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Assessment of The Impact of Gold Panning on The Physicochemical and Bacteriological Parameters of The Waters of The Niger River in Guinea.

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ABSTRACT

Artisanal mining, or gold panning, plays a key role in Guinea's socio-economic activities. Today, this ancestral activity has undergone changes with the introduction of new extraction techniques that affect the population's living environment. The objective of this study is to assess the impact of artisanal mining on the physicochemical and bacteriological parameters of the waters of the Niger River in Guinea. To carry out this work, we chose five (05) sites (sampling points) taking into account the intensity of the mining activity taking place around it and on the Niger. We took fifteen samples to determine physicochemical and bacteriological parameters at the regional water quality laboratory. These were: pH, conductivity, turbidity, TDS, dissolved oxygen, nitrates, phosphates, nitrites and coliforms (faecal and total coliforms).This study enabled us to determine the impact of gold panning on the physicochemical and bacteriological parameters of the waters of the River Niger in Guinea, and to identify possible solutions. Analysis of the results shows that the waters sampled are generally of good quality. However, some parameters at certain measurement sites showed signs of pollution.

KEYWORDS : « Bacteriological, Impact, Gold mining, Physicochemical parameters

INTRODUCTION :

Artisanal gold mining, or traditional gold panning, has been present in Guinea since the 11th century, and perhaps even earlier under the Mali empire. At the time, gold miners used to dig very shallow pits, according to testimonies gathered in the region. However, the dry season was the time chosen by the communities to carry out this activity, and they would give up extracting ore after the end of the season to deal with field work. [6 ; 22]

Today, this ancestral activity has undergone changes with the introduction of new extraction techniques, notably the use of modern equipment and chemicals such as mercury, cyanide and zinc chips, to name but a few. These techniques not only affect the health and living conditions of the population, but also pollute our waterways and destroy the environment as a whole, not forgetting the fauna and flora. [6 ; 22]

Artisanal and industrial mining cause more harm than good to the environment, despite being one of the best sources of revenue and wealth creation for our country, the Republic of Guinea, because they cause enormous problems and considerable disruption, gradually contributing to an ecological imbalance [5].

Major companies are already mining in the Kankan region, including Société Kouroussa mining gold (KMG) in Kouroussa, Société Aurifère de Guinée (SAG) in Siguiri, Société Minière de Dinguiraye (SMD) in Dinguiraye, Société de Mines de Mandiana (SMM) in Mandiana, Société Guinean Birinian Gold (GBG) in Mandiana, Société New Japan Mining Company sarl in Mandiana and Société Guinean Gold and exploration (GGE) in Siguiri, while many other companies are in the exploration phase preparing their future operations, such as SICAMORE in Kouroussa, Société Predictive Discovery in Kouroussa and many others, and all have already been engaged in major stand-offs with local populations and authorities.

Protecting the quality of water resources and transboundary waterways such as the River Niger is high on the global agenda. Most of the world's countries have made the fight against such pollution a national priority. In Guinea, for example, the Niger Basin Authority (ABN) and the National Focal Point (SNF-ABN) have been set up to safeguard the River Niger and its tributaries.

The River Niger is the largest river in West Africa, with over 4,200 km of main course, including 550 km in Guinea. The River Niger's contribution to Guinea is inestimable. Despite this importance and all its potential, the River Niger is seriously threatened by major phenomena such as climate change, the continuing decline in its flows, silting and other pollution due to various activities (industrial, mining, agricultural, urban, etc.). [15]

For many years now, the River Niger has been under attack from various polluting activities in its basin, threatening its biodiversity, the quality of its waters and the health of its populations. In urban and mining centers, the River Niger has literally become a dumping ground for solid and liquid waste, to the detriment of its users and the environment. Having long been self-purifying, the nature and extent of the pollution can no longer be left to the river's own self-purification capacity. Life-saving action is therefore needed to deal with the many sources of deterioration in the quality of the waters of the River Niger. [15]

Upper Guinea is the region that concentrates most of the country's gold production. The watercourses that flow through this area are greatly threatened by the effects of this activity, including the Niger. In fact, the adverse impacts of mining activities are visible on all the waterways that cross this region (banks, flora, bed) are strongly threatened by the effects of this activity.

The Guinean basin of the Niger has numerous gold panning sites. There are gold-panning sites along certain watercourses and even in places in the riverbed.

MATERIAL AND METHODS :

Presentation of the study environment :

Study area :

Haute-Guinée is one of Guinea's four “natural regions”. It is bordered to the north by the Republic of Mali, to the south by Guinée Forestière, to the east by the Republic of Mali and Côte d'Ivoire, and to the west by Moyen Guinée.

It is a region of high plains, with shrub savannah vegetation and a majority Malinke population.

It covers an area of 95,643 km2.

The main towns are : Kankan, Faranah, Siguiri, Dinguiraye, Kouroussa, Kérouané, Mandiana.

It is located between 10° 44′ 24″ north and 9° 54′ 00″ west

Agricultural production :

Food crops: Cereals (Rice, millet, maize and fonio) ;

Tubers (Cassava, Yam, Sweet potato) :

Vegetables (Tomatoes, Onions) ;

Industrial crops (Peanuts, Cotton, Shea, Cashew nuts)

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Map of sampling sites in the study area

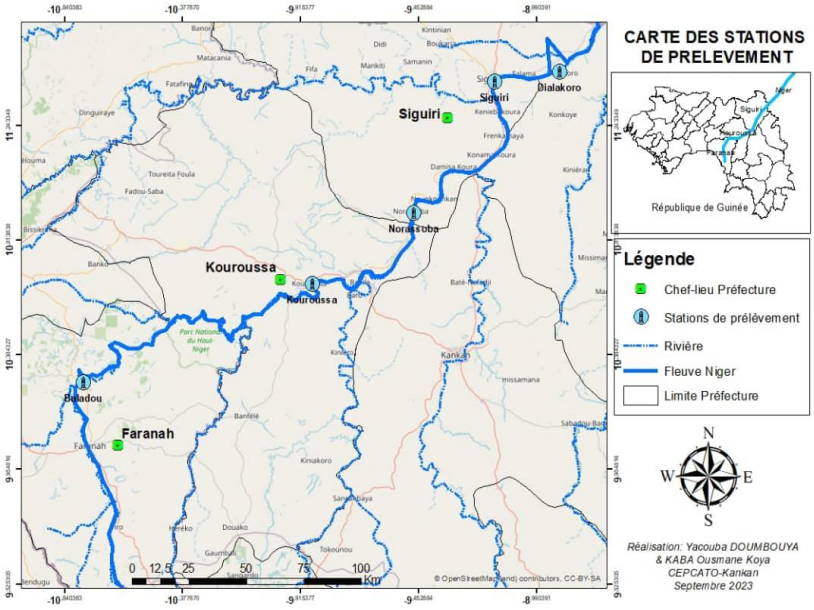

Figure 1 : Map of sampling stations on the Niger River in Guinea.

Current status of waterways in the area:

The Niger River was one of the main waterways in the sub-region. At the time, it was used for fishing and river transport between Mali and Guinea. It was a navigable river. The banks were wooded. There was hardly any threat, and the aquatic ecosystem was protected. [22].

Nowadays, with the galloping demography and the development of mining, rivers are savagely attacked by the population in search of their daily needs. Both mining industries and traditional operators discharge effluents and ore washing sludges, sometimes containing toxic chemicals such as cyanide, mercury, zinc, lead, arsenic, cadmium, etc. These assaults on our watercourses are a major source of pollution. These assaults on our waterways can be seen in the destruction of riverbanks and the silting-up of riverbeds by dredgers, leading to a spectacular increase in turbidity and the disappearance of other small streams. As the number of farmers increased, so did human pressure on the waterways, and the Niger ceased to be navigable. Fishing is almost non-existent, and the large rice-growing plains produce less because they are always flooded, as the rivers no longer have protective banks. [26]

RESULTS OF THE OBSERVATIONS :

The results of the observations are recorded in the table below :

Table 1 : Human activities detected in the study area.

N°	PREFECTURES	LOCALITIES	WATERCOURSE	OBSERVED ACTIVITIES
1	**BALADOU(FARANAH)**	Baladou	NIGER	Fisheries – Agriculture.
2	**KOUROUSSA**	Kouroussa	NIGER	Dwelling – Washing – Bathing.
3	**NORASSOBA**	Norassoba	NIGER	Market gardening, leaching, fishing, agriculture.
4	**SIGUIRI - STATION POMPAG**	Siguiri	NIGER	Station pompage - pisciculture Exploitation de l'or- Agriculture-Jardinage
5	**DIALAKORO**	Dialakoro	NIGER	Ore washing – Gold panning.

Work materials

Methodology :

- The geographical coordinates were determined using a Trimble GeoXM GPS device. [17]

- The pH and temperature were determined by potentiometry using a Multi parameter Multi 3420 SET G WTW device. [15]

- The Electrical Conductivity and TDS were determined by electrometry using a Multi parameter Multi 3420 SET G WTW device. [9]

- The dissolved oxygen was determined by the potentiometric method using a Multi 3420 SET G WTW Multi parameter device. [34]

- Turbidity was determined using a TB 210 R device. [35]

- Nitrate was determined by photometry using a Palintest DR 7100 Photometer device. [30]

- Nitrite was determined by photometry using a Palintest DR 7100 Photometer device. [32]

- Phosphates were determined by photometry using a Palintest DR 7100 Photometer device. [31]

- Bacterial levels (total coliforms, feces, and Escherichia coli) were determined using the membrane filtration seeding method. [47]

Sampling :

Sampling consists of choosing locations in the study area according to their relevance upstream, inside and downstream of gold panning outbreaks located on average 3 km along the course of the Niger River in Guinea. At these points water samples will be taken for laboratory analysis; It should be noted that some parameters will be analyzed in situ such as (PH, conductivity, dissolved oxygen, temperature and turbidity) thanks to the devices: Multi parameter Multi 3420 SET G WTW and the TB 210 R turbidity meter.

To carry out this work, we have chosen five (05) sampling or sampling sites, the characteristics of which will be recorded in the table below. These sites were chosen taking into account the intensity of mining activity taking place around it and on the Niger.

- The NIGER at Baladou (Faranah) as the sampling point upstream of the study area, This point considered as a witness, will be free of any impact of mining exploitation, since it is upstream of the study area;

- Four additional points within and downstream of the study area will be selected, including:

• Niger at Kouroussa below bridge (10°39'8" N / 9°52'17" W);

• Niger at Norassoba (10°55'9" N / 9°28'25" W);

• Niger at Siguiri at the pumping station (11°24'40" N / 9° 9'20" W);

• And finally the NIGER at Dialakoro as a sampling point downstream of the study area (11°26'51" N / 8°54'1" W).

Therefore, five (5x3=15) water samples will be taken in previously sterilized vials, placed in coolers whose temperature is reduced to 4° C using the pieces of ice placed on the samples and brought back to the laboratory 72 hours after their collection for their examination, except for pH, conductivity, turbidity and dissolved oxygen.

Therefore, for this study, fifteen (15) samples will be taken and brought back to the regional water quality laboratory in which the physical parameters (Ph, conductivity, turbidity, TDS, dissolved oxygen), nutrients (nitrates, nitrite phosphates, etc.) will be determined. etc.), and bacteriological parameters (total coliforms, fecal coliforms, Escherichia colis).

TABLE 2 : Sampling sites and their geographical position.

№	SAMPLING STATIONS	WATERCOURSE	GEOGRAPHIC COORDINATES		OBSERVATION
1	**BALADOU(FARANAH)**	NIGER	10°16'59" N	10°46'10"W	Demonstration site / upstream study area
2	**KOUROUSSA**	NIGER	10°39'8" N	9°52'17" W	Study area
3	**NORASSOBA**	NIGER	10°55'9" N	9°28'25" W	Study area
4	**SIGUIRI - STATION POMPAG**	NIGER	11°24'40" N	9° 9'20" W	Study area
5	**DIALAKORO**	NIGER	11°26'51" N	8°54'1" W	Downstream study area

Analysis of the results obtained :

The analysis concerns all the water samples brought to the Laboratory and will mainly focus on the physicochemical and bacteriological parameters of the water samples.

Results and Interpretation : Results of the analysis of surface water samples :

Some of the recorded data was measured in the field and subsequently confirmed in the laboratory.

They concern physical parameters (PH, Conductivity, Turbidity, Temperature, etc.) Confirmed in the laboratory, accompanied in addition to the measurements of certain nutrients such as: nitrate, nitrite and phosphate and bacteriological parameters (total coliforms, fecal coliforms and Escherichia colis).

These results are recorded in the tables (3, 4, 5, 6, 7, 8) below:

TABLE 3 : Analyses of the physicochemical parameters of the surface waters of the study area taken from November 18 to 20, 2022.

N	SITES	PHYSICO-CHEMICAL PARAMETERS							
		PH	Cnd	TDS	TURB.	T°	NO3	NO2	PO4
			µcm/s	mg/l	NTU	°C	mg/l	mg/l	mg/l
1	**BALADOU(FARANAH)**	7,22	44	28,16	5,22	23	0,89	0,03	0,21
2	**KOUROUSSA**	7	21,2	14,07	8,70	25,1	0,34	0,02	0,33
3	**NORASSOBA**	8,34	89,51	57,28	22	27,3	5,55	0,08	2,75
4	**SIGUIRI STATION POMPAG**	7,02	37,8	25,32	10,18	24,9	0,5	0,01	0,11
5	**DIALAKORO**	7,02	37,8	24,18	5,62	24,9	0,5	0,00	0,14
	STANDARDS	**6,5 -9,5**	**60**	**1000**	**25**	**30**	**50**	**0,01**	**0,5**

TABLE 4 : Analyses of the physicochemical parameters of the surface waters of the study area collected from March 14 to 30, 2023.

ND	SITES	PHYSICO-CHEMICAL PARAMETERS							
		PH	Cnd	TDS	TURB.	T°	NO3	NO2	PO4
			µcm/s	mg/l	NTU	°C	mg/l	mg/l	mg/l
1	**BALADOU(FARANAH)**	8,17	52,9	34,38	4,82	30,6	0,18	0,00	0,42
2	**KOUROUSSA**	7,92	54,9	35,68	4,41	27,7	<<	0,01	<<
3	**NORASSOBA**	7,46	68,5	44,52	3,70	31,2	0,02	<<	0,10
4	**SIGUIRI - STATION POMPAG**	8,25	55,1	35,81	3,70	27,7	0,18	0,00	0,29
5	**DIALAKORO**	8,11	53,8	34,97	4,43	28,4	0,24	0,01	0,43
	STANDARDS	**6,5 -9,5**	**60**	**1000**	**25**	**30**	**50**	**0,01**	**0.5**

TABLE 5 : Analyses of the physicochemical parameters of the surface waters of the study area taken from June 6 to 25, 2023.

ND	SITES	PHYSICO-CHEMICAL PARAMETERS							
		PH	Cnd	TDS	TURB.	T°	NO3	NO2	PO4
			µcm/s	mg/l	NTU	°C	mg/l	mg/l	mg/l
1	(BALADOU)FARANAH	7,88	34,8	22,27	47,11	27,4	0,30	0,01	0,61
2	KOUROUSSA	7,59	55,3	35,39	12,82	29,1	0,24	0,02	0,22
3	NORASSOBA	8,01	47,6	30,46	14,21	28,8	0,22	0,05	0,19
4	SIGUIRI - STATION POMPAG	8,22	89	56,96	44	30	0,45	0,01	0,35
5	DIALAKORO	8,54	112	71,68	72	29	0,66	0,02	0,75
	STANDARDS	**6,5 -9,5**	**60**	**1000**	**25**	**30**	**50**	**0,01**	**0,5**

TABLE 6 : Analyses of bacteriological parameters of surface water in the study area collected from November 18 to 20, 2022.

N°	SITES	BACTERIOLOGICAL PARAMETERS		
		CT	CF	EC
		Col/ 100ml	Col/ 100ml	Col/ 100ml
1	BALADOU	0,00	0,00	0,00
2	KOUROUSSA	13	9	12
3	NORASSOBA	3	5	8
4	SIGUIRI	25	13	18
5	DIALAKORO	44	21	15
	STANDARDS	**50/100ml**	**20/100ml**	**20/100ml**

TABLE 7 : Bacteriology analyses of surface water parameters in the study area collected from March 14 to 30, 2023.

N°	SITES	BACTERIOLOGICAL PARAMETERS		
		CT	CF	EC
		Col/ 100ml	Col/ 100ml	Col/ 100ml
1	BALADOU	12	21	11
2	KOUROUSSA	13	06	44
3	NORASSOBA	09	34	66
4	SIGUIRI	12	10	11
5	DIALAKORO	11	00	15
	STANDARDS	**50/100ml**	**20/100ml**	**20/100ml**

Table 8 : Analyses of the bacteriology parameters of the surface waters of the study area taken from 06 to 25 June 2023.

N°	SITES	BACTERIOLOGICAL PARAMETERS		
		CT	CF	EC
		Col/ 100ml	Col/ 100ml	Col/ 100ml
1	BALADOU	10	10	32
2	KOUROUSSA	06	11	31
3	NORASSOBA	06	21	23
4	SIGUIRI	15	24	08
5	DIALAKORO	33	66	09
	STANDARDS	**50/100ml**	**20/100ml**	**20/100ml**

III- 2 Analysis of the results obtained :

The analysis of the results was based on a comparative study of the parameters measured from November 2022 (low water) to March 2023 (low water) in the study area.

• Evolution of PH during the three sampling periods (2022 water average – 2023 low water – 2023 water average).

Table 9 : Evolution of PH during sampling periods in the study area.

N°	SITES	Sampling periods				
		Medium Water – November 2022	Low water – March 2023	Medium Water – June 2023	Average	Standard deviation
1	BALADOU(FARANAH)	7,22	8,17	7,88	7,75	2,78
2	KOUROUSSA	7	7,92	7,59	7,50	2,73
3	NORASSOBA	8,34	7,46	8,01	7,93	2,81
4	SIGUIRI - STATION POMPAG	7,02	8,25	8,22	7,65	2,76
5	DIALAKORO	7,02	8,11	8,54	7,89	2,80

There is a variation in pH from November 2022 to June 2023 (Table 10). Their evolution describes an upward trend except for the Norassoba site. (Fig.2).

The differences in pH observed are very small between the three hydrological seasons of November 2022 and June 2023 and are all positive. The largest peaks are observed in Norassoba (2.81), Dialakoro (2.80) and Baladou (2.78).

These results confirm an intensification of human activities in this area. The data collected in this way are all illustrated through the figure below.

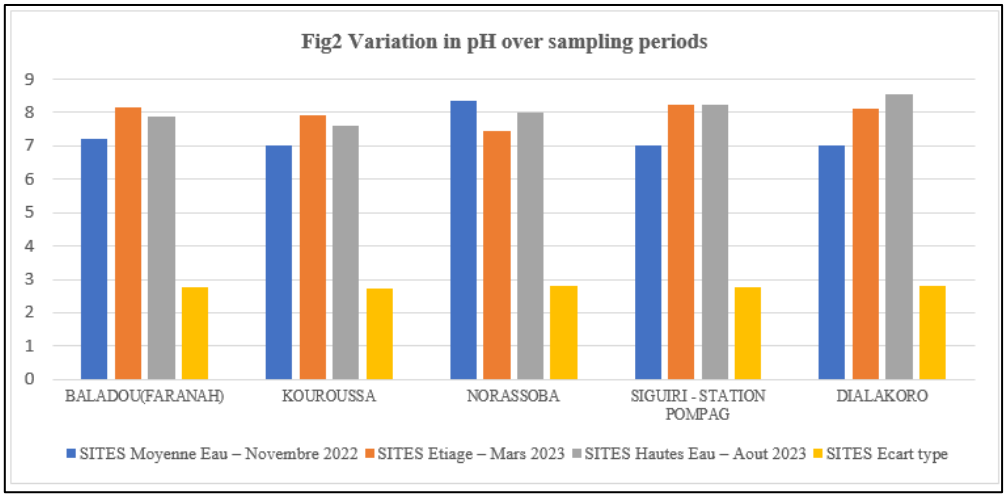

Figure 2 : PH variation over sampling periods

• Evolution of Conductivities during the three sampling periods (Average water 2022 – Low water 2023 – Average water 2023).

Table 10 : Evolution of conductivities during sampling periods in the study area.

N	SITES	Sampling periods				
		Low Water – November 2022	Low water – March 2023	Average water – June 2023	Average	Standard deviation
1	BALADOU(FARANAH)	44	52,9	34,8	43,9	6,62
2	KOUROUSSA	21,2	54,9	55,3	43,8	6,61
3	NORASSOBA	89,51	68,5	47,6	68,53	8,27
4	SIGUIRI - STATION POMPAG	37,8	55,1	89	60,63	7,78
5	DIALAKORO	37,8	53,8	112	67,86	8,23

The differences are all positive. This result reflects an increase in mining activity at these sites at the time of sampling (Table 11).

The data collected are all illustrated in Figure 3.

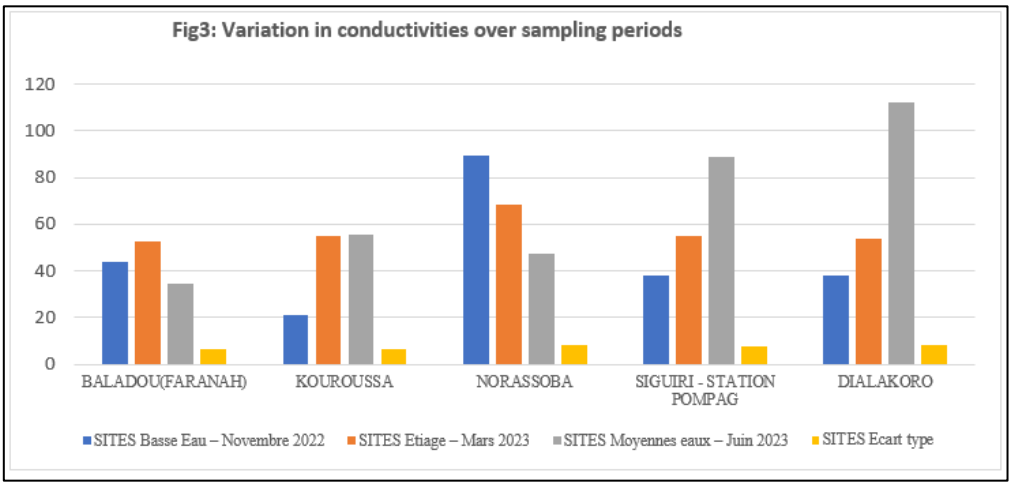

Figure 3: Variation in conductivities over sampling periods

The evolution of the Conductivities shows in June 2023 strong values at Dialakoro on the Niger (downstream of the study area), at Norassoba and Siguiri at the pumping station (inside the study area) all on the Niger during the average water period. This explains why mineral salts and other mineral pollutants flow into NIGER and pollute it during this period. (Fig.3).

• Evolution of turbidity during sampling periods (low water November 2022, low water in March 2023 and medium water in June 2023).

Table 11 : Evolution of turbidity during sampling periods in the study area.

ND	SITES	Sampling periods				
		Low Water – November 2022	Low water – March 2023	Average water – June 2023	Average	Standard deviation
1 -	**BALADOU(FARANAH)**	5,22	4,82	47,11	19,05	4,36
2 -	**KOUROUSSA**	8,70	4,41	12,82	8,64	2,93
3 -	**NORASSOBA**	22	3,70	14,21	13,30	3,64
4 -	**SIGUIRI - STATION POMPAG**	10,18	3,70	44	18,06	4,24
5 -	**DIALAKORO**	5,62	4,43	72	27,35	5,22

At the time of our study, the highest turbidities were observed during the average water period.

These can be explained by the fact that during this period of averages, sludge from washing ores and other pollutants is drained by rainwater from mining areas (pollution areas) to the Niger River and thus increases their turbidity. Secondly, the turbidity values are also high within the study area and downstream in Dialakoro, as evidenced by the values of the observed deviations. This means that the intensification of water disturbance activity within the study area affects the waters of the river.

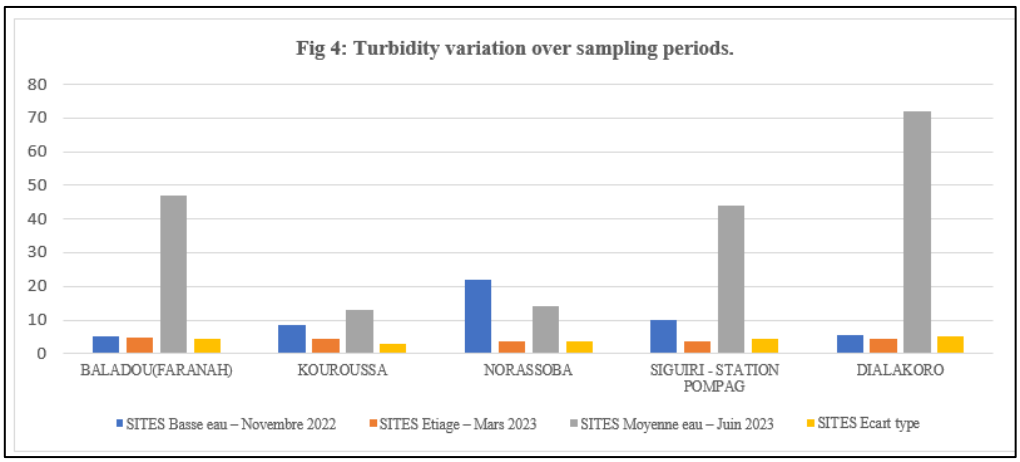

Figure 4: Turbidity variation over sampling periods.

Interpretation:

The reference standards are the standards for assessing the quality of surface water (Agence ADOUR – GARONNE).

The analysis of the results of the tables (3, 4, 5) provided the following information:

The PH are all within the permitted standard (6.5 – 9.5). Although they are almost all slightly basic in the period of average water - June 2023 (Table 9).

- Conductivities are out of the norm in some sampled sites (60 µs/cm), particularly in Norassoba where, during low water periods (89.51 µs/cm), low water (68.5 µs/cm) and medium water periods, in Siguiri (pumping station) and Dialakoro (89 µs/cm) and (112 µs/cm) respectively. This explains the presence of mineral salts in high concentrations.

- The turbidities recorded are in accordance with the standard in 5 sites (25 NTU) during the low water periods and at low water, during the average water period the turbidities are exceeded in three of the five sampled cites, in particular in Baladou upstream of the study area (47.11 NTU), in Siguiri (pumping station 44 NTU) within the study area and downstream of the study area in Dialakoro (72 NTU).

- For temperatures, it is only at low water that we record a slight exceedance of the standard (30°C) at two out of five sites, including the sites of Baladou (30.6°C) and Norassoba (31.2°C). This is acceptable according to the standards for assessing the quality of surface water (Agence ADOUR – GARONNE).

- Continuing the same analysis, the nutrient concentrations (nitrate, nitrite, phosphate) found in the waters of the Niger River in the study area do not comply with the limit required by the surface water quality assessment standards (Agence ADOUR – GARONNE) in all the sites sampled.

- Nitrate meets the standard at all sampled sites. Phosphates are exceeding in Norassoba (Table 4), Baladou and Dialakoro (Table 5);

- Nitrites are also present in Baladou, Kouroussa and Norassoba (Table 3) and in Kouroussa, Norassoba and Dialakoro (Table 5).

- Continuing the same analyses, the bacteria exist in all the measurement sites and the values are below the standard authorized by the standards for assessing the quality of surface water (Agence ADOUR – GARONNE) except for the Dialakoro site during the average water period, in June 2023 when the fecal coliforms are exceeded. At the time of our study.

Conclusion:

In short, with the increase in population, increasing urbanization, industrialization, and the intensification of gold panning and agriculture, the users of water have multiplied and its consumption has increased tremendously. This development has been accompanied by an inevitable increase in household, urban, agricultural and industrial discharges in Niger and its main tributaries in Guinea (subject of study): pollution rates of aquatic environments have increased.

✓ The synthesis of the results obtained from November 2022 to June 2023 in the study area generally shows a trend towards an increase in the parameters taken into account (PH, Conductivity and Turbidity), nutrients (phosphates, nitrates and nitrites) and bacteria;
✓ Pollutants or mineral salts have taken a high proportion in the waters of Niger, influencing conductivity, water transparency (turbidity) and nutrient levels;
✓ The washing of ore in the bed of watercourses, the discharge of mining effluents, the degradation of banks and riverbeds are at the origin of the increase in turbidity and the levels of the parameters detected.

This information attests that gold panning activities are increasing in the study area. This is evidenced by the multiplicity of sites of anarchic gold panning and ore washing along the main tributaries and sub-tributaries of the Niger, and even in the bed in some cases in the study area. Also, laundries have stormed the banks of these main rivers, polluting them, as well as the latter in washing mud which in turn pollute the Niger downstream (Dialakoro).

This is why, in view of these results, it is urgent to take adequate measures to reverse this destructive trend of the waters of the Niger River.

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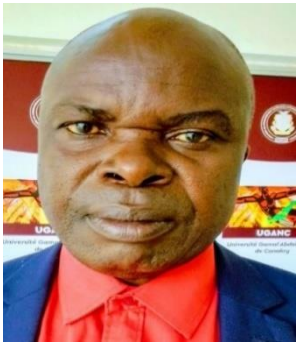	Kalaya GOUMOU Department of Chemistry, Faculty of Natural Sciences, Julius NYERERE University, Kankan, Republic of Guinea BP : 209
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