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Study of the Impacts Caused by Anthropogenic Activities over the Last Ten Years on the Djoliba River in the Urban Commune of Kouroussa (Republic of Guinea)

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Abstract

Water is at the heart of sustainable development, socio-economics, the survival of ecosystems and humanity as a whole; it is therefore vital that mankind takes care of its quality. The aim of this study is to assess the level and causes of water degradation and pollution in the Djoliba River in the commune of Kouroussa (Republic of Guinea) over the past ten years, from 2014 to 2024. To do this, observations, surveys and physico-chemical analyses were used to collect certain data. Several anthropogenic activities were carried out, including extensive agro-pastoral activities, artisanal mining, brick-making and cooking. The alarming finding is the presence of open savannah (37.45%), followed by anarchic housing construction (27.03%), extensive agro-pastoral activities (18.91%), etc. Granulometric and chemical analysis revealed that the soil of the riverbank has a sandy-silty, acidic texture, with high levels of phosphorus pentoxide and especially potassium monoxide at the two sampling sites Pont E 5 and Briqueterie PE 5: (25.10%; 18.20) and (90.22 and 104.50%) respectively, which are sources of chemical pollution, and the presence of other chemical elements and parameters such as organic matter, organic carbon, available nitrogen, total nitrogen, carbon-nitrogen ratio, sum of bases, cation exchange capacity.

Keywords

Impacts, Human Activity, Degradation, Djoliba River, Kouroussa

1. Introduction

The Republic of Guinea's hydrography is rich and varied. There are over 1300 rivers [1]-[3]. Many of Africa's rivers and tributaries have their sources in Guinea [1]. However, one of the country's most important watercourses is the Djoliba River, which is a remarkably important source of water for the populations of the African countries it flows through, including the town of Kouroussa, whose population is estimated at 42,134 [4]. The Djoliba or Djaliba river, the name of the Niger river in its Guinean course, after crossing the northern slope of the Daro Massif as a torrent, heads towards the plains of Upper Guinea, crossing the towns of Faranah, the urban district of Kouroussa and some of its villages and sub-prefectures. On its way, it meets other tributaries of the River Niger, such as the Niandan at Babila (confluent in French), the river (Korossala in the Malinké language) in the urban district of Kouroussa, before arriving in the Republic of Mali [5]. **Figure 1** shows the confluence (the place where this river flows into the Djoliba River in the urban commune of Kouroussa, called Köbila in the drawer language or confluence). It flows for 643 km and occupies a catchment area of 70,000 km^2 in the Republic of Guinea. It is navigable from Kouroussa in (Republic of Guinea) to Bamako in (Republic of Mali) when the water level is high. On the other left bank of the river is a vast plain of grassland, providing fodder for livestock (**Figure 2**). The two banks are linked by the historic and first metal railway bridge of the colonial era, built in the 1900s by the Boyer and Brothers metal construction factory, now Ets Star (Republic of France), over the River Niger and the water levels of the periods: May 31 and August 16, 2024, with the presence of riparian vegetation and washing and leaching activities (**Figure 3**) [6]. It flows for 643 km and occupies a catchment area of 70,000 km^2 in the Republic of Guinea. However, the influence of human activities along the river means that this water resource is now threatened, as are most water sources in the Republic of Guinea [7]. Deforested and deformed riverbanks resulting from brick-making and digging for precious metals are just some of the factors that can threaten aquatic life [8] [9]. It should be noted that the riparian vegetation along a watercourse is responsible for producing shade on the watercourse. The presence of riparian vegetation considerably reduces water temperature and, as an added benefit, increases the concentration of oxygen in the water, thus promoting the survival of species. It also provides food and shelter for aquatic fauna, structures the morphology of the watercourse, and stabilizes the banks by fixing the soil with its roots [10]. This vegetation, which plays such a vital role in the survival of a watercourse, is now threatened by human activities. The level of pollution of the Djoliba River is a fact that most of the population urban of Kouroussa no longer consume it. In view of this problem of supplying drinking water from the Djoliba River to the population of Kouroussa, the Company of Water of Guinea (SEG) recently completed work to install and equip two new industrial boreholes in addition to the existing networks, in order to improve the drinking water supply system in the town of Kouroussa, whose current drinking water supply rate is 45%.

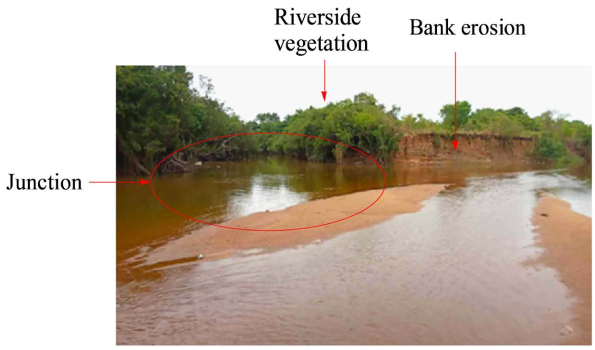

Figure 1. Showing the confluence of the Djoliba river and its bank, with vegetation and signs of erosion.

Figure 2. Remote sensing mapping of the Djoliba River at Kouroussa.

(a) (b)

Figure 3. Showing the historic old metal railway bridge linking the two banks of the Djoliba River at Kouroussa, water levels on May 31 (a) and August 16 (b) 2024 with presence of diversified riparian vegetation and washing and leaching activities on a form of dead arm of the natural bank (a) but fed in winter by water (b).

Although insufficient, this has improved water production and supply from 900 m^3/day to 2300 m^3/day [11] [12]. Numerous studies have been reported on the pollution of water sources worldwide, as well as in the Republic of Guinea [12]-[16]. However, to our knowledge, the Djoliba River in Kouroussa has been little studied, because 40 years ago, the waters of this river were the only major source of water supply for the urban population of Kouroussa. However, to our knowledge, the Djoliba River in Kouroussa has been little studied, because 40 years ago, the waters of this river were the only major source of water supply for the urban population of Kouroussa. The aim of this work is to determine the main physico-chemical causes of deterioration in the environmental quality of this important river over the last ten years, in order to propose some traditional solutions for improving this watercourse, which is in the process of disappearing as a result of human aggression during this last 10 years.

2. Materials and Methods

2.1. Presentation of the Study Area

This study was carried out in the urban commune of Kouroussa.

2.2. Study Framework

The laboratories of: National Service of soils (SENASOL) of kenien/Conakry and biology of Mamou Higher Institute of Technology, provided the framework for this study.

2.3. Materials Used

50-meter decameter Appareil GPS
Pen
Nikon cameras

2.4. Method

2.4.1. Observation Mechanisms and Sampling

The results of the river observations were recorded on pre-established forms. The elements selected were: slope and occupation of the banks, bank vegetation, water level in the river, degree of silting up of the river, distances between the river and dwellings, latrines, distance between public infrastructures and the river, sampling of a portion of the soil hosting bank vegetation for analysis, decameter for measuring.

2.4.2. Soil Sample Analysis at the Laboratory

The physico-chemical analysis of certain parameters of the soil sample taken was carried out according to the procedure reported in the literature [17].

3. Results and Discussion

In this study of the Djoliba River at Kouroussa, it was observed that the river's yield had deteriorated considerably over the last ten years as a result of natural and anthropogenic influences on the river [14].

3.1. Observations

Observation of the Djoliba River took place from May 31 to May 1 and from August 16, 2024. The following results showed extensive degradation of the river by local people, as shown in (**Figure 4**), an almost dry river from May 31st to May 1st 2024 and a completely full river from August 16th 2024 onwards, as shown by the limnimetric scales on (**Figure 5**).

(a) (b)

Figure 4. Showing one example among others of a riparian forest suffering (a) from erosion, and brick kiln for firing bricks (b) along the Djoliba River in Kouroussa.

Figure 5. Showing the limnimetric scale for measuring the water level in the river bed.

3.2. Measurement of the Distance Added to the Natural River Bank, Sand Level and the Distance between the Bank and the Water Level, the Width of the Bed

The destruction of the river arms by the builders of the brick kilns (Figure 4), has deformed in some places, the normal river bed and causes flooding during the rainy season of homes near the river. For example, on the site (brickyard) not far from the metal bridge, there is an overflow of the river bed caused by these brick manufacturers, either: 29.7 meters from the natural river bed and 10 meters from the homes and a slaughterhouse next door not shown. The water level in the Djoliba River in Kouroussa has become dangerously low, which suggests the flow stop of the river in the dry season (season without rain). The silting is visible and very worrying for a better future for the riverside populations. However, the distance between the natural bank and the current water level of the river, as well as the width of the river bed are 30.80 and 188.6 meters respectively. In addition, the bank and water level of the Djoliba River, which extends over approximately 50 km in the Kouroussa prefecture, have experienced major disturbances over the last ten years.

3.3. Occupation of the River Bank between 2014-2024

The results of occupation of the bank of the Djoliba River from 2014-2024 are in

(Table 1 and Figure 6 and Figure 7) and the hydromorphological mapping of the Djoliba River in Kouroussa indicating a legend to this effect is shown in (Figure 7).

Table 1. Land use areas along the Djoliba River (urban commune of Kouroussa) from 2014 to 2024.

Class	Area occupied in 2014	Percentage in 2014	Area occupied in 2014	Percentage in 2014
Built	513.082	25.007%	554.649	27.033%
Routes and waterways	105.143	5.125%	108.122	5.270%
Gallery forests	39.598	1.930%	39.598	1.930%
Mines/Quarries	37.287	1.817%	105.249	2.56%
Meadows (riparian forests)	97.09	4.732%	82.133	4.003%
Sands	5.538	0.270%	5.538	0.270%
Savannas	976.971	47.616%	768.404	37.451%
Growing area	277.053	13.503%	388.069	18.914%
Total	2051.762		2051.762	

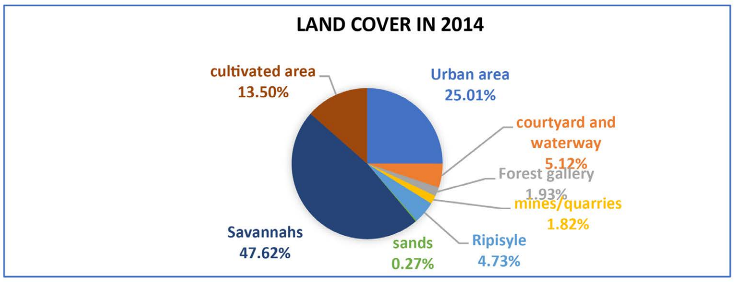

Figure 6. Showing the percentage of land occupation (bank) in 2014.

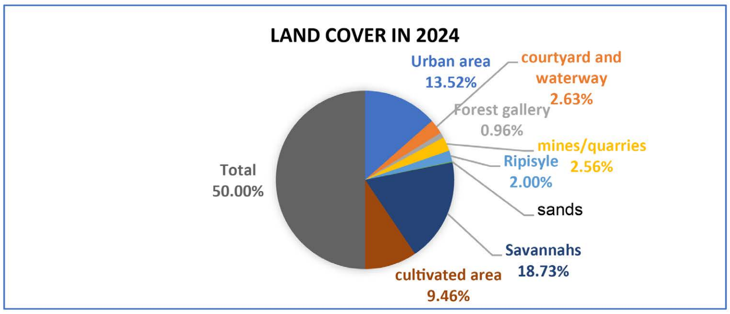

Figure 7. Showing the percentage of land occupation (bank) in 2024.

3.4. Physicochemical Analyses of the Soil Sample from the Bank (PE 5 Brickyard and E5 Bridge)

Samples from two sampling sites were analyzed, namely: Samples from the port and from the bridge (PE 5 and bridge E5 respectively). The results are reported in (Table 2 and Table 3).

Table 2. Shows the results of physical soil analysis

Lab No.	Reference samples	Granulometry (%)					Texture	pH water	Da g/cm^3
		A	Lf	Lg	Sf	Sg			
440	Bridge E 5	3.4	10	7.2	42.20	36.36	SL	4.48	1.32
441	PE 5 brickyard	3.6	7	5.6	45.23	37.32	SL	4.84	1.00

A = clay; Lf = weak silt; Lg = coarse silt; Sf = fine sand; Sg = coarse sand; texture: SL = sandy-silty; Da = apparent density.

Table 3. Shows the results of soil chemical analysis.

Lab No.	Reference samples	M.O (%)	C.O (%)	Nass mg/kg	N/T mg/kg	C/N	P_2O_5 mg/kg	K_2O mg/kg	SBE meq/100g	CEC meq/100g
440	Bridge E	2.10	1.35	5.40	0.11	12.27	25.10	90.22	1.20	5.10
441	PE 5 brickyard	2.20	1.10	5.50	0.10	12.20	18.20	104.50	2.10	6.78

M.O = organic matter; C.O = organic carbon; Nass = available nitrogen (mg/k); N/T = Total nitrogen (mg/k); C/N = Carbon-Nitrogen ratio; P_2O_5 = phosphorus oxide; K_2O = potassium oxide; SBE = Sum of bases (meq/100g); CEC = Cation exchange capacity (meq/100g).

4. Discussion

A watercourse showing a good hydromorphological state contributes to improving the proper functioning of the ecosystem of aquatic environments while strengthening its capacities to adapt to climate change [18]. According to [19] and [18], by citing some elements that enter into the proper functioning of a watercourse and a disturbed or undisturbed hydromorphology indicates that: a diversification of the morphology of the minor bed of watercourses brings a heterogeneity of habitats (alluvial banks, wetlands, riffles), supports biodiversity in the watercourse, thus promoting its capacities for biological, chemical or physical transformations of organic substances brought to it from the outside (self-purification), natural banks as well as a stratified riparian forest, a place of habitation of numerous animal and plant species, a longitudinal ecological continuity allowing sediments and all fish or migratory fish to move. The observation of the Djoliba River in Kouroussa showed us an arid river from May 31 to 1, 2024, and anarchic occupations all along the river by human activities which led to the destruction of the arms of the river causing deformations in certain places of the normal river bed which causes each year in the heavy rains season, the flooding of homes near the river. For example, on the site (brickyard), there is an overflow of the river bed caused by these brick manufacturers of 29.7 meters from the natural river bed and 10 meters from the homes and a slaughterhouse next door not shown. Silting with puddles, stopping the flow of the river, measurement between the bank and the water level in the river bed, as well as the width of the bed which is (10 m) in May 2024. The results of occupation of the bank of the Djoliba River from 2014-2024 are mentioned in (**Table 1**, **Figure 6** and **Figure 7**). However, our second visit on Djoliba River site on 16 August 2024 showed us a river completely filled with water, as shown in (**Figure 3(b)**). This filling of the river is thought to be due to the long period of rainfall in Kouroussa in August, with an average rainfall of 335 millimeters [20]. So, the water evacuations of runoff towards the river and the reloading of groundwater at the time of these heavy rains, would be sources of supply of water and sand to the river following the degradation of the soil over time (erosion phenomenon) disfavoring the rooting of trees, shrubs, bushes (riparian forest) (**Figure 1** and **Figure 5**) maintenance factor banks [21] [22]. The absence of riparian forest can also cause the movement of a watercourse [21]. The quantity of sand in the river has been transported gradually over the years and has increased by 0.13%. Thus, a trailing hopper dredging technique, for example, can be considered for the survival of this river. The granulometry analysis of the soil on the bank of the Djoliba River in Kouroussa (Republic of Guinea) allowed us to determine the apparent density of these two sampling points (PE 5 brickyard and E5 bridge). The results showed that the soil has a sandy-silty texture with apparent densities of 1.32 and 1.00 g/cm^3 respectively and pH = 4.48 and 4.84. However, the soil density which is a necessary element for plant growth, because it determines the penetration capacity of the roots and the soil structure, according to [23] a soil with a texture of about 50% pore space will have an apparent density of 1.33 g/cm^3. This value is close to that found at the sampling point bridge E5 which is at 1.32 g/cm^3, and a difference of 0.33 with the sampling point brickworks PE 5 (**Table 2**). The results of chemical analysis of the samples showed the presence of certain oxides such as: P_2O_5 and K_2O with contents: (25.10; 18.20 and 90.22; 104.50 respectively (**Table 3**). It should be noted that although these oxides diphosphorus pentoxide (P_2O_5) and potassium monoxide (K_2O) are essential nutritional components for plant growth, as they represent the phosphorus and potassium content of many fertilizers [24] [25], but their excess presence in water and soil samples is an indication of pollution. The sources can be: erosion, leaching; pollution with agricultural fertilizer, urban effluents, artisanal miners of precious metals who directly discharge detergents or other toxic solutions into the water. The percentages of organic matter (OM); organic carbon is: 2.10%; 1.35%. Those of the PE5 brickyard sample are: 2.20%; 1.10%. The contents of assimilable nitrogen; total nitrogen; carbon nitrogen ratio; sum of bases; Cation Exchange Capacity of the Point E and PE5 brickyard samples are: 5.40 mg/kg; 0.11 mg/kg; 12.271 meq/100g; 1.20 meq/100g; 5.10 meq/100g and 5.50; 0.10 mg/kg; 12.201 meq/100g; 2.10 meq/100g; 6.78 respectively.

5. Conclusion

This work shows the impact of anthropogenic activities on the Djoliba River in the urban commune of Kouroussa in the Republic of Guinea over the last ten years (2014-2024). The studies were based on the degree of degradation, riverbank and pollution of the river water. The results show that intensive agriculture, small-scale mining and the uncontrolled construction of buildings have contributed to the considerable degradation of the river and the quality of its biodiversity. The results of the physico-chemical analysis of the soil on the bank showed that the soil pH is acidic. The soil texture is sandy-loamy. The current state of the Djoliba River is a cause for concern and requires restoration to ensure the sustainability of this essential hydric resource for a large part of West Africa, through which the river flows (period without rain). To deal with it, an extensive reforestation and restoration programme of head and along of the headwaters major rivers by plant species adapted to aquatic environments, which combats erosion, balances the hydrological system and stabilizes the soil thanks to its roots, sand dredging techniques, the palisade fence used by certain Sahelian, destruction habitats and banning human activities, use of synthetic fertilizers by farmers on the bank vegetation could be an alternative. However, other additional studies are recommended because this document can be used by the Ministry in charge of the environment of the Republic of Guinea and even other African countries crossed by this river.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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