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Hydrological Study (2021-2024) and Physico-Chemical and Microbiological Analysis of the Djoliba River Water in Kouroussa (May-December 2024)

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Abstract

Water is an essential resource for life on earth, and is involved in many aspects of the environment and human life. It is therefore important to protect it. The aim of this study is to assess the level of microbial and physico-chemical pollution and the degree of hydrological disturbance in the waters of the Djoliba River in the commune of Kouroussa (Republic of Guinea) over the last ten years (2014 to 2024). To do so, methods spectrophotometric analyses of samples I and II were carried out and have shown more or less satisfactory results in relation to the presence of heavy metals and mineral elements in samples I. However, the presence of coliforms in samples KPE2 and KBRIQUETERIE was 126 and 124 respectively. For sample II, contamination is widespread and exceeds acceptable total coliform thresholds. Particle size analysis reveals a mixture of medium grains with a very narrow S, shaped particle size class, unsorted homogenous material transported into the watercourse at short intervals. According to a study by the Max Planck Institute for Marine Microbiology in Bremen, grains of sand are home to thousands of bacteria. The hydrological study showed that the river has experienced disturbances in the years 2021-2024 as a result of human aggression.

Keywords

Physicochemical, Microbiology, Hydrology, Sand, Djoliba River, Kouroussa

1. Introduction

Water scarcity and management is now a global phenomenon. The world's demand for water is increasing day by day, in all areas of life. However, the level of water in the springs only decreases from year to year [1]-[3]. In any given year, some 2.67 billion people worldwide face water shortages every month, a phenomenon caused by aggressive human activities on the environment [1]. The Republic of Guinea is considered the water tower of West Africa, because of its abundant water resources, with over 1,300 rivers, and almost all of the water resources of Africa's great Niger River, is still struggling to take full advantage of this natural wealth due to a poor policy for developing and protecting its water and environmental resources, and under-investment in water and environmental infrastructure [4]-[7]. Djoliba, the name of the Niger River in the commune of Kouroussa, waters many towns and villages in Upper Guinea and crosses several West African countries after the northern slope of the Daro Massif [8] [9]. It has a catchment area of 70,000 km^2 and flows for 643 km. However, its vegetative environment, which provides shade to reduce water temperature and ensure good oxygenation for aquatic life, and its role as a bank soil fixer through its roots, which helps maintain the hydrological structure of the watercourse, are now in a state of advanced degradation and pollution, which means that consumption of its water by the urban population of Kouroussa has become a real health risk [8] [10]. For this reason, the Guinean government is carrying out additional water supply work through standpipes in the urban commune of Kouroussa, with a view to reinforcing its drinking water supply network current August 2022. This increased production from 900 to 2300 m^3/day [11]. Studies on source water pollution have been reported [12]-[14]. However, we have recently published on the impacts caused by anthropogenic activities on this river [8]. As a continuation of this work, we report on a physico-chemical and microbiological study and four years of hydrological measurement of the water level of this river in the urban commune of Kouroussa, twice a day and once a month (7 a.m. and 6 p.m.), using a graduated limnimetric scale 2 meters long, 13 cm wide, installed at the foot of the bridge and in the bed of the Djoliba River (**Figure 1**), in order to propose some traditional restoration solutions, as the silting up of this river in periods without rain looks as if it will disappear in the future.

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 the Office National of Control of Quality and Biology the Institute Superior of Technology of Mamou, served as the framework for this study.

2.3. Sampling

The sand sample and the two water sampling periods (water samples I and II) used in this study were carried out in the Djoliba River at Kouroussa on May 31, 2024 (for the sand and first water sample) and December 22, 2024 (second water sample) and Monthly bulletins of water level measurement results for 4 years (2021-2024) were used as raw material for the physico-chemical, microbiological and hydrological analysis. So, it was carried out at six representative sites along the Djoliba River in Kouroussa. The sites were chosen based on their immediate proximity to the main anthropogenic pressures (domestic activities and discharges, agricultural activities on the riverbanks, craft activities). The distances from potential sources of pollution and the precise GPS coordinates are as follows:

- ***Site 1*** (upstream, little impact): 10.4002˚N, 9.3010˚W—located approximately 4 km from the city centre, outside the area of direct influence. 1.5 L volume of water, number of replicates: 3
- ***Site 2*** (urban area): 10.3961˚N, 9.3057˚W—1 km downstream from the main urban discharges (domestic wastewater). 1.5 L volume of water, number of replicates 3
- ***Site 3*** (near market gardening areas): 10.3938˚N, 9.3083˚W—300 m from irrigated agricultural perimeters. 1.5 L of water sampled, number of replicates 3
- ***Site 4*** (downstream): 10.3905˚N, 9.3122˚WW-150 m downstream from the urban centre, incorporating cumulative effects. 1.5 L water volume, number of replicates 3
- ***Site 5*** (downstream): 10.3867˚N, 9.3165˚ W—100 - 200 m, close to crafts/riparian localities. 1.5 L water volume, number of replicates 3
- ***Site 6*** (downstream): 10.3830˚N, 9.3210˚W—150 m, cumulated downstream 2.5 km downstream from urban discharges, 1.5 L water volume, number of replicates 3. Samples were taken from the surface of the water at a depth of 0 - 30 cm, in sterile bottles, using gloves and of the previously disinfected equipments. The samples were stored in a refrigerator at 4˚C and transported immediately to the laboratory within 6 hours. These analyses were performed taking into account the average values of the replicates for each sample.

2.4. Physico-Chemical and Microbiological Analysis

Water samples were analyzed using a range of techniques, including enumeration, spectrophotometry, conductivity and pH meters.

2.5. Sand Granulometric Analysis

Sand is generally from by the degradation under the action of the weather and erosion of rocks. Then, drained into water sources and constantly decomposing along the way, forming particles of various sizes. Ains, with granulometric methods, the different sizes of their particles can be known using sieving techniques after washing and drying sand grains from 3 kg samples using a series of square meshed sieves with standard NF XP 13-901 on CEB (A. F.N.O. R) [15]-[18]. These meshes are superimposed one on top of the other, their diameters successively decreasing downwards [9]. The results are shown in **Table 1** and **Figure 2**.

2.6. Study of the Hydrological Regime

The hydrological study technique for the Djoliba River used in this work is based on the monthly determination of water levels over a 4 year period between 2021-2024, of observations using a graduated limnimetric scale, 2 m long and 13 cm wide, installed at the foot of the historic bridge (Niger, Djoliba) in the urban commune of Kouroussa and in the riverbed (Figure 1). To take the measurement, stand next to the limnimetric scale and fix your eyes at the water level on the scale closest to the water surface. Read the value found, which will be taken as the height of the water. These measurements were carried out twice a day (7 a.m. and 6 p.m.) for 4 years. Average values for each month and year were obtained by adding the daily values measured at 7 a.m. to each other and those measured at 6 p.m. to each other, divided by 2 respectively, to find the average value for each month (averages h1 and h2).

Figure 1. Enamelled steel sheet water level gauge installed at the foot of the historic bridge and in the riverbed in the urban commune of Kouroussa.

3. Results and Discussion

In this study of the Djoliba River at Kouroussa, we found that the watercourse was suffering from severe degradation. We have carried out certain analysis.

3.1. Granulometric Analysis

The extensive silting of the Djoliba River led us to take a number of steps, including a granulometry study, to determine the type and origin of the sand in the Djoliba River at Kouroussa (Figure 2 and Table 1).

3.2. First Physico-Chemical Analyses of General Parameters and Enumeration of Micro-Organisms in Sample Group I (Sampling on May 31, 2024)

The initial physico-chemical and microbiological analyses of the general parameters of the first series of water samples gave us more or less appreciable results, which are reported in Tables 2-4.

3.3. Second Enumeration of Microorganisms in Sample Group II (Sampling on December 22, 2024)

The results of the second series of water samples (samples II) are reported in (Table 5).

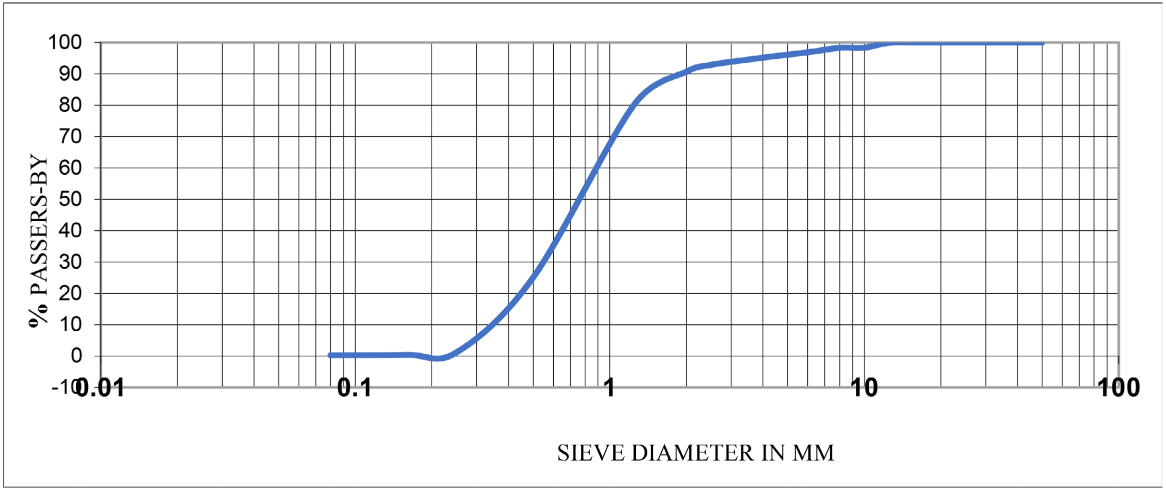

Figure 2. Granulometric curve of the sand sample from the Djoliba River (Kouroussa).

Table 1. Granulometric characteristics.

sieve opening (mm)	50	40	31.50	25.0	20.0	16.0	12.50	10.0	8.0	6.30	5.0	4.0	2.50	2.00	1.25	0.500	0.250	0.160	0.080
Passes (%)	100	100	100	100	100	100	100	98.4	98.3	97.1	96.1	95.2	92.9	90.7	80.3	25.1	1.17	0.38	0.25

Table 2. Results for general parameters.

Samples	Parameters					
	pH	Temperature (˚C)	Conductivity (μ at S/Cm)	Dissolved salt content (mg/l)	Turbidity (FTU)	Salinity (mg/l)
KPE_1	6.67	25.3	98	92.87	3.43	ND
KPE_2	6.82	25.6	98	92.87	5.24	ND
KPONT E_1	6.64	25.5	104	98.55	4.59	ND
KPONT E_2	6.83	25.4	100	94.76	3.24	ND
KBRIQUETERIE E_1	6.77	25.7	98	92.87	6.09	ND
KBRIQUETERIE E_2	6.56	25.6	106	100.45	7.50	ND
Criteria	5 - 9.5	-	65 - 830	≤1500	0.6 - 280	00

Table 3. Determination of heavy metals by spectrophotometric method.

Examples	Parameters									
	Nitrites (mg/l)	Nitrates (mg/l)	Aluminium (mg/l)	Chlorides (mg/l)	Copper (mg/l)	Iron (mg/l)	Sulphates (mg/l)	Manganese (mg/l)	DBO5 (mg/l)	DCO (mg/l)
KPE_1	0.02	1.3	0.007	9.4	< 0.002	0.14	44.6	0.0014	1.8	8.9
KPE_2	0.01	0.9	0.008	9.6	< 0.002	0.11	49.1	0.020	1.8	9.4
KPONT E_1	0.07	1.6	0.012	9.6	< 0.002	0.09	51.4	0.025	2.1	12.9
KPONT E_2	0.09	0.8	0.007	10.1	< 0.002	0.10	49.6	0.015	1.6	12.1

Continued

KBRIQUETERIE E_1	0.02	0.9	0.006	9.9	< 0.002	0.11	40.5	0.010	1.9	9.6
KBRIQUETERIE E_2	0.08	1.6	0.01	12.4	< 0.002	0.13	56.4	0.03	2.25	15.4
Criteria	**≤1**	**≤50**	**≤0.2**	**≤250**	**≤0.002**	**0.3**	**≤250**	**≤0.5**	**≤5**	**≤30**

Table 4. Enumeration of micro-organisms.

Examples	Total coliforms (UFC/100ml)	Faecal coliforms (UFC/100ml)
KPE_1	34	13
KPE_2	93	05
KPONT E_1	42	14
KPONT E_2	185	126
KBRIQUETERIE E_1	09	01
KBRIQUETERIE E_2	216	124
Criteria	**580 - 13.10^4**	**0 to 83.10^3**

Table 5. Results of microbial enumerations in river water samples.

Samples	Total coliforms (UFC/100ml)	*Escherichia coli* (*E. coli*) (UFC/100ml)	Faecal coliforms (UFC/100ml)
E1 (KPONT E_1)	750	120	600
E 2 (KP1)	1200	250	900
E 3 (KBRIQUETERIE E2)	1800	400	1500
E 4 (KPONT E2)	2200	500	1800
E 5 (KP2)	950	180	750
E 6 (KBRIQUETERIE E2)	3000	700	2500
Criteria	**≤500 UFC/100mL**	**≤1000 UFC/100mL**	**≤4000 UFC/100mL**
Methods	**Filtration membrane (ISO 9308-1: 2014, revised in 2022)**		**ISO 9308-2: 2012**

3.4. Hydrological Analyses of the Last 4 Years (2021-2024) of the Djoliba River (Urban Commune of Kouroussa)

Measuring the volume of water in a river is important for understanding its capacity to transport sediments, pollutants and other substances. This can help assess certain hydrological aspects of the river, such as flood management, environmental impacts such as water quality, and the impact on ecosystems. This information is important for infrastructure planning, flood prevention and water resource management, as sediment transport can influence water quality. Solid particles can carry heavy metals, pollutants, chemicals and organic substances into watercourses, and can cause bank erosion by altering the topology and morphology of the watercourse. This can also lead to heavy silting of the river. Measuring the volume of water in a river can take from several months to several years. As one of the key steps in the hydrological study of a river, we opted to measure and collect data on water levels during the 2021-2024 period, twice a day (7 a.m. and 6 p.m.), using the limnimetric scale installed at the foot of the bridge and in the riverbed (**Figure 1**). Thus, based on the results found, sustainable solutions can be proposed to mitigate risks and improve the water management method. The results are shown in tables. All averages have been rounded to 2 decimal places for greater readability. At the time the water samples were taken for analysis, a number of dead arms were observed in certain areas of the river. Average monthly values of the water level observed on the limnimetric scale (year 2021 to 2024) of the Djoliba River in the urban commune of Kouroussa are in **Tables 6-9**.

Table 6. Average monthly values of the water level observed on the limnimetric scale (year 2021) of the Djoliba River in the urban commune of Kouroussa.

Month	Average h1	Average h2	Monthly mean height 2021
Jan-21	95.94	95.35	95.64
Feb-21	64.00	63.66	63.83
March-21	47.65	47.52	47.58
Apr-21	33.80	33.90	33.85
May-21	32.29	31.77	32.03
June-21	70.87	72.20	71.54
Jul-21	160.90	160.61	160.76
August-21	367.19	366.94	367.07
Sept-21	413.90	411.13	412.52
Oct-21	323.52	315.61	319.57
Nov-21	321.83	319.93	320.88
Dec-21	239.45	238.39	238.92

Table 7. Average monthly values of the water level observed on the limnimetric scale (year 2022) of the Djoliba River in the urban commune of Kouroussa.

Month	Average h1	Average h2	Monthly mean height 2021
Jan-22	63.94	63.00	63.47
Feb-22	77.29	76.79	77.04
March-22	49.29	48.87	49.08
Apr-22	36.27	36.00	36.14
May-22	32.32	32.29	32.31
June-22	90.63	91.27	90.95
Jul-22	210.29	212.61	211.45
August-22	339.13	341.19	340.16

Continued

Sept-22	330.23	419.55	374.89
Oct-22	418.97	418.32	418.65
Nov-22	264.23	264.13	264.18
Dec-22	173.29	170.42	171.86

Table 8. Average monthly values of the water level observed on the limnimetric scale (year 20223) of the Djoliba River in the urban commune of Kouroussa.

Month	Average h1	Average h2	Monthly mean height 2021
Jan-23	110.29	108.19	109.24
Feb-23	73.04	72.43	72.74
March-23	47.00	46.81	46.91
Apr-23	29.70	29.67	29.69
May-23	44.07	44.83	44.45
June-23	120.77	122.13	121.45
Jul-23	264.87	270.16	267.52
August-23	404.16	405.58	404.87
Sept-23	473.84	475.29	474.57
Oct-23	512.58	511.13	511.86
Nov-23	399.53	398.60	399.07
Dec-22	337.97	336.68	337.33

Table 9. Average monthly values of the water level observed on the limnimetric scale (year 20224) of the Djoliba River in the urban commune of Kouroussa.

Month	Average h1	Average h2	Monthly mean height 2021
Jan-24	263.63	262.67	263.15
Feb-24	194.93	194.21	194.57
March-24	162.03	161.65	161.84
Apr-24	132.73	132.03	132.38
May-24	85.71	85.10	85.40
June-24	91.40	92.33	91.87
Jul-24	233.19	239.55	236.37
August-24	547.13	560.81	553.97
Sept-24	744.94	746.39	745.66
Oct-24	557.65	551.55	554.60
Nov-24	268.50	266.07	267.28
Dec-24	174.23	172.97	173.60

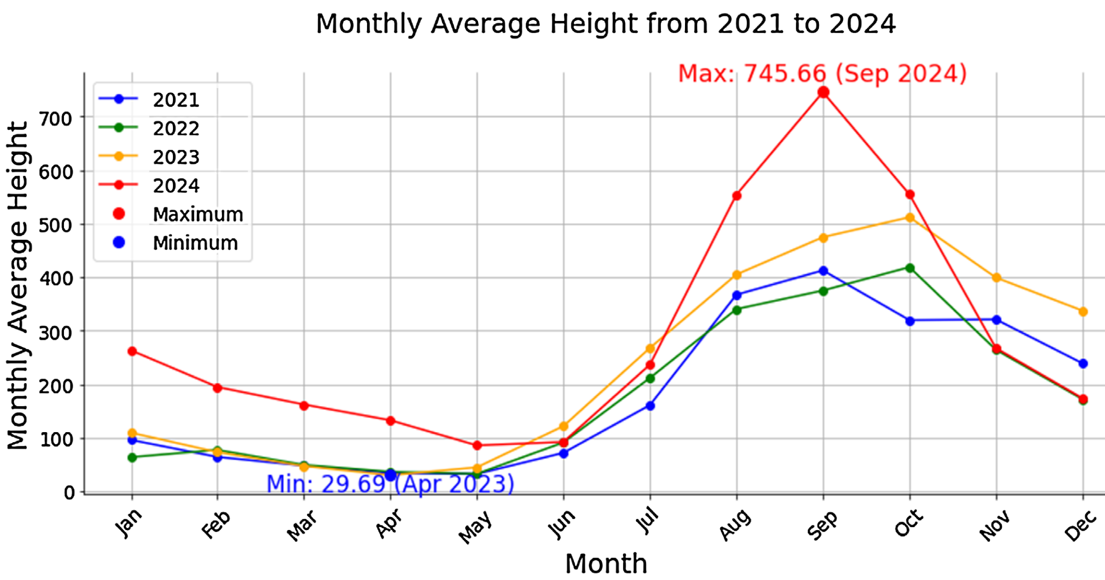

Figure 3. Showing a summary and comparison of the four years of observation of the water level of the Djoliba River in the urban commune of Kouroussa.

Figure 4. Showing a dead arm fed during high water.

4. Discussion

According to the results in (**Table 1**), the number of 100% passes was obtained with 50 to 12.50 mm sieves. However, refusals were obtained with 10.0 to 0.080 mm sieves, which may probably be due to the size of certain aggregates. However, analysis of **Figure 2**, shows the particle size classification of particles presenting a very narrow ʃ-shape blend. An important element here, but little developed, is the correlation that can exist between the composition of the sand on the bank and the quality of the water. The results of field observations show that the nature of the sand can influence the dynamics and quality of the river water. The sites located upstream (**S1** and **S2**) (**Tables 2-4** in order), where the substrate (soil on which the bank rests) is formed of coarse and less compact sand, one of the factors for better infiltration of water thanks to the level porosity of the soil. This granular structure allows water to pass through in depth. It limits the speed of surface runoff and acts as a natural filter, in order to obtain water of relatively better quality.

On the other hand, in the downstream and intermediate sites (S3 to S6), (**Tables 2-4** in order) we remark the presence of areas has homogeneous but unsorted sand, containing a mixture of fine grains, clays and silts. This type of granular structure forms an impermeable and more compact soil, which reduces infiltration and promotes surface runoff. This situation causes direct transport of pollutants to the river (organic matter, fertilizers, domestic waste), factors that aggravate the degradation of water quality, for example: turbidity, absorption capacity and retention of nutrients. The existence of fecal bacteria in water can be explained by the role of sand as a temporary microbiological reservoir, as shown by several studies [18]. Bacteria such as *E. coli*, fecal enterococci, or Clostridium perfringens can survive in wet sandy sediments and be released into water under certain hydrodynamic conditions. This observation is consistent with studies carried out by a group of researchers (microbiologists) from the Max Planck Institute for Marine Microbiology in Bremen on (genus of Vibrio bacteria, more specifically the group named "Candidatus Tecttiglobus diatomicola") in as part of their role sands [19], He affirms that a single grain of sand is a habitat for thousands of bacteria. It can house up to 100,000 microorganisms emanating from thousands of species through the cracks and hollows of the grains and bacterial or mycophages (*Escherichia coli*) contamination can be due for example to the presence of faecal matter on the sand which is responsible for gastrointestinal disorders, mycoses etc. [19] [20]. Thus, the composition of the substrate in water sources should be considered as a modulating factor of vulnerability to pollution, particularly in connection with urban runoff or agricultural practices. This work has give results physicochemicals and microbiological analysis of two types of sample collection in two periods of the year, namely: May and December 2024, are shown in Tables A, B, C, D and E. Samples I for May 2024 (KPE1, KPE2, KPONT E1 and KPONT E2) showed turbidity below the standard indicated by the analysis laboratory, either (0.6 - 280). However, the other parameters in this table are appreciable. The spectrophotometric method for Group I samples showed satisfactory results for the presence of heavy metals and other mineral elements. Microbiological analysis of the same I samples from May 2024 shows the presence of coliforms in samples KPE2 and KBRIQUETERIE either: 126 and 124 respectively. For the microbiological analysis of sample group II, the second sampling with six samples (E1, E2, E3, E4, E5 and E6) of water from the Kouroussa river during the period December 22, 2024 (**Table 5**), which took place between 12 hours 11 minutes and 12 hours 24 minutes, reveals widespread contamination, characterized by systematic exceedance of acceptable thresholds for total coliforms, with concentrations ranging from 750 to 3000 CFU/100mL. The presence of *Escherichia colis*, detected in all samples at concentrations between 120 and 700 CFU/100 mL, indicates pollution of fecal origin, reflecting a potential risk of transmission of enteric pathogens. In particular, sampling points E3 (1800 CFU/100mL total coliforms; 400 CFU/100mL *Escherichia coli*; 1500 CFU/100mL faecal coliforms) E4 (2200 CFU/100mL total coliforms; 500 CFU/100mL *Escherichia coli*; 1800 CFU/100mL faecal coliforms) and E6 (3000 CFU/100mL total coliforms; 700 CFU/100mL *Escherichia coli*; 2500 CFU/100mL faecal coliforms) show particularly high levels of contamination, far exceeding sanitary quality standards. These contaminations are mainly attributed to the artisanal activities of the brickworks, which generate discharges and wastewater directly into the river, to the surrounding agricultural practices favoring runoff of fertilizers and animal excrement, and to bathing and other domestic uses of the water, which contribute to the microbial load. This situation accentuates the health risks for local populations, who are exposed to gastro-intestinal infections and other water-borne diseases if they consume or use the water at home without appropriate treatment. The hydraulic study of this river has enabled us to measure the water level in meters relative to a zero point between 2021-2024 (**Tables 6-9**; **Figure 3**). These tables and figures show that the lowest water level after measurement was found in April 2023, with an average value of (29.69) cm; and the highest average water level in September 2024, at (745.66) cm. It should be noted that a gradual increase in water level was observed for the four years between June to September 2021; June to October 2022; June to October 2023 and June to September 2024, then decreases until December for all years. In many parts of the river, there are oxbows that are fed during flood periods, with the risk of flooding (**Figure 4**). These variations can be linked to disturbed climatic conditions, precipitation and human activities.

5. Conclusion

The second sampling with six samples (E1, E2, E3, E4, E5 and E6) of water from the Djoliba River in Kouroussa on December 22, 2024, showed widespread contamination. Given the state of the water in the Djoliba River when we visited in May 2024, it would have been implausible to limit ourselves to the results of the microbiological analysis of sample I (during May 2024). The abundance of sand in the Djoliba River prompted us to carry out a granulometric analysis to determine the nature of the sand, which is a mixture of medium and fine grains transported downstream by the river current over a short period of time, because, according to one study, each grain of sand is a microbial storehouse capable of harboring thousands of bacteria, and can have an impact on water turbidity. The 4 years of measurements (2021-2024) of the river's water levels have shown that the river has experienced hydrological disturbances periodically causing the floodplains to be invaded by devastating floods as a result of human aggression, such as irrigation, mining and waste discharge into the watercourse. This river, which is a source of wealth for the countries it crosses in West Africa, is in need of environmental restoration as natural habitats, wetlands, meadows and waste management. It is timely for these areas found to consult with environmental restoration professionals to establish a better restoration method for this important river.

Conflicts of Interest

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

References

[1] Linh, L.V., Nguyen, T.A., Duc, N.A., Tra, T.V., Long, N.T., Duc, D.D., *et al.* (2024) Assessment of Water Scarcity Levels in the Srepok River Basin. *Open Journal of Modern Hydrology*, **14**, 231-249. https://doi.org/10.4236/ojmh.2024.144013

[2] Li, S., Li, C., Luan, J., Dong, S., Li, Y., Tai, Y., *et al.* (2025) Analysis and Prediction of the Lowest Ecological Water Level of the Inland Lake in Arid Region of China. *Open Journal of Modern Hydrology*, **15**, 76-90. https://doi.org/10.4236/ojmh.2025.152006

[3] Hoekstra, A.Y., Mekonnen, M.M., Chapagain, A.K., Mathews, R.E. and Richter, B.D. (2012) Global Monthly Water Scarcity: Blue Water Footprints versus Blue Water Availability. *PLOS ONE*, **7**, e32688. https://doi.org/10.1371/journal.pone.0032688

[4] Guinée. https://fr.wikipedia.org/wiki/Guin%C3%A9e#:~:text=aux%20r%C3%A9gions%20administratives.-,Hydrographie,l'Afrique%20de%20l'ouest

[5] Selly, C. and Abdelkader, B. (2017) Valorisation des ressources en eau en Guinée en vue d'un développement économique, social et durable. *Journal of Water and Environmental Sciences*, **1**, 106-114.

[6] Sow, M.M., Cisse, A., Sakho, A.M. and Kante, C. (2023) Removal of Nitrate and Phosphate Ions from the Bafing River by an Adsorbent Obtained from the Shells of Mango Cores. *Journal of Geoscience and Environment Protection*, **11**, 67-78. https://doi.org/10.4236/gep.2023.111005

[7] (2023) S.E.G: Les défis de la fourniture d'eau potable. https://emergencegn.net/s-e-g-les-defis-de-la-fourniture-deau-potable/#google_vignette

[8] Sagno, S., Cissé, H., Sow, M.M., Sylla, F. and Sakho, A.M. (2024) 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). *Journal of Water Resource and Protection*, **16**, 757-766. https://doi.org/10.4236/jwarp.2024.1612042

[9] https://webguine.site/pays/geographie/bam/geogn-bam.html

[10] https://reart66.fr/lentretien-des-rivieres/le-role-de-la-ripisylve/

[11] (2022) Kouroussa: Remise technique des installations d'adduction pour plus d'eau potable aux autorités de la ville par la Direction Générale de la SEG. https://www.visionguinee.info/kouroussa-remise-technique-des-installations-dadduction-pour-plus-deau-potable-aux-autorites-de-la-ville-par-la-direction-generale-de-la-seg/

[12] Camara, S. and Bangoura, A. (2017) Valorisation des ressources en eau en Guinée en vue d'un développement économique, social et durable. *Journal of Water and Environmental Sciences*, **1**, 106-114.

[13] Sharma, G., ALOthman, Z.A., Kumar, A., Sharma, S., Ponnusamy, S.K. and Naushad, M. (2017) Fabrication and Characterization of a Nanocomposite Hydrogel for Combined Photocatalytic Degradation of a Mixture of Malachite Green and Fast Green Dye. *Nanotechnology for Environmental Engineering*, **2**, Article No. 4. https://doi.org/10.1007/s41204-017-0014-y

[14] Guinée—Projet Hydraulique Rurale en Haute Guinée. https://mapafrica.afdb.org/fr/projects/46002-P-GN-AB0-004

[15] (2001) Norme XP P 13-901. Blocs de terre comprimée pour murs et cloisons: Définitions-Spécifications-Méthodes d'essais-Conditions de réception. AFNOR.

[16] Kourouma, M., Diallo, A.D., Sow, M.M., Sakho, A.M., Kourouma, A. and Dramé, M.

(2025) Physico-Chemical Studies and Improving the Strength of Earth Bricks Stabilized with Crushed Cellulose Paper: The Case of the Urban Communities of Mamou and Kouroussa. *Journal of Materials Science and Chemical Engineering*, **13**, 53-67. https://doi.org/10.4236/msce.2025.132004

[17] Mamady, K., Adama, M.S., Aboubacar, D., Mamadou, M.S., Abdoulaye, I.C. and Mamoudou, C. (2023) Physico-Chemical Studies of the Bricks in Mud Raw Used in the Construction of Century-Old Huts (Straw Huts): Case of the Urban Commune of Kouroussa. *Journal of Environmental Science and Engineering A*, **12**, 201-213.

[18] Whitman, R.L., Shively, D.A., Pawlik, H., Nevers, M.B. and Byappanahalli, M.N. (2003) Occurrence of *Escherichia coli* and Enterococci in *Cladophora* (Chlorophyta) in Nearshore Water and Beach Sand of Lake Michigan. *Applied and Environmental Microbiology*, **69**, 4714-4719. https://doi.org/10.1128/aem.69.8.4714-4719.2003

[19] (2017) Every Grain of Sand Is a Metropolis for Bacteria. https://www.mpg.de/11830658/sand-bacteria

[20] Badie, V. (2023) Plage: Les maladies qui peuvent se cacher dans le sable. https://www.doctissimo.fr/sante/dangers-du-soleil/maladies-sable-plage