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Research Article

Evaluation of Physico-chemical and Algal Properties in the Estuary Bay of Bietry in the Neighborhood of Port-Bouët Slaughterhouse (Abidjan, Côte D'ivoire)

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Abstract

Background and Objective: Untreated municipal sewage, garbage and industrial effluents are directly or indirectly discharged into the lagoon and are the contributing factors of its degradation. Many water quality studies conducted in Côte d'Ivoire revealed that this problem contributes to the pollution of water resources. This study aims to evaluate the physico-chemical parameters and algal variation in the bay of Bietry in the neighborhood of Port-Bouët slaughterhouse in order to appreciate the impact of its effluents on this bay. **Materials and Methods:** Sampling was carried out in the South of Bietry bay towards the slaughterhouse during the dry season and the wet season. Water samples were collected at 10 stations for biological oxygen demand (BOD_5), chemical oxygen demand (COD), total suspended solids (TSS), pH, temperature, salinity, redox potential and chlorophyll analyses. Variation of each parameter between sites and seasons was analyzed statistically through the test of Mann-Whitney at 5% level of significance. **Results:** It was found that, the COD (1988.50-10965.00 mg L^{-1}), BOD_5 (612.50-3813.50 mg L^{-1}) and TSS (195.00-285.00 mg L^{-1}) concentrations, as well as temperature (23.20-32.40°C), pH (7.65-9.01) and salinity (16.40-23.90) values were higher during the dry season than the values of wet season. On the contrary, during the dry season, chlorophyll values (0.65-13.25 mg L^{-1}) were lower than the values (8.94-41.3 mg L^{-1}) of wet season. **Conclusion:** The study revealed that the pollution of Bietry bay is controlled by its exchange with the ocean, freshwater inputs and rainfall. Thus, the dilution during the raining season by oceanic water and the rain reduces considerably the concentrations of pollutants and increases salinity and algal production.

Key words: Organic pollution, slaughterhouse, coastal water, biological oxygen demand, chemical oxygen demand, total suspended soils

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Physico-chemical variation of coastal water quality depends of anthropogenic activities. Water quality deterioration of half-closed bay is one of the most important stresses impacting coastal ecosystems. Estuaries and coastal area exhibit a wide array of human impact that can compromise their ecological integrity, because of rapid population growth and uncontrolled development in many coastal region worlds wide[1]. Estuaries, coastal area and bay receive significant anthropogenic inputs from both point and non-point upstream sources and from metropolitan areas, tourism and industries located along the estuarine edges. Pollution has been very damaging to aquatic ecosystems and may consist of agricultural, urban and industrial wastes containing contaminants that have proven to be very damaging to aquatic habitats and species[2]. In Ivory Coast, the partly closed of Bietry bay is situated in the estuary part of the Ebrié lagoon[3]. This bay is an important ecological site. The 6 km long S-form bay is in the East-West axis and has a mean depth of 3.8 m[4]. Its catchment basin is in the industrial zone of the Abidjan agglomeration (Zone 4-Bietry, Port-Bouët, Marcory and Koumassi). The main opening of the Bietry bay, East of Ebrié lagoon, is a 450 m^2 pass with a maximum depth of 6.30 m[4]. This bay receives effluents of Port-Bouët slaughterhouse without treatment since 1959[5]. These effluents contribute to Bietry bay degradation today. An important environmental impact of the animal processing industry results from the discharge of wastewater. Most processes in slaughterhouses require the use of water. This water and water used for general cleaning purposes will produce wastewater. Discharge of wastewater to surface waters affects the water quality in different ways. The discharge of biodegradable organic compounds may cause a strong reduction of the amount of dissolved oxygen, which in turn may lead to reduced levels of activity or even death of aquatic life[6]. Macro-nutrients may cause eutrophication of the receiving water bodies. Excessive algae growth and subsequent dying off and mineralization of these algae, may lead to the death of aquatic life because of oxygen depletion[6]. The main source of pollutants in the slaughterhouses is a liquid sewage that contains different amounts of solids[7,8]. The results of the studies conducted on slaughterhouses indicated that the sewage of such units had a density of 3 times more than human sewage[7]. These studies are generally devoted to slaughterhouses sewage characterization for their treatment[9,10]. This study describes physico-chemical parameters and algal variation of Bietry bay around the slaughterhouse of Port-Bouët in order to evaluate the impact of its sewage on this bay.

MATERIALS AND METHODS

Description of study area: Bietry bay is one of principal bays of the Ebrié lagoon. The partly closed Bietry bay is situated in the estuary part of the Ebrié lagoon (Fig. 1). The main opening of the Bietry bay is a 450 m^2 pass with a maximum depth of 6.30 m. In the East end, an opening was made in the Komassi embankment in 1981 to control the superficial water containment in this part of the bay[4].

Sampling and analysis: Sampling was carried out in the South of Bietry bay towards the slaughterhouse on approximately 3 km during the two seasons in March, 2014 for the dry season and in July, 2014 for the wet season. For each season, four sampling campaigns were carried out. Ten stations (Fig. 1) were selected and their geographical coordinates were registered using a GPS (MAGELLAN 320). The samples were collected each week by bottle direct immersion into lagoon on the surface and in the depth using a bottle of Niskin. Samples were kept cool in thermos with ice and brought back to the laboratory for analysis imperatively within 48 h according to AFNOR standards[11]. Temperature, pH, salinity and redox potential of water have been measured *in situ* using a multiple-sondes WTW 340i.

The physico-chemical parameters such total suspended solids (TSS), biological oxygen demand (BOD), chemical oxygen demand (COD) were analyzed using the standard analytical methods. Standard laboratory methods as described by the APHA[12] for the examination of water and wastewater samples was employed for the analysis of TSS. The BOD was measured based on oxygen consumed in a 5 days test period (BOD_5) at 20°C after arrival of sample to the laboratory. The COD was measured by Hach Lange kits using HACH DR/2800 spectrophotometer. Chlorophyll a and phéopigments were determined using procedures recommended by Lorenzen and Downs[13]. It consists in measuring optical density at 750 and 665 nm of the extract not acidified, then on the same extract after acidification.

Variation of each parameter between sites and seasons was analyzed statistically through the test of Mann-Whitney at 5% level of significance using STATISTICA 7.1 software.

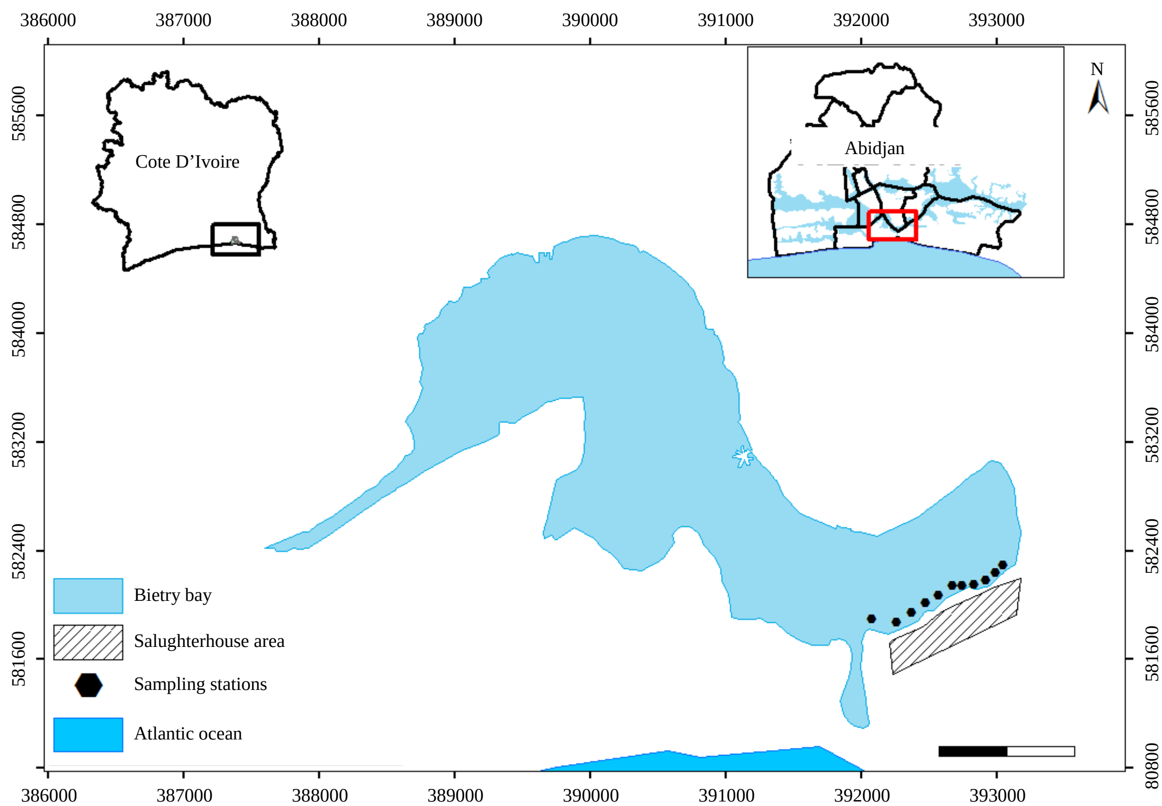

Fig. 1: Localization of sampling stations

RESULTS

Seasonal variation of some parameters characteristic of Bietry bay

Temperature and pH: Figure 2 show spatial and temporal variation of temperature and pH of Bietry bay on surface and in-depth. Temperature and pH of Bietry bay were higher in dry season than in wet season. There was no significant difference between surface temperature and that of in-depth in dry season as in wet season. It was the same observation for the pH. Temperature values ranged from 29.80-32.40°C during the dry season and from 23.20-28.80°C in wet season. The pH values were slightly basic in wet season with mean values ranged from 7.22-7.58. During the dry season, water of Bietry bay became more basic with pH values ranged from 7.65-9.01.

Salinity and redox potentiel: During both seasons, salinity and redox potential of Bietry bay do not varied significantly from surface to depth (Fig. 3). However, salinity values were higher in dry season than in wet season and the means values ranged from 16.40-23.90 in dry season and from 1.45-1.67 in wet season. In addition, redox potential values ranged from -127.50 to -88.13 mV in dry season and from -53.50 to -34.10 mV in wet season were negative during both seasons.

Spatio-temporal variation of chlorophyll a and pheopigments concentrations of Bietry bay on surface and in-depth: Spatial and temporal variation of chlorophyll a and pheopigments concentrations on surface and in-depth in Bietry bay showed that concentrations of pheopigments were higher than chlorophyll a values in dry season (Fig. 4). Pheopigments concentrations varied between 1.61 and 39 mg L^{-1} for surface and between 1.95 and 68.25 mg L^{-1} for the depth. About chlorophyll a, means values varied between 0.65 and 12.35 mg L^{-1} for surface and between 0.98 and 13.25 mg L^{-1} for the depth. Contrary to the dry season, the wet season wasn't presented any value of pheopigments. However, during the wet season chlorophyll a values for surface (from 14.04-38.76 mg L^{-1}) and for the depth (from 8.94-41.30 mg L^{-1}) were higher than those obtained in dry season for surface (from 0.65-12.35 mg L^{-1}) as in-depth (from 0.98-13.25 mg L^{-1}).

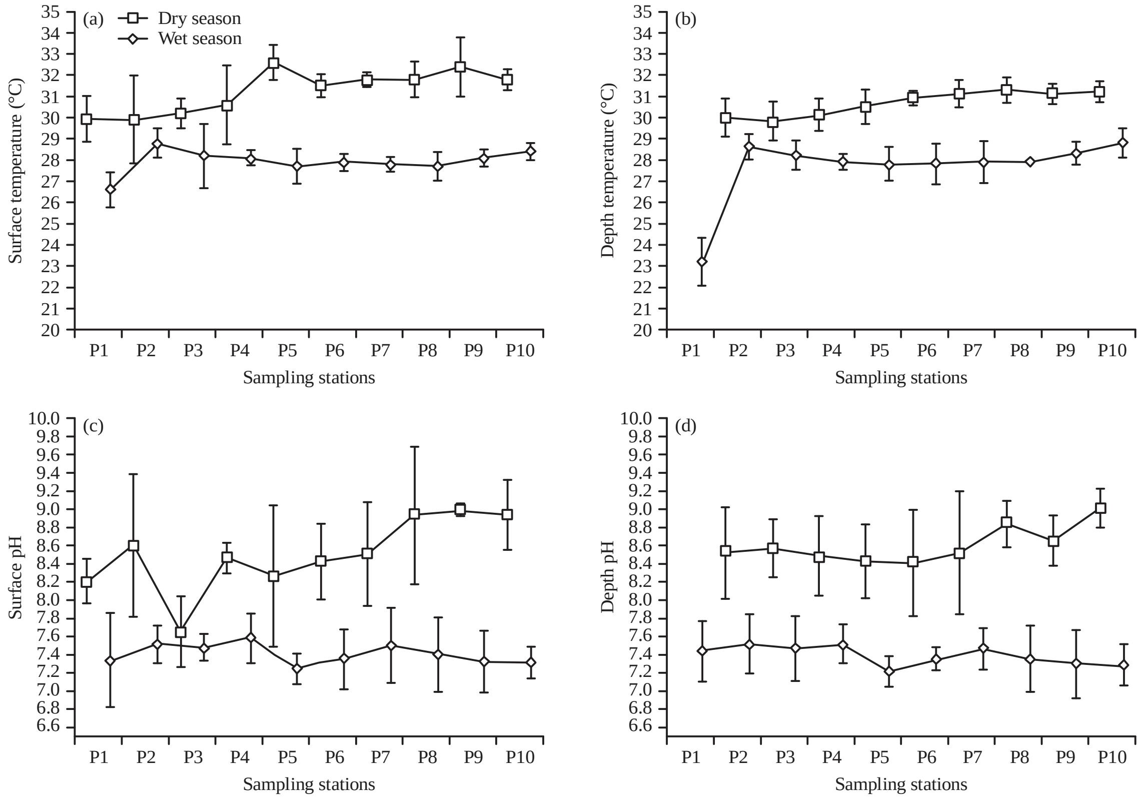

Fig. 2(a-d): Mean±SD of spatio-temporal variation of Bietry bay temperature and pH on surface and in-depth

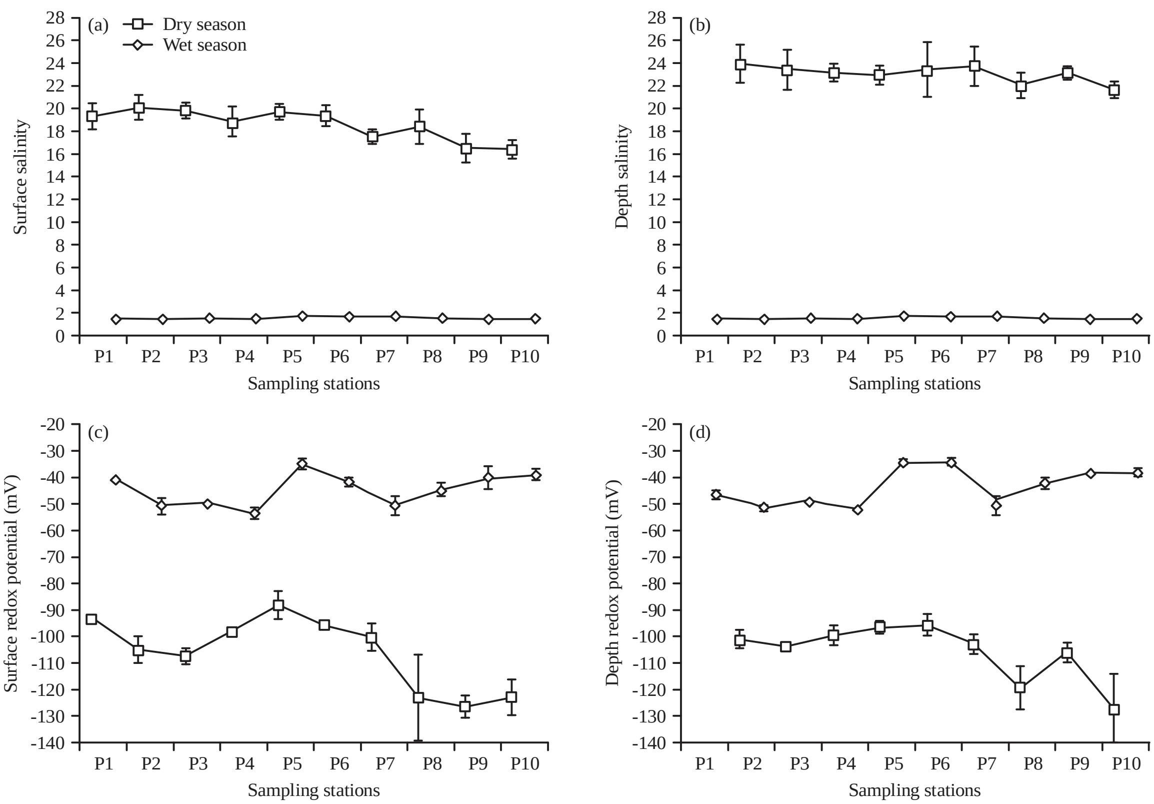

Fig. 3(a-d): Mean±SD of spatio-temporal variation of Bietry bay salinity and redox potential on surface and in-depth

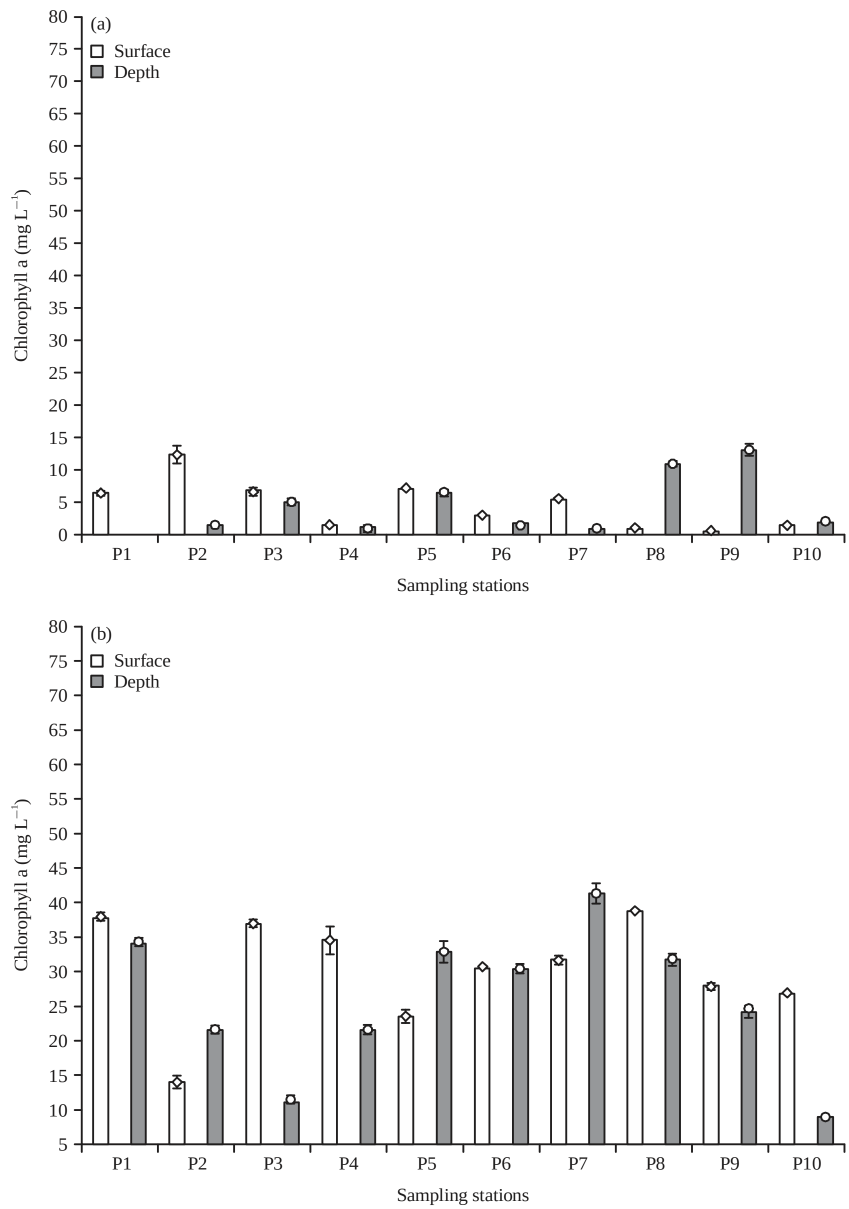

Fig. 4(a-b): Mean±SD of spatio-temporal variation of chlorophyll a and pheopigments concentrations of Bietry bay on surface and in-depth (a) Dry season and (b) wet season (b)

Comparison of BOD_5, COD, TSS and chlorophyll a concentrations of Bietry bay in dry season and in wet season: The following Table 1 shows BOD_5, COD, TSS and chlorophyll a contents of Bietry bay in dry season and wet season. They are the average values of surface and depth for each sampling station. During the dry season, BOD_5 and COD concentrations were highly higher than their concentrations in wet season. In dry season, BOD_5 and COD values were ranged from 612.50-3813.50 mg L^{-1} and from 1988.50-10965.00 mg L^{-1}, respectively. In contrast, during the wet season, BOD_5 and COD concentrations were ranged from 20.00-97.50 mg L^{-1} and from 62.30-382.30 mg L^{-1}, respectively. The COD/BOD_5 ratio was varied between 2.87 and 3.92. In wet season, TSS values were also lower than those obtained in dry season. In contrast, during the wet season, concentrations of chlorophyll a were largely higher than their values in dry season. Chlorophyll a concentrations were varied between 17.82 and 36.50 mg L^{-1} during the wet season and between 1.46 and 6.99 mg L^{-1} in dry season.

Table 1: Mean±SD values of BOD_5, COD, TSS and chlorophyll a contents of Bietry bay in dry season and wet season

Sampling stations	BOD_5 (mg L^{-1})		COD (mg L^{-1})		TSS (mg L^{-1})		Chlorophyll a (mg L^{-1})	
	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season
P1	1439.50±71.85	97.50±12.02	4002.75±107.83	345.50±10.30	200.00±21.60	12.90±1.53	6.45±0.34	35.92±0.61
P2	3743.00±216.94	30.00±3.82	10965.00±81.27	83.75±5.31	215.00±17.29	11.00±1.32	6.99±0.84	17.82±0.72
P3	612.50±38.01	40.00±4.67	4268.76±49.92	107.18±3.54	250.00±15.09	11.20±1.40	6.07±0.36	24.07±0.45
P4	3339.00±69.99	22.50±3.12	7581.50±65.30	62.30±1.31	265.00±15.51	26.50±2.05	1.46±0.19	28.15±1.20
P5	794.50±49.30	42.50±6.42	1988.50±54.05	133.45±6.29	280.00±17.21	14.03±0.90	6.80±0.38	28.21±1.25
P6	1558.00±75.41	95.00±9.11	3796.75±88.93	382.30±8.06	260.00±16.86	11.00±1.62	2.38±0.11	30.51±0.57
P7	3064.50±62.40	32.50±3.62	8911.00±359.86	97.04±2.31	280.00±13.80	13.38±1.56	3.26±0.23	36.50±1.04
P8	1038.50±75.97	32.50±5.09	2746.75±151.91	111.25±2.34	285.00±16.20	10.20±1.44	6.02±0.28	35.23±0.69
P9	3813.50±112.69	20.00±4.35	8917.50±194.50	68.01±1.49	230.00±8.16	12.00±2.04	6.95±0.50	26.06±0.65
P10	3018.50±67.27	22.50±4.93	6279.00±69.24	97.89±3.58	195.00±16.20	8.80±1.06	1.79±0.14	17.89±0.23

DISCUSSION

The present study was conducted to assess the physico-chemical parameters of Bietry bay to assess the impacts related to the organic pollution. Physico-chemical degradation of Bietry bay was showed by high concentrations of COD (from 1988.50-10965.00 mg L^{-1}), BOD_5 (from 612.50-3813.50 mg L^{-1}) and TSS (from 195.00-285.00 mg L^{-1}) in dry season. The BOD_5 and COD are overall parameters that give an indication of the concentration of organic compounds in any wastewater[6]. The BOD_5 is particularly taken as a measure of the concentration of biodegradable organic compounds present in any water. The greater the decomposable matter present, the greater the oxygen demand and the greater the BOD values[14]. In this study, the high BOD values recorded in all stations could be an indication of organic pollution due to the loads of wastewater from the anthropic activities. Similarly, other findings also showed that a high level of BOD causes to decrease the value of dissolved oxygen in water[15,6]. The concentration of TSS represents the amount of insoluble organic and inorganic particles in the wastewater. The high values of DCO, DBO_5 and TSS would be also related to the contribution of the effluents resulting from Port-Bouët slaughterhouse. According to Noorijangi and Noorijangi[6], the effluents resulting from slaughterhouses have a significant, biodegradable organic compounds and high concentrations of TSS. The COD/BOD_5 ratio was varied between 2.87 and 3.92 indicating that water pollution was highly biodegradable. Water temperature obtained during the sampling period (from 29.80-32.40°C) was also favourable for the microorganisms activities and could contribute to this biodegradation. However, nature's mechanisms became overburdened and pollution problems started to occur because the concentration of wastewater products frequently increases[16]. Moreover, high biodegradable organic compounds were contributed to the water anoxia, because of the dissolved oxygen uptake during the natural process of organic compounds degradation. This could reduce considerably the photosynthesis of the chlorophyllian algae already disturbed by high concentrations of TSS which reduced the penetration of sunlight in the water column[17,18]. This harmful effect on the algae development which would result in their degradation during the dry season could justify the values of chlorophyl a (from 0.65-13.25 mg L^{-1}) lower than pheopigments concentrations (from 1.61-68.25 mg L^{-1}) in this season. In addition, the low values of BOD_5 (from 20.00-97.50 mg L^{-1}), DCO (from 62.30-382.30 mg L^{-1}) and TSS (from 8.80-26.50 mg L^{-1}) obtained in wet season were related to the phenomenon of dilution with a strong reduction of salinity. During the wet season, the organic pollutants compounds were decreased and algal amount were increased.

This study constitutes an approach of the domestic and industrial wastes impact on Bietry bay half-closed. The impacts related to organic pollution of this bay were highlighted. The results were indicated a strong deterioration of the physico-chemical quality of Biétry bay in dry season. The BOD_5, DCO and TSS concentrations were high with pheopigments contents higher than chlorophyll a in the dry season. During the wet season, phenomena of dilution involved a decrease of the organic pollutants and an increase in the algal amount. Domestic and industrial wastewaters discharges in Bietry bay could increase the phenomenon of eutrophication of this medium.

CONCLUSION

The results revealed that a strong deterioration of the physicochemical quality of Bietry bay in dry season. BOD_5, DCO and TSS concentrations were high with pheopigments contents higher than chlorophyll a in the dry season. During the wet season, phenomena of dilution involved a decrease of the organic pollutants and an increase in the algal amount. A seasonal comparison of the results shows that the pollution of Biétry bay is controlled by its exchange with the ocean, freshwater inputs and rainfall. The impacts related to organic pollution of this bay were highlighted. Thus, it would be better to determine the effects of this organic pollution on aquatic organisms such as fish.

SIGNIFICANCE STATEMENT

This study constitutes an approach of the domestic and industrial wastes impact on bay half-closed. It revealed also that the pollution of Bietry bay is controlled by its exchange with the ocean, freshwater inputs and rainfall. This study makes it possible to quantify the exposure of Bietry bay to domestic pollutants.

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