Quest Journals
Journal of Research in Environmental and Earth Sciences
Volume 11 ~ Issue 6 (June 2025) pp: 26-33
ISSN(Online) :2348-2532
www.questjournals.org

Research Paper

Determination of Physico-Chemical and Microbiological Parameters Indicative of the Pollution Level of the Kabondo Stream in Kisangani (DRC)

LIKANGO LUTHA Pascaline[1]
KAYISU KALENGA[1-2], TSHINYANGU KANDANDA[1-3], FOMA KIBWEGA[2].
[1.] *Faculty of the Institute of Agronomic Sciences of Yangambi, Department of Industrial Agricultural Chemistry.*
[2.] *Faculty of the Institute of Agronomic Sciences of Yangambi, Laboratory of Biochemistry and Human Nutrition, P.O. Box 1232, Kisangani, DR Congo.*
[3.] *Faculty of the Institute of Agronomic Sciences of Yangambi, Laboratory of Process Engineering and Microbiology , P.O. Box 1232, Kisangani, DR Congo.*

Abstract
Environmental disturbances caused by anthropogenic activities are increasing in many regions of the world, leading to various forms of water pollution. These types of pollution are significant and pose major regional and local public health challenges. The Kabondo stream is a marshy plain where groundwater emerges and converges to form a stream that flows through a densely populated urban area, making it subject to pollution. In the city of Kisangani and its surroundings, there are clear signs of pollution resulting from human activities.
In this context, it is crucial to conduct a systematic study of the Kabondo stream to evaluate the influence of seasonality on water quality. Such a study is essential to propose appropriate strategies for the integrated management of water resources and the protection of public health. The absence of recent and reliable local data on these parameters under the specific conditions of Kisangani represents a scientific and technical gap that must be filled (Mukadi & Kayembe, 2019).
To assess the impact of seasonality on water quality, this study was carried out on the Kabondo stream, located in the urban area of Kisangani. Physico-chemical (temperature, pH, dissolved oxygen, conductivity, turbidity, nitrates, BOD5) and microbiological (fecal coliforms and fecal streptococci) analyses were performed both in situ and in the laboratories of the Faculty of Sciences and the Bralima brewery in Kisangani, Democratic Republic of the Congo, across three sites during the dry and rainy seasons.
According to the statistical ANOVA analysis performed on the data collected during the dry and rainy seasons, there is a significant difference between the various physico-chemical and microbiological parameters of the Kabondo stream water. In fact, the Student's t-test conducted on the data showed no significant difference in pH, NO3-, conductivity, and fecal streptococci ($p > 0.05$). However, for temperature, turbidity, dissolved oxygen content, and biological oxygen demand (BOD5), the differences were statistically significant ($p < 0.05$).
The mean values of the physico-chemical and microbiological parameters for the dry and rainy seasons respectively were as follows: pH (5.36±1.38 to 5.47±0.06), dissolved oxygen (3.87±0.28 and 6.08±0.13 mg/L), biological oxygen demand (BOD5) (59.81±4.77 and 17.38±1.38 mg/L), fecal coliforms (19.56 log CFU/100 mL), and fecal streptococci (320.78 log CFU/100 mL). These values indicate that the waters of the Kabondo stream are polluted, as all values fall outside acceptable standards.
In light of these results, it appears that the Kabondo stream, which flows through a densely populated urban area, is polluted. Human activities are the primary source of this pollution. These include waste discharge, dishwashing, agricultural runoff, ponds, bathing, laundry, septic tanks, wild animals, rodents, squirrels, domestic animals, poultry, pig and goat farming, animal feces, and bathing of these animals in the stream—all of which are potential pollution sources.
Keywords: *water, physico-chemical and microbiological parameters, pollution, urban stream.*

***R**eceived 05 June., 2025; **R**evised 12 June., 2025; **A**ccepted 16 June., 2025 © The author(s) 2025.*
P**ublished with open access at **www.questjournas.org

I. INTRODUCTION

Freshwater, as a vital natural resource essential to life, is increasingly threatened by anthropogenic activities, especially in unplanned urban areas. In many African cities such as Kisangani, urban watercourses like the Kabondo River are experiencing a gradual decline in water quality, mainly due to domestic discharges, the absence of proper sanitation systems, and the direct use of river water for household activities. This phenomenon is further exacerbated by rapid, often uncontrolled urbanization, which places additional pressure on urban aquatic ecosystems (Barume et al., 2021).

The issue of water quality in the Kabondo basin is particularly concerning during the two main climatic seasons: the dry season and the rainy season. In the dry season, pollutant concentrations may increase due to reduced dilution, while during the rainy season, runoff results in a massive influx of organic matter, nutrients, and microbial loads into the watercourse. These seasonal variations directly influence physical parameters (turbidity, temperature, conductivity, pH, dissolved oxygen) and microbiological indicators (fecal coliforms, fecal streptococci), thereby impacting the health of nearby communities (Nkongolo & Ngoy, 2018).

Despite the severity of the problem, there is little recent and localized data on the water quality of small urban streams such as the Kabondo River. Most existing studies are either outdated or general and do not take seasonal variability into account. It is therefore imperative to conduct a comprehensive comparative study of the physicochemical and microbiological quality of this river during both the dry and rainy seasons, in order to provide scientific data necessary for informed decision-making (Ngnikam et al., 2010).

The microbiological contamination of watercourses has direct impacts on the health of nearby populations, particularly those who use the water for domestic purposes (laundry, dishwashing, bathing, and even consumption). The presence of coliforms and fecal streptococci indicates a high risk of waterborne diseases such as dysentery, typhoid fever, or cholera (Mukadi & Kayembe, 2019).

Previous studies conducted in similar African contexts have shown that the combined analysis of physicochemical and microbiological parameters of watercourses provides a better understanding of the pollution status and helps identify the dominant sources of contamination. For example, in Cameroon, a study on urban rivers in Yaoundé revealed a strong correlation between fecal streptococci and increased biological oxygen demand during the rainy season, indicating fresh fecal contamination (Ngnikam et al., 2010).

In this context, it is crucial to conduct a systematic study on the Kabondo River to assess the influence of seasonality on water quality. Such a study is essential to propose appropriate strategies for integrated water resource management and public health protection. The lack of recent and reliable local data on these parameters under the specific conditions of Kisangani represents a scientific and technical gap that urgently needs to be filled (Mukadi & Kayembe, 2019).

II. SETTING AND METHODS

II.1. Study Area

This study was conducted in the Kabondo municipality, in Kisangani, the capital of the Tshopo Province in the Democratic Republic of the Congo. The Kabondo River flows through densely populated areas, where the lack of effective sanitation systems promotes the direct discharge of wastewater and solid waste. This type of urban setting is typical of tropical developing regions where aquatic environments are under high anthropogenic pressure. According to UNEP (2006), rapidly growing urban areas in developing countries are the most exposed to the degradation of water resources.

The city of Kisangani covers an area of 1,910 km² and is located in the northeastern arc of the Congo River, about 1,700 km from Kinshasa, near the famous Wagenia rapids. It lies at 00°31' North latitude and 25°11' East longitude. https://fr.wikipedia.org/wiki/Kisangani 23/03/2022 à 12:55). Figure 1 shows the geographical map of the city of Kisangani.

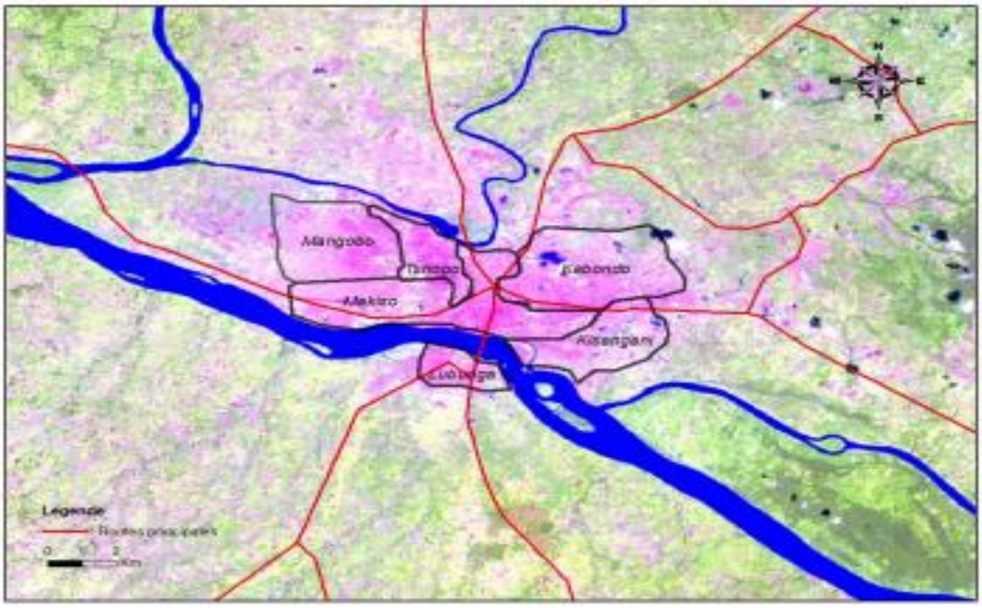

Figure 1. Administrative entities of the city of Kisangani on a LandSat 2000 background (map created from Google Earth 2004), modified (source). https://fr.wikipedia.org/wiki/Kisangani 23/03/2022 à 12:55).

II.3. METHODS

II.3.1. Water Sampling

Water samples were collected on the same day between 7:00 a.m. and 2:00 p.m. in clean, sterile Erlenmeyer flasks placed in a cooler with ice packs, following the method of Rodier et al. (2009). Samples were taken from three sites along the river: at the source, midstream, and at the mouth. Two liters of water were collected at each sampling point during the dry season (January–February) and the rainy season (October–November) of 2023, and were immediately transported to the Biotechnology Laboratory of the Faculty of Sciences at the University of Kisangani and to the Bralima Laboratory for analysis.

II.3.2. Physico-chemical Analyses

Temperature, pH, conductivity, and nitrate concentration were measured in situ using a multiparameter probe device (HACH SL1000). Turbidity was measured in the laboratory using a turbidimeter. Dissolved oxygen was measured in the laboratory using an oximeter, an oxygen probe that determines the dissolved oxygen concentration of a water sample. The operation was repeated after five days of incubation of the sample at 20°C. The difference between the two values corresponds to the BOD5 (Golterman et al., 1978; APHA, 1989).

Fecal coliforms and fecal streptococci were enumerated in lactose broth and Charman's milk after 24 hours of incubation at 44°C and 37°C respectively, using the multiple-tube fermentation technique.

The most probable number (MPN) of presumptive coliforms present in 100 mL of analyzed water was determined by referring to the Mac Crady table (Rodier, 2009; Lambert, 1989).

II.3.4. Data Processing

The data were statistically analyzed using Excel and R software, with calculations of means, standard deviations, Student's t-test, analysis of variance (ANOVA), and Pearson correlation tests between physico-chemical and microbiological parameters. The results were compared with WHO water quality standards. According to Zar (2010), correlation analysis helps identify factors that significantly influence the concentration of indicator bacteria.

III. RESULTS AND DISCUSSION

The results presented below concern samples collected during the dry and rainy seasons, i.e., January–February and October–November 2023. These are averages of three replicates.

III.1. Physico-chemical Parameters

The results of the physico-chemical parameters of the Kabondo stream are summarized in Figure 1 below.

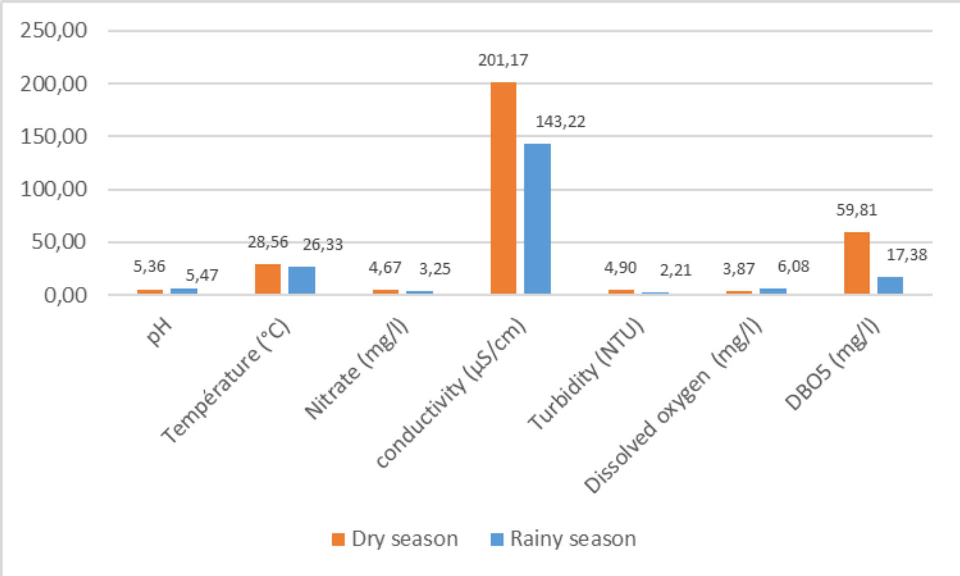

Figure 2 : Values of physico-chemical parameters of the Kabondo stream water

During the dry season, the average water temperature in the Kabondo stream was 28.56±0.64°C, compared to 26.33±0.06°C in the rainy season. Regarding pH, the waters were acidic in both seasons, with an average pH of 5.36±1.38 in the dry season and 5.47±0.06 in the rainy season. For nitrate concentration, the mean was 4.67±4.27 mg/L during the dry season and 3.25±2.60 mg/L during the rainy season. Electrical conductivity reached values of 201.17±141.65 µS/cm in the dry season and 143.22±107.57 µS/cm in the rainy season. Dissolved oxygen levels averaged 3.87±0.28 mg/L in the dry season, versus 6.08±0.13 mg/L in the rainy season. BOD_5 (Biochemical Oxygen Demand over 5 days) averaged 59.81±4.77 mg/L during the dry season and 17.38±1.38 mg/L during the rainy season. Turbidity was significantly higher in the dry season, with an average of 4.90±0.92 NTU, compared to 2.21±1.00 NTU in the rainy season.

III.1.2. Microbiological Parameters

The results of the microbiological analysis of Kabondo stream water are presented in the following figure :

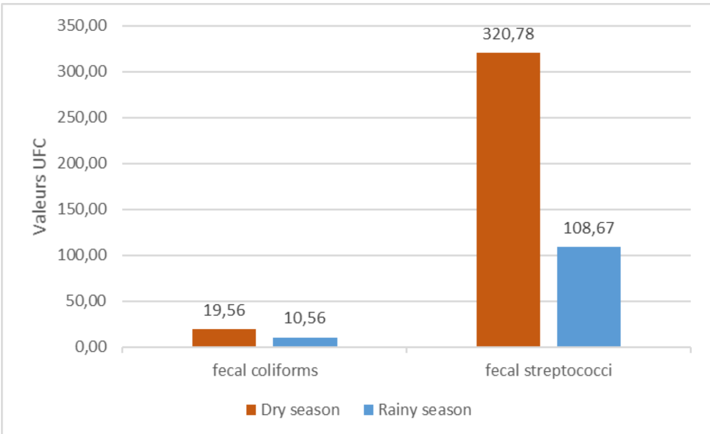

Figure 3: Fecal Coliforms and Fecal Streptococci in Kabondo Stream Water (CFU/100 mL)

The results reveal a high presence of fecal coliforms in the Kabondo stream water, with an average of 10.56 CFU/100 mL during the rainy season and 19.56 CFU/100 mL during the dry season. Regarding fecal streptococci, the most probable number in 100 mL of water was 108.67 CFU/100 mL in the rainy season and 320.88 CFU/100 mL in the dry season. The bacterial counts were significantly higher in the dry season than in the rainy season.

III.1.3. Influence of Physico-chemical Parameters on Polluting Microbial Flora
Pearson Correlation of Results from the Kabondo Stream

The results of the Pearson correlation analysis are presented in the following table:

Table 1: Pearson Correlation between Physico-chemical Parameters and Polluting Microbial Flora in Kabondo Stream During the Dry Seasons.

	Oxygene_Dissout	CF	Nitrates	Conductivite	DBO5	pH	Temperature	Turbidite	SF
Oxygene_Dissout	1.00	0.70	0.66	0.59	-0.59	0.56	0.52	-0.08	0.21
CF		1.00	0.88	0.79	-0.35	0.36	0.25	-0.35	[illegible]
Nitrates			1.00	0.90	-0.21	0.49	0.35	-0.06	0.32
Conductivite				1.00	-0.08	0.69	0.50	0.05	0.13
DBO5					1.00	0.04	[illegible]	0.47	0.19
pH						1.00	0.93	0.60	0.43
Temperature							1.00	0.69	0.53
Turbidite								1.00	0.75
SF									1.00

Table 2: Pearson Correlation between Physico-chemical Parameters and Polluting Microbial Flora in Kabondo Stream +During the Rainy Seasons.

	Nitrates	Conductivite	pH	Turbidite	DBO5	SF	Oxygene_Dissout	Temperature	CF
Nitrates	1.00	0.98	0.95	0.83	0.46	0.34	-0.10	-0.11	0.50
Conductivite		1.00	0.93	0.83	0.54	0.34	0.06	-0.22	0.40
pH			1.00	0.94	0.53	0.51	-0.18	-0.18	0.28
Turbidite				1.00	0.71	0.65	-0.15	-0.23	0.05
DBO5					1.00	0.68	0.07	-0.06	-0.18
SF						1.00	-0.49	-0.24	-0.35
Oxygene_Dissout							1.00	-0.15	[illegible]
Temperature								1.00	0.54
CF									1.00

The table reveals that, based on the overall data collected during the dry season, nitrates, conductivity, and dissolved oxygen show a strong positive correlation with fecal coliforms, with correlation coefficients (r) of approximately 88%, 79%, and 70%, respectively. pH and temperature have a weak influence on coliforms, with correlation coefficients of 36% and 25%, respectively. Biochemical oxygen demand (BOD5) and turbidity exhibit a weak and negative correlation, both around 35%.

However, all physico-chemical parameters correlate positively with fecal streptococci. A strong correlation is observed with turbidity, showing an r of approximately 75%. Temperature and pH show moderate correlations of 53% and 43%, respectively. Nitrates and conductivity exhibit weak correlations, with r values ranging from 32–13% and 34–34%, respectively.

During the rainy season, temperature, nitrates, and conductivity correlate positively with fecal coliforms, while pH and turbidity show weak correlations (approximately 28% and 5%, respectively). Biochemical oxygen demand and dissolved oxygen have a weak negative influence on these microorganisms, with correlation coefficients of 18% and 5%, respectively.

IV. DISCUSSION

Water temperature plays a crucial role in modifying chemical and physical properties, as well as biological reactions (Abboudi et al., 2014). During the rainy season, the average water temperature of the stream is 26.33 ± 0.06°C, whereas it reaches 28.56 ± 0.64°C in the dry season. This seasonal increase is explained by stronger sunlight exposure, as well as the discharge of organic matter which contributes to temperature rise during decomposition, and reduced cloud cover, typical of equatorial regions. According to the World Health Organization (WHO), tropical surface waters generally have temperatures ranging from 25 to 30°C, which pose no direct danger but strongly influence biochemical reactions and oxygen solubility. Similar temperatures were reported by Bitton (2005) in equatorial urban environments, where the impact of the tropical climate is amplified by urban heat.

Moreover, this temperature range favors the proliferation of fecal bacteria, as highlighted by Van Donsel & Geldreich (1967), who demonstrated a direct correlation between high temperatures and prolonged survival of fecal coliforms.

The pH values range between 5.36 ± 1.38 and 5.47 ± 0.06, indicating acidic water. These values fall outside the recommended range by the WHO (6.5 < pH < 8.5) (cited by Aguiza et al., 2014). During the rainy season, a trend towards acidification was observed, linked to the runoff of organic matter and the absence of natural buffering capacity. According to Rodier et al. (2009), a pH below 6.5 can alter the solubility of heavy metals and negatively impact aquatic biodiversity as well as water usage.

Nitrate contamination appears to be related to inputs from groundwater sources contaminated by infiltration of these compounds from agricultural lands (Neal et al., 2000), as well as soil leaching. Nitrate concentrations fluctuate between 3.25 ± 2.60 mg/L and 4.67 ± 4.27 mg/L, with peaks during the dry season. These values remain within the limits recommended by WHO for water intended for domestic use (10 mg/L). They differ from those reported by Zirirane (2014), who conducted a comparative study of watercourses using benthic macroinvertebrates. During the dry season, reduced water volume and increased evaporation lead to higher nitrate concentrations, whereas in the rainy season, rainfall causes dilution of nitrates in the stream, reducing their concentration.

Conductivity values range from 143.22 ± 107.57 to 201.17 ± 141.65 µS/cm, with the highest values recorded during the dry season, indicating ion concentration due to evaporation. This is typical of urban watercourses affected by untreated domestic discharges, as noted by UNEP (2006). WHO guidelines suggest that drinking water should have conductivity below 400 µS/cm. According to Barume et al. (2021), surface waters in Kisangani exhibit higher conductivities in areas under strong anthropogenic pressure, especially during low-flow periods.

Dissolved oxygen decreases during the dry season (3.87 ± 0.28 mg/L) compared to the rainy season (6.08 ± 0.13 mg/L). The dry season values are below the recommended threshold of 5 mg/L for healthy aquatic life (WHO, 2017). This deficit is related to the decomposition of organic matter in stagnant or poorly renewed waters. Wetzel (2001) reports a significant decrease in dissolved oxygen in eutrophicated environments. Nkongolo & Ngoy (2018) showed that dissolved oxygen varies strongly with season, and low values (<4 mg/L) can indicate excessive biological degradation.

BOD_5 values range from 17.38 ± 1.38 mg/L in the rainy season to 59.81 ± 4.77 mg/L during the dry season, which are very high compared to the natural water standard (<5 mg/L). These results indicate severe organic pollution, consistent with the findings of Bartram & Balance (1996), who attribute such increases to urban domestic discharges. Kayembe (2017) confirms that in Congolese urban areas, elevated BOD_5 results from the lack of sanitation and proximity of dwellings to watercourses.

Turbidity values increased significantly during the dry season, reaching an average of 4.90 ± 0.92 NTU, compared to 2.21 ± 1.00 NTU in the rainy season. The rise in turbidity is linked to low flow conditions, where water moves slowly, allowing particles to accumulate and remain suspended, especially in the presence of human activities such as agriculture and livestock farming. The WHO guideline recommends turbidity below 5 NTU for drinking water, indicating that Kabondo water is not highly turbid, particularly during the rainy season. These observations contrast with findings by Ngnikam et al. (2010) on African urban waters, which highlight turbidity peaks during the wet season in densely populated areas.

Fecal coliform concentrations ranged from 10.56 to 19.56 CFU/100 mL, with a clear increase during the dry season. These values greatly exceed the WHO standard for recreational waters (<1,000 CFU/100 mL). Geldreich (1978) attributes these levels to human and animal fecal contamination.

Fecal streptococci ranged from 108.67 to 320.88 CFU/100 mL, confirming a mixed fecal origin (both human and animal). Leclerc et al. (2001) recommend the combined use of both indicators to identify contamination sources.

A high number of fecal streptococci and fecal coliforms during the dry season can be explained by the increased concentration of pollutants due to reduced river flow. In the absence of rainfall, there is no natural dilution, which promotes the accumulation of untreated domestic wastewater directly discharged into the watercourse. Moreover, higher temperatures in the dry season stimulate bacterial activity, favoring the proliferation of fecal microorganisms in stagnant or poorly renewed waters (Mara, 2004).

The analysis of variance (ANOVA) test performed on data from the dry and rainy seasons showed no significant difference for pH, NO3-, conductivity, and fecal streptococci ($p > 0.05$). However, significant differences were observed for temperature, turbidity, oxygen content, BOD, and fecal coliforms ($p < 0.05$). This significant variation is attributed to changes in hydrological regime, human activities (lack of wastewater treatment, population density), and the seasonal climatic characteristics specific to Kisangani (Rodier et al., 2009; Bartram & Balance, 1995; Bartram & Cairncross, 2010; Payment & Pinck, 2006; WHO, 2003).

Nitrates, conductivity, and dissolved oxygen showed a strong positive correlation with fecal coliforms (r = 88%, 79%, and 70%, respectively). These parameters indicate fresh and concentrated pollution that promotes the proliferation of fecal coliforms in the context of reduced flow and low dilution during the dry season (Bartram & Cairncross & WHO, 2010; Chapman, UNESCO/WHO/UNEP, 1996; Leclerc et al., 2001).

pH and temperature have a weak influence on fecal coliforms (r = 36% and 25%, respectively), while biological oxygen demand (BOD) and turbidity have a weak negative influence (r ≈ 35% for both). This can be explained by particle sedimentation, UV exposure, and the decrease of biodegradable matter, which limit their survival and proliferation (Leclerc et al., 2001; Bitton, 2005).

However, all parameters correlate positively with fecal streptococci. A strong correlation is observed with turbidity (r ≈ 75%). Temperature and pH show correlation coefficients of 53% and 43%, respectively. Nitrates and conductivity have a weak influence on these microorganisms (r = 32-13% and 34-34%, respectively). All studied parameters indicate recent or active pollution favorable to their persistence.

During the rainy season, temperature, nitrates, and conductivity correlate positively with fecal coliforms, while pH and turbidity show weak correlations (r ≈ 28% and 5%, respectively). Biological oxygen demand and dissolved oxygen have a weak negative influence on these microorganisms (r = 18% and 5%, respectively). The dilution of organic loads and better oxygenation of water during the rainy season explain the weak negative impact of BOD_5 and dissolved oxygen on fecal coliforms in the Kabondo stream. This trend aligns with previous studies on surface waters in urban areas under equatorial climate conditions (Bitton, 2005; Rodier, 2009; Bartram & Cairncross, 2010).

V. CONCLUSION

This study was conducted to assess the influence of seasonality on the water quality of the Kabondo stream. Physical parameters (temperature, turbidity, conductivity, BOD_5, dissolved oxygen) and microbiological parameters (fecal coliforms, fecal streptococci) were sampled during January-February 2023 (dry season) and October-November 2023 (rainy season) and compared to standards, highlighting a significant seasonal variation in water quality.

Pollution was more pronounced during the dry season. The results obtained—including an acidic pH of 5.36, low dissolved oxygen concentration (3.8 mg/L), extremely high BOD_5 (59.81 mg/L), as well as significant microbial loads with 19.56 log CFU/100 mL of fecal coliforms and 320.78 log CFU/100 mL of fecal streptococci—exceed the recommended quality thresholds for bathing and domestic use waters (WHO, 2017). This reflects ongoing organic and microbiological pollution primarily originating from direct domestic discharges, notably untreated wastewater. These parameters are consistent with those observed in studies by Ngnikam (2010) and Kazadi (2012) in high-density urban areas lacking sanitation infrastructure.

This situation reflects diffuse pollution linked to uncontrolled urbanization, the lack of stormwater drainage systems, and open dumping sites near the riverbed.

The responsible anthropogenic activities include direct discharge of domestic wastewater (absence of sewage systems), washing of clothes and vehicles in the stream, spreading of garbage and plastic waste, deforestation of riverbanks, subsistence agriculture, livestock rearing, presence of latrines close to the riverbank, and spontaneous settlements along the watercourse, often lacking adequate sanitation systems (Ngnikam, 2010).

BIBLIOGRAPHIE

[1]. **Abbouti 2014**. La protection des forêts tropicales, Presses universitaires d'Aix-Marseille

[2]. **Aguiza, A. E., Ombolo A., Ngassoum, M. B., et Mbawala, A. 2014.** Monitoring of the Physicochemical and Bacteriological Quality of the Watercourses of Ngaoundéré, Cameroon. Afrique Science, 10, 135-145.

[3]. **Gorlterman, H.L., Clymo, R. S. et Ohnstad, M.A.M, 1978** : Etudes limnologiques sur Treukemeer – un reservoir de polder néerlandais typique. Proc Symposium I.B.P. 6 UNESCO sur les problèmes de productiité des eaux douces (éd. Par ZKajak & A. Hillbricht-lllkowska) p.421.

[4]. **Neal, A., Griffin, M. A., & Hart, P. M. 2000**. The Impact of Organizational Climate on Safety Climate and Individual Behavior. Safety Science, 34, 99-109

[5]. **Lambert, D. 1989** : Dénombrement des streptocoques fécaux. Université de Louvain, Louvain, la neuve, p 35 – 39.

[6]. **Organisation mondiale de la santé (OMS), 2003**, World Health Organization Health and environment in sustainable development five years after the earth summit Geneva, pp. 19-133.

[7]. ***Paul, M.J. and Meyer, J.L.*** 2001. Streams in the Urban Landscape. Annual Review of Ecology and Systematics, 32, 333-365p.

[8]. **Rodier, J., Legube, B.et Merlet (2009).** Analyse de l'eau.Analyse physico-chimique des eaux naturelles. 9e edition. Dunod. Paris. France. P.1384.

[9]. **Zirirane, D. 2014**. Évaluation comparée de la pollution des rivières Kahuwa et Mpungwe par l'utilisation des macroinvertébrés benthiques » Université du Québec à Montréal Éditions en environnement VertigO p8

[10]. **Barume, S., Bshwira, G., et Mbelu, A., 2001**. Environnement urbain et gestion de l'eau à Kisangani. Kisangani : Université de Kisangani, Faculté des Sciences, Département de chimie. p. 91

[11]. **Nkongolo, K., et Ngoy, N., 2018**. Pollution des cours d'eau en milieu urbain : cas de rivière Tshopo à Kisangani. Lubumbashi : Press Universitaires de Lubumbashi, p.56

[12]. **Ngnikam, E., Nola, M., Kamgamp Kabeyene, V. et Voti, D., 2010**. Pollution des eaux de surface par les déchets organiques en Afrique urbaine : cas du bassin versant de Mefou à Yaoundé (Cameroun). Paris : Editionss l'Harmathan, p. 198)

[13]. **Mukadi, J., et Kayembe, B., 2019**. Pollution microbiologique des rivières urbaines à Kisangani, Éditions Universitaires Congolaises, p. 132

[14]. **United Nations Environment Outlook 2. (UNEP) 2006. UNEP**, Urban Water – Towards Sustainable Solutions, Earthscan, Londres, p. 34

[15]. **American Public Health Association (APHA), 1989**. Standard Methods for the Examination of Water and Wastewater, 23rd ed., American Public Health Association, Washington DC, p. 1-3

[16]. **Zar, J.H., 2010**. Biostatistical Analysis, 5e éd., Pearson Prentice Hall, New Jersey, p. 234

[17]. **Donsel et Geldreich 1967**. Relationship of Salmonellae to fecal coliforms in polluted waters .Applied Microbiology, American Society for Microbiology, vol. 15, p. 1362
[18]. **Mara, D. D., 2004**. Domestic Wasterwater Treatment in Developing Countries. Earthscan Publications Ltd. London p.132
[19]. **Bartram, J., et Ballance, R., 1995**. Water Quality Monitoring: A Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programmes*. Chapman & Hall, Londres, pp. 45–89.
[20]. **Bartram, J et Cairncross, S., 2010**. Hygiene, Sanitation and Water: Forgotten Foundations of Health", World Health Organization, p. 64