while the bottom ones exhibited a mean of 7.65±0.04 (Table 2).

Temperature values were found in the ranges of 20.99 to 23.48 °C and 21.43 to 28.77 °C in surface and bottom waters respectively (Figure 2b, Table 2). Respective average values of 22.28±1.31°C and 24.22±3.17 °C were determined in surface and bottom waters from Biétri Bay (Table 2).

Table 2: Physicochemical properties measured in waters from Biétri Bay in the Ebrié Lagoon.

Statistics		pH	Temperature (°C)	Salinity	Electric Conductivity (mS/Cm
Surface	Min	7.24	20.99	25.85	40.38
	Max	7.82	23.48	26.50	41.33
	Mean	7.61	22.28	26.13	40.80
	SD	0.26	1.31	0.33	0.46
Bottom	Min	7.61	21.43	25.78	40.32
	Max	7.69	28.77	36.66	55.46
	Mean	7.65	24.22	29.97	46.14
	SD	0.04	3.17	4.68	6.51

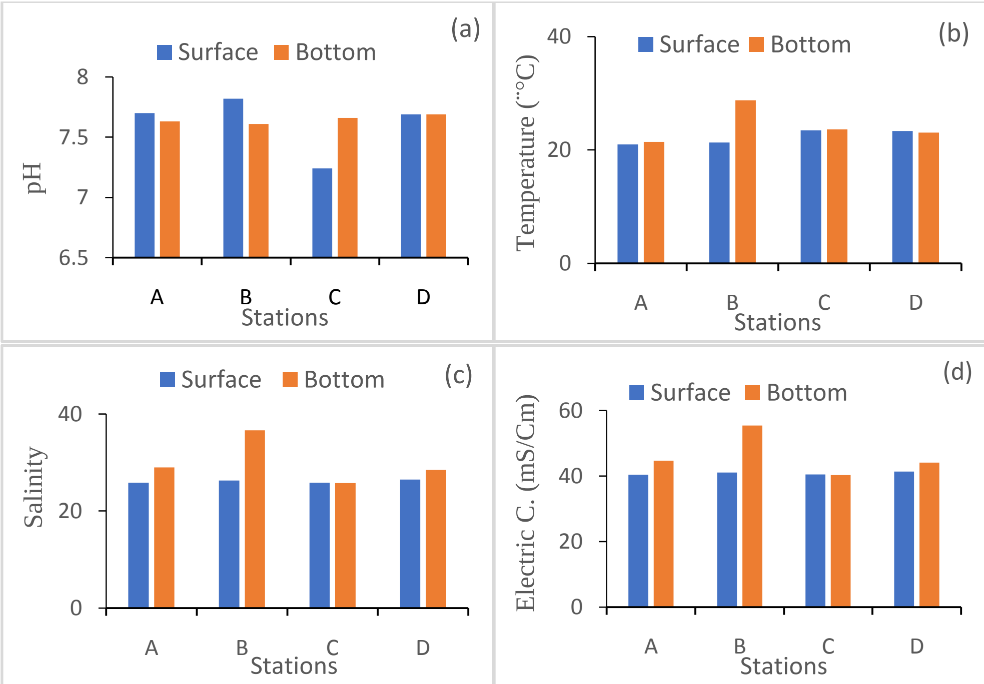

Figure 2: Spatial distribution of physicochemical properties observed in waters from Biétri Bay. (a): pH; (b): Temperature; (c): Salinity and (d): Electric Conductivity.

Regarding salinity, the measured values ranged from 25.85 to 26.50‰ and from 25.78 to 36.66 ‰ in surface and bottom waters respectively (Figure 2c, Table 2). The average salinity value was 26.13±0.33 in surface waters and 29.97±4.68 ‰ in bottom layers(Table 2).

The Electric conductivity was measured in waters from Biétri Bay. The observed values ranged from 40.38 to 41.33 mS/Cm in surface waters and from 40.32 to 55.46 mS/Cm in bottom layers (Figure 2d, Table 2). The averages values of Electric conductivity were 40.80±0.46 mS/Cm and 46.14±6.51 mS/Cm in surface and bottom waters respectively (Table 2).

3.2. Nutrients (Ammonium, nitrite, nitrate and orthophosphate)

Nitrogen and phosphorus are the two major elements generally incriminated in surface waters eutrophication, and more particularly in coastal areas. The dissolved species of nitrogen as ammonium (NH_4^+), nitrite (NO_2^-), and nitrate (NO_3^-), phosphorus as orthophosphates (PO_4^{3-}) were determined in water samples collected in surface and bottom layers. The results are presented in Table 3 and Figure 3.

Ammoniumconcentrations varied from 0.19 to 0.56 mg/L in surface waters, and from 0.23 to 0.66 mg/L in the bottom ones. The averages values in were 0.40±0.16 mg/L and 0.48±0.18 mg/L respectively in surface and bottom layers. NH_4^+ values found in bottom waters were higher than those observed in the surface ones. An important vertical gradient (0.21 mg/L) occurred at station B, which is the deepest (12 m depth) among the four stations (Figure 3a).For nitrite, the contents were in the ranges of 0.024 to 0.033 mg/L and 0.013 to 0.038 mg/L in surface and bottom waters (Table 3; Figure 3b). An average value of 0.029±0.004 mg/L was observed in surface waters, while that of the bottom ones was 0.028±0.011 mg/L (Table 3). The lowest concentration in nitrite was observed in bottom waters from Station B (0.013 mg/L), while the highest (0.038 mg/L) was recorded in bottom waters from station D (Figure 3b). Apart from station B where the surface waters were found enriched in nitrite than the bottom ones with a vertical gradient of 0.02 mg/L, nitrite concentrations observed in bottom waters were higher than the surface ones elsewhere (Stations A, C and D) (Figure 3b).

Table 3: Nutrients concentrations observed in waters from Biétri in the Ebrié Lagoon.

Statistics		**NH_4^+ (mg/L)**	**NO_2^- (mg/L)**	**NO_3^-(mg/L)**	**PO_4^{3-} (mg/L)**
Surface	Min	0.19	0.024	1.70	0.23
	Max	0.56	0.033	3.00	0.43
	Mean	0.40	0.029	2.50	0.35
	SD	0.16	0.004	0.59	0.09
Bottom	Min	0.23	0.013	1.20	0.31
	Max	0.66	0.038	2.50	1.35
	Mean	0.48	0.028	1.95	0.60
	SD	0.18	0.011	0.56	0.50

Nitrate concentrations ranged from 1.70 to 3.0 mg/L in surface waters, and from 1.20 to 2.50 mg/L in bottom ones. The respective mean values of nitrate for surface and bottom waters were 2.50±0.59 mg/L and 1.95±0.56 mg/L (Table 3; Figure 3c). Nitrate concentrations observed in surface waters were higher than the bottom ones at stations A, B and D, while nitrate contents in the bottom waters were slightly higher than that observed in the surface ones (Figure 3c).

Orthophosphates concentrations values in surface and bottom waters ranged respectively from 0.23 to 0.43 mg/L and from 0.31 to 1.35 mg/L (Table 3; Figure 3d). Orthophosphates exhibited averages values of 0.35±0.09 mg/L in surface waters and 0.60±0.50 mg/L in bottom ones (Table 3). Ortho-P concentrations observed in waters from Biétri Bay were generally less than 0.5 mg/L, apart from bottom waters in station B that exhibited the highest concentration of 1.35 mg/L (Figure 3d).

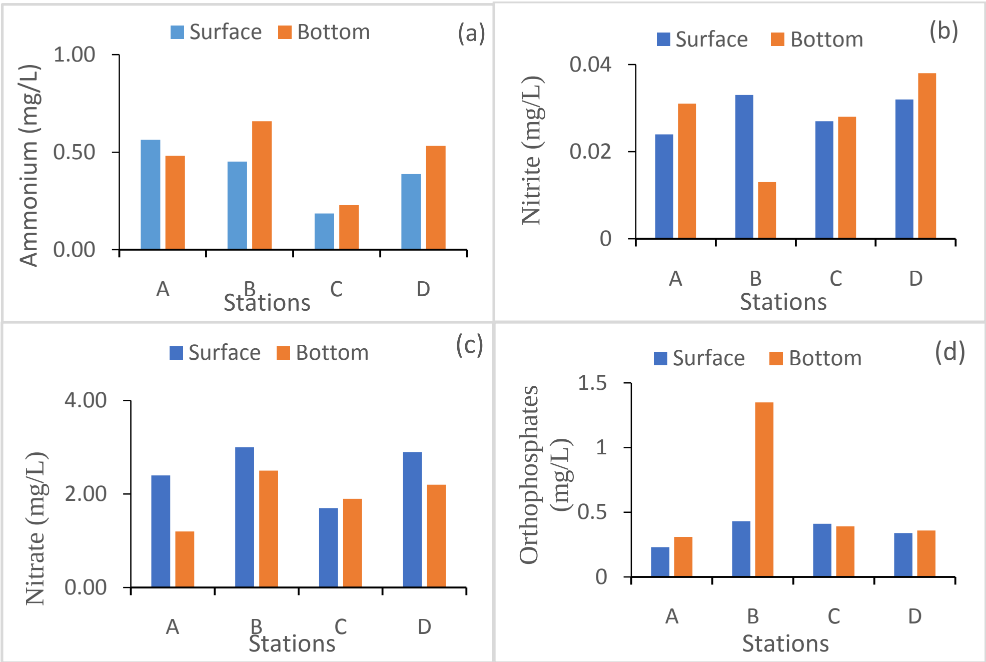

Figure 3: Nutrients concentrations observed in waters from Biétri Bay.
(a): Ammonium; (b): Nitrite; (c): Nitrates and (d): Orthophosphates.

3.3. Trace elements

Trace metals are naturally present in all parts of the environment (air, soil and waters), but, in concentrations that are safe for both fauna and biota. Some are known for their biological benefits (Mn, Na,Mg, K, Zn, etc), while some, like arsenic, cadmium, lead, mercury, etc. do not have any benefit known at present. Twelve trace elements (Na, Mg, Cr, Mn, Fe, Ni, Cu, Zn, Cd, Hg, Pb and As) were analyzed in surface and bottom waters collected from Biétri Bay in Ebrié Lagoon (Table 4).Among the twelve elements, eightof them (Cr, Mn, Fe, Ni, Cu, Zn, Cd and Hg) were not detected in the samples collected. The four elements effectively detected in waters were sodium (Na), magnesium (Mn), lead (Pb) and arsenic (As) (Table 4). Regarding Na, station A recorded the lowest value of 365.02 mg/L and the highest one of 2018.6 mg/L (Table4).

Table4: Trace metal concentrations observed in surface and bottom waters from Biétri Bay.

Trace element	Station A		Station B		Station C		Station D	
	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
Na	365.02	2018.6	1980.83	2033	2003	1979.7	2014.1	2009
Mg	0.33	29.93	27.19	29.81	27.08	26.44	28.09	28.45
Cr	ND	ND	ND	ND	ND	ND	ND	ND
Mn	ND	ND	ND	ND	ND	ND	ND	ND
Fe	ND	ND	ND	ND	ND	ND	ND	ND
Ni	ND	ND	ND	ND	ND	ND	ND	ND
Cu	ND	ND	ND	ND	ND	ND	ND	ND
Zn	ND	ND	ND	ND	ND	ND	ND	ND
Cd	ND	ND	ND	ND	ND	ND	ND	ND
Hg	ND	ND	ND	ND	ND	ND	ND	ND
Pb	0.22	ND	0.01	ND	0.15	0.67	ND	ND
As	0.86	ND	ND	ND	ND	ND	ND	ND

Values are in mg/L; ND: *Not detected*

For magnesium, like for sodium, station A exhibited the lowest Mg concentration of 0.33 mg/L and the highest one of 29.93 mg/L observed in bottom waters (Table 4). Lead was exclusively detected in surface waters from stations A and B with respective values of 0.22 mg/L and 0.01 mg/L (Table 4). At station C, the bottom waters were more contaminated with Pb that exhibited a concentration value of 0.67 mg/L against a value of 0.15 mg/L in the surface ones (Table 4). Pb was not detected in waters from station D. In Biétri Bay, and for arsenic, apart from station A that exhibited a value of 0.86 mg/L, As was not detected elsewhere (Table 4).

IV. Discussion

In Biétri Bay, pH values ranged between 7.24 and 7.69. These values are in the range of 6.5 to 8.5 considered to be safe for marine biota (WHO, 2011; Tuo et al, 2012, Tuo et al., 2020a). Regarding pH values observed in the present study (Table 2, Figure 3a), the analyzed waters were of "Acceptable Class" according the Water Quality Classification proposed by Sargaonkar and Deshpande (2002) and in the range of values reported for the same Ebrié Lagoon waters (Tuo et al., 2012; Tuo et al., 2020a). In coastal aquatic systems, pH below 4.5 and above 9.5 are usually lethal to aquatic organisms, and even less extreme pH values can effect reproduction and other biological processes (Tuo et al., 2020b). Temperature values observed in waters from Biétri Bay were less than 25°C in both surface and bottom waters apart from the bottom waters in station B that exhibited a value of 28.77 °C. This high temperature could have some hazardous effects on the biota in general, and particularly on benthic organisms in Biétri Bay. As example, higher temperature can accelerate the organic matter'smineralization previously accumulated in sediments, leading to a release of pollutants such as nutrients, trace metals, etc. Such situation can induce a disturbance in the affected ecosystem with the risk of proliferation in resistant species and the disappearance of the most sensitive organisms. Temperature values observed after the bay's area reduction were slightly lower than other reported values (Tuo et al., (2012). Highest levels in salinity and conductivity were observed in waters during the sampling periodin Biétri Bay. Tuo et al. (2012) reported respective ranges of 13.4-14.4 and 23.67-25.44 mS/Cm for salinity and Electric conductivity respectively. These values were lower then those observed at present (Table 2). The saline status of waters from Biétri Bay is linked to its communication with the Atlantic Ocean through the Vridi Channel drilled for Abidjan Port exploitation. Indeed, the Ebrié Lagoon waters are diluted with waters of marine origin during the dry seasons like the sampling one (Yao et al., 2009; Inza et al, 2015; Tuo et al., 2020a). Thus, the high values of Electric Conductivity is due to the presence of saline waters of marine origin in the studied area in relation with a long residence time that is linked to the reduction in waters' renewal rate.

Regarding phosphorus, phytoplankton and most plants assimilate orthophosphate, although some can directly access dissolved organic phosphorus using phosphatase enzymes. However, particular organic forms of phosphorus and nitrogen are slowly converted back into soluble forms. Phosphorus is a vital nutrient in sunlight conversion into usable energy and is therefore essential to cellular growth and reproduction. Unfortunately, in high amounts in surface waters, it can be responsible of excessive algae growth, leading to the degradation of water quality. Dissolved inorganic nitrogen (DIN) was mainly found as nitrates because of its stable status, compared to NH_4^+ and NO_2^-, finally oxidized in nitrate in oxygenated waters (Table 3, Figure 3). According to the data, dissolved inorganic species of nitrogen observed in waters from Biétri Bay were in the following descending rank: $NO_3^- > NH_4^+ > NO_2^-$ (Table 3). Tuo et al., (2020b) reported the same rank between the dissolved inorganic nitrogen species in waters from Fresco Lagoon. The lowest observed concentrations of nitrite is due to the fact that NO_2^- is an intermediate ion between ammonium and nitrate in both nitrification and denitrification process, in relation with the available dissolved oxygen in the water column. Nitrite concentrations observed in Bietri Bay were less than 3.0 mg/L, so safe for marine organisms (WHO, 2011). Highest ammonium and orthophosphates concentrations observed in bottom waters from Station B seems to be link to the slaughterhouse's activities of Port-Bouët (Figures 1 and 3). Indeed, organic matters from this activity and accumulated in bottom waters, are progressively mineralized in inorganic components, mainly in ammonium and orthophosphates that are released in the surrounding waters. According to the Classification of Water Quality proposed by Sargaonkar and Deshpande (2002), nitrate concentrations were less than 20 mg/L and the waters could be considered to be of 〝Excellent Quality〞 (Table 3, Figure 3). Station C generally recorded the lowest vertical gradient in nutrients due to its low depth that was favorable for surface and bottom waters mixing (Figure 3). Before the reduction in Biétri Bay's area, Tuo et al., (2012) reported respective average values of 0.54 and 0.23 mg/L (for NH_4^+), 0.05 and 0.06 mg/L (for NO_2^-), 0.21 and 0.26 mg/L (PO_4^{3-}) in surface and bottom waters in Ebrié Lagoon (for the Long Dry Season that include April),so the same season than the present study. Thus, a decrease in nitrite concentrations was observed, while ammonium and orthophosphates concentrations tended to increase in Biétri Bay's waters after its volume reduction (Figures 1 and 3, Table 3).

The high concentrations in Na and Mg observed for the present study are due to the presence in Biétri Bay of waters of marine origin, particularly enriched in dissolved salts like Na, as confirmed with the high values of salinity and Electric conductivity (Tables 2 and 4, Figure 2). Sodium concentrations values largely exceeded the guideline value of 50 mg/L for chemicals used in water treatment reported by the World Health

Organization (WHO, 2011). Excessive sodium concentrations in waters can threaten the studied area's ecology with long-term exposure of marine organisms. Lead and arsenic are known to be toxic for all forms of life even at low concentrations (Kontoghiorghes et al., 2004; Bronstein et al., 2011; Crisponi et al., 2013). Surface waters from Stations A and C exhibited lead concentrations values 22 and 15 times higher than the WHO (2011) guideline value of 0.01 mg/L, so found contaminated (Table 4). Lead concentrations observed in waters from Biétri Bay were in the range (0.075-0.67 mg/L) observed in waters collected in Ebrié Lagoon around Abidjan City (Tuo et al. (2012). The highest As value of 0.67 mg/L observed in bottom waters from Station C, closed to a great gutter have highlighted the fact that effluents from both domestic and industrial activities are potential sources of lead in Biétri Bay. The determined arsenic value in surface waters from Station A (0.86 mg/L) was 860 times higher than the recommended value of 0.001 mg/L (WHO, 2011), and largely higher than the reported value of 0.2 µg/L for waters collected along Abobo-Doumé Fish Market in the same Ebrié Lagoon (Tuo et al., 2020c). Waters from Station D were safe of metal contamination (Table 4).

V. Conclusion

pH, temperature, salinity, Electric conductivity (EC) were measured *in situ*, nutrients and trace metals concentrations were determined in both surface and bottom waters in Biétri Bay after its volume reduction for Abidjan Port extension. Waters were alkaline, less hot, more saline with high Electric conductivity, compared to the values recorded in the study area prior its surface reduction. Considering the nutrients contents reported before the reduction in Biétri Bay's area, the data of the present has shown an increase in nitrate and orthophosphates concentrations. For the twelve analyzed trace elements, there was a particular concern regarding lead and arsenic, due to their high concentrations observed in waters. These high concentrations observed for lead and arsenic have highlighted the key role of liquid effluents on water quality in Biétri Bay. Biétri Bay's volume reduction associated to continuous inputs of pollutants mainly nutrients, organic materials and trace elements can threaten its ecology equilibrium at long-term. Therefore, there is a need in effluents treatment before their introduction in lagoon water for a best management of the waters resources.

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