Journal Homepage : -www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

ISSN NO. 2320-5407

Article DOI :10.21474/IJAR01/15755
DOI URL : http://dx.doi.org/10.21474/IJAR01/15755

RESEARCH ARTICLE

EVALUATION OF THE PHYSICAL AND CHEMICAL QUALITY IN WATERS OF THE IVORY COASTAL ZONE (Toukouzou Hozalem-Assinie)

Laure Emma Oura[1,5], Meledje Djedjess Essoh Jules-César[2], Horo Koné [3], Vanh Eric-Simon Zran[4], Kouassi Benjamin Yao[1] and Fofana Bakary[5]

1. Laboratoire des Procédés Industriels de Synthèse de l'Environnement et des Energies nouvelles (LAPISEN) de l'Institut National Polytechnique Félix Houphouët Boigny de Yamoussoukro, BP 1093 Yamoussoukro.
2. Laboratoire des Sciences Physiques, Fondamentales et appliquées, Ecole Normale Supérieure d'Abidjan, 08 BP 10 Abidjan 08 Côte d'Ivoire.
3. Department of Science and Technology, Université Alassane Ouattara de Bouaké, BP V18 Bouaké 01, Côte d'Ivoire.
4. Laboratoire de Constitution et réaction de la matière (LCRM), Université Félix Houphouet Boigny, 22 BP 582 Abidjan, Cote d'Ivoire.
5. Centre d'analyses et de recherche de la PETROCI (DCAR) Côte d'Ivoire. Immeuble les Hevéas-14 Bd Carde, BP V 194 Abidjan Cote d'Ivoire.

Manuscript Info

Manuscript History
Received: 28 September 2022
Final Accepted: 30 October 2022
Published: November 2022

Key words: -
Evaluation, drinking water, Pollution, ivory Coastal

Abstract

Water pollution remains an issue that concerns the whole world. That of the coastline is mentioned but remains less mediatized compared to that of fresh water for consumption. Therefore, in view of the issue of availability of drinking water resources, this study was initiated with a view to resorting to the evaluation of coastal waters in case of need. After characterization, it appears that the waters of the coast are loaded with salts. They have an average content of sulfate ions ranging from 400 to 1000 mg/L and a high biochemical oxygen demand ranging from 100 to 700 mg/L. On the whole, the waters of the Ivorian coast are polluted with organic loads for possible uses. But they cannot be consumed without prior treatment.

Corresponding Author : Laure Emma Oura
Address **:** Laboratoire des Procédés Industriels de Synthèse de l'Environnement et des Energies nouvelles (LAPISEN) de l'Institut National Polytechnique Félix Houphouët Boigny de Yamoussoukro, BP 1093 Yamoussoukro.

Introduction: -

The Ivorian coastline receives water from the north of the country. Various activities take place on the different waterways. Among these activities, gold panning is the most widespread. For gold extraction, gold miners use heavy metals such as lead, mercury and many others. However, these metals, which could accumulate in the coastal area by simple drainage, attract the attention of some researchers, even if the coastal populations are little interested in the consequences of the increase of these pollutants. To this effect, Kouakou et al (2014) reported a continuous and accelerated degradation of coastal aquatic ecosystems. They believe that this acceleration is related to the growth of anthropogenic activities that are the source of discharges of organic and inorganic pollutants that contribute to the pollution of coastal hydrosystems (Chouti et al., 2018); (Keumean et al., 2020). To date, developments are proposed by the government to limit ecosystem degradation even if their impact remains low visibility in the face of increasing pollutant discharges. The visibility of this pollution could be better appreciated at the level of bays, lagoons near Abidjan and all Ivorian coastal waters. In addition, several consequences arise from these environmental problems. Among these consequences, there is the contamination of sediments that do not leave indifferent the organisms that live there (Dong et al., 2015). Some petroleum products from oil platforms installed on the Atlantic coast of the Ivory Coast could impact both the sediments and the water quality of the coastline (Adeniji et al., 2019). Thus, due to their persistence and carcinogenicity, they could affect public health (Edjere et al., 2020). Previous studies have reported water quality degradation and sediment contamination in the Ebrié Lagoon (Rodrigue et al., 2016) ;(Toure et al., 2018); (Naga et al., 2018) ;(Yao et al., 2019); (Coulibaly et al., 2019); (Kouamenan et al., 2019) ;(Kouame et al., 2020); (Keumean et al., 2020); (Kouakou et al., 2014); (Kouassi et al., 2015); (Koffi et al., 2019). However, no researcher has raised the possibility of treating seawater for consumption despite its immensity. However, today, faced with the growth and persistence of certain activities on the coast, a concern arises. This concern raises questions about the current quality of coastal water that could be a source of food in the face of a scarcity of drinking water and the increase in global warming. Moreover, Libya already consumes sea water, why not other countries and in particular the Ivory Coast? Also, the consumption of organisms as a source of protein for many people living along the coast are concerns that have prompted this study in order to better understand the dangers that we could face in the future.

Materials and Methods:

Sampling sites

The selected study area is located along the coastline which is 204 km long from Toukouzou Hozalem to Assinie. It extends between latitude 5°15’0’’N - 5°00’0’’N and longitude 4°35’0’’ W - 3°20’0’’ W (Figure 1). The coastline is exposed to various anthropogenic (intensive fishing, industrial activities, destruction of mangroves, galloping demography and overexploitation of aquatic resources) and especially natural (beach erosion, sea level rise, storm surges). There are many threats to the coastline caused by human activity. These include pollution caused by urbanisation, overpopulation and the industrialisation of the coasts. It also includes chemical, organic, microbial, hydrocarbon and air pollution. The best-known sources of organic pollution are industrial discharges and various domestic wastes. The most important sources of oil pollution are usually the deballasting of tankers or cargo handling operations. There is also pollution caused by the exploration and exploitation of crude oil off the coast of Côte d’Ivoire (tar balls are found on the beaches). In this study, 12 sampling sites were selected and numbered as follows: Toukouzou (TKZ), Addah (ADA), Adjué (ADJU), Jacqueville (JAC), Adjouffou (ADJ), Bassam-Modeste Plage (BMP), Bassam-Modeste Lagune (BML), Azurety (AZT), Assinie-Plage (AP), Assinie-Lagune (AL), Assinie Canal Droite (ACD), Assinie Canal Gauche (ACG). In the area from Jacqueville to Toukouzou, the water depth of the lagoon varies between 30–40 m; in the Assinie area it varies between 15–20 m. All the towns on the coast have a bathymetry of 0 m.

Sampling

Sampling activities were carried out in six campaigns over four seasons (GSS: long dry season from January to March, GSP: long rainy season from April to June, PSS: short dry season from July to September, PSP: short rainy season from October to December), for a total of 72 samples. These sediment samples were collected from the surface to the bottom (0-15 cm) from November 2017 to February 2019, using the Van Veen sampler and placed in glass bottles previously washed and then rinsed with deionised water. All samples were stored in refrigerators at 4°C until analysis.

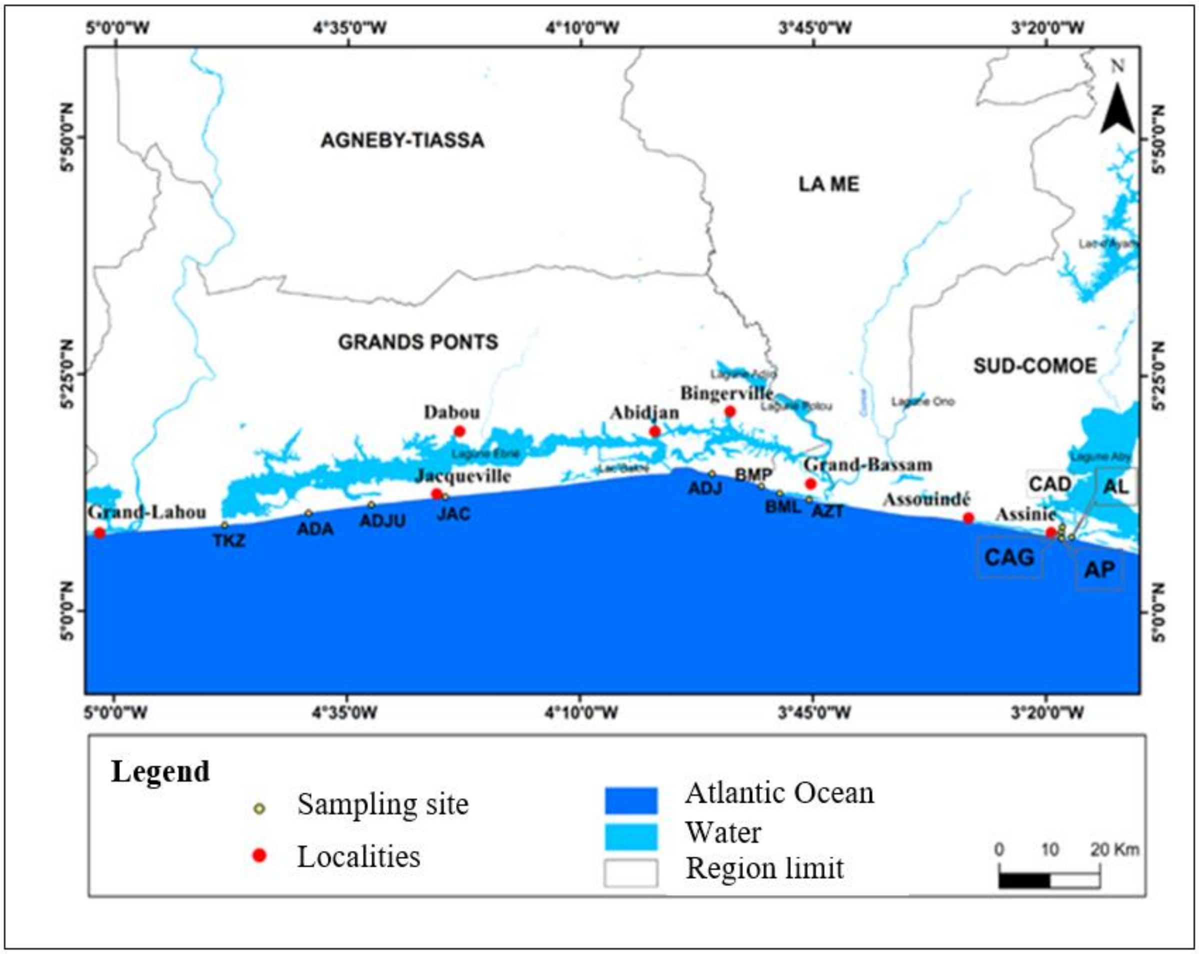


Figure 1. Location map of the coastal zone (Toukouzou Hozalem -Assinie)

Physical parameters

The concentrations of the different physical and chemical parameters were determined using the essential equipement summarized in Table 1.

Temperature

Water temperature is an important ecological factor for aqueous environments. It is linked to seasonal and daily variations in ambient temperature on the one hand, and to discharges from human activities (cooling water) on the other. Its disturbance can influence aquatic life (thermal pollution). It plays an important role in bacterial processes such as nitrification and denitrification (Fouzi et al., 2020).

Hydrogen potential (pH)

The pH plays a very important role in the development of aquatic life. It influences the behavior of certain elements such as metals, which it can decrease or increase the dissolution and therefore the toxicity by making them bioavailable. Generally, the pH values of natural waters are between 6 and 8.5 (Frisbie et al., 2012).

Electrical Conductivity (EC)

Electrical Conductivity indicates the level of dissolved salts present in a water and therefore its conductivity. It is used as an indicator of pollution in environmental studies, to show significant inputs of salts of natural and/or anthropogenic origin (desalination plant discharges and industrial discharges).

Total Dissolved Solids (TDS)

Total Dissolved Solids are frequently used as a water quality parameter, especially in coastal areas. This parameter is one of the indicators of salinity level, which makes them very useful to study seawater intrusion (Rusydi, 2018). The desirable limit for TDS is between 500 mg/L and 1000 mg/L (Frisbie et al., 2012).

Salinity

Salinity is a parameter that conditions the distribution range of living species in an environment according to their preferences. If salinity varies, the survival of organisms will depend on their tolerance. Like temperature, salinity is a critical abiotic factor in fish physiology (Togue et al., 2017).

Dissolved Oxygen (DO)

Dissolved oxygen comes primarily from the atmosphere and from the photosynthetic activity of algae and aquatic plants. It is very important in that it conditions the state of several mineral salts, the degradation of organic matter, and the life of aquatic animals (Ciwanine et al., 2020). Dissolved oxygen concentration levels below 5 mg/L have a negative effect on aquatic life (Fouzi et al., 2020; Frisbie et al., 2012). Dissolved oxygen is an important parameter to consider, as it provides information about the condition of the water and promotes the growth of microorganisms that degrade organic matter.

Chemical parameters

Nitrogen (N)

Nitrogen occurs naturally in the environment (air, water and soil). It plays a principal role in many biological processes, thanks to its cycle that allows its assimilation by primary producers and its regeneration after degradation by heterotrophic bacteria. In the aquatic environment, nitrogen is present in three forms: gaseous, organic and mineral (Benkaddour et al., 2018).

Nitrates (NO_3^-)

Nitrates represent the final oxidized form of nitrogen after the nitration step corresponding to the conversion of nitrite (NO_2^-) to nitrate (NO_3^-) (Benkaddour et al., 2018). Nitrates are present in water through leaching of nitrogen products in the soil, decomposition of organic matter or synthetic or natural fertilizers (Sonawane, 2019). Nitrate concentration is used as an indication of the level of micronutrients in water bodies and the ability to support plant growth. High nitrate concentration (≥ 50 mg/L) supports phytoplankton growth (Benkaddour et al., 2018). Nitrates become harmful to humans when they convert to methemoglobin according to the different equations (Okunola et al., 2008):

$$NO_3^- + 2e^- + H^+ \rightarrow NO_2^- + H_2O \qquad (1)$$

The nitrites obtained are acidified to give nitrous acid (Equation 2)

$$NO_2^- + H^+ \rightarrow HNO_2 \qquad (2)$$

Nitrous acid is in turn transformed into nitric oxide (Equation 3)

$$2HNO_2 \rightarrow N_2O_3 + H_2O \qquad (3)$$

Nitric oxides give nitrogen dioxide and monoxide (Equation 4)

$$N_2O_3 \rightarrow NO + NO_2 \qquad (4)$$

Then, nitric oxides will lead to N-nitro compounds such as nitrosonium which evolves into nitroso thiol compounds and nitrosamines (Ameur et al., 2014) according to the following equations 5, 6 and 7 :

$$N_2O_3 \rightarrow NO^+ + NO_2^- \qquad (5)$$

$$NO^+RSH \rightarrow RSNO + H^+ \qquad (6)$$

$$NO^+ + RR'NH \rightarrow RR'NNO + H^+ \qquad (7)$$

Finally, we end up with the formation of methemoglobin (Ameur et al., 2014) (Equation 8)

$$NO + Hb^{2+} + O_2 \rightarrow NO_3^- + Hb^{3+} \qquad (8)$$

Nitrite (NO_2^-)

Nitrites are the intermediate form between ammonium and nitrates, resulting from nitrification processes. Their presence in the aquatic environment is the cause of an oxygenation imbalance of the bacterial flora. The normal level of nitrite is set at 0.1 mg/L (OMS, 2012).

Ammonium (NH_4^+)

Ammonia nitrogen is one of the links in the complex nitrogen cycle in its primitive state. Ammonia is a water-soluble gas. Therefore, it is a good indicator of stream pollution by organic discharges from agricultural, domestic (human discharges), or industrial sources (Mkadmi et al., 2018). The limit value for ammonium is 0.5 mg/L (OMS, 2012).

Orthophosphate (PO_4^{3-})

Phosphorus is a vital nutrient for all living things, but the introduction of excess phosphorus in the form of phosphates into the aquatic environment can cause eutrophication (Togue et al., 2017). Phosphates returned to the environment mainly come from industrial, agricultural (fertilizer), excreta, and other sources.

Sulfates (SO_4^{2-})

Sulfates (SO_4^{2-}**)** also result from the activity of certain bacteria (chlorothiobacteria, rhodothiobacteria, etc.). This activity can oxidize toxic hydrogen sulfide (H_2S) to sulfate (Benkaddour et al., 2019). This is one of the main anions present in natural waters. It is contributed by industrial and domestic discharges and has the effect of decreasing the pH of the water and increasing the bacterial load, i.e. sulfate-reducing bacteria (Benkaddour et al., 2019). The threshold value set is 250 mg/L (OMS, 2012).

Biochemical Oxygen Demand (BOD_5)

The BOD_5 measures the quantity of oxygen necessary to oxidize the organic matter by biological way (bacteria). It is expressed in mg of oxygen /L. BOD_5 is a measure of the contamination of water by organic matter. BOD5 is the amount of dissolved oxygen required for the biochemical decomposition of organic compounds and the oxidation of some inorganic matter. This could be an indication of organic pollution due to the waste load. Effluent with high BOD_5 content can deplete oxygen in receiving waters, causing fish kills and changes in the ecosystem (Aissaoui et al., 2017).

Table 1:- Essential material used.

Equipment	Parameters	Standard
Portable multi-parameter mobile type pH/Cond 340i SET B	T (°C)	AFNOR NF T90-008
	pH	AFNOR NF ISO 10523
	EC	AFNOR NF EN 27888
	TDS	AFNOR NF T90-014
	Salinity	
	Dissolved Oxygen	AFNOR NF EN 25813
Spectrophotometer DR 2800	Nitrates (NO_3^-)	AFNOR ISO 7890-3
	Nitrites (NO_2^-)	AFNOR ISO 7890-3
	Ammonium (NH_4^+)	AFNOR ISO 6778
	Orthophosphates (PO_4^{3-})	AFNOR NF T90-023
	Total Phosphore (P)	AFNOR ISO 6878
	Total Azote (N)	AFNOR (T90-040)
	Biochemical Oxygen Demand (BOD_5)	AFNOR NF EN 1899
	Sulfates (SO_4^{2-})	AFNOR (T90-040)

Results and Discussion:

Physical Characteristics

The physical properties of the nearshore water collected from the 12 stations are recorded in Table 2. Recorded temperatures ranged from 26.52 °C (ADJ) to 30.39 °C (BML) with an average of 28.23 ± 1.19°C. At all 12 stations, there was a small change in pH ranging from 6.88 (ACD) to 7.74 (ADDA) with an average of (7.44 ± 0.32). The analysis of table 2 shows that the waters of the Ivorian coast are almost neutral and relatively cold. The pH and temperature values are comparable to those encountered in most of the waters of the coastal lagoon of Benin Chouti et al. (2017) subjected to anthropogenic stress and also to those found by Kouame et al. (2020) at the Ebrié lagoon. These authors obtained pH values ranging from 6.45 to 7.89 and temperatures between 25 and 31 °C. The pH of the coastal water is similarly comparable to those obtained by Chouti et al. (2017), which range from 7.2 to 7.53. These waters correspond to the guideline set by the World Health Organization (WHO) for surface waters. This allows us to conclude that the values obtained are within the tolerable range (WHO, 2020). Dissolved oxygen levels vary from 5.93 mg/L (ACG) to 7.46 mg/L (AZT) with an average of 6.56 ± 0.52 mg/L. With regard to the different dissolved oxygen values, the water of the coastline constitutes a less favorable environment for fish and aquatic life. Indeed, Koffi et al. (2019) mention that an environment conducive to aquatic life must have a dissolved oxygen concentration between 4 and 5 mg/L while it is 6 mg/L on average for human consumption. Overall the dissolved oxygen values all meet the WHO standard, (2020) which recommends values between 5 and 14 mg/L. The results also show that these waters have high values of electrical conductivity, TDS and salinity. These waters contain high levels of salts. Since the values obtained are higher than those set by the WHO (between 200 and 1,500 µS/cm for electrical conductivity and between 500 and 1,000 mg/L, for dissolved salt levels), the coastal water is not suitable for human consumption, as it attests to a high mineralization (Chouti et al.,2017). The mineralization of the waters of the Ivorian coast would be mainly due to saline intrusion of seawater. The high salinity values obtained by the present study are in agreement with those of Adandedjan et al. (2012) stipulating that the salinity of the water on the coastal lagoon is high with an average of 5.28 mg/L. Furthermore, the coastal waters, particularly those of Abidjan, receive the city's wastewater from the various communes. This wastewater imposes its pH on the coastal waters, especially in the Ebrié lagoon. For all the parameters studied, the results show a more or less small variation from one station to another.

Table 2: Physical properties of the water of the Ivorian coastline.

Sites	T (°C)	pH	Dissolved Oxygen (mg/L)	EC (mS/cm)	Salinity (‰)	TDS (g/L)
TKZ	27.50	7.72	6.58	50.64	33.14	25.36
ADDA	27.29	7.74	6.98	51.46	33.73	25.72
ADJU	26.52	7.72	6.87	52.03	34.18	26.02
JAC	28.22	7.71	6.67	48.85	31.99	24.51
ADJ	26.52	7.74	6.61	50.87	33.70	25.41
BML	30.39	7.01	6.13	20.69	11.95	23.56
BMP	28.41	7.57	7.14	49.43	32.61	24.72
AZT	27.22	7.57	7.46	51.89	33.65	25.97
ACD	29.46	6.88	5.94	10.14	21.97	5.69
ACG	29.33	6.99	5.93	10.39	6.09	23.27
AL	28.88	7.23	6.18	18.77	12.17	19.05
AP	28.78	7.37	6.90	37.74	24.22	18.87
Mean ± Standard Deviation	(28.23 ± 1.19)	(7.44 ± 0.32)	(6.56 ± 0.52)	(37.74 ± 17.45)	(24. 46 ± 11.82)	(24.14 ± 2.52)

Toukouzou (TKZ), Addah (ADDA), Adjué (ADJU), Jacqueville (JAC), Adjouffou (ADJ), Bassam-Modeste Plage (BMP), Bassam-Modeste Lagune (BML), Azurety (AZT), Assinie-Plage (AP), Assinie-Lagune (AL), Assinie Canal Droite (ACD), Assinie Canal Gauche (ACG).

Chemical characteristics

Table 3 presents the values of the chemical parameters of the water (N, NO_2^-, NO_3^-, NH_4^+, P, PO_4^{3-}, $SO_4^{2-}$and BOD). Sulfate ions are in very high concentrations in the different localities (Table XII). The concentrations of $SO4^{2-}$ are high compared to the regulation of (OMS, 2012). This would result from the increase in bacterial load due to industrial and domestic discharges in large quantities in these waters (Frisbie et al., 2012). Nitrate ion concentrations range from 0.560 to 5.390 mg/L and nitrite ion concentrations range from 0.005 to 0.200 mg/L and are all below the OMS predicted value. The low concentrations of nitrate and nitrite ions are thought to be related to the weak nitrification process between ammonium and nitrate on the one hand, and low decomposition of organic matter and low use of nitrogen products and synthetic fertilizers in the soil on the other (Sonawane, 2019). Indeed, nitrates are the result of ammonium ions (Ameur et al., 2014). This indicates that the waters are not at risk of nitrate pollution. Phosphate values range from 0.100 mg/l (BMP) to 0.420 mg/l (BML) with an average of (0.25 ± 0.10) mg/L. In general, phosphate values encountered in nearshore waters are very low in phosphate and are all below the OMS threshold value (≤ 6.7) (OMS, 2012). Excess nutrient input as well as eutrophication would be negligible. Thus, there would be no risk of pollution related to agricultural activities. Most of the sampling sites show a net pollution with respect to BOD_5. Mean BOD_5 values range from 148.33 mg/L (ACD) to 764.17 mg/L (TKZ). The increase in BOD_5 levels in coastal waters can be explained by the introduction of conditions for the degradation of organic matter by microorganisms whose activity increases with the decrease in flow velocity and with the warming of waters Togue et al. (2017).

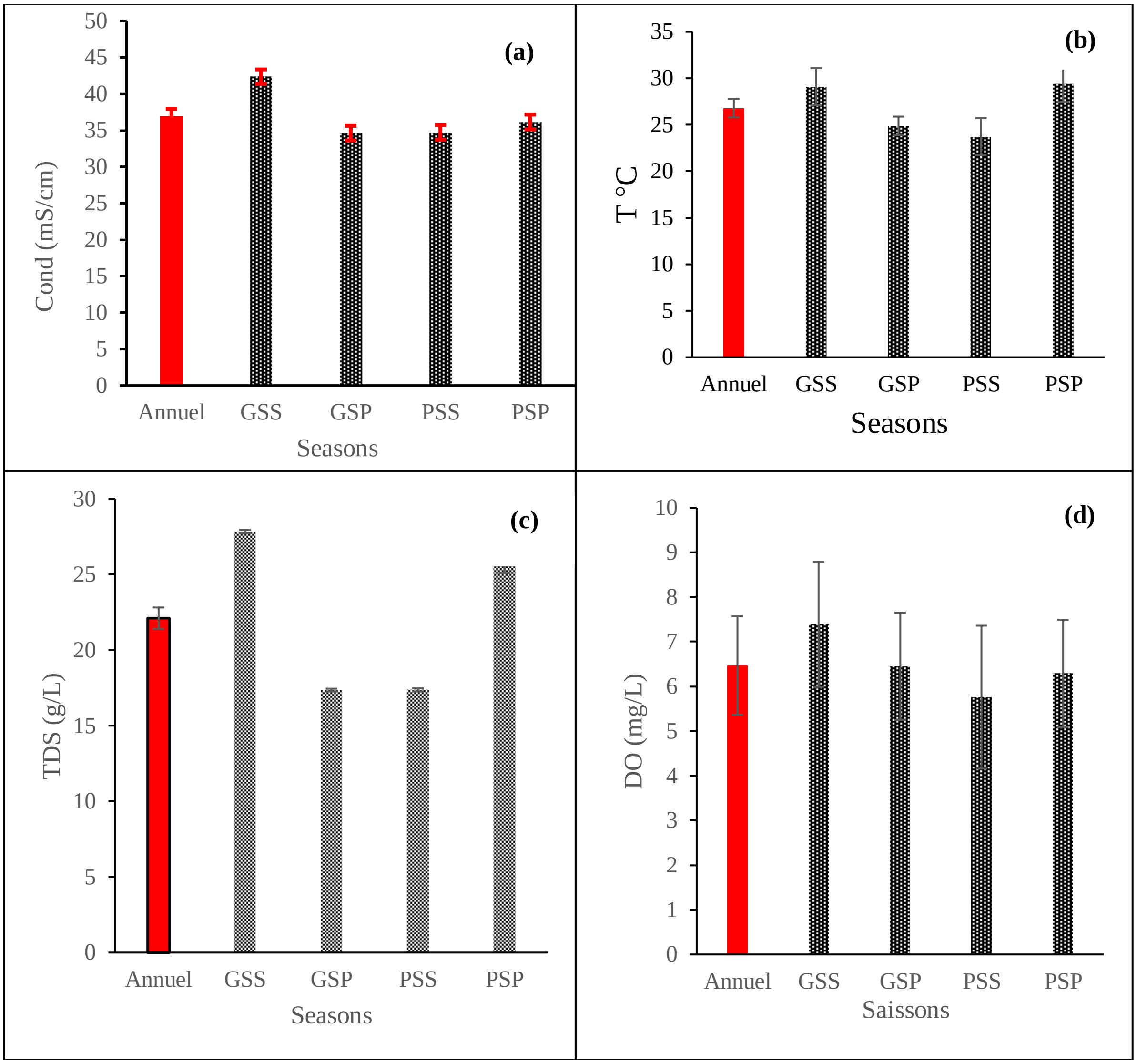
Table 3:- Chemical characteristics of the water of the Ivorian coastline.

Sites	N (mg/L)	NO_2^- (mg/L))	NO_3^- (mg/L)	NH_4^+ (mg/L)	P (mg/L)	PO_4^{3-} (mg/L)	SO_4^{2-} (mg/L)	BOD_5 (mg/L)
TKZ	20.170	0.010	2.690	0.120	5.440	0.250	895.710	764.170
ADDA	18.680	0.020	2.830	0.110	3.540	0.270	915.560	671.830
ADJU	14.830	0.010	2.690	0.160	4.900	0.290	919.120	675.000
JACQ	23.070	0.005	3.050	0.110	11.350	0.140	911.950	501.600
ADJ	41.830	0.020	2.280	0.120	21.470	0.140	858.380	535.870
BML	14.830	0.010	3.800	0.150	9.670	0.420	709.960	456.330
BMP	23.670	0.010	3.000	0.100	6.630	0.100	835.690	689.670
AZT	20.120	0.020	0.560	0.170	14.710	0.240	852.080	528.570
ACD	9.170	0.020	4.560	0.150	9.080	0.320	419.280	148.330
ACG	9.570	0.200	3.990	0.130	9.530	0.400	436.730	165.670
AL	10.170	0.020	5.390	0.140	11.280	0.250	630.280	244.000
AP	19.330	0.010	4.140	0.100	7.130	0.160	823.420	747.830
Mean ± Standard Deviation	(18.780 ± 8.840)	(0.030 ± 0.050)	(3.250 ± 1.240)	(0.130 ± 0.020)	(9.560 ± 4.900)	(0.250 ± 0.100)	(767.350 ± 180.460)	(510.739 ± 219.698)

Seasonal variation of physical parameters

Parameters such as conductivity, temperature, TDS, pH and dissolved oxygen were chosen to evaluate the impact of rainfall on chemical parameters. Statistical analysis shows that the concentrations of the different physical parameters vary with different seasons (Figure 2). The seasonal variation of the different parameters according to the seasons is not significant ($P > 0.05$). Conductivity and temperature are significant during the long dry season. The importance of temperature during this season (Figure 2) could be related to the very high solar radiation during the long dry season. This confirms the results of Soro et al. (2016) who observed low temperature values during the rainy season and high values during the dry season. Increased temperature does not affect nearshore water quality because it does not affect bacterial and microbial processes such as nitrification and denitrification. The overall temperature values remain below 30° C (Frisbie et al., 2012). The high conductivity (42.37 mS/cm) during the long dry season could be related to the fact that during this season, the cessation of rainfall leads to a lack of water dilution. This finding is in agreement with those of Gadhia et al. (2012); Izonfuo and Bariweni (2001) who noted that conductivity decreases under the effect of dilution. It still remains high during the 4 seasons observed at the Ivorian coastline. TDS are an indicator of the presence of inorganic salts. They take into account both positive ions (Na^+, Ca^{2+}, mg^{2+}, K^+...) and negative ions (Cl^-, SO_4^{2-}, PO_4^{3-}, CO_3^{2-}, HCO_3^-) as well as some inorganic and organic matter. During the dry season, the increase in TDS in coastal waters is related to a lack of river water. Indeed, during the dry season, this state of the waters is caused by the penetration of the ocean water in the coastline but also by the anthropic intervention very loaded in dissolved matter and very mineralized. Thus, these very high values of TDS in the waters of the coastline lead to a high toxicity of these (Koffi et al., 2019). Also, it is noted that the values of conductivity and those of TDS have a proportional variation during the different seasons of the year. This proportionality was proven by Rusydi. (2018). These authors determined a correlation coefficient of 0.98 between

TDS and electrical conductivity. Like temperature and conductivity, dissolved oxygen is important during the major dry season. Dissolved oxygen values range from 6 to 8 mg/L over all seasons and are comparable to those of Kouame et al. (2020) who estimated values of 3 to 8 mg/L at the Ebrié Lagoon. Togue et al. (2017) made a similar finding of increased dissolved oxygen during drought in the Nkam River in Cameroon. pH is also a very important parameter in assessing water quality and treatment. The pH of coastal water is less affected by the seasons. It varies from 7.32 to 7.58. The lowest pH value is recorded during the long dry season and the highest pH value during the long rainy season (Figure 1). In fact, during the rainy season, the various rivers and wastewater that feed the coastal waters are loaded with chemical matter that is more or less alkaline and responsible for the increase in pH. These waters can be qualified as natural if we refer to Rodier et al (1984). According to these authors, for pH values between 6 and 8.5, the water is considered natural. The waters of the coastline as a whole meet the standard set by the World Health Organization (WHO) for surface waters (OMS, 2020).



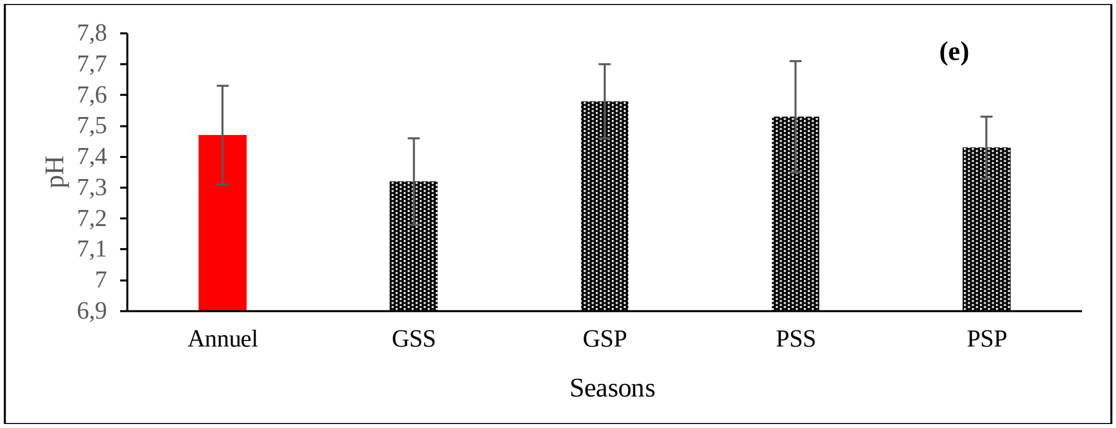


Figure 2 : Impact of seasons on conductivity (a), temperature (b), TDS (c), dissolved oxygen (d) and pH (e)
GSS: long dry season; GSP: long rainy season; PSS: short dry season; PSP: short rainy season

Seasonal variation of Biochemical Oxygen Demand (BOD)

The seasonal variation of Biochemical Oxygen Demand (BOD) is shown in Figure 3. BOD is highest during the rainy season. This increase in BOD_5 during the rainy season was observed by Kouamé et al. (2020) during the seasonal assessment of mercury in the Ebrié Lagoon of Côte d'Ivoire. This increase would be linked to river water coming from the cities along the coastline. In fact, by flowing into the waters of the coastline, rainwater brings a high level of organic matter due to soil particles and human waste. Several studies (Togue et al., 2017; Aissaori et al., 2017) have shown that river water is partly responsible for the elevation of BOD_5 because it contributes to the dilution of the organic load. This finding is similar to that of Gadhia et al. (2012) in India. Indeed, these authors noted the responsibility of anthropogenic activities such as agriculture, fishing, industry, shipping and urban discharges.

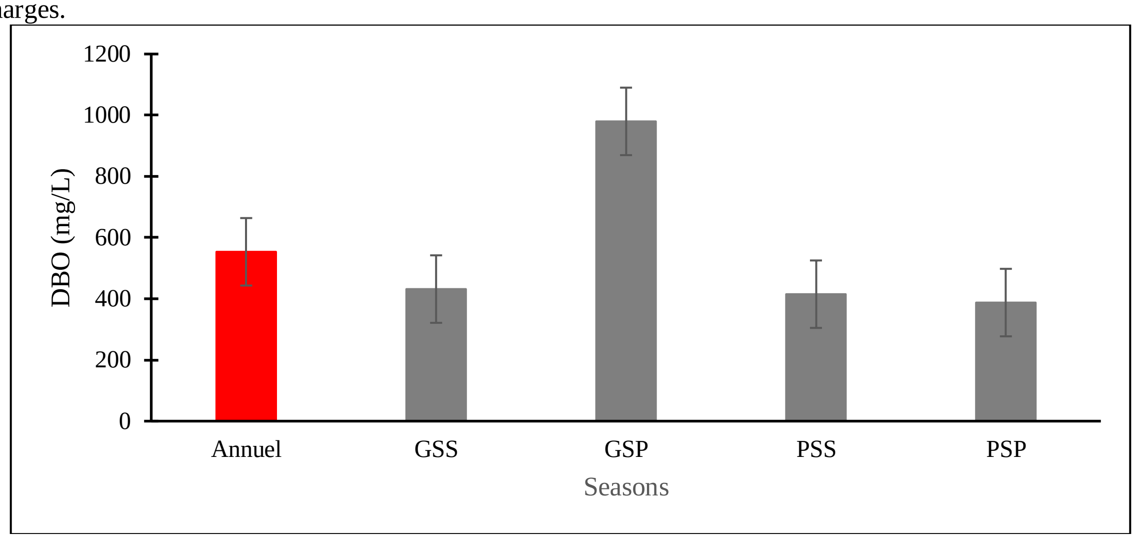


Figure 3 : Impact of seasons on BOD_5.
GSS: long dry season; GSP: long rainy season; PSS: short dry season; PSP: short rainy season

Seasonal variation of nutrients (phosphorus and total nitrogen)

The seasonal variation of nutrients (phosphorus and nitrogen) by season is shown in Figure 4. Analysis of Figure 3 indicates that phosphorus is significant during the major rainy season compared to other seasons. In contrast to phosphorus, total nitrogen is more important during the short rainy season. Phosphorus and nitrogen, which are important elements for plant growth, are included in the various fertilizers used. Thus, the river waters could drain them and accumulate them in the coastal waters that receive almost all the water from all the surrounding localities. This finding is similar to that of Koffi et al. (2019). These authors found increased nitrogen in the Elala River related to surrounding field activities.

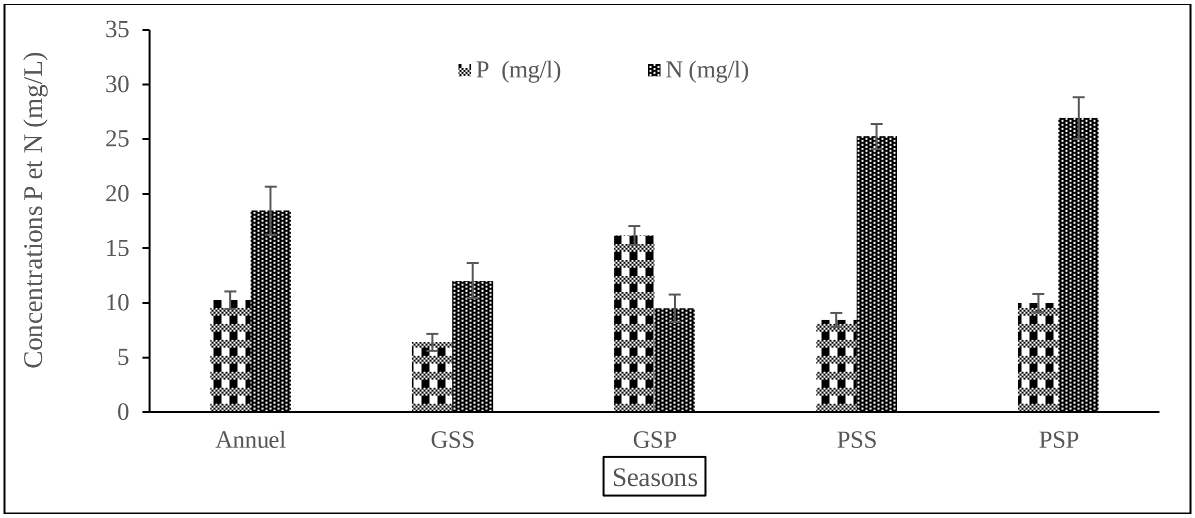


Figure 4:- Impact of seasons on nutrients.

GSS: long dry season; GSP: long rainy season; PSS: short dry season; PSP: short rainy season

Seasonal variation of sulfates in coastal waters

The concentration of sulfate ions is high during the long dry season as is the concentration of TDS (Figure 5). This shows a relationship between these two parameters. However, the variation in sulfate ions during the different seasons is not significant ($P > 0.05$). These waters cannot be used without prior treatment. Indeed, the waters of the coast have concentrations of sulfate ions above the standard (OMS, 2012). This finding is consistent with that of Koffi et al. (2019) for the Adjin Lagoon and that of Kouamé et al. (2020) for the Ebrié Lagoon.

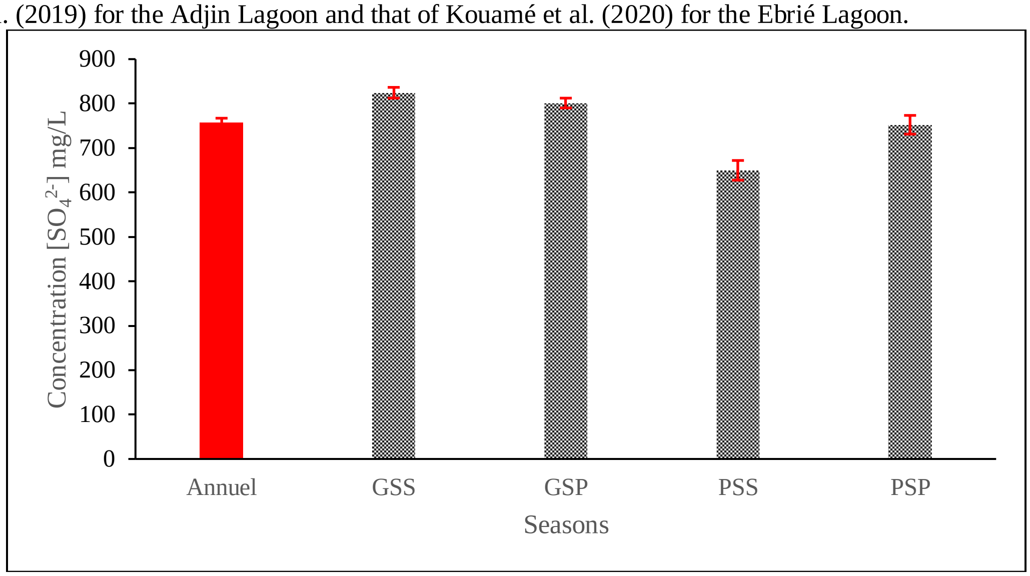


Figure 5- Impact of seasons on sulfate ions.

GSS: long dry season; GSP: long rainy season; PSS: short dry season; PSP: short rainy season

Conclusion:

The sedimentological, physical and chemical characteristics of the water of the Ivorian coast are variable according to the season. The biochemical oxygen demand is strongly impacted by the long rainy season and nitrogen by the dry season. Apart from this fluctuation of physical and chemical parameters, the water of the Ivorian coast cannot be consumed or used for irrigation without prior treatment. It would be interesting to protect the waters of the coastline, which could be used to feed households in the event of an extreme situation of access to drinking water.

References:

1 Adeniji, A.O., Okoh, A.I., 2019. Levels of Polycyclic Aromatic Hydrocarbons in the Water and Sediment of Buffalo River Estuary, South Africa and Their Health Risk Assessment. Arch Environ Contam Toxicol 76, 657–669. https://doi.org/10.1007/s00244-019-00617-w.

2 Aissaoui, M., Benhamza, M., Guettaf, M., 2017. Caractéristiques hydro chimiques des eaux de l'oued Seybouse-Cas de la région de Guelma (Nord est Algérien). Synthèse : Revue des Sciences et de la Technologie 35, 178–186.

3 Ameur, M., Hamzaoui-Azaza, F., Gueddari, M., 2014. The contribution of the geographic information system to evaluate the water quality of the triassic aquifer in the South-East of Tunisia. International Journal of Innovation and Applied Studies 7, 1090–1103.

4 Adandedjan, D., Lalèyè, P., Gourene, G., 2012. Macroinvertebrates communities of a coastal lagoon in southern Benin, West Africa. International Journal of Biological and Chemical Sciences 6, 1233–1252.

5 Benkaddour, B., Abdelmalek, F., Addou, A., Noguer, T., Aubert, D., Vouvé, F., 2019. Assessment of anthropogenic and natural factors on Cheliff river waters (North-West of Algeria) at two contrasted climatic seasons. International Journal of Environmental Research 13, 925–941.

6 Benkaddour, B., 2018. Contribution à l'étude de la contamination des eaux et des sédiments de l'Oued Chéliff (Algérie). Thèse de doctorat en Chimie. Université Abdelhamid Ibn Badis Mostaganem (Mostaganem, Algérie), 193.

7 Chouti, W.K., Chitou, N.E., Kelome, N., Kpako, B.B.H., Vlavonou, D.H., Tossou, M., 2017. Caractérisation physico-chimique et étude de la toxicité de la lagune côtière, De Togbin à Grand-Popo (Sud-Ouest Bénin). European Scientific Journal, (13)(27) 131–151.

8 Ciwanine, K.D., Katho, L.J., Kankonda, B.A., Micha, J.-C., 2020. Qualité physico-chimique des eaux littorales de la partie Sud-Ouest du Lac Albert, RD Congo. International Journal of Biological and Chemical Sciences 14, 1831–1842.

9 Dong, B., Kahl, A., Cheng, L., Vo, H., Ruehl, S., Zhang, T., Snyder, S., Sáez, A.E., Quanrud, D., Arnold, R.G., 2015. Fate of trace organics in a wastewater effluent dependent stream. Science of the Total Environment 518, 479–490.

10 Edjere, Agbozu, I., Asibor, G., Otolo, S., Bassey, U., 2020. Seasonal Trend of Polyaromatic Hydrocarbons (PAHs) in Sediments from River Ethiope in the Niger Delta Region of Southern Nigeria. International Research Journal of Pure and Applied Chemistry 69–77.

11 Fouzi, T.A., Youness, M., Bouchra, L., Ali, B., 2020. Spatio-temporal typology of the physico-chemical parameters of a large North African River: the Moulouya and its main tributaries (Morocco). African Journal of Aquatic Science 45, 431–441.

12 Frisbie, S.H., Mitchell, E.J., Dustin, H., Maynard, D.M., Sarkar, B., 2012. World Health Organization discontinues its drinking-water guideline for manganese. Environmental health perspectives 120, 775–778.

13 Gadhia, M., Surana, R., Ansari, E., 2012. Seasonal variations in physico-chemical characterstics of Tapi estuary in Hazira industrial area. Our Nature 10, 249–257.

14 Izonfuo, L., Bariweni, A., 2001. The effect of urban runoff water and human activities on some physico-chemical parameters of the Epie Creek in the Niger Delta. Journal of Applied Sciences and Environmental Management 5, 47–55.

15 Keumean, K.N., Traore, A., Ahoussi, K.E., Djade, P.J.O., Bamba, S., 2020. Influence des activités anthropiques sur la dégradation de la qualité des sédiments de la lagune Ouladine (Sud-Est De La Côte d'Ivoire). https://doi.org/10.19044/esj.2020.v16n15 ; 378.

16 Koffi, S.É., Koffi, T.K., Perrin, J.-L., Séguis, L., Guilliod, M., Goné, D.L., Kamagaté, B., 2019. Hydrological and water quality assessment of the Aghien Lagoon hydrosystem (Abidjan, Côte d'Ivoire). Hydrological Sciences Journal 64, 1893–1908.

17 Kouakou, R., Kopoin, A., Yao, B., 2016. Assessment of heavy metals contamination in sediments of the Vridi Canal (Côte d'Ivoire). Journal of Geoscience and Environment Protection 4, 720–726. https://doi.org/10.4236/gep.2016.410004.

18 Kouame, L.B.C., Bi, E.B.B., Aka, N., Alphonse, V., Goula, B.T.A., Balland-Bolou-Bi, C., 2020. Seasonality of Hg dynamics in the Ebrié Lagoon (Côte d'Ivoire) ecosystem: influence of biogeochemical factors. Environmental Science and Pollution Research 27, 19810–19825.

19 Kouamenan, N.M., Coulibaly, S., Atse, B.C., Goore, B.G., 2019. Seasonal and spatial variations of heavy metals in water and sediments from mainland and maritime areas of Ebrie lagoon (Côte d'Ivoire, Western Africa).

International Journal of Biological and Chemical Sciences 13, 2374–2387. https://doi.org/10.4314/ijbcs.v13i4.39.

20 Mkadmi, Y., Benabbi, O., Fekhaoui, M., Benakkam, R., Bjijou, W., Elazzouzi, M., Kadourri, M., Chetouani, A., 2018. Study of the impact of heavy metals and physico-chemical parameters on the quality of the wells and waters of the Holcim area (Oriental region of Morocco). J Mater Environ Sci 9, 672–679.

21 Naga, C., Talnan Jean Honoré, C., Delfin, O.A., Bernard, Y.O., Guillaume, Z.S., Henoc Sosthène, A., Mpakama, Z., Issiaka, S., 2018. Spatio-Temporal Analysis and Water Quality Indices (WQI): Case of the Ébrié Lagoon, Abidjan, Côte d'Ivoire. Hydrology 5, 32.

22 Okunola, O.A., Santacroce, P.V., Davis, J.T., 2008. Natural and synthetic receptors for nitrate anion. Supramolecular chemistry 20, 169–190.

23 OMS, Organisation des Nations Unies pour l'alimentation et l'agriculture, Organisation mondiale de la santé animale, 2020. Note d'orientation technique relative à l'eau, l'assainissement et l'hygiène et la gestion des eaux usées pour prévenir les infections et réduire la propagation de la résistance aux antimicrobiens. Organisation mondiale de la Santé.

24 OMS (Organisation Mondiale de la Santé). 2012. Progrès en matière d'eau potable et d'assainissement, World Health Organization Geneva, 11-16 p.

25 Rodier, J., Geoffray, C., Rodi, L., 1984. L'analyse de l'eau (8 ième édition) eaux naturelles, eaux résiduaires, eau de mer ; chimie, physico-chimie, bactériologie, biologie. Dunod Paris, 1434.

26 Rodrigue, M., Elango, V., Curtis, D., Collins, A.W., Pardue, J.H., 2020. Biodegradation of MC252 polycyclic aromatic hydrocarbons and alkanes in two coastal wetlands. Marine Pollution Bulletin 157, 111319.

27 Rusydi, A.F., 2018. Correlation between conductivity and total dissolved solid in various type of water: A review. Presented at the IOP conference series: earth and environmental science, IOP Publishing, pp. 012–019.

28 Sonawane, D., 2019. Study of the impact of heavy metals and physico-chemical parameters on the quality of the wells water around Yedgaon Dam area Junner, Dist: Pune. Journal of Current Pharma Research 9, 2867–2877.

29 Soro, G.É., Dao, A., Fadika, V., Goula Bi, T.A., Srohorou, B., 2016. Estimation des pluies journalières extrêmes supérieures à un seuil en climat tropical : cas de la Côte d'Ivoire. Physio-Géo. Géographie physique et environnement 211–227.

30 Togue, F., Kuate, G., Oben, L., 2017. Physico-Chemical characterization of the surface water of Nkam River using the Principal Component Analysis. Journal of Materials and Environmental Sciences 8, 1910–1920.

31 Toure, M., N'guessan, A.Y., Konan, E.K., 2018. Etude géochimique des sédiments superficiels d'une baie lagunaire et son impact sur l'environnement : Cas de la baie d'Abouabou (lagune Ebrié ; Côte d'Ivoire). International Journal of Biological and Chemical Sciences 12, 2371–2380. https://doi.org/10.4314/ijbcs.v12i5.

32 Yao, K.M., Sangare, N., Trokourey, A., Metongo, B.S., 2019. The mobility of the trace metals copper, zinc, lead, cobalt, and nickel in tropical estuarine sediments, Ebrie Lagoon, Côte d'Ivoire. Journal of soils and sediments 19, 929–944.