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Seasonal Evaluation Of The Microbiological Quality Of The Waters Of The Tshuenge River Located East Of The City Of Kinshasa/Dr Congo

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Abstract:
Background: *Kinshasa's rivers are subject to urban, agricultural and industrial pressures. Due to poor waste management and the lack of an effective sanitation system, these rivers have become dumping sites and collectors of all kinds of waste. With a view to assessing the quality of surface waters used for domestic, market gardening and other purposes by the population living along the banks of this megalopolis, a study aimed at evaluating the microbiological quality of the waters of the Tshuenge river located to the east of Kinshasa was carried out between the last quarter of 2022 and the first quarter of 2023.*
Materials and Methods: *Three sites were selected for sampling. Beforehand, a survey was carried out to obtain information from 30 people on socio-demographics, water use, perception of pollution and river management strategies. Next, microbiological analyses were carried out on the water samples collected during both dry and rainy seasons. The microbial germs tested were total coliforms (TC), faecal coliforms (FC), Escherichia coli (EC), intestinal enterococci (IE) and Salmonella and Shigella (SS). R and SPSS software were used to analyze the data collected.*
Results: *The results of these microbiological analyses of Tshuenge river water showed that the samples taken were polluted, with average values of 2566.7±115.5 CFU/100 ml for CT, 2000±264.6 CFU/100 ml for CF, 1700±100 CFU/100 ml for EC, 2466.7±321 CFU/100 ml for EI and 102±7 CFU/100 ml for SS.*
Conclusion: *These averages far exceed the standards recommended by the World Health Organization (WHO) for drinking water, from which prior treatment would be mandatory for any domestic use.*
Keywords: *faecal contamination, index, quality, pollution, season*

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I. Introduction

The demographic growth experienced by the Democratic Republic of Congo (DRC) since its independence has resulted in an increase in the population's primary needs, including access to drinking water, food, health and education. This great demographic pressure on natural resources is reflected in a reduction in agricultural land and the growing production of waste of all kinds. Such is the case of the city of Kinshasa, which produces at least 10,000 tonnes of solid waste every day [1].

Due to poor land management and a lack of sanitation systems, most of this waste is dumped in rivers and on the streets. Today, Kinshasa's waterways have become collectors of waste and garbage of all kinds [2]. The consequences of this insalubrious behaviour on the part of the Congolese population in general, and Kinshasa's population in particular, are widespread insalubrity, pollution of river water and the atmosphere, degradation of biodiversity, especially aquatic biodiversity, and soil deterioration [3]. To remedy this tragedy, we need to monitor the quality of the water in these rivers.

In recent years, several authors have addressed the issue of water resource quality in the provincial city of Kinshasa, warning of the danger to the population of Kinshasa from the degree of pollution of these rivers. In this context, mention should be made of the work carried out by Bipendu et al [4] on the effects of industrial discharges from the Kinshasa water treatment plant (REGIDESO) on the physico-chemical and biological quality of water in the Matete and N'djili rivers, in the DRC; another study carried out in this field is that of Konunga et al [5] on the assessment of the degradation of certain physico-chemical parameters of water in the Lukaya river.

To date, the problem of urban water pollution in the city of Kinshasa remains unresolved, despite the combined efforts of various national and international institutions. It is in the search for solutions aimed at the rational management of Kinshasa's watercourses that we plan to carry out a study on the evaluation of the microbiological quality of the waters of the Tshuenge River, which crosses the eastern part of the capital of the DRC.

The hypotheses put forward for this study are as follows: Given the quantity of solid waste and wastewater dumped into the Tshuenge River by the riverside population, (1) the river's waters would contain microorganisms indicative of faecal pollution and pathogens that could harm human health, and (2) these waters would present a quality index characteristic of heavily polluted rivers due to the consequences of the anthropogenic activities to which it is subjected.

The overall aim of our study is to carry out a seasonal assessment of the microbiological quality of the waters of the Tshuenge River. Specifically, this research aims to: Identify the various sources of pollution in the Tshuenge River; Determine the level of compliance of the load of water pollution indicator microorganisms with international drinking water potability standards; Identify the water quality index classes of this river. The choice of this subject was guided by the importance of this river in the city of Kinshasa, both in terms of the number of communes it crosses and the number of families it serves.

II. Materials And Methods

The present research was carried out in a large portion of the Tshuenge river watershed, located in the city-province of Kinshasa, precisely in the Tshangu district. It began with an exploratory survey to determine the importance of this river in the lives of the local population and their behaviour towards it. Samples were then taken for analysis of the microbiological quality of the Tshuenge River.

Description of sampling and survey sites

The study was carried out on the Tshuenge River, located to the northeast and 20 km from downtown Kinshasa. Its origin lies at the foot of the N'sele hills, at an altitude of 340 m. It crosses the communes of N'séle, Kimbanseke and Masina. It receives few streams and carries polluting discharges of household wastewater, valve water and other domestic waste before flowing into the river swamps.

For the purposes of this study, three points on the river were selected for sampling. The sampling points were chosen to cover the entire river, with one point located upstream, one in the middle and one downstream. The geographical coordinates and other information relating to these three points are given in Table 1 (geographical coordinates, communes and observations). Samples were taken at two different times of the year, each corresponding to a season in the city of Kinshasa. The first samples were taken in September 2022 and the last in February 2023. The three points are shown in Table 1 with their geographical coordinates.

Table n° 1: Geographical coordinates of sampling sites

Sampling point	Longitude East	Latitude South	Municipality	Comment
Upstream	15.436165°	4.4181°	Kimbanseke	At Mikondo district
Middle	15.427739°	4.4039°	N'sele	At Boulevard Lumumba
Downstream	15.418458°	4.3875°	N'sele	At Tshuenge market-gardening site

In addition to taking water samples from the Tshuenge River, a survey was carried out among the riverside population living in the vicinity of the sampling points. The main points of investigation were the Mikondo district in the commune of Kimbanseke, households on either side of Boulevard Lumumba, and the Tshuenge market garden.

Materials

Water samples taken against the current of the river, at the three points mentioned above, constitute the main material for this study. Alternatively, the questionnaire form was used to investigate the behaviour of this population in relation to the Tshuenge river.

Methods

Preliminary field investigations

A field survey was carried out prior to sample collection. We presented a questionnaire to the inhabitants of various sampling sites (30 in total), but also used interviews and observation to obtain information. The main information collected concerned: (1) socio-demographics, (2) description of river water use, (3) respondents' perceptions of river pollution and, finally, river management strategies.

Tshuengé River water sampling

For each sampling site, we took two series of samples, one per season. Samples were taken during the dry season, precisely in the first fortnight of September 2022, then during the flooding period corresponding to the rainy season in February 2023.

At each sampling point, a 2-liter volume of river water was collected using polyethylene bottles previously rinsed with distilled water, then with the river water concerned. The bottles were then hermetically sealed and transported directly to the laboratory in a cooler at around 0°C for microbiological analysis within a few hours.

The collected and conditioned samples were taken to the Microbiology laboratory located within the Faculty of Science and Technology of the University of Kinshasa for microbiological analysis.

Measurement of physical parameters

Three parameters were measured: Temperature (°C), pH and Turbidity (NTU). These parameters were determined in situ using a WTW 340i/SET Multiparameter. During the measurement, the electrode was immersed in the sample and the values of the various parameters were read directly on the instrument's display. These parameters were measured because they have a potential influence on the survival and growth of microorganisms in aquatic environments.

Determination of microbiological parameters

Microbiological analysis was carried out for pathogenic germs and indicators of faecal pollution. The germs tested in the sampled waters were: Total Coliforms (TC), Faecal Coliforms (FC), *Escherichia coli* (EC), Intestinal Enterococci (IE), Salmonella and Shigella (SS). We used two different methods to search for germs in the samples we took. The first is the agar incorporation method (for total Coliforms, Faecal Coliforms and *Escherichia coli*) [6] and the second, the membrane filtration technique (for Enterococci, Salmonella and Shigella) [7].

The culture media specific to each bacterium were weighed on a balance and introduced into sterile beakers containing distilled water. These mixtures were immediately sterilized at 120°C for 15 minutes. After cooling (approx. 45°C), the culture media were introduced into the petri dishes. In the case of overly-charged water, a series of dilutions from 10^1 to 10^2 was carried out using distilled water, in order to achieve a high colony count. For TC and FC culture, we used Mac conkey gelose medium, while Rapid E. coli medium was preferred for EC enumeration. For intestinal enterococci, Salmonella and Shigella, a 50 ml volume of the water sample was filtered and the membrane incubated on a specific agar medium. Intestinal enterococci, Salmonella and Shigella were enumerated on Slanetz and Bartley media and BD Hektoen Enteric Agar respectively. After inoculation, these media were incubated at 37°C for 24 and 48 hours for the enumeration of total coliforms, Salmonella and Shigella, and at 44°C for 24 and 48 hours for faecal coliforms, *Escherichia coli* and intestinal enterococci. Results were expressed as colony-forming units (CFU) per unit volume (CFU/100ml).

Determining the origin of faecal contamination

The origin of faecal contamination is determined by the quantitative ratio R: FC/IE. According to the criteria defined by Borrego and Romero cited by Bou Saab et al [8], contamination is of animal origin if the R ratio is less than 0.7; it is of human origin if R is greater than 4. The origin of contamination is predominantly animal if R is between 0.7 and 1, uncertain if R is between 1 and 2, and predominantly human if R is between 2 and 4.

Determining the Microbiological Quality Index

The method for processing microbiological data is based on the Microbiological Quality Index (MQI). The MQI depends on water concentrations of total coliforms, faecal coliforms and intestinal enterococci. 5 concentration classes are defined for each of these parameters (Table 2). The principle is to divide the values of the pollutants into different classes and to determine the corresponding class number for each parameter from your own measurements (the data collected in situ), in order to calculate the average [9].

Table n° 2: Class limits for the Microbiological Quality Index and interpretation of the MQI class average [9].

Classes	Total coliforms	Faecal coliforms	Intestinal enterococci	IQM	Faecal contamination
5	< 2000	< 100	< 5	4.3 - 5	None
4	2000 – 9000	100 – 500	5 – 10	3.5 – 4.2	Low
3	9000 – 45000	500 – 2500	10 – 50	2.7 – 3.4	Moderate
2	45000 – 360000	2500 – 20000	50 – 500	1.9 – 2.6	Strong
1	> 360000	> 20000	> 500	1.0 – 1.8	Very strong

Statistical analysis and data processing

Excel software was used to calculate means and standard deviations, and SPSS software was used to analyze survey data. R software (4.3.0) was used to perform the analysis of variance of the data and Tukey's test for the detection of significant differences. Statistical significance was defined as $p<0.05$.

III. Results

In order to identify the sources of contamination and determine the level of microbiological pollution in the Tshuenge River, a series of surveys and water sampling operations were carried out. The following section summarizes the results of these investigations.

Survey results

A total of 30 people were surveyed, with 10 individuals in the vicinity of each part of the river sampled. Tables 3 to 5 show the results obtained.

Table n° 3: Socio-demographic data of respondents

Parameters	Variables	Number	%
Gender	Male	14	46.7
	Female	16	53.3
Age range	10-20 years old	1	3.3
	21-30 years	5	16.7
	31-40 years	8	26.7
	41-50 years	9	30.0
	51-60 years	7	23.3
Level of education	No education	1	3.3
	Primary	9	30.0
	Secondary	11	36.7
	Higher	9	30.0
Marital status	Single	10	33.3
	Married	18	60.0
	Widowed	2	6.7
Main profession	Civil servant	3	10.0
	Private company employee	3	10.0
	Businessman	6	20.0
	Lawyer	1	3.3
	Veterinarian or agronomist	2	6.7
	Student	2	6.7
	Motorcycle cleaner	6	20.0
	Farmer	6	20.0
	Unemployed	1	3.3

Table 3 shows that the majority of respondents are female (53.3%) and aged between 41-50 (30%). In terms of level of education, most had completed secondary school (36.7%), and only one had not attended school. With regard to marital status, the values recorded show that 60.0% of respondents are married, and with regard to main occupation, the dominant occupations are, in order of importance, trade, motorcycle cleaning and market gardening.

Table n° 4: Main uses of Tshuenge river water and associated risks

Parameters	Variables	Number	%
Use of river water	Agricultural	12	40.0
	Domestic	14	46.7
	Industrial	3	10.0
	Other	1	3.3
Problems related to use of river water	Diseases (toxic infections and/or skin pathologies)	14	48.3
	Flooding due to filth	2	6.9
	Other	13	44.8

Table 4 shows that water from the Tshuenge river is used more in the agricultural and domestic sectors, while the other sectors make very little use of it.

With regard to the problems associated with the use of these waters, 48.3% of the population surveyed felt that this river was the cause of food poisoning or skin diseases among its users.

Table n° 5: Behaviour and opinions of respondents regarding pollution of the Tshuenge river

Parameters	Variables	Number	%
Types of waste thrown into the river	Plastic bottles	1	3.6
	Plastic bags	12	42.9
	Toilet waste	6	21.4
	Household waste	8	28.6
	Distillation residues from local beverages	1	3.6
Causes of garbage disposal in the river	Dragging of garbage by rainwater currents	1	3.3
	Lack of sanitary facilities	3	10.0
	Lack of garbage cans	11	36.7
	Lack of awareness	13	43.3
	Lack of sanitation service	1	3.3
	No reason	1	3.3
Recommendations for the proper use of the river's waters	Raise public awareness	21	70.0
	Improve safety along the river	1	3.3
	Put garbage cans along the river	3	10.0
	Set up a sanitation service	4	13.3
	Construction of sanitation facilities	1	3.3

With regard to the type of waste disposed of in the Tshuenge river, Table 5 shows that the majority of respondents felt that plastic bags (42.9%) predominated over other types of garbage, and that the lack of awareness or notions of environmental hygiene on the part of the riverside population was at the root of this behaviour. With regard to the recommendations and corrective measures proposed to avoid misuse of the river's waters, the results show that 70% of the subjects suggested raising the population's awareness to combat river pollution.

Microbiological analysis results

The results of the microbiological analyses carried out on the various water samples taken from the Tshuenge River are shown in Table 6.

Table n° 6: Results of microbiological analyses of water samples taken at various sites on the Tshuenge River

Sites	Seasons	Microbial germ content (CFU/100 ml)				
		TC	FC	EC	IE	SS
Upstream	Dry	173.3±35.1	113.33±20.8	0	200±26.5	0 ± 0
	Rainy	205±8.7	201±11.5	165±8.7	201±3.6	75±6
Middle	Dry	2133.3±208.2	1933.3±321.4	1400±173.2	2100±200	20.3±9.3
	Rainy	1800±200	1733.3±153	1333.3±153	1766.7±404.1	102±7
Downstream	Dry	2566.7±115.5	2000±264.6	1700±100	2466.7±231	41.7±3.1
	Rainy	2033.3±208.2	1833.3±57.7	1633.3±404.1	2033.3±153	89±21.3

Legend: TC: Total Coliforms; FC: Faecal Coliforms; EC: *Escherichia coli*; IE: Intestinal Enterococci; SS: Salmonella and Shigella

Total coliform counts range from 173.33±35.1 CFU/100 ml to 2566.7±115.5 CFU/100 ml during the dry season, and from 205±8.7 to 2033.3±208.2 CFU/100 ml during the rainy season. The highest TC content was observed downstream during the dry season. Overall, the TC levels recorded are above the WHO standard (00 CFU/100 ml) for drinking water.

Average faecal coliform levels ranged from 113.33±20.8 CFU/100 ml to 2000±264.6 CFU/100 ml during the dry season, and from 201±11.5 to 1833.3±57.7 CFU/100 ml during the rainy season. The highest concentration was recorded downstream during the dry season.

For *Escherichia coli*, mean concentrations ranged from 00 CFU to 1700±100 CFU/100 ml during the dry season, but increased from 165±8.7 to 1633.3±404.1 CFU/100 ml during the rainy season. The highest concentration was recorded downstream during the dry season.

Intestinal Enterococci levels vary from 200±26.5 CFU/100 ml to 2466.7±231 CFU/100 ml during the dry season, and from 201±3.6 CFU/100 ml to 2033.3±153 CFU/100 ml during the rainy season. The highest levels were recorded downstream during the dry season. The levels recorded are higher than the WHO standard (00 CFU/100 ml) for drinking water.

As for Salmonella and Shigella, average levels range from 00 CFU/100 ml to 41.7±3.1 CFU/100 ml in the dry season, and from 75±6 CFU/100 ml to 102±7 CFU/100 ml in the rainy season. The highest content is observed in the middle of the rainy season.

Determining the origin of faecal contamination

Table 7 shows the different values obtained by the Ratio: FC/IE and the origin of the pollution for each site and season.

Table n° 7: Ratio values and pollution origin for the various sampling sites and for each season

Location/Season	**FC/IE**	**Pollution origin**
Upstream/Dry	0.57	Mainly or entirely of animal origin
Upstream/Wet	1	Mixed, predominantly animal origin
Middle/Dry	0.92	Mixed, predominantly animal origin Mixte à prédominance animale
Middle/Wet	1	Mixed, predominantly animal
Downstream/Dry	0.81	Mixed, predominantly animal
Downstream/Wet	0.90	Mixed, predominantly animal

This table shows that the FC/IE ratio for the various sampling points shows that pollution is mainly or entirely of animal origin upstream during the dry season, and mixed but predominantly animal at other sites and seasons.

Microbiological quality index of Tshuengé river waters

Table 8 shows the different values obtained by averaging the different quality classes and the degree of faecal contamination by site and season.

Table n° 8: Microbiological Quality Index (MQI) and degree of faecal contamination

Localisations/saisons	MQI	Faecal contamination
Upstream/Dry	3.6	Low
Upstream/Wet	3.6	Low
Middle/Dry	2.6	High
Middle/Wet	3	Moderate
Downstream/Dry	2.6	High
Downstream/Wet	2.6	High

Table 8 shows that by averaging the different classes for each site and season, the MQI values obtained indicate that faecal contamination is low upstream and in both seasons; it is moderate in the middle during the rainy season, but high in the middle during the dry season and downstream in both seasons.

IV. Discussion

In this research work, samples taken from three different points on the Tshuenge River were subjected to microbiological analyses in order to test the quality of these waters and the dangers incurred by the riparian population in using them for their various needs.

Indeed, several studies carried out in sub-Saharan Africa have shown that water resources, especially surface water resources, are highly vulnerable to pollution, as they have become veritable dumping grounds for domestic sewage and black water, as well as collectors of waste and refuse of all kinds [2].

Microbiological analyses revealed that all water samples taken from the Tshuengé River were contaminated, notably with germs such as total and faecal coliforms, *Escherichia coli*, intestinal enterococci, Salmonella and Shigella, which are indicators of faecal pollution of human or animal origin.

The average levels obtained for total coliforms (TC), faecal coliforms (FC), Escherichia coli (EC) and intestinal enterococci (IE) (respectively from 173.33±35.1 CFU/100 ml to 2566±115 CFU/100 ml ; 113.33±20.8 CFU/100 ml to 2000±264 CFU/100 ml; 0 CFU to 1700 CFU/100 ml and 200±26.5 CFU to 2466.7±231 CFU/100 ml) far exceed the standards set by the WHO for drinking water (0/100 ml). Based on the survey carried out in conjunction with these analyses, we understand that this high microbial load can be explained by the various human activities carried out around the Tshuenge River along its course, and the proximity of pollution sources such as uncontrolled garbage dumps and wastewater discharges. This reflects the lack of environmental sanitation, which exposes water resources to heavy contamination by bacteria of faecal origin [2, 10].

Added to this is the insalubrity of the sites, which have become garbage dumps, and the unsanitary behaviour of the riverside population and certain market gardeners who defecate in the river. Added to this is the presence of piggeries along the river, which dump animal excrement into the river. This unfortunate reality is also confirmed by the work of Mpakam et al [11], who studied the pollution factors of water resources in urban areas: the case of Bafoussam (West Cameroon). In addition, the levels of faecal pollution indicator bacteria in the water samples obtained in this study are much higher than the results reported by Tamungang et al [12], who analysed the quality of domestic water in the village of Babessi in north-west Cameroon, and Ahoussi et al [13] in their study of the hydrogeochemical and microbiological characteristics of drinking water in the peri-urban area of the town of

Man. However, the average values obtained in this work remain lower than those obtained by Kalonga et al [2], who determined the physicochemical and microbiological quality of water from the Kalamu River prior to its purification with Moringa oleifera seed powder.

With regard to Salmonella and Shigella (SS), the average values recorded range from 0 CFU to 102±7 CFU/100ml. These results can be explained by the poor condition and/or lack of hygienic facilities along the river, the poor disposal of human and animal excrement, untreated wastewater and the failure of users to observe basic hygiene rules [14]. In addition, the use of manure (slurry, cow dung, chicken droppings) as fertilizer can also be a source of water pollution [15]. Our results corroborate those of Tamungang et al [12] on domestic water quality control in the village of Babessi in North-West Cameroon.

The microbiological analyses carried out for the two study seasons reveal that, contrary to what was noted during the survey, people living along the Tshuenge should not directly use the water from this river, as it is unfit for consumption. Prior treatment would be mandatory before any domestic use. Indeed, water intended for consumption and household needs must not contain pathogenic micro-organisms, and no 100 ml sample of water intended for consumption should contain Clostridium, coliforms or enterococci [16].

Site 3 (downstream) is the Tshuenge market-gardening area, where a large proportion of this water is used by certain market-gardeners to water their vegetables, and also for washing motorcycles by hand. The quality of the harvest depends in part on the type of water supplied to the plant [17]. Given the ever-increasing importance of market garden produce in the diet of urban and peri-urban populations, it is of the utmost importance to know the quality of this water. As some market garden produce is consumed raw, particular attention must be paid to the quality of the water used for irrigation, so that it does not represent a health hazard for consumers. Buyers of these vegetables are also exposed to the risk of microbial contamination, as are consumers of raw vegetables. The water samples taken at this site contain a high microbial load. This could constitute a health risk and a direct potential hazard, as the use of this water for irrigation could be the source of contamination for vegetables, farmers or consumers [18].

Another important observation is that water samples collected during the dry season seem to carry a higher bacterial load than those collected during the rainy season.

These results are at odds with those of Bou Saab et al [8], who studied the bacteriological quality of surface water (Nahr Ibrahim River, Lebanon) and found significant quantitative increases in germs during the flooding period compared with the low-water period.

For our study, the decrease in microbial germs during the rainy season can be explained by the fact that the quantities of rainwater coming from everywhere and flowing into the river have a diluting effect, and consequently the bacterial concentration in the water decreases during the rainy season [19].

Overall, the concentration of intestinal enterococci was higher than that of faecal coliforms in the samples taken. According to Leclerc [20], faecal coliforms are abundant in faeces and represent the predominant environmental indicators. Faecal coliforms are generally more abundant in human faeces than intestinal enterococci. The latter are thought to be more numerous than faecal coliforms in animals [14]; hence the importance of the ratio of faecal coliforms to intestinal enterococci in determining faecal contamination.

The FC/IE ratio values obtained in this work indicate that pollution is mainly of animal origin upstream in the dry and mixed seasons, but predominantly animal for the other sites and seasons. This characteristic is linked to the presence of pigsties on the banks of the river, the poor condition and/or lack of hygienic facilities, poor evacuation of human and animal excrement, and the use of manure (slurry, cow dung, chicken droppings) as fertilizer.

As a result, surface waters that are used for a variety of purposes (drinking, economic activities, bathing, etc.) can represent a danger to these users. Consequently, water intended for human and animal consumption, for watering fruit and vegetables, for bathing and for a wide range of other uses must be free from any pathogenic organism likely to cause health problems in those who consume or use it [21].

V. Conclusion

The present study was carried out to determine the sources of pollution and assess the microbiological quality of the waters of the Tshuenge River during the two seasons (dry and rainy). During the two sampling campaigns (September and February), the water samples collected were subjected to microbiological analysis for total coliforms, faecal coliforms, Escherichia coli, intestinal Enterococci and Salmonella and Shigella using the standard water analysis method. The results obtained at the three sampling points through the counts carried out throughout the sampling campaigns indicate increased microbiological contamination. Overall, the Tshuenge water supplied to the local population for domestic use does not meet the quality standards recommended by the WHO. Indeed, the evolution of the loads of the various groups showed very marked spatial and temporal variations, with maximum concentrations noted during the month of September, and during both study seasons, the downstream site is the point with the highest microbial load. Faced with the problems of surface water pollution and the associated health risks, it is important that educational and legislative measures are taken to protect water resources and safeguard the health of river users as effectively as possible.

References

[1] Falanga Nzf, Mbutabuba X, Biey M.E., Musibono E.D. Les Bassins Des Rivières Mokali Et Tshuenge A Kinshasa En République Démocratique Du Congo Comme Poubelles Publiques Et Impacts Socio-Environnementaux. International Journal Of Innovation And Applied Studies, 36 (1), 158-169, 2022.

[2] Kalonga Kr, Mubiala Km, Sifa Km. Effet D'un Traitement Couplant La Coagulation-Floculation Par La Poudre Des Graines De Moringa Oleifera Lam. Et La Filtration Sur Sable Fin Associé Au Charbon De Bois Sur La Purification Des Eaux De La Rivière Kalamu A Kinshasa. International Journal Of Innovation And Scientific Research, 66 (1), 122-131, 2023.

[3] Binzangi Kl, Falanka. Réflexions Sur L'évolution De L'environnement De Kinshasa : D'une Portion Biophysique A Une Cupidosphère. Cahier Congolais De L'aménagement Et Du Bâtiment, N°003, Inbtp/Kinshasa, 2014.

[4] Bipendu Mn, Lukanda Mv, Musibono Ead, Pwema Kv, Ngbolua K. Effets De Rejets Industriels De L'usine De Traitement D'eau De Kinshasa (Regideso) Sur La Qualité Physico-Chimique Et Biologique Des Eaux Des Rivières Matete Et N'djili, Rd Congo. International Journal Of Innovation And Scientific Research, 29 (2), 96-109, 2017.

[5] Konunga G, Muyaya B, Muamba P. Évaluation De La Dégradation De Quelques Paramètres Physicochimiques De L'eau De La Rivière Lukaya En République Démocratique Du Congo. Afrique Science, 14 (2), 292 – 303, 2018.

[6] Rodier T, Bazin C, Broutin J, Champsaur H, Rodi L. Analyse De L'eau : Eaux Naturelles, Eaux Résiduaires, Eaux De Mer. Dunod, Paris, 1997.

[7] Rodier J. (2009). Analyse De L'eau : Eaux Naturelles, Eaux Résiduaires, Eau De Mer, 9ème Ed. Dunod, Paris, 2009.

[8] Bou Saab H, Nassif N, El Samrani Ag, Daoud R, Medawar S, Ouaïni N. Suivi De La Qualité Bactériologique Des Eaux De Surface (Rivière Nahr Ibrahim, Liban). Revue Des Sciences De L'eau, 20 (1), 341–352, 2007.

[9] Fella H-C, Raihana K, Celia O, Afafe D. Evaluation Of The Bacteriological Pollution Of The Mazafran Wadi Waters And Study Of The Resistance Profile Of Escherishia Coli. Jowset, 4 (2), 507-512, 2020.

[10] Robertson Wd, Schiff S.L, Ptacek Cj. Reviews Of Phosphate Mobility And Persistence In 10 Septic System Plumes. Groundwater, 36(6), 1000-1010, 1998.

[11] Mpakam Hg, Kouam Kg, Tamo Tt, Maire E, Boeglin Jl, Ekodeck Ge, Dupre B. Etude Des Facteurs De Pollution Des Ressources En Eau En Milieu Urbain : Cas De Bafoussam (Ouest-Cameroun). Actes Du Colloque International Sur Le Thème « Changements Climatiques Et Evaluation Environnementale », Niamey (Niger) Du 26 Au 29 Mai 2009.

[12] Tamungang Neb, Biosengazeh Nf, Alakeh Mn, Tameu Dy. Contrôle De La Qualité Des Eaux Domestiques Dans Le Village Babessi Au Nord-Ouest Cameroun. Int. J. Biol. Chem. Sci. 10(3) : 1382-1402, June 2016. Issn 1991-8631.

[13] Ahoussi Ek, Keumean Nk, Kouassi Ma, Koffi By. Etude Des Caractéristiques Hydrogéochimiques Et Microbiologiques Des Eaux De Consommation De La Zone Périurbaine De La Ville De Man : Cas Du Village De Kpangouin (Côte D'ivoire). Int. J. Biol. Chem. Sci., 11(6), 3018-3033, 2018.

[14] Koffi-Nevry R, Manizan Pn, Wognin Sa, Koussemon M, Koffi So, Tano K. Caractérisation De La Répartition Spatio-Temporelle Des Bactéries A L'interface Eau Sédiment D'une Lagune Tropicale : Cas De La Baie Du Banco, Abidjan, Côte D'ivoire. European J. Scientific Res, 21 (1), 164-174, 2008.

[15] Krira A, Chakour B, Fouta H. Intensification De L'agriculture Et Son Impact Sur L'environnement. Cas Des Nitrates Dans La Nappe Phréatique De M'nasra Du Gharb. Actes 1er Colloque Sur Le Développement Agricole Et La Recherche Agronomique Au Niveau De La Région Du Gharb, Maroc, 2001.

[16] Who. Guidelines For Drinkink-Water Quality, Third Edition Incorporating The First And Second Addenda, Volume 1, Recommandations, Geneva, 2008.

[17] World Water Vision. Rapport Du World Water Council. 2ème Forum Mondial De L'eau A La Haye, 2000.

[18] Derwich E, Beziane Z, Benaabidate L, Belghyti D. Evaluation De La Qualité Des Eaux De Surface Des Oueds Fès Et Sebou Utilisées En Agriculture Maraichère Au Maroc. Larhyss Journal, 7 (1), 59-77, 2008.

[19] Bahir M, Mennani A, Jalal M, Fakir Y. Impact De La Sécheresse Sur Les Potentialités Hydriques De La Nappe Alimentant En Eau Potable La Ville D'essaouira (Mogador, Maroc). Notes Méthodologiques. Science Et Changements Planétaires/Sécheresse, Maroc, 2002.

[20] Leclercq L. Intérêt Et Limites Des Méthodes D'estimation De La Qualité De L'eau. Station Scientifique Des Hautes-Fagne, Belgique, 2001.

[21] Awomon Df. Etude De La Vulnérabilité Des Lavandiers De La Rivière Banco Par La Recherche Et Le Dénombrement Des Indicateurs De Contamination Fécale. Revue Africaine Des Sciences Sociales Et De La Santé Publique, 2 (2) 1987-1023, 2020.