International Journal of Innovation and Applied Studies
ISSN 2028-9324 Vol. 31 No. 1 Nov. 2020, pp. 14-20

http://www.ijias.issr-journals.org/

Seasonal variations of physicochemical parameters and nutrients of a coastal tropical lagoon's waters: Aby lagoon (Côte d'Ivoire)

Sylvie Assemian-niango[1], Sévérine Estelle Konan[1], and Jean-marie Konan Kouakou[2]

[1]Center of Oceanological Research (C.O.R.), BP V 18 Abidjan, Côte d'Ivoire

[2]Central Laboratory of Agrochemistry and Ecotoxicology (C.L.A.E.), 04 BP 612 Abidjan, Côte d'Ivoire

ABSTRACT: In response to many anthropogenic pressures on Aby lagoon, the aim of this study is to determine, according to seasons, physicochemical characteristics and nutrients content of lagoon waters. To do this, from September 2007 to July 2009, during monthly sampling campaigns, physico-chemical parameters such as temperature, salinity, conductivity, pH and transparency of waters of lagoon were measured, in situ, at twenty (20) stations distributed along lagoon. Water samples were collected at these stations, at the depth of 0.2 m below the surface, to determine in laboratory levels of dissolved oxygen and nutrients such as orthophosphate, nitrite, nitrate and ammonium, using standard methods. Statistical treatments were performed using XLSTAT 7.5 software. Data processed, using Friedman test, show significant seasonal differences between physico-chemical parameters and nutrients of lagoon waters.

KEYWORDS: Rainy season, Dry season, Physicochemical characteristic, water samples, Tropical lagoon, Aby lagoon, Côte d'Ivoire.

1 INTRODUCTION

Estuaries and coastal areas are regions of high polulation density and intense human activities [1]. In addition, tropical estuaries are the most bio-geochemically active zones and are more easily affected by anthropogenic nutrient laoding than estuaries at higher latitudes [2], [3]. Aby lagoon, like tropical coastal lagoons, is subject to many anthropogenic pressures [4]. Indeed, in addition to big cities of Adiake, Étuoboué and Tiapoum and many villages that populate the banks of this lagoon, its watershed is the site of intense socio-economic activities and establishment of immense peasant plantations and agro-industrial complexes of coconut, rubber trees and oil palm trees. Therefore, this lagoon is the receptacle of domestic and industrial effluents and runoff from agricultural areas likely to pollute it. According to [5], nutrients enrichment lead to deterioration of water quality. In addition, Aby lagoon waters are used for all uses except consumption [6]. However, it shall be noted that the specific impacts of nutrients loads vary according to structure of individual ecosystems and other factors such as meteorological and hydrological conditions [7]. In order to preserve ecological quality of Aby lagoon, the aim of this present study was to determine, according to seasons, physico-chemical characteristics and nutrients content of this lagoon waters.

2 MATERIALS AND METHODS

2.1 STUDY AREA

Located at extreme south-east of Côte d'Ivoire, between longitudes 2 ° 50 ' W and 3 ° 21' W and latitudes 5 ° 04 ' N and 5 ° 22' N, Aby lagoon covers an area of 424 km^2 and has 3.8 meters in average depth (Fig. 1). In eastern part, it constitutes a natural border between Côte d'Ivoire and Ghana [4]. Aby lagoon contains three straits broad of 4.5 km, 2 km and 1.25 km. These straits allow subdivision into four parts with different hydrological regimes due to variable marine, fluvial and atmospheric influences

Corresponding Author: Sylvie Assemian-niango

from one part of lagoon system to another. These are, from North to South and from West to East, Aby north lagoon and Aby south lagoon, which constitute Aby part of lagoon complex, Tendo lagoon and Éhy lagoon [8], [4]. This lagoon also contains many islands. Six (6) of them (Assokomonobaha or, Balouate, Meha, Nyamouan, Eloamin and sacred island Bosson-Assoun) constitute the national park of Éhotilé islands [9]. Aby lagoon is fed by two main forest rivers, Bia at north and Tanoé at east. There are also several smaller rivers so important such as Éholié at north and Toudoum at Eplémlan. Lagoon is still connect with Atlantic Ocean through grau of Assinie Mafia. However, exchanges are reduced because of a set of channels that constitute barrier islands located in Aby South lagoon [10]. Aby lagoon is in Adiaké region whose climate is transitional equatorial type characterized by following seasonal division:

- Long dry season from December to March;
- Long rainy season from April to July;
- Short dry season from August to September and
- Short rainy season from October to November [11], [6].

Fig. 1. Aby lagoon system (Source: Oceanological Research Center Abidjan/ Côte d'Ivoire)

2.2 SAMPLING SITES

Samples were collected from twenty (20) stations distributed along Aby lagoon system (Fig. 2). Selection criteria of stations are on one hand representability of whole Aby lagoon system and on other hand zones close to big cities (Adiaké, Tiapoum), mouths of main rivers (Bia, Éholié and Tanoé) that feed lagoon, agro-industrial plantations and Aby lagoon system mouth in Atlantic ocean. The positions of sampling stations were accurately located by using GARMIN Geographical Positioning System (GPS) (Tab. 1).

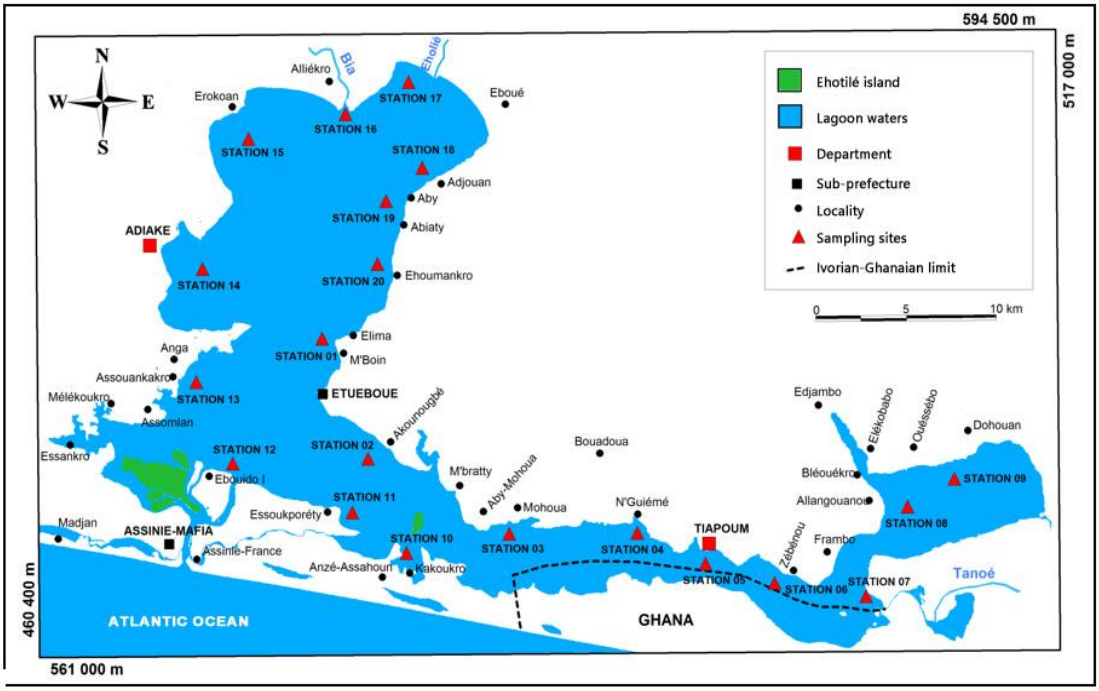

Fig. 2. Aby lagoon system and sampling sites (Source: Oceanological Research Center Abidjan/ Côte d'Ivoire)

Table 1. Geographical coordinates of sampling stations

Stations names	Stations numeros	Geographical Coordinates (UTM)		Stations names	Stations numeros	Geographical Coordinates (UTM)	
		X	Y			X	Y
Éléman-M'boin	1	476200	578100	Angboudjou	11	477800	568700
Akounougbé	2	478700	571600	Éboïndo I	12	471200	571400
Mowa	3	486500	567500	Assouankakro	13	469200	575800
N'guiémé	4	493600	567500	Adiaké	14	469600	581900
Tiapoum	5	497300	565600	Érokoan	15	472200	588900
Zébénou	6	501100	564600	Bia	16	477600	590200
Tanoé	7	506100	565300	Éholié	17	481100	591900
Allangouanou	8	508600	568800	Adjouan	18	482300	58800
Ouessébo	9	511200	570300	Aby-Abiaty	19	479800	585500
Kakoukro	10	480800	566500	Éhoumankro	20	479300	582100

2.3 SAMPLING

In situ measurements as well as monthly water sampling were made from September 2007 to July 2009. Water samples were collected using a Niskin bottle, at the depth of 0.20 m below the surface of lagoon. Table 2 presents analyzed parameters and methods of analysis. Statistical treatments were made from XLSTAT 7.5 software. Data were processed using Friedman test to compare parameters during seasons.

Table 2. Analyzed parameters and methods of analysis

Analyzed parameters	Methods of analysis and/or measuring appliances
Temperature (T), Salinity (S) Electrical conductivity (EC)	In situ with Multiparameter TURO T-611 (Turo technology, 1996)
pH	In situ with pH-meter HI/98/150 brand HANNA
Transparency (t)	In situ with Secchi Disc
Dissolved Oxygen (DO)	Winkler modified by Carritt and Carpenter (1966)
Phosphate (PO_4^{3-})	Colorimetric method (NF T 90 023EN ISO 6878 (2005))
Nitrite (NO_2^-)	Griess reaction NF T 90 013 EN 26777, 1993
Nitrate (NO_3^-)	Spectrophotometer HACH DR 2010 (EN 50082-1, 1997)
Ammonium (NH_4^+)	Method of blue of indophenol (NF T 90 015, 2000)

3 RESULTS

Table 3 presents means, extreme values (minimum, maximum) and coefficients of variation of analyzed parameters of lagoon watres during seasons. The results of Friedman test for comparison of K paired samples, from XLSTAT 7.5 software, are presented in table 4.

Table 3. Means, extreme values (Min, Max) and Coefficients of Variation (CV) of Physico-chemical parameters and nutrients during seasons

	Analyzed Parameters									
	T (°C)	S (‰)	EC (µs/cm)	pH	t (m)	DO (mg/L)	PO_4^{3-} (mg/L)	NO_2^- (mg/L)	NO_3^- (mg/L)	NH_4^+ (mg/L)
Long Dry Season (LDS)										
Means	30,73	1,65	3794,8	7,87	1,05	6,04	0,067	0,03	1,62	0,19
Min	29,25	0	88,35	6,4	0,5	4,91	0,01	0,01	0,3	0,03
Max	32,65	3,5	8181,07	8,9	1,9	7,78	0,107	0,055	3,8	0,44
CV	3,2	81	76,58	10,45	31,22	14	60,68	48,02	55,31	52,86
Long Rainy Season (LRS)										
Means	29,82	0,36	840,74	7,17	0,43	6	0,13	0,12	4,64	0,2
Min	27,1	0	50,47	5,44	0,15	3,7	0,07	0,03	1,7	0,05
Max	33,35	1,6	1974,67	8,47	0,75	6,91	0,20	0,40	9,2	0,37
CV	5,81	122,9	72,01	8,93	26,47	11,8	29,51	106,57	51,86	47,03
Short Dry Season (SDS)										
Means	27,72	0,46	621,68	7,12	1,23	5,74	0,09	0,02	0,13	0,052
Min	26,4	0	67,65	5,65	0,88	3,99	0,03	0,01	0,08	0,02
Max	28,73	4,75	1341,93	8,08	1,88	11,13	0,28	0,05	0,23	0,12
CV	2,44	227,5	76,56	8,02	26,6	32,07	74,37	41,54	34,76	54,63
Short Rainy Season (SRS)										
Means	29,32	0,17	674,67	7,17	0,95	4,26	0,069	0,021	0,55	0,092
Min	28,13	0	54,05	6,82	0,6	1,39	0,04	0,01	0	0,04
Max	29,95	0,68	1901	7,73	1,6	6,77	0,10	0,04	2,5	0,46
CV	1,62	119,22	90,11	3,3	29,44	31,09	26,43	44,41	128,6	107,03

Table 4. Matrix of pairs comparisons (difference and conclusion)

	Intra-seasonal variations		**Inter-seasonal variations**			
Parameters	Seasons		Seasons			
	LDS-SDS	LRS-SRS	LDS-LRS	LDS-SRS	LRS-SDS	SDS-SRS
T	52,0000*	10,000	17,000*	27,000*	35,000*	25,000*
S	29,500*	16,500*	22,000*	38,500*	7,500	9,000
CE	42,000*	6,000	32,000*	38,000*	10,000	4,000
pH	19,000*	9,000	14,000	23,000*	5,000	4,000
t	9,5000	32,500*	41,000*	8,500	50,500*	18,000*
OD	18,00*	34,000*	0,000	34,000*	18,000*	16,000
PO_4^{3-}	7,000	33,000*	37,000*	4,000	30,000*	3,000
NO_2^-	7,500	40,500*	28,000*	12,500	35,500*	5,000
NO_3^-	32,000*	42,000*	19,000*	23,000*	51,000*	9,000
NH_4^+	33,000*	30,000*	9,500	20,500*	42,500*	12,500

*Critical value for difference: 16,003; *: Significant values*

4 DISCUSSION

The temperature of lagoon waters are characteristic of tropical areas [12]. Aby lagoon waters are characterized by a lower thermal variation as indicated by low coefficients of variation observed (< 6%) during seasons [13]., [14], [15] in Ébrié, Fresco and Grand-Lahou lagoons, respectively, found the same result. This thermal stability of waters seems to be characteristic of Ivorian lagoons [16]. in lake Nokoué in Benin, [17] in Lomé lagoon system in Togo and [18] in hydrosytem Lake Togo- lagoon of Aného made also this finding. According to these authors, the thermal stability of waters is due to shallow depths of lagoon systems that favor good mixing waters. Minimum temperature in short dry season is due to upwelling phenomenon characterized by the rise of cold ocean waters. As for very high temperatures of waters in long dry season, they are the result of insolation, temperature of a surface water being closely related to variations of ambient temperature and seasonal variations [19].

Seasonal average values of lagoon waters salinity are less than 2 ‰. Aby lagoon is therefore less saline than Fresco, Grand-Lahou and Ébrié lagoons, whose average surface salinities are 15.69 ‰, 13.5 ‰ and 15 ‰, respectively [20], [15], [21]. Aby lagoon is also less saline than hydrosystem Lake Togo- lagoon of Aného [18]. These low salinities of this lagoon are due to its communication with ocean hampered by channels located at the mouth. Salinity in long dry season is however higher, due to oceanic water intrusions. The high values of coefficients of variation of salinity (> 80 %) show that Aby lagoon is an open environment. This environment is at the same time under influences of contributions of continental waters (fluvial and precipitations) and contributions of oceanic waters.

Waters of Aby lagoon are almost neutral. The high pH values of lagoon waters are recorded in long dry season. Like temperature, low coefficients of variation of pH (< 11%) indicate a small variation in pH of waters within different seasons. Temperature and pH of are uniform within each season but generally differ from one season to another. Lagoon waters are more conducive in long dry season [16]. in lake Nokoué in Benin also made this observation. In addition, pH, conductivity and transparency show seasonal fluctuations in relation to salinity. Thus, at periods of high salinity (consecutive to oceanic inflow), correspond waters of high conductivities, basic and transparent and at periods of low salinity (period of inflow of inland water), water of low conductivities, less transparent and weakly acidic. Like salinity, changes in pH, conductivity and transparency show, in general, significant differences during seasons.

With regard to dissolved oxygen level, high values in long dry season (6.04 mg / L) can be explain by mixing of waters as showed by [22] in Ébrié lagoon and [23] in Grand-Lahou lagoon. Indeed, quantities of dissolved oxygen also depend on exchanges with atmosphere, exchanges that are favored by agitation of waters, itself depending on the wind, the tide and the currents [24]. Dissolved oxygen levels recorded in this study are almost similar to those obtained by [25] in this lagoon in long rainy season and long dry season. However, they are higher than those obtained by [14] and [26] in Fresco lagoon (average: 5.16 mg / L) and Grand-Lahou (average: 3.29 mg / L) lagoon, respectively and lower than those obtained by [24] in Ebrié lagoon around Vitré Island (average: 6.73 mg / L). There is no significant difference between dissolved oxygen levels in long dry season and in long rainy season. It is the same between short dry season and short rainy season.

In rainy seasons, nutrient levels in lagoon waters are higher, compared to dry seasons [14]. and [23] in Fresco lagoon and Grand-Lahou lagoon respectively, also made this observation. Waters are therefore enriched with nutrients during rainy seasons. This enrichment is due to runoff from agricultural areas and urban areas. Indeed, forest rivers in flood, runoff from agricultural areas and urban areas due to rainfall are main sources of nutrients in Aby lagoon. With regard to agricultural areas, precipitation brings by runoff fertilizers spread on plantations towards lagoon waters. The floods of forest rivers also bring into lagoon, waters that have run off into areas mostly occupied by forests or by large areas of crops and bare soil. Moreover, according to [27], oceanic influence being weak in Aby lagoon, abundance of nutrients measured is mainly due to continental and atmospheric inputs and mineralization of organic matter in deep layers.

Except between short dry season and short rainy season, nutrients levels generally differ from one season to another. In addition, nutrients levels in lagoon waters during long rainy season differ significantly from those of other seasons [1]. in lagoons of tropical island of Hainan in China also found seasonal variations in nutrients. Nutrients content of waters in rainy seasons is different; it is the same with values of temperature, salinity, pH and electrical conductivity in dry seasons. With exception of transparency and temperature, physicochemical parameters and nutrients content in short dry season and in short rainy season are the same. At the opposite, physicochemical parameters and nutrients content in long dry season and in long rainy season are different except pH and ammonium ion content.

5 CONCLUSION

Aby lagoon is characterized by low salinity values. Waters are more saline, more conductive and more transparent in long dry season and highly oxygenated in long dry season and long rainy season. On the contrary, abundance of nutrients is recorded in long rainy season. Generally, there is a significant difference between physico-chemical parameters and nutrients content in lagoon waters from one season to another. Intra-seasonal and inter-seasonal variations in physicochemical parameters and nutrients are significant with exception of temperature and pH, which show a low intra-seasonal variation in rainy seasons. Climatic seasons therefore govern values of the physicochemical parameters and nutrients content. However, considering the semi-closed nature of Aby lagoon and over lagoon waters temperatures (suitable for algal development), nutrients inputs should be monitored. This will contribute to preserve the ecological quality of this immense natural heritage and will ensure long-term well-being of local populations.

ACKNOWLEDGEMENTS

We thank the **Center for Oceanological Research (COR)** Abidjan / Côte d'Ivoire, which funded the campaigns and which made it possible to do the analysis of our samples in its laboratories. We also thank **Doctors Sévérine Estelle KONAN** and **Jean-Marie Konan KOUAKOU** who contributed, respectively, to the writing of the manuscript and to the statistical processing of the data of the study.

REFERENCES

[1] R. H. Li, S. M. Liu, Y. W. Li, G. L. Zhang, J. L. Ren and J. Zhang, « Nutrient dynamics in tropical rivers, lagoon and coastal ecosystems of eastern Hainan island, South China Sea. Biogeosciences » 11, 481-506, 2014.

[2] C. M. Yule, L. Boyero and R. Marchant, « Effects of sediment pollutionon food webs in a tropical river (Borneo, indonesia)", Mar. Freshwater Res., 61, 204-213, 2010.

[3] J. Smith, M. A. Burford, A. T. Revill, R. R. Haese and J. Fortune, « Effect of nutrient loadingon biogeochemical processes in tropical tidal creeks", Biogeochemistry,.

[4] S. Assemian-Niango, A. M. Kouassi, K. S. Traoré, A. Dembélé Et J. Biemi, « Distribution des ions sulfate (SO42-) dans un écosystème tropical à forte influence continentale: Lagune Aby, Côte d'Ivoire", European Journal of Scientific Research, volume 124, N° 3, pp. 256-273, 2014.

[5] TH. A. Singh, N. S. Meetei and L. B. Meitei, « Seasonal variation of some physico-chemical charasteristics of thr major rivers in Imphal, Manipur: A comparative evaluation", Current World Environment, Vol. 8 (1), 93-102, 2013.

[6] S. G. Eblin, A. P. Sombo, G. Soro, N. Aka, O. Kambiré et N. Soro, « Hydrochimie des eaux de surface de la région d'Adiaké (sud-est côtier de la Côte d'Ivoire)", Journal of Applied Biosciences 75: 6259-6271, ISSN 1997-5902, 2014.

[7] Y. Yang, H. Zhenli L. Youjian J. P. Edwward, Y. Jinyang, C. Gouochao, J. S. Peter and A. P. Charles, « Temporal and spatial variations of nutrients in the Ten Mile Creek of South Florida, USA and effects on phytoplankton biomass", J. Environ. Monit., 10, 508-516, 2008.

[8] Y. N. N'goran, « Biologie, écologie et pêche de l'ethmalose; Ethmalosa Fimbriata (Bowdich, 1825) en lagune Aby (Côte d'Ivoire)", Thèse de Doctorat de l'Université de de Brétagne Occidentale. Spécialité: Océanologie Biologique, 227p., 1995.

[9] D. F. Malan, A. L. Aké, F. H. Tra Bi, D. Neuba, « Diversité floristique du parc national des îles Ehotilé (littoral est de la Côte d'Ivoire)", Bois et Forêt des Tropiques, N° 292 (2). Diversité biologique flore, Côte d'Ivoire, 2007.

[10] Y. J.-M. Koné, G. Abril, K. N. Kouadio, B. Delille & A. V. Borges, « Seasonal variability of carbon dioxide in the rivers and lagoons of Ivory Coast (West Africa)", Estuaries and Coasts, 32: 246-260, 2009.

[11] N. M. Seu-Anoï, « Structuration spatiale et saisonnière des peuplements phytoplanctoniques et variabilité des facteurs abiotiques dans trois complexes lagunaires de la Côte d'Ivoire (Aby, Ebrié, Grand-Lahou)", Thèse Unique Université Nangui Abrogoua, Côte d'Ivoire, 135 p., 2012.

[12] A. Traoré, G. Soro, E. K. Kouadio, B. S. Bamba, M. S. Olga, N. Soro and J. Biemi, « Évaluation des paramètres physiques, chimiques et batériologiques des eaux d'une lagune tropicale en période d'étiage: la lagune Aghien (Côte d'Ivoire)", International Journal of Biological and Chemical Sciences, Vol. 6, no 6, pp 7048-7058, 2012.

[13] A. M. Kouassi, A. S. Tidou, A. Kamenan, « Caractéristiques hydrochimiques et microbiologiques des eaux de la lagune Ebrié (Côte d'Ivoire) Partie I: Variabilité saisonnière des paramètres hydrocimiques", Agro. Afr. ISSN n) 1015-2288, XVII (2): 73-162, 2005.

[14] Y. Issola, A. M. Kouassi, B. K. Dongui et J. Biemi, « Caractéristiques physico-chimiques d'une lagune côtière tropicale: lagune de Fresco (Côte d'Ivoire) ». Afrique SCIENCE, Vol. 4, N°3 (2008), 1 septembre 2008.

[15] K. S. Konan, A. M. Kouassi, A. A. Adingra, B. K. Dongui, et D. Gnakri, ≪Variations saisonnières des paramètres abiotiques des eaux d'une lagune tropicale: la lagune de Grand-Lahou, Cote d'Ivoire≫, European Journal of Scientific research 21 N° 3, n° ISSN 1450-216X, 2008.

[16] D. Mama, « Méthodologie et Résultats du diagnostic de l'eutrophisation du lac Nokoué (Bénin)", Thèse Université de Limoges 157 p., 2010.

[17] M. Ayah, M. Gribos, L. Tampo, L. M. Bawa, H. Bril et G Djaneye-Boundjou, « Qualité et pollution des eaux d'un hydrosystème littoral: cas du système lagunaire de Lomé, Togo", European Scientific Journal, edition vol. 11, No. 15 ISSN: 1857-7881 (print) e- ISSN 1857-7461, 2015.

[18] K. Ouro-Sama, G. Tanouayi, H. D. Solitoke, T. E. E. Badassan, H. Ahoudi, A. Y. Nyametso & K. Ghandi, « Seasonal variation, quality and typology of water's abiotic parametrs of a tropical lagoon: The hydrosystem Lake Togo-Lagoon of Aného (South-East of Togo) » International Journal of innovation and Applied Studies, pp. 656-673, 2018.

[19] M. B. Lamizana-Diallo, S. Kenfac et J. Millogo-Rasolodimby, « Évaluation de la qualité physico-chimique de l'eau d'un cours d'eau temporaire du Burkina Faso- le cas du Massili dans le Kadiogo", Sud Sciences et Technologie, ISSn 0796-5419, 6 p., 2008.

[20] Y. Issola, « Étude des caractéristiques climatiques, hydrochimiques et de la pollution en métaux lourds d'une lagune tropicale: la lagune de Fresco (Côte d'Ivoire)", Thèse de Doctorat unique, Université de Cocody, 177 pp., 2010.

[21] A.M. Kouassi, « Hydrochimie et qualité des eaux des lagunes Ebrié et Grand-Lahou de Côte d'Ivoire", Thèse de Doctorat, Université de Cocody, Abidjan, 167 p., 2005.

[22] D. Guiral, « L'instabilité physique, facteurs d'organisation et de structuration d'un écosystème tropical saumâtre peu profond, la lagune Ebrié", Vie et Milieu 42 (2): 73 – 92., 1992.

[23] K. S. Konan, "Étude de l'hydrochimie et de la qualité des eaux de la lagune de Grand-Lahou (Côte d'Ivoire)", Thèse Université Abobo-Adjamé, Côte d'Ivoire, 189 p., 2010.

[24] B. S. Bamba, S. Ouffoué, M. C. Blé., S. B. Metongo et S. Bakayoko, « État de l'envitonnement lagunaire de l'île Vitré (Grand-Bassam, Côte d'Ivoire): aspects physiques, chimiques et Biologiques », Rev. Ivoir. Sci. Technol., 12 (2008) 77 – 92 ISSN 1813-3290, 2008.

[25] O. Kambiré, A. A. Adingra, S. G. Eblin, N. Aka, A. C. Kakou et R. Koffi-Nevry, « Caractérisation des eaux d'une lagune estuarienne de la Côte d'Ivoire: Lagune Aby", Larhyss Journal, ISSN 1112-3680, pp.95-110, 2014.

[26] K. S. Konan, A. M. Kouassi, A. A. Adingra et D. Gnakri, "Spatial and temporal variation of fecal contamination indicators in Grand-Lahou lagoon, Côte d'Ivoire" Journal of Applied Biosciences 23: 1422-1435. ISSN 1997-5902, 2009.

[27] B. S. Metongo, « Production primaire d'une lagune tropicale à forte influence continentale: la lagune Aby (Côte d'Ivoire) » Doc. Sci. Cent. Rech. Océanogr. Abidjan. Vol. XVII, n° unique, 1-27, 1989.