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RESEARCH ARTICLE

IMPACT OF URBAN DISCHARGES FROM THE TOWN OF ADZOPÉ ON THE MASSAN RIVER WATER RESERVOIR USED FOR THE PRODUCTION OF WATER FOR HUMAN CONSUMPTION (SOUTH-EAST OF CÔTE D'IVOIRE)

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Abstract

The town of Adzopé, in the southeast of Côte d'Ivoire is faced with a sanitation problem, the direct consequence of which is the untreated discharge of wastewater into the Massan River reservoir. The objective of this work is to carry out a physico-chemical characterization of urban wastewater in the town of Adzopé. This characterization of urban wastewater is a good indicator of the quality of discharges and their impact on the receiving environment. The pH, temperature, electrical conductivity (EC) and dissolved oxygen (O₂) were measured in situ using a multi-parameter HANNA HI 9829. In the laboratory, the various physico-chemical parameters were analysed according to the analysis methods recommended by the French Association for Standardization. The results obtained show that the parameters studied (T, pH, EC, DO, COD, DOB₅, TSS, NH₄, NO₃, PO₄ and Cl) have variable contents from one site to another. Most of the parameters studied comply with the discharge standards established by Ivorian legislation, except suspended particles and phosphate ions. These two parameters have values that exceed the established standards. Thus, the discharge of this wastewater into the Massan River reservoir can lead to eutrophication.

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Introduction:-

The availability of good quality freshwater is one of the major issues facing the world today, and about one-third of the world's drinking water needs are met from surface waters such as rivers, dams, lakes, and canals [1]. These surface water sources also serve as receiving environments for urban wastewater discharges [2,3]. Indeed, demographic growth accompanied by rapid urbanization, intensive water use and a lack of wastewater treatment are causing numerous disturbances to the natural environment [4]. This is the case in most developing countries where the major problems that municipal officials in large African cities constantly face are those related to the sustainable management of urban wastewater discharge [5]. Pollution from urban wastewater discharges is a threat to public health, aquatic species and the livelihoods of people who depend on fishing [4]. This municipal wastewater effluent contains many toxic substances that degrade aquatic environments, primarily nutrients as well as pharmaceuticals, pathogens, and chlorides [6]. In the city of Adzopé in the southeast of Côte d'Ivoire, as in many other cities in the country, the issue of wastewater management remains one of the main environmental problems, due to the lack of sanitation infrastructure and treatment systems. This lack of sanitation in the city leads to the degradation of the

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waters of the Massan River reservoir, which has become the receptacle for urban wastewater. Thus, these discharges can have disastrous consequences for the health of the population who are fed from the Massan River reservoir. In this context, data on the quality of these effluents about all priority substances are essential. The objective of this work is to carry out a physico-chemical characterization of urban wastewater in the town of Adzopé. This characterization of urban wastewater is a good indicator of the quality of discharges and their impact on the receiving environment.

Material and Methods:-

the measurement and sampling campaigns were carried out at five (05) stations distributed around the reservoir (fig. 1). these selected points or stations represent the points of discharge of the city's urban wastewater into the reservoir. At each station, one (01) litre of water was collected. The samples were then stored in a cooler for later analysis in the laboratory. pH, temperature, electrical conductivity (EC) and dissolved oxygen (O₂) were measured in situ using a multi-parameter HANNA HI 9829. In the laboratory, the various physico-chemical parameters were analyzed according to the analytical methods recommended by [7, 8].



Fig. 1:- Measurement and sampling station in the study area.

Results And Discussion:-

Statistical data on the physico-chemical properties of the water samples taken from the different urban wastewater discharge points are presented in the table below.

Table 1:- Statistics on physio-chemical parameters of urban wastewater.

	pH	T°C	EC μS/cm	DO mg/L	COD mg/L	DOB mg/L	TSS mg/L	NH ₄ mg/L	NO ₃ mg/L	PO ₄ mg/L	Cl mg/L
Min	7,79	26,9	350	1,29	93,8	31	73,4	0,59	1,9	0,23	10
Average	8,13	28,3	959,2	2,69	143,72	47,44	112,48	2,07	5,76	20,57	19
Max	8,41	30,4	1700	2,88	254,4	84	199	2,70	13	54,8	29
ECARTYPE	0,22	1,35	630,03	0,62	1,69	66,66	22,04	52,20	0,93	5,09	27,90

Hydrogen potential

PH is one of the important parameters in water quality monitoring because it governs most of the chemical reactions that take place in water. It is a measure of the acidity or alkalinity of water. Variations in pH affect many aquatic organisms [9]. In the present study, the pH of the wastewater varies from a minimum of 7.79 at point E1 to a maximum of 8.41 at point E4 with an average of 8.13 (Fig. 2). The pH of the effluents from the different discharge points measured shows that these waters are alkaline overall. The variation of the pH remains low between the different measuring points with a standard deviation of 0.22 (Table 1). The pH values obtained during the study revealed that all effluents from the discharge points were within the Ivorian reference standards (5.5-8.5) for untreated effluents [10]. The alkalinity of the pH at the different discharge points could be strongly attributed to the carbon dioxide (CO₂) content of the wastewater discharged by some socio-economic activities in the town of Adzopé [11]. The discharge of this wastewater into the Massan River reservoir is likely to influence physico-chemical exchanges and disrupt the structure of aquatic communities through the alkalization of the receiving environment [12].

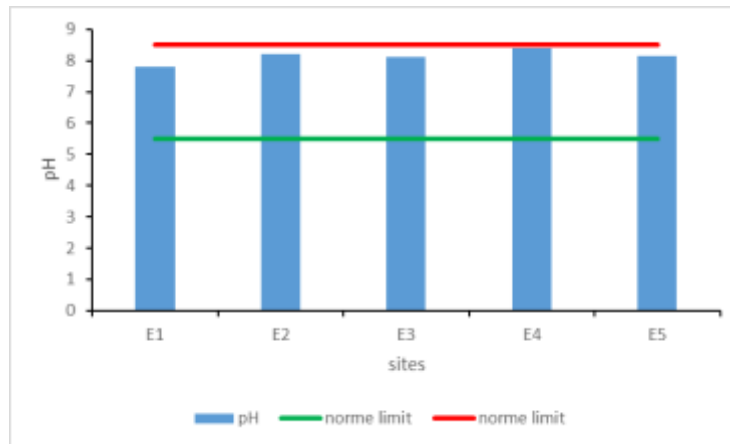


Fig. 2:- Variation of pH at different sampling sites.

Temperature

Temperature is one of the most important ecological characteristics of aquatic environments. It controls the behavioural attributes of organisms, the solubility of gases and salts in water. The basis of all life functions is formed by a complex set of biochemical reactions influenced by physical aspects such as temperature [13]. The recorded effluent temperature values range from 26.9°C to 30.4°C with an overall average of 28.3°C. The warmest waters were at site E2 (Fig. 3). For most of the sample series, the effluent temperature varies slightly from one site to another with a difference of 1.35°C (Table 1). norms (≤ 40 °C) which is considered the limit value for direct discharge into the receiving environment [10]. The temperature of the effluents does not seem to be a threat to the homeostatic equilibrium of the water reservoir [15].

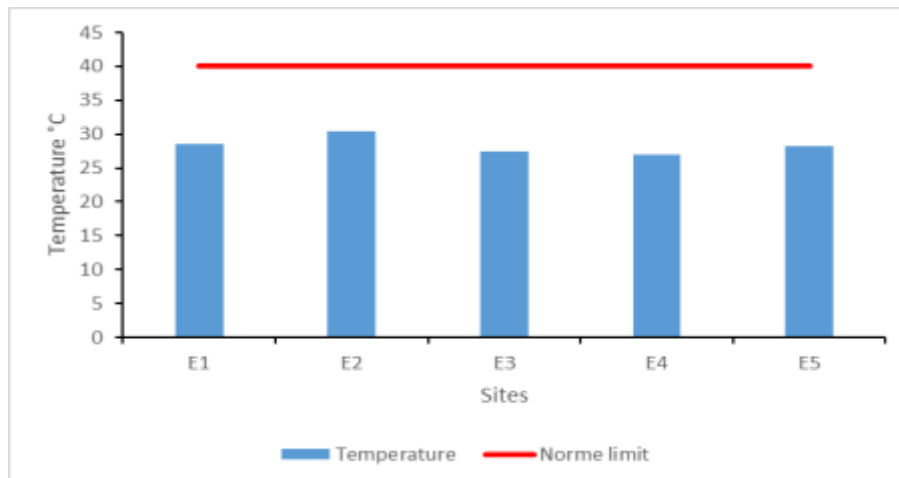


Fig. 3:- Temperature variation at different sampling sites.

Electrical conductivity

Electrical conductivity is one of the most important parameters for monitoring wastewater quality. It reflects the degree of mineralization of the water and provides information on the salinity level. It is also a measure of the concentration of dissolved salts in the water [4]. For most of the sampling points, the conductivity of the wastewater varies significantly from one site to another. The recorded conductivity ranges from 1700 to 350 $\mu\text{S}/\text{cm}$. The most mineralized waters are those at stations E3 and E4 (Fig. 4). The high conductivity values at these two sites can be explained by the fact that they receive more discharge than the other sites. The values recorded during this study indicate that the electrical conductivity of the wastewater is characterized by relatively high values, probably due to the pollutant loads in the town of Adzopé [16].

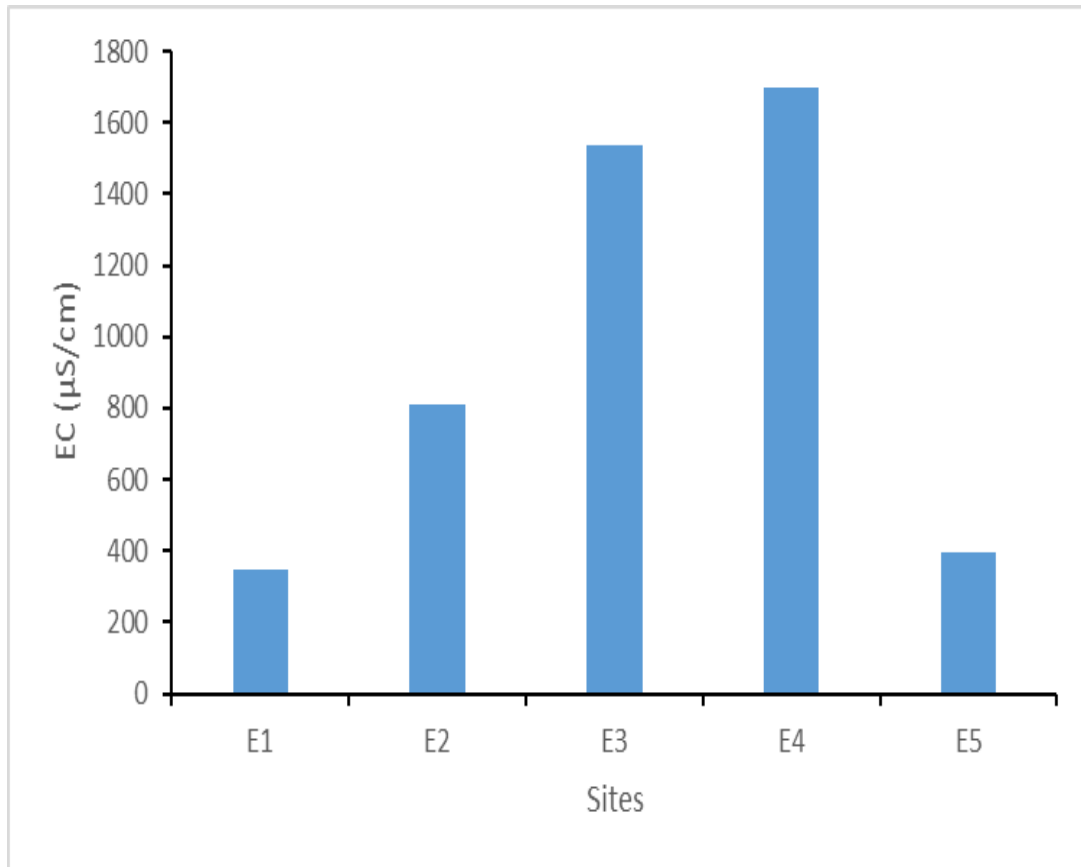


Fig. 4:- Variation in conductivity at different sampling sites.

Dissolved oxygen

Dissolved oxygen is essential for the survival of aquatic life and is therefore an important indicator of the state of ecosystems. Dissolved oxygen levels in water depend in part on the chemical, physical and biochemical activities occurring in the water. Dissolved oxygen concentrations are directly dependent on the production of oxygen through photosynthesis and its consumption by living organisms, particularly bacteria. Oxygen has limited solubility in water, which is directly related to atmospheric pressure and inversely related to water temperature and salinity [17]. The dissolved oxygen concentrations analyzed in the wastewater show small variations from one site to another. The concentrations vary between 1.29 and 2.88 mg/L with an average of 1.89 mg/L. The highest concentrations were recorded at sites E2 and E5 (Fig. 5). This is mainly due to the high-water temperature values. Indeed, cold water contains more dissolved oxygen than warm water. The decrease in dissolved O₂ concentration at the discharge sites is related to bacterial metabolism, which uses this element to degrade the abundant organic matter contained in these waters. Excessive nutrient loading can lead to dissolved oxygen depletion by stimulating algal blooms, resulting in the suffocation and death of aquatic organisms in the receiving environment [18].

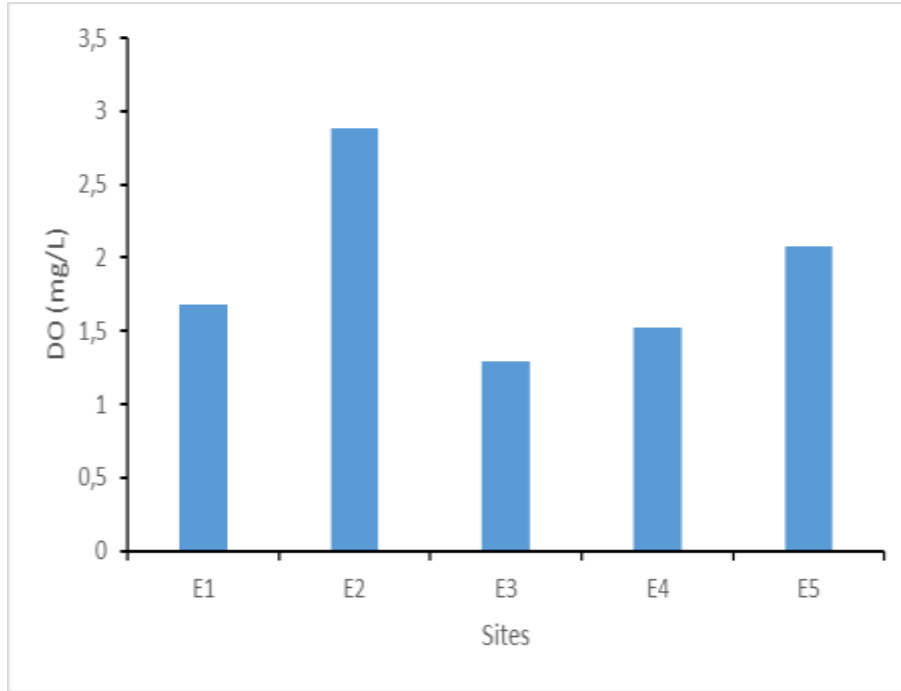


Fig. 5:- Variation of dissolved oxygen at different sampling sites.

Chemical oxygen demand

Chemical oxygen demand is the measure of the oxygen equivalent of the organic content of the sample that is susceptible to oxidation by a strong chemical oxidant. It is an assessment used to measure the level of contamination of water by organic matter [19]. The COD content of the wastewater of the town of Adzopé analyzed shows significant variations from one site to another. These levels range from 93.8 to 254.2 mg/L with an average of 143.72 mg/L. The high COD levels are recorded at sites E3 and E4 (Fig. 6). The COD values obtained in the present study revealed that all the effluents from the discharge points still comply with the Ivorian reference standards (300 mg/L) for unsettled effluent [10] According to these COD content data, nuisance in the receiving environment is noticeable in case of a large input of organic matter from untreated wastewater. Previous studies [20] have shown the influence of untreated wastewater on the quality of the receiving river.

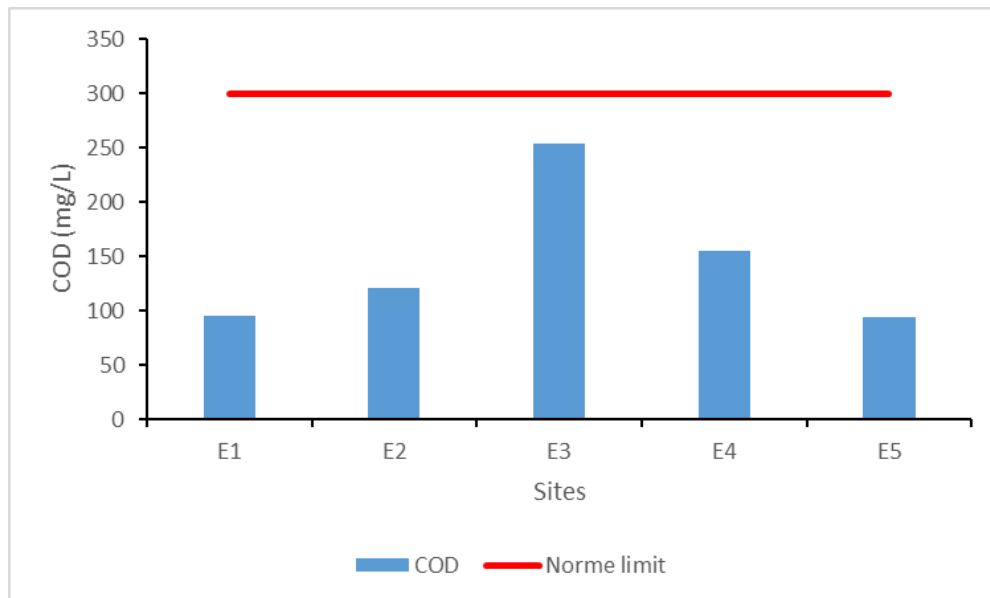


Fig. 6:- COD variation at different sampling sites.

Biochemical oxygen demand

BOD is the amount of oxygen used by micro-organisms to break down organic matter in water. The measurement of BOD is used to assess the degree of pollution of wastewater and the effectiveness of effluent treatment methods [19]. The BOD content of the wastewater analyzed in the town of Adzopé shows significant variations from one site to another. These levels range from 31 to 84 mg/L with an average of 47.44 mg/L. The high BOD levels are recorded at discharge point E3 (Fig. 7). The COD values obtained in the present study revealed that all the effluents from the discharge points still comply with the Ivorian reference standards (100 mg/L) on unsettled effluent [10]. A high BOD content would reduce the ability of micro-organisms to decompose the organic matter in the effluent, which can lead to the generation of noxious odours and the pollution of receiving surface waters [19].

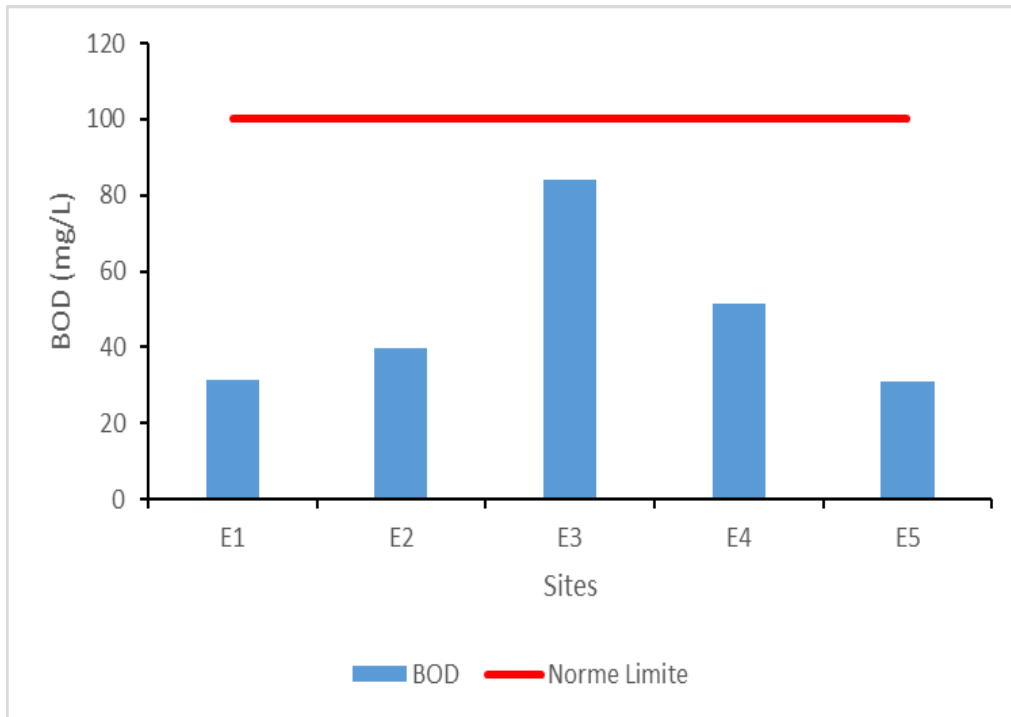


Fig. 7:- BOD variation at different sampling sites.

Total suspended solids

Suspended solids represent all the mineral and organic particles contained in wastewater. Knowledge of the concentration of colloidal elements in wastewater is necessary to assess the impact of pollution on the aquatic environment [21]. The concentrations of suspended particulate matter in the wastewater analyzed show very significant variations from one site to another. These concentrations vary between 73.4 and 199 mg/L with an average of 112.48 mg/L. The high concentrations of suspended particles are recorded at discharge point E3 (Figure 8). The TSS concentrations obtained in the present study are higher than the Ivorian reference standards (50 mg/L) which is considered as the limit value for discharge into the receiving environment [10]. This high concentration of suspended solids can prevent light from reaching submerged vegetation, which reduces the amount of oxygen released into the water. It also leads to an increase in surface water temperature [22].

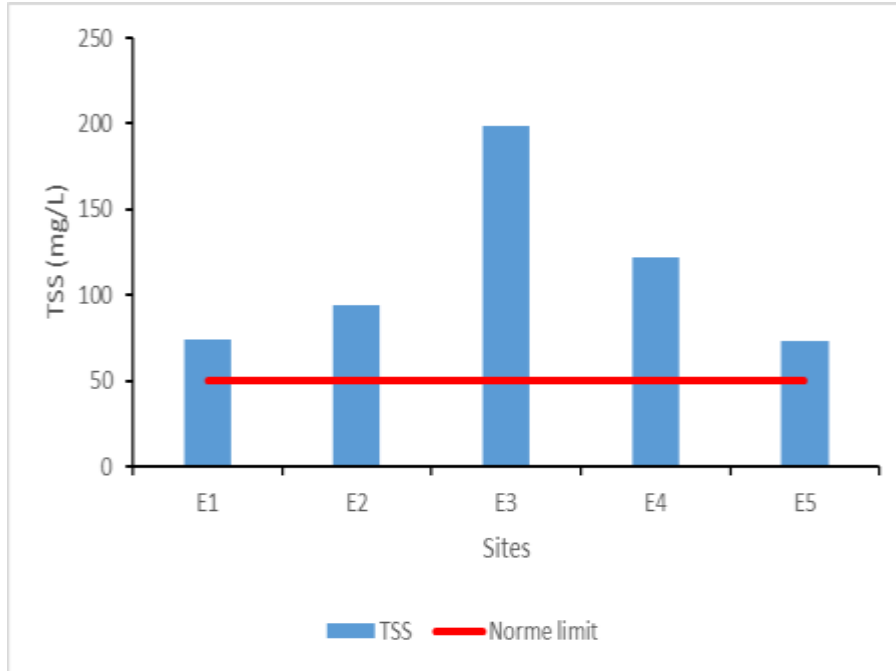


Fig. 8. Variation in total suspended solids at different sampling sites

Ammonium and nitrate

Nitrogen in wastewater can be organic or inorganic. Inorganic nitrogen including ammonium (NH₄⁺), nitrite (NO₂⁻) and nitrate (NO₃⁻) constitutes a major part of the total nitrogen [23]. The ammonium content of the analyzed wastewater shows very small variations from one site to another. The levels vary between 0.59 and 2.7 mg/L with an average of 2.07 mg/L. The levels remain low at all the study stations (Figure 9). The nitrate levels in the wastewater analyzed show average variations from one site to another. The levels vary between 1.9 and 13 mg/L with an average of 5.16 mg/L. The levels remain low overall at all study stations (Fig. 9). Nitrates are inorganic sources of nitrogen that, at appropriate concentrations, support the growth and development of living organisms. However, high nitrate levels can lead to excessive nutrient enrichment in aquatic systems (eutrophication), resulting in a loss of diversity in aquatic biota and overall ecosystem degradation through algal blooms [23]. The presence of the ammonium ion in water usually reflects a process of incomplete degradation of organic matter and is therefore an excellent indicator of the organic pollution of water [16]. In the present study, the various ammonium and nitrate levels remain very low, indicating that there is no risk of pollution of the receiving environment by the wastewater.

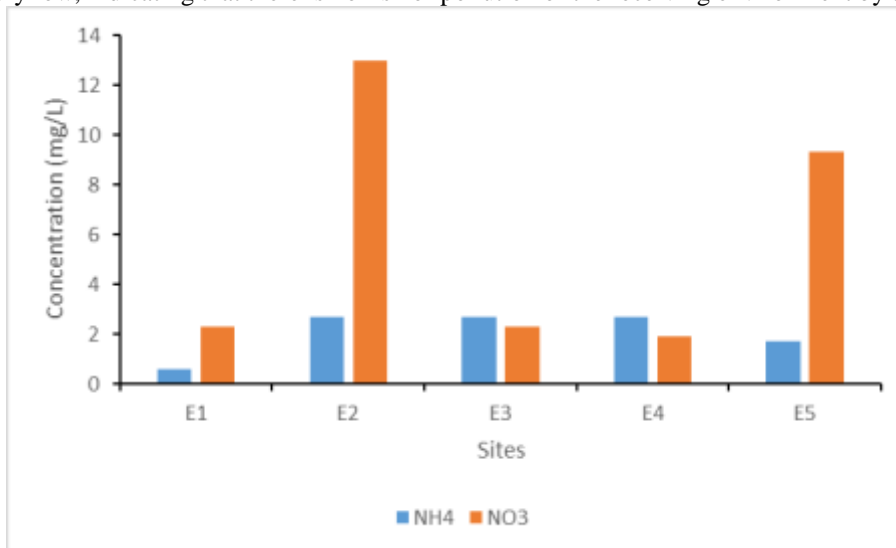


Fig. 9:- Variation of ammonium and nitrate at different sampling sites.

Phosphates

Phosphorus compounds exist in natural waters and wastewater in different forms which are soluble orthophosphates, water-soluble phosphates, and organophosphorus derivatives [23]. The recorded phosphate concentrations show significant variations during the sampling cycle from one site to another. The concentrations found vary between 0.23 and 54.8 mg/L with an average of 20.57 mg/L. The highest phosphate concentrations are recorded at discharge points E3 and E4 (Fig. 10). The phosphate concentrations obtained in the present study are higher than the Ivorian reference standards (15 mg/L) which is considered as the limit value for discharge into the receiving environment [10]. These high phosphate concentrations may be due to domestic activities and wastewater discharges that are very rich in phosphorus and may pose a risk to the Massan River reservoir [4].

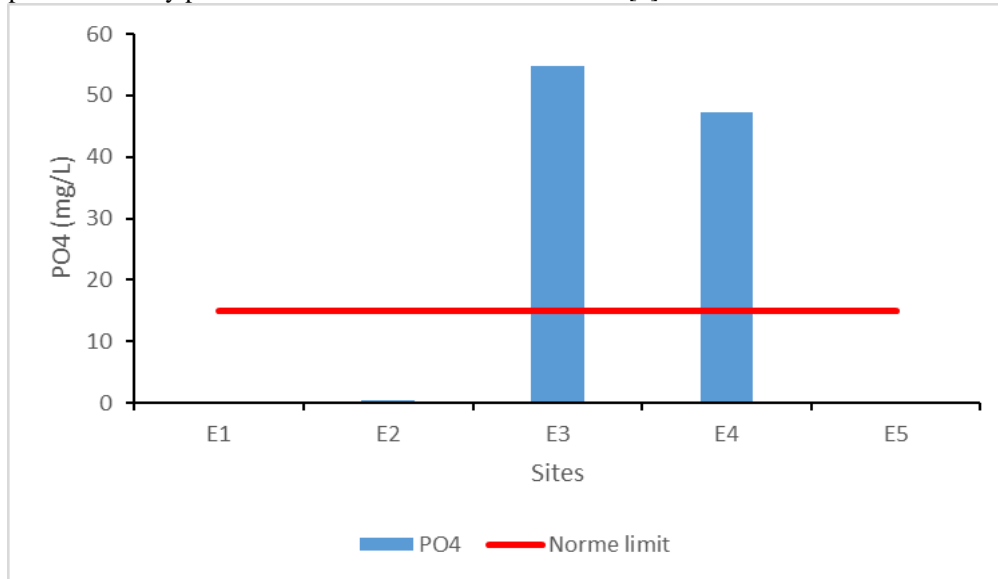


Fig. 10. Variation of phosphates at different sampling sites

Chlorides

Chlorides are very abundant ions in the environment. In the present case, the chloride ion concentrations recorded show small variations from one site to another. The concentrations found vary between 10 and 29 mg/L with an average of 19 mg/L. Chlorine ion concentrations remain low at all the study sites (Fig. 11). The high value of chlorides in the effluent pollutes the drinking water by making it suitable for the easy growth of microbes. The presence of chloride ions increases the salinity of the receiving water body [24]. For the time being, the chloride ion concentrations in the wastewater are generally low and do not pose a threat to the receiving water body.

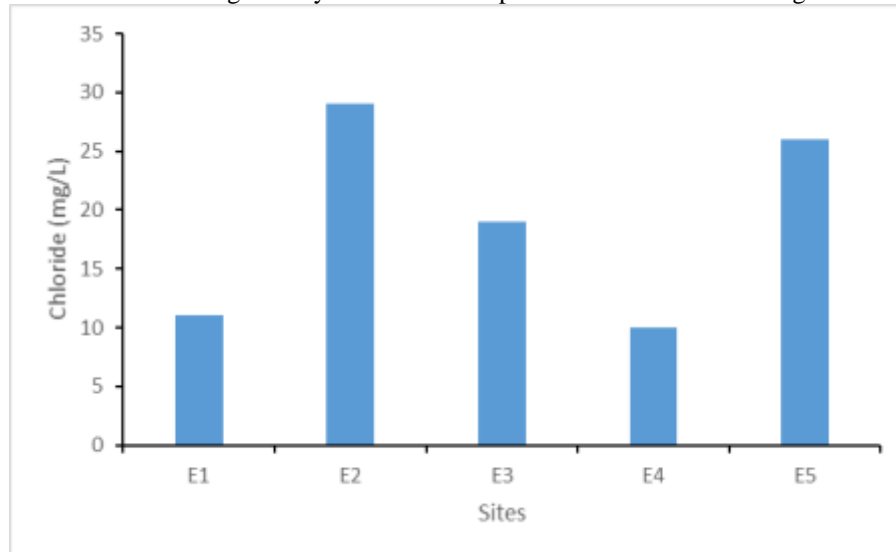


Fig. 11:- Variation of chloride ions at different sampling sites.

Conclusion:-

The quality of the water in the Massan River reservoir used to produce water for human consumption depends on the nature of the wastewater from the town of Adzopé, which is discharged directly without any prior treatment. The results of the analyses revealed the presence of the parameters studied at variable levels from one site to another. However, most of the parameters analyzed comply with the discharge standards established by Ivorian legislation, except for suspended particles and phosphate ions. These two parameters have values that exceed the established standards. This study showed that the discharge of wastewater into the water body remains the main source of its contamination. Thus, the discharge of this wastewater into the aquatic environment can lead to eutrophication and the depletion or death of fish. The need to pre-treat this wastewater before discharge to improve its quality to meet the standards required for the protection of the environment and human health is necessary.

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