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Contribution to the Study of the Environmental Impact of Microbiological Pollution of the Water in the Lukaya River, Kinshasa DR of Congo

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Abstract:- The data used in this work were collected between the month of January and February of the year 2016 in the Lukaya River, located in the commune of Mont-ngafula, in the city province of Kinshasa. The DRC does not have a specific law or a water code and a clear national policy on integrated water resources management. Several projects exist and are underway with the support of German cooperation. The framework for the application of the laws of the related sectors is hardly applied this favors pollution, the irrational exploitation of fishery resources, inappropriate use of chemicals raising hygienic and environmental concerns. The objective of this work is to assess the environmental impact of the microbiological pollution of the water in the Lukaya River. The water samples were taken from the different sites in 600 ml plastic Canadian bottles and their analysis was performed at the INRB laboratory and the approach adopted in this work is that of membrane filtration which led to the following results: a high bacteriological concentration and numerous pathogens such as Escherichia coli, Proteus vulgaris, Enterobacter, Proteus penneri, Citrabacter and many other bacteria which testify to faecal contamination such as coliforms and faecal streptococci.

Keywords:- *Microbiological Pollution, Lukaya River, Fecal Coliforms, Total coliforms, Enterococci.*

I. INTRODUCTION

The water which covers three quarters of the planet's surface is essentially sea water (97.3%) and fresh water reserves only represent 2.7%. A large part of this reserve is found in solid form (Atlantic ice cap, arctic and mountain glaciers) while liquid fresh water is often difficult to access because it is very deep [20]. This unavailable water (glaciers and deep groundwater) represents 2.4% of total water reserves.

Different industries easily get rid of their waste either voluntarily or unintentionally by dumping it into rivers. In addition, the runoff waters considered by some to be temporal rivers after having collected all the impurities on the surface of the ground quickly move towards a nearest permanent river and thus accentuate the pollution of the latter [2].In recent decades the problems relating to the protection and use of water resources have become more acute around the world. The water problem affects both developing and developed countries [9].

In fact, the pollution which reaches the aquatic environment constitutes a major environmental problem which sometimes reaches levels which are harmful to the life of fish, invertebrates, aquatic plants and humans. Concentration of pollutants can alter the taste, odor, color of water and increase the cost associated with producing drinking water [12].Human activities (agriculture, animal husbandry, industries, etc.) are the source of water pollution because man seeks to get rid of wastes by dumping them directly or indirectly into a watercourse [4]. This is the case of the Lukaya River, which houses farms (pigsties, poultry) and vegetable crops on both sides.

Finally, we will focus on the bacteriological analysis of the waters of the Lukaya River by visiting the various sites below: upstream of Mino Congo, downstream of Mino Congo, the Régideso catchment, downstream of kiala, downstream of the lake Ma Vallée bridge and downstream of the Mélo bridge.

The question remains that of knowing if the level of pollution of the waters of the Lukaya constitutes a real environmental problem and therefore an influence on public health and this in order to assess the sources of pollution of the Lukaya river, identify the microorganisms in the water of the lukaya watershed, identify the types of degradation of the site and the impact of environmental problems on the lukaya watershed and suggest possible solutions for better sanitation of the aquatic environment.It is in this context, our work consists in carrying out the bacteriological analysis of the waters of the Lukaya River, in order to identify the various problems which generally generate serious degradation of the various compartments which constitute the ecosystem (water, fauna and flora) and therefore an influence on public health.

In time, this study took place during the period from January 18 to February 18 and in space, it was carried out on the Lukaya watershed located in the commune of Mont Ngafula in the city of Kinshasa province.

II. MATERIAL AND METHODS

II.1 Study environment

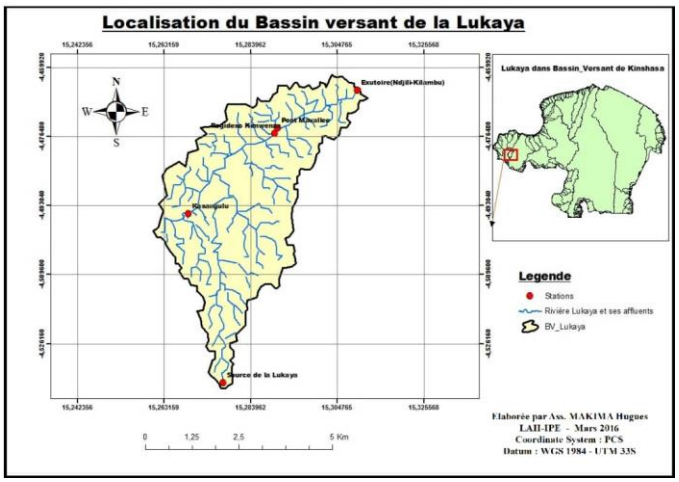

Fig 1: Map of the location of the Lukaya watershed (CNG, 2016).

II.1.1 Geographic location.

The Lukaya watershed is located between the city of Kinshasa and the province of Kongo-Central. The Lukaya River has its source in rural areas in the village of Ntampa in Kongo-Central and flows into the Ndjili River (2000 km2 watershed), a tributary of the Congo River, near Ndjili-kilambu in the outskirts of Kinshasa. This river, whose course is about fifty kilometers long, has a fairly variable profile and knows many tributaries. The Lukaya watershed covers an area of 350km2, a perimeter of 133km and its drainage capacity is 993.46 m / km2 [5].Regarding our study, we will limit ourselves upstream of Mino Congo to the Melo Bridge upstream.

II.1.2 Weather.

The climate of the city province of Kinshasa belongs to the type AW_4, according to the classification of Koppen. It is made up of a large rainy season lasting 8 months, i.e. from mid-September to mid-May, and a dry season which runs from mid-May to mid-September [15].

1. Rainfall

From a pluviometric point of view, during the last three decades, the average annual rainfall observed in the City-Province of Kinshasa is 1,529.9 mm and the monthly minimum is below 50 mm. November has the highest volume of precipitation, averaging 268.1 mm. About 40% of precipitation falls between October, November and December, which are the wettest months of the year. Peak rainfall amounts to 203.3 mm in April and the number of rainy days reaches the annual average for the period of 112 days, with a peak of 17.8 rainy days in April [15].

2. Temperature

The temperature differences are generally established as follows: more than 18 ° C for the daytime temperature of the coldest month of the year and about 22 ° C for the night temperature of the hottest month (UNDP / UNOPS, 1997).

3. Vegetation

According to the botanical study carried out by Habari in 2006 (cited by Lemba, 2009) at the level of a part of the Lukaya watershed, the floral composition is estimated at 256 plant species divided into 240 species of Angiosperms, 1 species of Gymnosperm , 13 species of Pteridophytes (ferns) and 2 species of Bryophytes (mosses). Seven species of Mycophytes (fungi) were also inventoried in the young forest of the Sanctuary of Bonobos in Kimwenza [7].

4. Soil types

The soils of the Lukaya watershed are sandy clay soils; they are infertile soils with strong laterization [5].

II.2. Equipment

Analyzes of water samples at the INRB laboratory were performed with the following standard equipment: Microscope.

- The water sample: is used in the microbiological analysis;
- A notebook, pen, camera, GPS
- Bunsen burner: This is for sterilizing glass materials
- Refrigerator: used for storing materials;
- 600ml Canadian bottle: used to collect the water sample;
- Petri dish: used to put the study medium
- Incubators: used to heat the culture medium to any temperature
- Cooler: transport and storage of the water sample
- Combisart: Used for water filtration.

II.3. Methods

II.3.1 Documentary Analysis

In relation to the documentary method, we have used books, published articles, lecture notes, reports from various public services as well as the Internet to develop this work.

II.3.2 Analysis of Water Samples in the Laboratory

To carry out this analysis, we used the membrane filtration technique which consists of putting the filter paper in the combisart which serves to filter all the deposits.

The methodology used in our work is the membrane filtration technique used in the INRB laboratory, this technique is a scanning technique adapted to enumerate bacteria present at very low concentrations in water. To be able to count these bacteria, it is then necessary to analyze the large volume of water [1].

1. Principle

The bacteria present in the samples to be analyzed are retained in a filter whose pores are smaller than the size of the bacteria (pores of 0.45 µm in diameter), the filter which

has retained contained in the water, is then deposited on a medium appropriate culture where the bacteria draw the elements necessary for its growth and develop. After incubation, the CFU are counted to assess the microbiological quality of the water. the presence of different types of microorganisms

Micro-organisms	***Volume***	***Culture center***	***Incubation***
Fecal coliform	250ml	MCF Agar	48h at 44 ° C
Enterococci	250ml	m. Entero agar	48h at 37 ° C
Total coliforms	250ml	mr. Endo agar	48h at 36 ° C

Table 1:- Microorganisms sought, volume filtered and culture medium used (mineral water plant)**Source: American P.H.A, 1985).**

2. Procedure

- Disinfection of the filtration system before water filtration: after assembly of the system, disinfected with ethanol and then rinsed with distilled water. Renew between each filter of different water;
- Gently place the filter with the ethanol-disinfected forceps (make sure not to remove the filter protection at the same time as the filter instead of the filter because the latter set is waterproof and do not allow the water to filter), filter grid facing up and well centered on the support plate;
- Screw the upper container back on to ensure the tightness of the system;
- Fill the upper container with the water to be analyzed up to the appropriate graduation (50ml to 250ml) and do not close it;
- Place the manual vacuum pump then filter by creating a vacuum;
- Rinse with sterile water;
- Demonstrate the system;
- Remove the filter using an ethanol disinfectant forceps and place on the appropriate medium in a Petri dish 5 cm in diameter grid upwards, without letting the air bubble enter the filter and the culture medium so that the entire filter is in contact with the culture medium and finally;
- Incubate at the chosen temperature.

II.3.2.1Taking water samples

In order to assess the bacteriological quality of the water, samples were taken from different sites which are shown in Table 3 below. River water samples were taken at 6 points, from January 18 to February 18, 2016.

At each sampling point, a 600 ml plastic bottle was introduced in the middle of the stream, after filling the bottle to the brim, the latter is placed in a cooler containing ice to maintain the internal temperature around 4 ° C. The samples were then transported to the INRB laboratory for microbiological analysis.

Sampling sites.	**Characteristic of the environment**
1. Upstream Mino Congo	Presence of market gardening
2. Downstream Congo	Discharge of droppings in the river. Poultry Farm.
3.RegidesoMino Congo catchment	Presence of market gardening. Water collection for the Regideso drinking water production plant.
4. Aval Kiala	Presence of carrikim quarry and market gardening.
5. Downstream of the lake of my valley bridge	Market gardening area located downstream of the Carrikim quarry
6. Downstream Melo bridge.	Presence of market gardening.

Table 2:- Presentation of the different sites for taking water samples from the LukayaRiver.

II.3.2.1Preservation of samples

The samples collected were stored in an insulated box fitted with ice packs maintaining the temperature at 4 ° C. In the laboratory, some samples were examined directly while others should be stored in the refrigerator at 4 ° C overnight. At the time of analysis, the samples thus stored were previously brought to the ambient temperature of the laboratory room by simple exposure to the open air.

Parameters	***Max***	***Units***
Faecal coliforms	0	CFU / 100ml
Total coliforms	10	CFU / 100ml
Enterococcus (faecal streptococcus)	0	CFU / 100ml

Table 3:- Microbiological standards for drinking water
Source: WHO drinking water quality regulation

II.3.3 Parameters to study

In order to determine the microbiological profiles of the waters of the Lukaya River, the following parameters were researched and analyzed:
- Microbiological parameters
- Impacts on the various pollution factors

II.3.3.1. Microbiological parameters

Analysis at this level allowed us to determine the various microbial contaminations.

II.3.3.2. Impacts on the various pollution factors

The various environmental problems have been noted, namely physical pollution, chemical pollution and biological pollution, details of which will be provided below 2.3.4. Identification of stakeholders and activities in the Lukaya watershed. This part of the work consisted essentially in the direct observation of the various sites studied in order to establish the responsibilities of each other in relation to all the environmental problems of the region, to determine the causes and their consequences on the population and finally to suggest some possible solutions.

II.3.4. Geographic information system and digital cartography

In order to produce geographic maps determining our study area on the Lukaya River, the geographic information system and digital cartography was used. 2 maps produced by the GIS software emerged: ARC gis 9.2.

- The first describes our study area while the second revolves around the sample collection points.

II.3.5. *Presentation of the results*

The results are presented in tables and histograms to facilitate their interpretation and use. They constitute in themselves the 3rd chapter of our study.

III. RESULTS AND DISCUSSIONS

This chapter presents the results of microbiological analyzes in the laboratory as well as the information received in the field from users of the Lukaya River.

III.1 Results

III.1.1. GPS location map of sampling points at the different sites of the Lukaya watershed

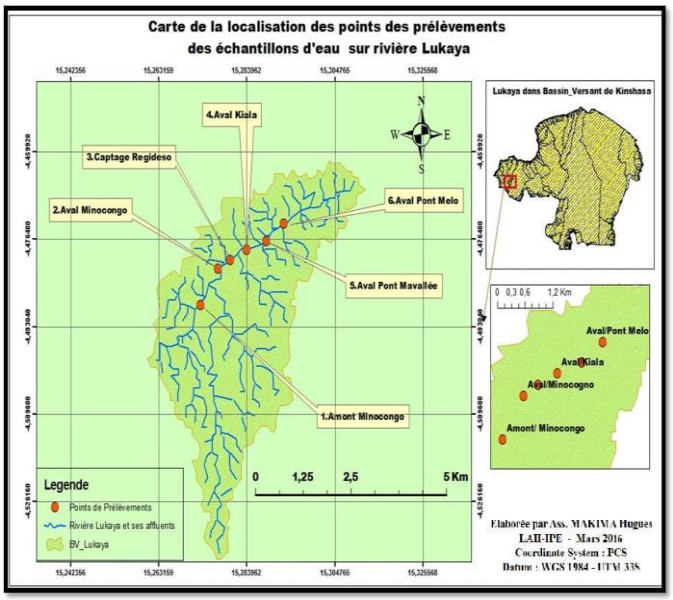

Fig 2: Map of the location of sites in the Lukaya watershed.

At the Lukaya River, we took water samples with a plastic bottle at the different sites using an extra type GPS. The collection points for said samples are best indicated on the map above.

III.1.2. Microbiological analysis

III.1.2.1. Result on fecal coliforms

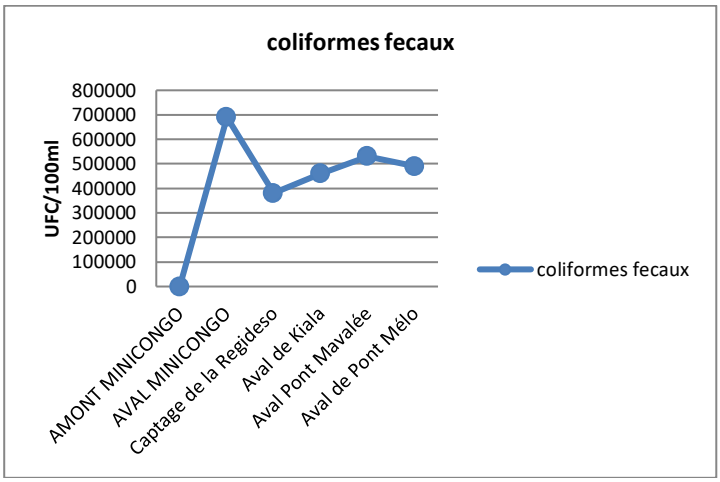

Fig 3: Pollution of the Lukaya River by Fecal Coliforms

The microbiological analyzes carried out at the laboratory level on the basis of water samples taken from the Lukaya River show that for fecal coliforms, the highest densities are located at sites 2, 4, 5 and 6 while the lowest densities weaker are at site 1 and 3.

III.1.2.1. Result on faecal streptococci

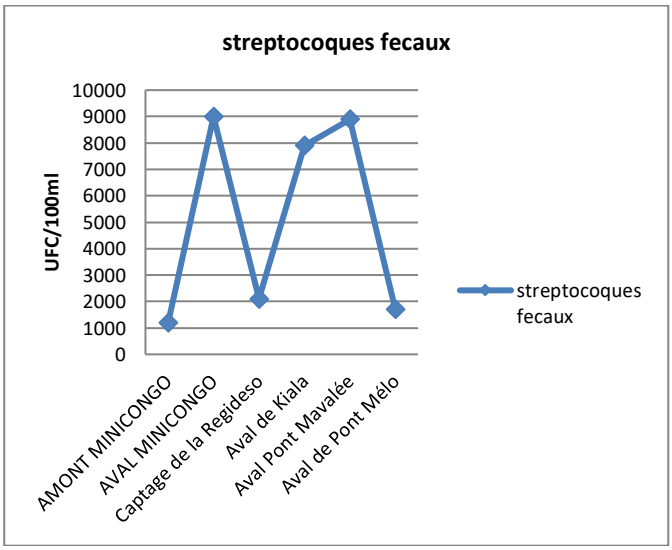

Fig 4: Pollution of the Lukaya River by faecal streptococci

The microbiological analyzes carried out at the INRB on water samples from the Lukaya River describe that for the faecal streptococci with the highest densities are located in sites 2, 4 and 5 while the lowest densities are observed at level of sites 1, 3 and 6.

III.1.2.3. Result on total coliforms

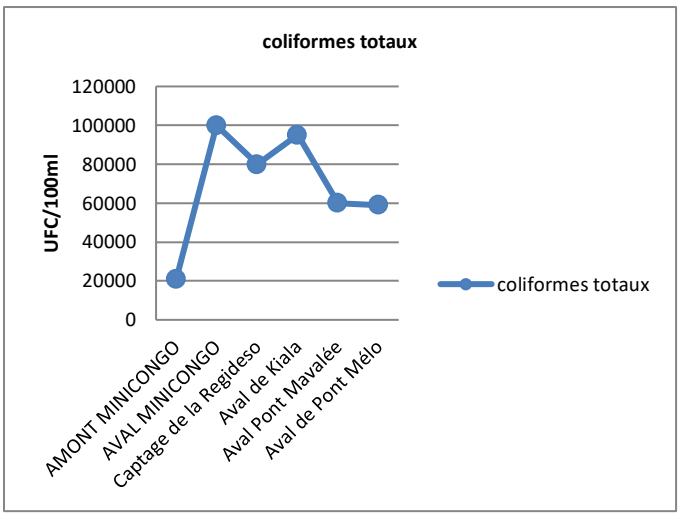

Fig 5: Pollution of the Lukaya River by Total Coliforms

With regard to total coliforms, the microbiological analyzes carried out on the water samples taken from the Lukaya River show that the highest densities are at the level of sites 2, 3 and 4 while the lowest are located at the level of sites 1, 5 and 6.

III.1.2.4. Pathogens identified

	Sampling sites	***Identified germs***
1.	Upstream Minocongo	*Proteus vulgaris, Faecal streptococcus, Escherichia coli, Proteus penneri*
2.	Downstream Minocongo	*Escherichia coli., Enterobactersp, Citrabactersp, Faecal streptococci, Proteus vulgaris Proteus penneri*
3.	Regideso catchment	*Enterobacterium, Faecal streptococci*
4.	Downstream from Kiala	Escherichia coli., Faecal streptococci
5.	Downstream Mavalée Bridge	Faecal streptococci Escherichia coli,
6.	Downstream from Mélo Bridge	Escherichia coli., Faecal streptococci

Table 4:- The following table gives the location of the germs identified according to the sites

Numerous pathogenic germs have been identified in the various sites of the Lukaya watershed. These are germs such as: Escherichia coli, Enterobacter sp, citrabacter sp, Faecal streptococci, Proteus penneri, Proteus vulgaris.

The bacteria Faecal Streptococci and Escherichia coli are found in all sites of the watershed while the bacteria Proteus vulgaris and Proteus penneri were found in sites 2 and 1; as for Enterobacter sp bacteria, they were only present in sites 2 and 3 while Citrabacter sp bacteria were only found in site 2.

III.1.3. Impacts of different factors of the pollution identified on the Lukaya River

The results on the impacts of the various factors linked to pollution are very diverse.

III.1.3.1 Physical pollution

This pollution visibly alters the environment. The waste thrown into the river is also a significant pollution and has many impacts on the Lukaya watershed, in particular:

- Disturbance caused by waste from market gardeners: the spillage of solid substances by market gardeners into the river infects the water to the point of causing a bad odor. While this same water is used for watering crops.
- Disturbance caused by the company Mino Congo: This Company dumps a large quantity of droppings producing a positive impact in favor of market gardeners but negative on the river because the high concentration of waste is a factor of physical pollution.

III.1.3.2 Chemical pollution

Chemical pollution is caused by the introduction of toxic chemical substances into the water by, among other things:

- The Carrikim Company, which spreads dust on market gardeners' fields, dumps it into the river causing a change in the color of the water caused by quarries.
- In addition, deforestation and the destruction of ecosystems because the loss of biodiversity modified the landscape through land filling, degrade the quality of water through the discharge of liquid substances from nitrate and limestone.

III.1.3.3Biological pollution

Biological pollution is noticeable on the Lukaya River following the introduction of an animal or plant species to the detriment of other species. This pollution is due to a significant increase in nutrient inputs, often of agricultural and livestock origin, which promote the development of other living organisms in the watershed.The consequences of this state of affairs are significant for aquatic biodiversity.

III.1. 4 Results on identified actors and their activities in the study area

- To identify the actors surrounding the Lukaya River at the sites chosen for sampling, we used observation during our stay in the field. However, the short duration of the work did not allow me to cover the extent of the watershed in its entirety.
- The results of our observation and the interviews carried out for this purpose show that for many years, the surrounding actors have been market gardeners, the MINO CONGO farm, REGIDESO, CARIIKIM and the tourist site of Bonobos.
- Market gardeners: often cultivate Hibiscus esculentus, Amaranthus hybridus etc. the cultures are carried out on the same spaces. Soils are impoverished in some places; the plants are visibly stunted, malnourished, and have yellowish leaves. This is why market gardeners use

natural fertilizers (pig manure, chicken droppings, dead leaves, etc.). This allows them to avoid the prices of chemical fertilizers.

- Mino Congo Farm: is located downstream of the river and carries out the breeding of poultry from which the droppings produced are dumped in large quantities directly into the river. This is causing major problems in the aquatic ecosystem of the Lukaya River. (REGIDESO): The plant was built in 1989, but has since been rehabilitated and resumed operations in 2006. The plant serves water to 9 neighborhoods within a 15 km radius. Unfortunately, the Kimwenza area where the plant is located does not benefit from this water since the discharge pressure at the outlet of the plant is too high (22 kg). To remedy this shortcoming, a project, funded by a Chinese company, plans to install water tanks in the Sébo district, located high up, to then serve the Kimwenza area by gravity feed. While waiting, the inhabitants obtain their supplies from the numerous sources present in the vicinity of the river. Some are fitted out with pumping systems while others have remained in their natural state.
- (Carrikim) downstream we have a quarry whose activities are based on the geological resources of the Lukaya watershed. Besides Carrikim, there are other quarries along the Lukaya watershed that have not been traveled for lack of time. These are SGI, Afriteck and Safricas careers. All these quarries are industrial, their presence has allowed the creation of jobs in the region. These industrial quarries develop the activities of gravel production and sand extraction on an artisanal scale.

Tourist sites, this area also has 3 sites, the first two of which are located upstream from the MinoCongo farm. These are the small falls of the Lukaya and the sanctuary of Bonobo (Pan paniscus) .As for the third, the lake site of my valley, it is landscaped with Palottes, it is located in the outskirts of the city and serves as a place of meditation and leisure. It is among rare forest islets. This sanctuary welcomes young bonobos seized by the Ministry of the Environment from poachers or families with a bonobo as a pet. The center tries as much as possible to rehabilitate orphans in the wild and to help them regain their autonomy.

III.2. Discussion

The watershed is a complex ecosystem organized in interaction. We define the ecosystem as a set of interacting elements between man and his environment. The Lukaya River watershed is very complex in structure and operation. This complexity is characterized by: an ecosystem approach in which there is the presence of elements which are more in interaction with the environment: the hydrographic system, the vegetation, the animals, the men as well as the various activities which are carried out there, environmental factors (precipitation, temperature) and eco-climatic factors.

The digital mapping allowed us to locate the water sample collection sites using GPS with a plastic bottle to allow us to bring out the results on the microbiological analyzes in the INRB laboratory.

The bacterial densities obtained at the various sites are well above the microbiological standards for drinking water set by the WHO. For fecal coliforms, the highest densities are located at sites 2, 4, 5 and 6 because there is a high concentration of activities downstream.

With regard to faecal streptococci, the highest densities are identified at sites 2, 4 and 5 compared to sites 1, 3 and 6 where the lowest densities are noted and caused by physical, chemical and biological pollution while along the watershed.

With regard to total coliforms, the highest densities are at sites 2, 3 and 4 while the lowest are located at sites 1, 5 and 6. This can be seen in the various environmental activities as proven by Céline's analyzes in 2009. However, the protection and sustainable management of watersheds absolutely require their development.

Thus, for a rational development of the territory, it should be remembered that the development plans of the watersheds must be integrated into the general development programs according to urban and habitat names.

IV. CONCLUSION

The catchment area of the Lukaya River is a complex system comprising two distinct parts: the upstream part located in the lower Congo and the downstream part which flows into the Ndjili River with some natural vegetation cover.

The urban sub-system of the city of Kinshasa is almost completely deforested and continues to undergo very strong anthropogenic pressure due to the systematic occupation of all available spaces. There is a situation in this area characterized by illegal housing estates and essential basic infrastructure with a negative impact on the environment.

This continuous degradation of the environment is a factor associated with extreme poverty and eco-climatic constraints; it creates an environment favorable to natural hazards.

The overall objective of this study was to assess the environmental impact and the quality of microbiological pollution in the Lukaya River.

To achieve this objective, the appropriate specific methods including the documentary study, the analysis of the water samples in the laboratory from the bacteriological point of view and other constants in the field during our direct observation in the field supported by numerous prospecting visits on all the different sites where our samples were taken, the development of participatory digital mapping which is the expression of zoning and the application of the ecosystem approach, etc. were used.

The direct observations and interviews carried out in the field during numerous prospecting visits throughout the watershed, made it possible to collect a lot of field data from

which specific geographical maps were produced using the GIS software arc ArGIS.

The digital map provided provides information on the location of the Lukaya watershed and the location of the various water sample collection sites using GPS

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