OPEN ACCESS

Journal of Ecology and The Natural Environment

January-March 2024
ISSN 2006-9847
DOI: 10.5897/JENE
www.academicjournals.org

ACADEMIC JOURNALS
expand your knowledge

About JENE

Journal of Ecology and the Natural Environment (JENE) provides rapid publication (monthly) of articles in all areas of the subject such as biogeochemical cycles, conservation, paleoecology, plant ecology etc.

The Journal welcomes the submission of manuscripts that meet the general criteria of significance and scientific excellence. Papers will be published shortly after acceptance. All articles published in JENE are peer-reviewed.

Indexing

The Journal of Ecology and The Natural Environment is indexed in:
CAB Abstracts, CABI's Global Health Database, Chemical Abstracts (CAS Source Index) Dimensions Database, Google Scholar, Matrix of Information for The Analysis of Journals (MIAR), Microsoft Academic

JENE has an h5-index of 10 on Google Scholar Metrics

Open Access Policy

Open Access is a publication model that enables the dissemination of research articles to the global community without restriction through the internet. All articles published under open access can be accessed by anyone with internet connection.

The Journal of Ecology and The Natural Environment is an Open Access journal. Abstracts and full texts of all articles published in this journal are freely accessible to everyone immediately after publication without any form of restriction.

Article License

All articles published by Journal of Ecology and The Natural Environment are licensed under the Creative Commons Attribution 4.0 International License. This permits anyone to copy, redistribute, remix, transmit and adapt the work provided the original work and source is appropriately cited. Citation should include the article DOI. The article license is displayed on the abstract page the following statement:

This article is published under the terms of the Creative Commons Attribution License 4.0
Please refer to https://creativecommons.org/licenses/by/4.0/legalcode for details
about Creative Commons Attribution License 4.0

Memberships and Standards

Academic Journals strongly supports the Open Access initiative. Abstracts and full texts of all articles published by Academic Journals are freely accessible to everyone immediately after publication.

All articles published by Academic Journals are licensed under the Creative Commons Attribution 4.0 International License (CC BY 4.0). This permits anyone to copy, redistribute, remix, transmit and adapt the work provided the original work and source is appropriately cited.

Crossref is an association of scholarly publishers that developed Digital Object Identification (DOI) system for the unique identification published materials. Academic Journals is a member of Crossref and uses the DOI system. All articles published by Academic Journals are issued DOI.

Similarity Check powered by iThenticate is an initiative started by CrossRef to help its members actively engage in efforts to prevent scholarly and professional plagiarism. Academic Journals is a member of Similarity Check.

CrossRef Cited-by Linking (formerly Forward Linking) is a service that allows you to discover how your publications are being cited and to incorporate that information into your online publication platform. Academic Journals is a member of CrossRef Cited-by.

Academic Journals is a member of the International Digital Publishing Forum (IDPF). The IDPF is the global trade and standards organization dedicated to the development and promotion of electronic publishing and content consumption.

Contact

Editorial Office: jene@academicjournals.org

Help Desk: helpdesk@academicjournals.org

Website: http://www.academicjournals.org/journal/JENE

Submit manuscript online http://ms.academicjournals.org

Academic Journals
73023 Victoria Island, Lagos, Nigeria
ICEA Building, 17th Floor,
Kenyatta Avenue, Nairobi, Kenya.

Editors

Table of Contents

Vol. 16(1), pp. 1-9, January-March 2024
DOI: 10.5897/JENE2023.0963
Article Number: AAC189072048
ISSN 2006-9847

http://www.academicjournals.org/JENE

ACADEMIC JOURNALS
expand your knowledge

Journal of Ecology and The Natural Environment

Full Length Research Paper

Evaluation of the spatio-temporal variation of the physico-chemical parameter and the level of ecological pollution in the waters of the Comoé River and its tributary Iringou

Amara Ouattara[1,2]*, Tanoh Marius Kamelan[1], Dimitri Ekissi[1], Maboridjon Diabate[1], François Djah Malan[3], Florence Bobele Niamke[4], Essetchi Paul Kouamelan[1]

[1]Natural Environment Laboratory and Biodiversity Conservation, Bioscience Training and Research Unit of Felix Houphouët-Boigny University, 22 BP 582 Abidjan 22, Côte d'Ivoire.
[2]Ivoirian Parks et Reserves Office (OIPR), 06 BP 426 Abidjan, Côte d'Ivoire.
[3]Nagui Abrogoua University, Abidjan, Côte d'Ivoire.
[4]Felix Houphouët Boigny National Polytechnic Institute, Yamoussoukro, Côte d'Ivoire.

Received 18 November, 2023; Accepted 4 March, 2024

The study was conducted from May 2022 to March 2023 on the Comoe and Iringou rivers in Comoe National Park. Its aim was to assess the physico-chemical parameters and ecological stress levels of these rivers. The results show that both rivers have fewer ecological pollution parameters, with average pH values close to neutral (6.8 to 7.3). The average dissolved oxygen recorded in these streams over the two seasons indicates a level of oxygenation favorable to aquatic life. The assessment of the level of ecological pollution reveals moderate pollution at the sites studied, with the exception of Kafolo and the Ecological Research Center. Principal component analysis shows two categories of stations on the Comoe River: Kafolo station is characterized by high electrical conductivity and total dissolved solids, and the Ecological Research Center and Ganse stations by high pH and temperature. On the other hand, the stations on the Comoe River contrast with those on the Iringou River, with higher values for physico-chemical parameters.

Key words: Comoe National Park, Comoe and Iringou rivers, physico-chemical parameter, spatio-temporal, ecological pollution.

INTRODUCTION

The hydrographic network of Comoe National Park (CNP) in northeastern Côte d'Ivoire (Figure 1) consists of the Comoe River, fed by numerous tributaries such as the Iringou, Kongo, and Bamago (GIZ, 2016). These watercourses play a fundamental role as they are useful for aquatic fauna, park staff, and the populations living on its periphery. The Comoe River watershed encompasses the CNP and covers 10,000 km² (13%) (OIPR, 2015).

*Corresponding author. E-mail: amaraouat2013@gmail.com. Tel: +225 57 00 41 17/0140 01 52 85.

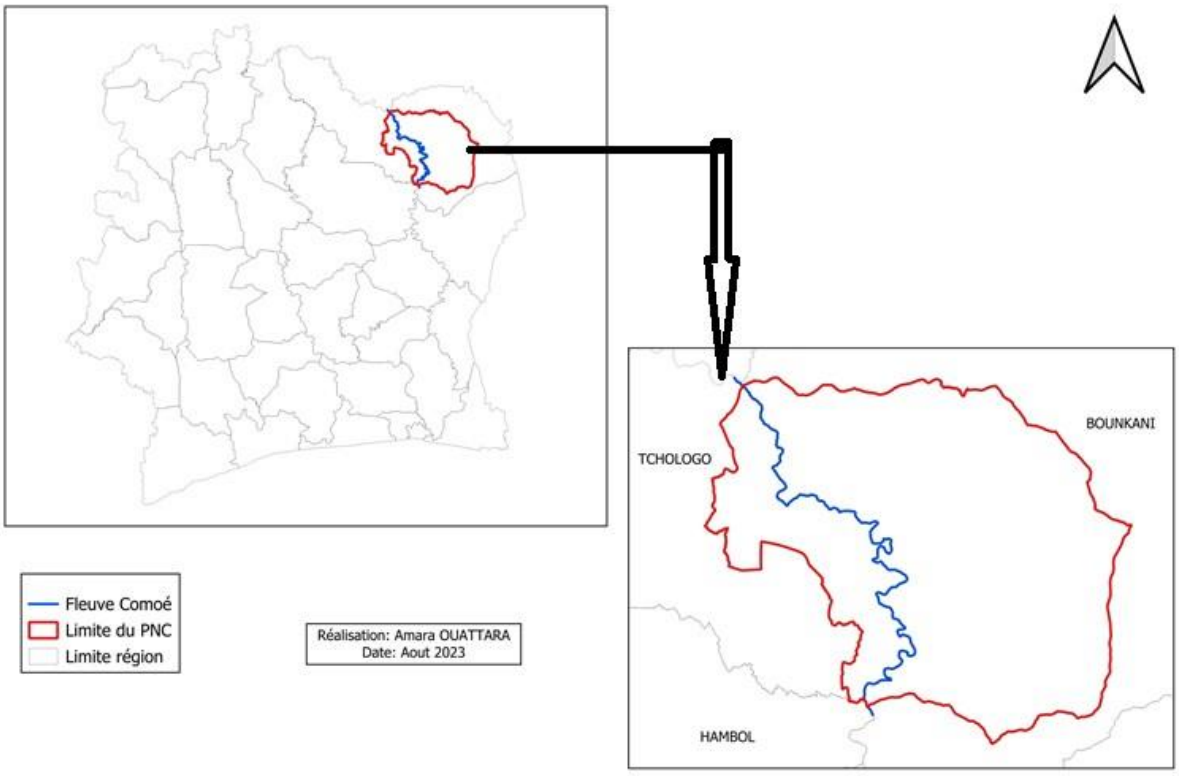

Figure 1. Location of study area.

Various ecosystem services are provided by these watercourses, which unfortunately face various pressures such as illegal fishing and gold panning.

In addition to these anthropogenic pressures, these park watercourses, positioned in the north of Côte d'Ivoire, are also subject to the influence of a sub-humid tropical climate (transitional sub-Sudanian). They suffer, in their northeastern part, the effects of a drier, sub-arid tropical climate (Sudanian). Pilot studies conducted in these rivers from 09 to 20 April 2019 and from 22 October to 03 November 2021 show variations due to the dry season (Kouamelan et al., 2019; Kouamelan et al., 2021).

Could the different pressures and seasonal variations experienced by the Comoe and Iringou rivers be the cause of changes in the physico-chemical parameters of their waters, impacting their quality and consequently affecting aquatic life and riparian populations? Indeed, according to (Muhammad, 2020; Ozovehe et al., 2015), the physico-chemical parameters of rivers provide information on their quality and suitability for human survival and the life of aquatic organisms.

The studies carried out by Kouamelan et al. (2021), over a relatively short period, were not able to address in-depth the issues of physico-chemical water quality and pollution. The present study was initiated as a contribution to improving knowledge of the physico-chemical quality of the waters of Comoe and Iringou rivers, on the one hand, and determining their level of ecological pollution on the other, based on data collected over a longer period.

MATERIALS AND METHODS

Study area

The study was conducted on the Comoe and Iringou rivers, situated within the Comoe National Park (Figure 1), spanning from May 2022 to March 2023. Five (5) sampling sites (Figure 2) were identified and underwent regular fish sampling and measurements of physico-chemical variables during this period. The Kafolo site (09°36'33.30"N; 03°40'24.10"W) is positioned under the bridge over the Comoe River at the entrance to Kafolo village, marking the point where the Comoe river enters the park. The second site is located at Ganse (08°36'54.81 "N; 03°55'12.82 "W) and corresponds to the exit of the Comoe River from the park. These two sites are distinguished by their proximity to the populations of the two villages they are named after. The third site, Ecological Research Center (SRE) (08°46'14.83 "N; 03°47'22.68 "W), is situated in the center of the park, close to the Comoe ecological research station. Unlike the first two sites, this one is less affected by human influences due to its geographical position.

On the Iringou River, two sites were sampled. One on the Tehini-Kafolo axis, approximately 5 km outside Tehini, characterized by its proximity to the peripheral zone of the park, is designated "Iringou-Tehini" (09°36'29.4"N; 03°41'58.9"W). The second site is inside the park on the road leading from Bania to the center of the park at Gawi. This site is approximately 60 km below the Iringou-Bania Bridge

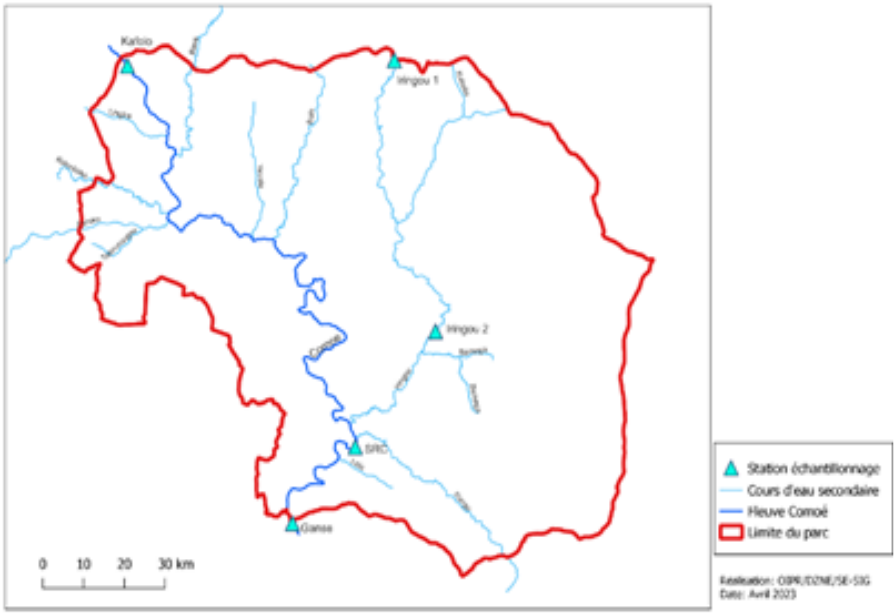

Figure 2. Location of study area and sampling stations.

(09°00'14.30'' N; 003°36'22.40'' W) and is less subject to human disturbance.

Material

The study utilized biological material, mainly consisting of fish caught during experimental fishing sessions. The technical equipment employed included gillnets with knots of 10, 20, 30, 40, and 50 mm and lengths of 30 m with a drop height of 1.5 m. A multi-parameter Lovibond SensoDirect 150 model with three (3) types of probes was used to measure physico-chemical variables (temperature, pH, electrical conductivity, total dissolved solids, and dissolved oxygen). Fish were identified using the identification key by Paugy et al. (2003). Microsoft Excel and XLstat version 2016 were used for statistical analysis.

Methods

Fishing campaigns and fish measurements

Two types of fishing were carried out. Nets were set from 7 a.m. to 12 p.m. for daytime fishing, and from 5 p.m. to 6 a.m. the following day for night-time fishing. For each fish caught, the following measurements were taken: total and standards length in centimeters (cm) using an ichthyometer; its weight in grams (g) was obtained using a 0.01g precision electronic balance. Each fish species was also counted to determine its abundance.

Measurement of physico-chemical variables

A Levibond SensoDirect 150 model multi-parameter equipped with three (3) types of probes was used to measure the following variables: temperature (T), dissolved oxygen (O_2), hydrogen potential (pH), electrical conductivity (EC) and total dissolved solids content (TDS). Measurements were taken *in situ*. To measure each of these variables, the corresponding probe is immersed in the water. The value of the variable is obtained by direct reading on the multi-parameter display screen, after 2 to 5 minutes immersion in water.

Assessment of pollution levels

To assess the level of ecological stress or pollution in the sites studied, the ABC method as highlighted by Warwick (1986) and Grall and Coïc (2006) was used to evaluate the pollution status of a marine benthic macroinvertebrate community. This author shows that comparison of biomass curves (total fish weight) and species abundance (specific richness) yields three possible forms of environmental conditions: unpolluted, moderately polluted and highly polluted.

Statistical analysis of data

To compare the mean values of the physico-chemical variables studied, we used Student's t-test for seasonal variations and bivariate ANOVA to compare the sampled sites. We also performed a principal component analysis (PCA) to characterize the sampled sites.

RESULTS

Spatial variation in physico-chemical variables

Table 1 displays the mean values, minimums, maximums, and standard deviations of the physico-chemical variables measured at the five study sites. In the Comoé River, mean temperatures ranged from 27.7±0.8 at the Kafolo station in the north of the park to 29.4°C ±1.2 at the Ecological Research Station (SRE) in the center of the

Table 1. Variation in physical Parameters by sampling station.

Rivers	Stations	Position/dispersion parameters	T	pH	O_2 (mg/L)	CE (µS/cm)	TDS (mg/L)
Iringou	Iringou-Bania	Min-Max	23.0-25.9	6.6-7.4	1.8-6.3	38-71.5	19-52.2
		Mean±SD	24.8±0.8	7.0±0.3	4.6±1.5	52.1±11.1	31.9±11.3
	Iringou-Tehini	Min-Max	22.8-26.2	6.2-7.5	1.5-9.3	27-58.6	13-37.7
		Mean±SD	25.1±0.9	6.8±0.4	4.1±2.4	42.4±12.2	24.3±9.8
		Overall mean±SD	24.9±8.9	6.9±0.4	3.4±2.1	47.3±12.7	28.1±11.2
Comoe	Ganse	Min-Max	26.4 - 31.8	6.4 - 8.0	2.7 - 9.9	23 - 69	11- 47.1
		Mean±SD	29.2±1.7	7.2±0.4	5.6±2.0	50.8±16.4	35±11.9
	SRE	Min-Max	27.1 - 31.7	6.6 - 8.9	2.5 - 10.5	49 - 67	24 - 45.1
		Mean±SD	29.4±1.2	7.3±0.6	5.7±2.2	56±5	33.5±6.8
	Kafolo	Min-Max	26.8 - 29.1	6.7 - 7.7	5.3 - 6.0	41.6 - 65.7	27.5 - 44.5
		Mean±SD	27.7±0.8	7.0±0.4	5.7±0.2	56.5±9.6	37.8±6.6
		Overall mean±SD	29.0±1.5	7.2±0.5	5.7±2.0	54.4±11.2	34.9±8.9
Reference limit values World Health Organization (WHO), 2017			16 - 32	6,5 – 8,5	4 - 6	1000	1000

pH: hydrogen potential; **EC**: electrical conductivity; **T**: temperature; **O_2**: dissolved oxygen; **TDS**: total dissolved solids.

Table 2. Variation in physical parameters by season.

Season	Position/dispersion parameters	T	pH	O_2 (mg/L)	CE (µS/cm)	TDS (mg/L)
Rainy	Min-Max	23-31.8	7.1 - 8.9	4.1 - 7.8	33.1 - 67.4	22.6- 47.1
	Mean±SD	28.8±2.4	7.5±0.4	5.7±0.8	50.1±9.9	35.8±7.5
Dry	Min-Max	22.8 - 31.4	6.2 - 8.0	1.5 - 10.5	23 - 71.5	11.0 - 52.2
	Mean±SD	26.9±2.1	6.9±0.4	4.9±2.5	52.9±13.2	30.8±11.1
Reference limit values World Health Organization (WHO) 2017		16 - 32	6.5 – 8.5	4 - 6	1000	1000

park. In the Iringou River, mean temperature values ranged from 24.8°C ±0.8 at the Iringou-Bania station (in the center of the park) to 25.1°C ±0.9 at the Iringou-Tehini station (in the north of the park). The highest temperature value (26.2°C) on this river was measured at the Iringou-Tehini station. Table 1 shows the mean, minimum, maximum values, and standard deviations of the various physico-chemical parameters measured at the five stations studied. The results indicate that, for all the physico-chemical parameters measured, the mean values obtained are greater in the waters of the Comoé River than in the waters of the Iringou River.

In the Comoé River, the waters are warmer, with temperatures varying between (26.4 and 29.2°C) and an average of (29.0±1.5°C), and a near-neutral average pH (7.2±0.5). These waters are relatively more oxygenated (5.7±2.0 mg/L). As for the Iringou River, the waters are rather cold, with temperatures ranging from (22.8 to 24.8°C) and an average of (25.1±0.9°C). The waters are acidic (6.8±0.4 mg/L) and less oxygenated (6.8±0.4 mg/L) than the Comoé. Table 2 shows the seasonal variations in physico-chemical parameters measured in the waters of the Comoé and Iringou rivers. The results indicate that, with the exception of electrical conductivity, which has a low mean value in dry season, all the other parameters studied have a higher mean value in the rainy season than in the dry season. With normality verified, the ANOVA comparison test was conducted, revealing that temperature varies significantly from one station to the next ($p=0.0001<0.05$) and that temperature and pH vary significantly from one season to the next ($p=0.0001 <0.05$) in both streams.

During the dry season, while mean electrical conductivity was highest (52.9±13.2 µS/cm), total dissolved solids recorded the lowest mean values (30.8±11.1 mg/L). Principal component analysis (PCA) was used in this study to highlight either physico-chemical similarities or differences between the different sites studied. The

Table 3. Correlation matrix (Pearson (n)) between variables.

Variables	T	pH	O_2	CE	TDS
T	1	0.85	0.90	0.65	0.68
pH	0.85	1	0.74	0.64	0.50
O2	0.90	0.74	1	0,90	0.91
CE	0.65	0.64	0.90	1	0.91
TDS	0.68	0.50	0.91	0.91	1

correlation matrix above (Table 3) shows a positive correlation between all the variables studied. Principal Component Analysis (PCA) reveals that the factors (F1=81.77) and (F2=13.32) explain 95.09% of the variability of the parameters studied (Figure 8). The physico-chemical variables studied are all correlated with F1, as are the stations studied. Temperature and pH on the one hand, and electrical conductivity and total dissolved solids on the other, are positively correlated with the F1 axis.

The F1 axis divides the stations into two opposing groups. Stations on the Iringou River (Iringou-Bania and Iringou-Téhini) are opposed to those on the Comoé River (Kafolo, Ganse and SRE). The Kafolo station is characterized by the influence of electrical conductivity, total dissolved solids, and dissolved oxygen, while the Ecological Research Center (SRE) and Ganse stations are distinguished by higher temperatures and pH (Figure 8). At the Comoe river sites, mean pH values ranged from 7.0±0.4 at Kafolo to 7.3±0.6 at the Ecological Research Center (SRE). The highest pH value (8.9) was measured at the SRE and the lowest (6.4) at Ganse (Table 1). At sites on the Iringou, average pH ranged from 6.8±0.4 at Iringou-Tehini to 7.0±0.3 at the Iringou-Bania station.

On the Comoe River, mean dissolved oxygen ranged from 7.0±0.4 mg/L at Kafolo to 7.3±0.6 mg/L at SRE. Minimum and maximum values were measured at SRE (2.5 and 10.5 mg/L). On the Iringou tributary, the average recorded was 3.4±2.1 mg/L. The maximum and minimum values (9.3 and 1.5 mg/L) were obtained at Iringou-Téhini. Table 2 shows the seasonal variations in the variables measured at Comoé National Park, with the highest mean temperature (28.8±2.4°C) recorded during the rainy season and the lowest (26.9±2.1°C) during the dry season. The ANOVA comparison test revealed that T was significantly different from one station to another ($p = 0.0001 < 0.05$). In terms of seasonal variation, a significant difference (p-value <0.05) for T and pH was also observed between stations on the Comoé River and those on its Iringou tributary between seasons.

Conductivity is defined as the ability of water to conduct electric current between two electrodes. During our study, the highest value recorded for conductivity was 71.5 µS/cm measured during the dry season. On the Iringou River, the average TDS value ranged from 25.5 to 31.9 mg/L. Minimum and maximum values, 13.0 mg/L and 52.2 mg/L respectively, were recorded at Iringou-Tehini and Iringou-Bania.

Assessment of pollution levels in the study area

In the present study, 62 fish species were caught in 18 families and 8 orders. Three families dominated the population: Citharinidae (26%), Schilbeidae (20%) and Alestidae (18%). Comparing the ABC curves obtained reveals a nearly overlapping pattern at the Ganse, SRE, and Iringou-Téhini sites (Figures 3, 4, and 7). For the Kafolo and Iringou-Bania sites (Figures 5 and 6), the biomass curve surpasses the abundance curve. Principal Component Analysis (PCA) was used in this study to highlight physico-chemical similarities or differences between the different sites sampled. The correlation matrix (Table 3) shows a positive correlation between all the variables studied.

In the Principal Component Analysis (PCA), we observe that factors (F1=81.77) and (F2=13.32) collectively explain 95.09% of the variability (Figure 8). All the physico-chemical variables studied show a correlation with F1, as do the sampled sites. The variables T°C and pH, on one hand, and EC and TDS, on the other, are positively correlated. The F1 axis segregates the stations into two opposing groups: the Iringou-Bania and Iringou-Téhini sites on one hand, and the Kafolo, Ganse, and SRE sites on the other. The Kafolo site is characterized by higher EC, TDS and O_2, while the SRE and Ganse sites stand out for their high T and pH (Figure 8).

DISCUSSION

The average temperature recorded in the Comoe River is (29.0±1.5°C). This value indicates that the river is relatively warmer than the range defined by the World Health Organization (between 22 and 25°C). However, this result is similar to that of Ahoussi (2021) and Silga et al, (2023) respectively in the surface waters of the Kokumbo mining sites (29.04±2.76°C) in central of Ivory Coast and Loumbila tank (29,69±0,96), in Burkina Faso. The high temperature recorded in this river is partly due to the low coverage of the canopy. Indeed, the large surface area of the water body in contact with the sun's rays increases the potential for water heating (Silga et al., 2023).

According to the Iringou River, the mean recorded temperature was (24.9±8.9°C). This river appears colder than the Comoe River but still aligns with WHO standards (2017). This value is also similar to that recorded at Toumanguié (25.2°C) in the south of the country (Eblin et al., 2014). This result is different to that obtained (25°C to 27°C) by (Aristide and Ernest, 2020) in waters of the Divo department and those located near the department's mining sites. The low temperature of the Iringou River could be linked to the closed canopy of the gallery forest

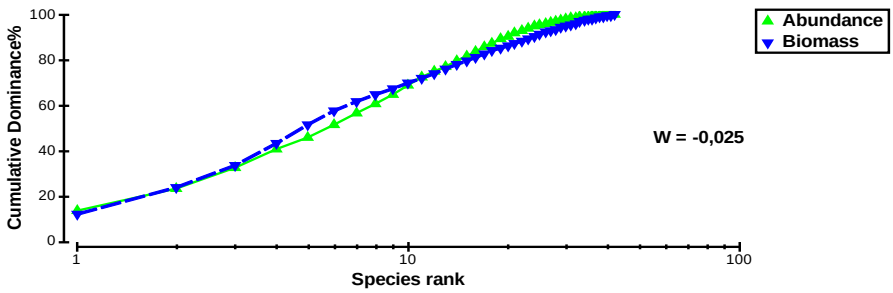

Figure 3. Abundance-Biomass comparison curve for Ganse site.

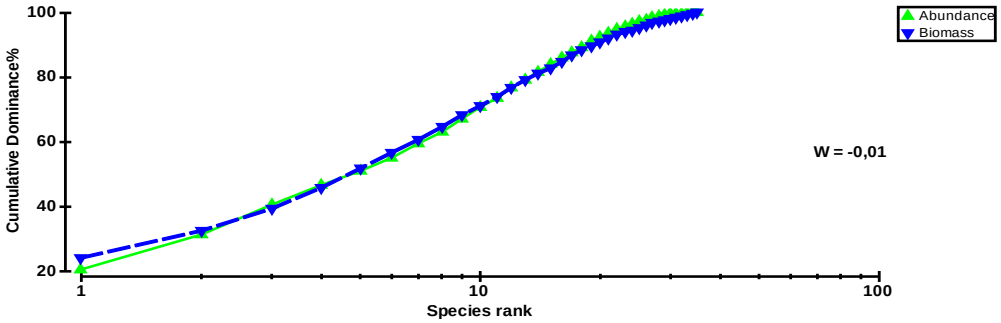

Figure 4. Abundance-Biomass comparison curve for SRE site.

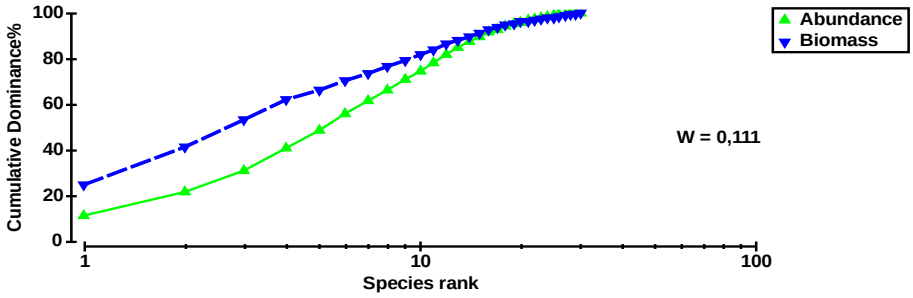

Figure 5. Abundance-Biomass comparison curve for Kafolo site.

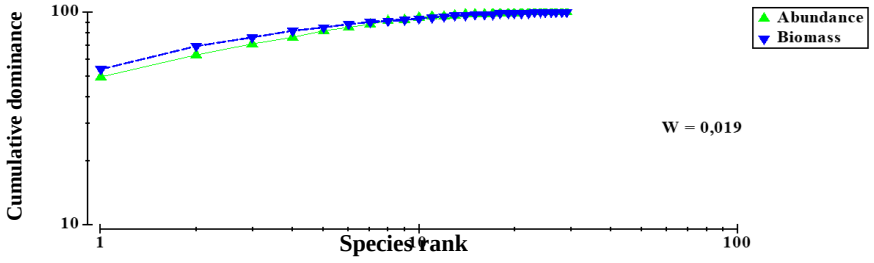

Figure 6. Abundance-Biomass comparison curve for Iringou-Bania site.

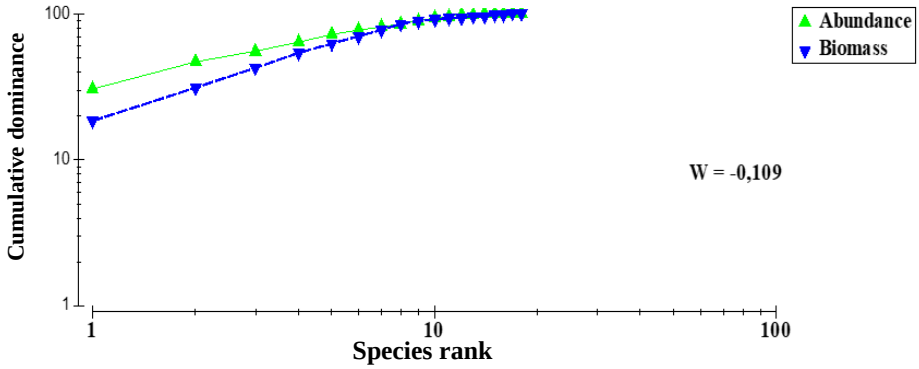

Figure 7. Abundance-Biomass comparison curve for Iringou-Tehini site.

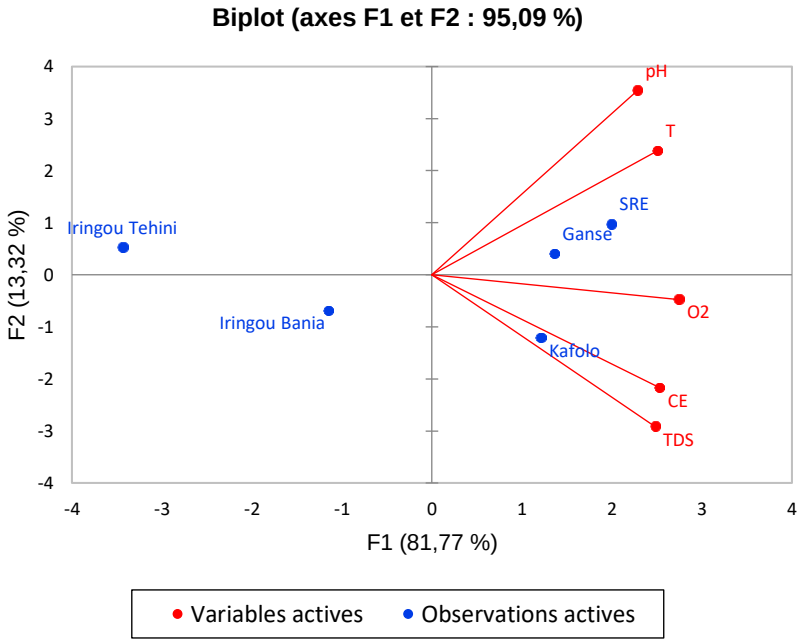

Figure 8. Distribution of statistical units on the F1 - F2 factorial plane.

along the river, which considerably reduces the water body's contact with solar radiation. Using a student's t-test, we compared the average temperatures obtained at our stations with the WHO (2017). The results suggest a significant difference ($p = 0.0001 < \alpha = 0.05$). The pH values recorded on the two rivers ranged from 6.2 to 8.9, with an average of 6.8±0.4 and 7.2±0.5 on the Iringou and Comoe respectively. These results are similar to those obtained in water from the Kokumbo mining site by Ahoussi (2021) and are in line with the WHO (2017) for drinking water (6.5 to 8.5).

These average pH values oscillate around neutrality, suggesting less aggressive water with ideal conditions for the development of aquatic life. (Muhammad, 2020) reports that aquatic animals thrive best when the pH is slightly acidic or slightly alkaline, that is, between (6.5 and 8.0). The average pH value (6.9±0.4) in the dry season is lower than that recorded in the rainy season (7.5±0.4). These values corroborate those obtained (6.8 and 7.7) in the Senegal River during the rainy season (September) by N'diaye et al. (2013). The low pH value obtained at Iringou in the dry season could be due to the canopy is closed, during this season the plant matter in the water decomposes, producing CO2, which is responsible for the reduction in pH (Niamké and Kôkôh, 2020). Our results are, however, contrary to those observed by Iltis and Leveque (1982), Soro et al. (2021). These authors found higher pH values in the dry season than in the rainy season. Kone et al (2022) observe that this parameter shows no significant variation from one season to the next.

The high average pH values observed in this study during the rainy season could be explained by the fact that in the Comoe river watershed, there are several anthropogenic activities, including agriculture using pesticides and fertilizers. During the rainy season, runoff water carries agricultural residues into the water studied, which could be responsible for the increase in pH due to photosynthetic activities. ANOVA analysis shows that temperature and pH are significantly different ($p= 0.0001$ and $p= 0.034<0.05$) from one stream to another, suggesting that these streams may be different in their functioning. The mean dissolved oxygen values obtained for the Comoe and Iringou rivers are 5.7±2.0 and 3.4±2.1 mg/L respectively. These values are broadly similar to those obtained (3.08 and 5.46 mg/L) by (Keumean et al. 2013) in the waters of the Comoe River estuary in the south-east of the country. However, our mean values are well above the WHO (2017) standard (0.5 mg/L) for surface waters.

The average dissolved oxygen content is higher (5.7±2.0 mg/L) during the rainy season in the Comoe River. Kone and al. (2022) also observed in the lake waters of the Kossou hydroelectric dam on the Bandama River in Côte d'Ivoire, higher dissolved oxygen concentrations in the rainy season (6.74 ± 1.03 mg/L) than in the dry season (5.50 ± 0.88 mg/L). This could be due to the rise in water levels, resulting in an increase in water current velocity favorable to exchanges between the ambient air and the water plane. The waters of the Comoe would therefore be favorable to the development of aquatic life (Muhammad 2020). This author reports that low oxygen concentration affects aquatic life and stresses fish. Principal Component Analysis (PCA) revealed that the factors (F1=81.77) and (F2=13.32) explained 95.09% of the variability in the parameters studied (Figure 8). Physico-chemical variables studied are all correlated with F1, as are the stations studied. Temperature and pH on the one hand, and electrical conductivity and total dissolved solids on the other, are positively correlated with the F1 axis.

The F1 axis divides the stations into two opposing groups. Stations on the Iringou River (Iringou-Bania and Iringou-Téhini) are opposed to those on the Comoe River (Kafolo, Ganse and SRE). Kafolo station is characterized by the influence of electrical conductivity, total dissolved solids and dissolved oxygen, while the Ecological research station (SRE) and Ganse stations are distinguished by higher temperatures and pH (Figure 8). Electrical conductivity measured at sites along the Comoe River ranged from 52.2 (µS/cm) at Ganse to 56.5 (µS/cm) at Kafolo. These values are broadly similar to those measured by YAO (2006) at Kafolo (55.41 µS/cm) and Ganse (47.76 µS/cm). The difference between these readings at Kafolo is not statistically significant (p-value = 0.681>0.05). The same applies to the Ganse station (p-value = 0.41> 0.05).

The electrical conductivity recorded in the two rivers studied is considered to be one of the lowest in Ivory Coast and sub-Sahelian Africa, where values between 800 and 2400 µs/cm and 60 and 240 µs/cm were recorded respectively in the Aby lagoon in Ivory Coast and in the Lake Oueme delta in Benin (Hasni et al., 2018). It is strongly influenced by total dissolved solids (TDS) (Konunga et al., 2018). The two rivers studied have overall conductivities <100 µS/cm, which classifies them among very low mineralized water (Konunga et al., 2018). The ABC curves show a near superposition of the two curves at the Ganse, SRE and Iringou-Tehini stations. According to (Warwick, 1986), these sites are considered moderately polluted. At the Kafolo and Iringou-Bania sites, the biomass curve is above that of abundance. In such situations (Warwick, 1986) indicates that these sites are not subject to any pollution. The pollution observed at Ganse and Iringou-Téhini is linked to their proximity to the park's peripheral zone, where various anthropogenic activities such as agriculture, ling leaching and fishing are carried out.

The absence of pollution observed at the Iringou-Bania site could be explained by its position in the center of the protected area, characterized by a low human presence. As for the absence of pollution noted at the Kafolo station, despite its position in close proximity to the population, this could be linked to the fact that the park manager organizes regular monitoring missions in this part of the park, which limits anthropogenic activities (fishing, laundry washing, etc.). The PCA analysis enabled us to characterize two groups of sites studied. Sites on the Comoe river differ from those on its Iringou tributary in having higher values for T, pH, O_2, EC and TDS. In contrast, these values are lower at Iringou sites. The low values recorded on the Iringou could be linked to the high canopy cover, which limits air exchange with the water surface, and to the smaller width of the water body compared with the Comoe River.

Further PCA analysis demonstrates a clear separation between stations on the Comoe and Iringou rivers. This divergence could be attributed to the flow rate and size of each of these two rivers. The Iringou, being smaller, allows for quicker observations of physico-chemical parameter variations compared to the larger and longer Comoe River. Figure 8 illustrates those stations along the Iringou exhibit lower values across all measured parameters compared to the Comoe River.

Analysis of the biomass-abundance curve indicates a low level of pollution at Kafolo and Iringou-Bania. This suggests that the studied stations may share similar physico-chemical characteristics and may also be less susceptible to pressure from fishermen and other anthropogenic activities that can cause ecological stress for fish.

CONCLUSION

The study conducted in the Comoe National Park on the Comoe and Iringou rivers reveals that the physico-

chemical variables in these two rivers are generally conducive to the development of aquatic life. The assessment of ecological pollution levels highlights moderate pollution at the studied sites, except for Kafolo and Iringou-Bania, where virtually no ecological pollution is observed. The Principal Component Analysis (PCA) demonstrates that the sites along the Comoe River differ from those along the Iringou River, exhibiting higher values for all the studied physico-chemical variables.

ACKNOWLEDGEMENTS

The authors would like to express their sincere thanks to all those who, in one way or another, contributed with advice, technical and financial support. They are particularly grateful to General Tondossama Adama, Colonel KOUADIO Yao Roger, Dr Djafarou Tiomoko, Dr Gba Clément and the entire GIZ team for their financial and technical support.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Ahoussi KE (2021). Étude de la minéralisation des eaux de surface en éléments traces métalliques (ETM) des zones d'orpaillage de la sous-préfecture de Kokumbo, Centre-Ouest de la Côte d'Ivoire ». Afrique SCIENCE 19(4):36-50.

Aristide YS, Ahoussi KE (2020). Caractérisation physico-chimique des eaux de surface dans un environnement minier du centre-Ouest de la Côte d'Ivoire: Cas du Département de Divo. European Scientific Journal 16(12).

Eblin SG, Sombo AP, Gbombele S, Aka N, Ollo K, Soro N (2014). Hydrochimie des eaux de surface de la région d'Adiaké (sud-est côtier de la Côte d'Ivoire). Journal of Applied Biosciences 75:6259.

GIZ (2016). Comptage aérien de la faune du Parc national de la Comoé, Site du Patrimoine mondial et Réserve de Biosphère - Côte d'Ivoire et des deux zones de biodiversité. Rapport d'Activités-Abidjan, Côte d'Ivoire.

Grall J, Coïc N (2006). Synthèse des méthodes d'évaluation de la qualité du benthos en milieu côtier. Institut Universitaire Européen de la Mer – Laboratoire des sciences de l'Environnement Marin. Université de Bretagne Occidentale.

Iltis A, Lévêque C (1982). Caractéristiques physico-chimiques des rivières de Côte d'Ivoire. Revue Hydrohiology 15(2):115-130.

OIPR (2015). Plan d'Aménagement et de gestion du Parc national de la Comoé 2015-2024. Rapport, Ministère de l'Environnement et du Développement Durable, Abidjan (Cote d'Ivoire).

Keumean KN, Bamba SB, Soro G, Metongo BS, Soro N, Biemi J (2013). Evolution Spatio-Temporelle de La Qualité Physico-Chimique de l'eau de l'estuaire Du Fleuve Comoé (Sud-Est de La Côte d'ivoire). International Journal of Biological and Chemical Sciences 7(4):1752-1766.

Kone N, N'DA AS, Kien K, Gnonléba B, Boguhé F, Berté S (2022). Caractérisation physico -chimique des eaux du lac du barrage hydroélectrique de Kossou, fleuve Bandama, Côte d'Ivoire. Revue Ivoirienne des Sciences et Technologie 39(2022):55-69.

Konunga G, Muyaya B, Muamba P (2018). Évaluation de la dégradation de quelques paramètres physicochimiques de l'eau de la rivière Lukaya en République Démocratique du Congo. 14(2):1-12.

Kouamelan EP, Kamelan TM, Diomandé A, Ekissi D, Ouattara A (2021). Evaluation de l'état de conservation de la biodiversité aquatique du Parc national de la Comoé - Patrimoine mondiale – Réserve de Biosphère de l'UNESCO. Rapport d'études. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Bouna (Côte d'Ivoire).

Kouamelan EP, Kamelan TM, Ekissi D, Ouattara A, Diabaté M, Gnamien TA (2019). Etude sur la qualité des eaux du fleuve Comoé Patrimoine mondial - Réserve de Biosphère. Rapport d'études. Office Ivoirien des Parcs et Reserve. Bouna, Côte d'Ivoire.

Muhammad F (2020). Study of Seasonal Variation of Physicochemical Parameters of River Kaduna, Kaduna State Nigeria. International Journal of Advances in Scientific Research and Engineering (ijasre) 6(1):1-6.

N'Diaye AD, K. Mint MS, Ould Sid'Ahmed M, Ould K (2013). Contribution à l'étude de la qualité physicochimique de l'eau de la rive droite du fleuve Sénégal. LARHYSS Journal P 12. https://larhyss.net/ojs/index.php/larhyss/article/view/148.

Niamké KH, Kôkôh RE (2020). Caractérisation des paramètres physiques et du taux de mercure des eaux dans un environnement d'orpaillage : cas de Kouamé fla dans le département d'Oumé (Centre de la Côte d'Ivoire). IOSR Journal of AppliedGeology and Geophysics (IOSR-JAGG) 8(1):48-56.

Ozovehe PS, Adakole JA, Suleiman B (2015). River Galma, Physico-Chemical Parameters, Xenobiotics, Anthropogenic Activities, Acceptable Limits. Resources and Environment 5(4):110-23.

Paugy D, Teugels GG, Lévêque C (2003). Poissons d'eaux douces et saumâtres de l'Afrique de l'Ouest. Muséum national d'Histoire naturelle, Paris (France), Vol. 1 & 2, 40 p.

Hasni T, Mahfoudh M, Mhamed BAM, Aliyen A, Yarba L, Hmeyada AMV (2018). Caractérisation physico-chimique des eaux de surface et étude de la diversité ichtyologique de quelques zones humides continentales en Mauritanie. European Scientific Journal, ESJ 14(6):83.

Silga S, Ouedraogo I, Oueda A, Bancé V, Djidama S, Kabré G, Komandan M, Gneme A (2023). Évaluation de la qualité des eaux de surface basée sur les paramètres physico-chimiques des eaux et les macroinvertébrés : cas du réservoir de Loumbila, Sciences Naturelles et Appliquées 41(2):73.

Soro TA, Silué KD, Gogbé ZM, Gooré BI G, Coulibaly L (2021). Paramètres physico-chimiques des eaux du bassin du Haut Bandama (Côte d'Ivoire). Revue des Sciences et de la Technologie 27(1):33-48.

Warwick RM (1986). A New Method for Detecting Pollution Effects on Marine Macrobenthic Communities. Marine Biology 92(4):557-562.

World Health Organization (WHO) (2017). Guidelines for Drinking-Water Quality: Fourth Edition Incorporating First Addendum.: Geneva, 4th ed + 1st add. 541p. https://iris.who.int/handle/10665/254637.

Yao SS (2006). Etude de la diversité biologique et écologie alimentaire de l'ichtyofaune d'un hydrosystème ouest africain: Cas du bassin de la Comoé (Côte d'Ivoire). These de doctorat, Cocody-Abidjan: Université Félix Houphouët Boigny, Cocody-Abidjan.

Related Journals: