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Assessment of the impact of gold panning on bacteriological parameters, heavy metals and cyanide in the waters of the Niger river in Guinea

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Abstract

Artisanal mining, or traditional 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 aim of this study is to assess the impact of artisanal mining on bacteriological parameters, heavy metals and cyanide in 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 them and on the Niger. We took fifteen samples to determine bacteriological parameters (fecal coliforms, total coliforms and Escherichia coli), free cyanide and certain heavy metals at the regional water quality laboratory.

This study enabled us to determine the impact of gold panning on bacteriological parameters, cyanide and certain heavy metals in the waters of the Niger River in Guinea, and to identify possible solutions.

Conclusion and outlook: Analysis of the results shows that, overall, the water sampled is of good quality. However, some parameters at certain measurement sites showed signs of pollution.

Keywords: Bacteriological; Cyanide; Impact; Metals; Gold panning

1. 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 gave up extracting the ore after the end of the season to get on with their work in the fields. [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, zinc chips, etc., to name but a few. These techniques

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not only affect the health and living conditions of the population, but also pollute our waterways and destroy the environment as a whole, not to mention the fauna and flora. [2 ;6]

Both 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, as well as considerable disturbances that gradually contribute to an ecological imbalance [1].

Large 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 flow, silting and other pollution caused by various activities (industrial, mining, agricultural, urban, etc.). [4]

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. Action is therefore needed to deal with the many sources of deterioration in the river's quality.

Upper Guinea is the region where most of the country's gold production is concentrated. The rivers that flow through this area, including the Niger, are heavily threatened by the effects of this activity. 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.

2. Material and method

2.1. Presentation of the study environment

2.1.1. Study area

Upper - Guinea is one of Guinea's four “natural regions”. It is bordered to the north by the Republic of Mali, to the south by Forest Guinea, to the east by the Republic of Mali and the Ivory Coast, and to the west by Middle Guinea.

- 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

2.1.2. 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).

2.2. Maps of sampling sites in the study area

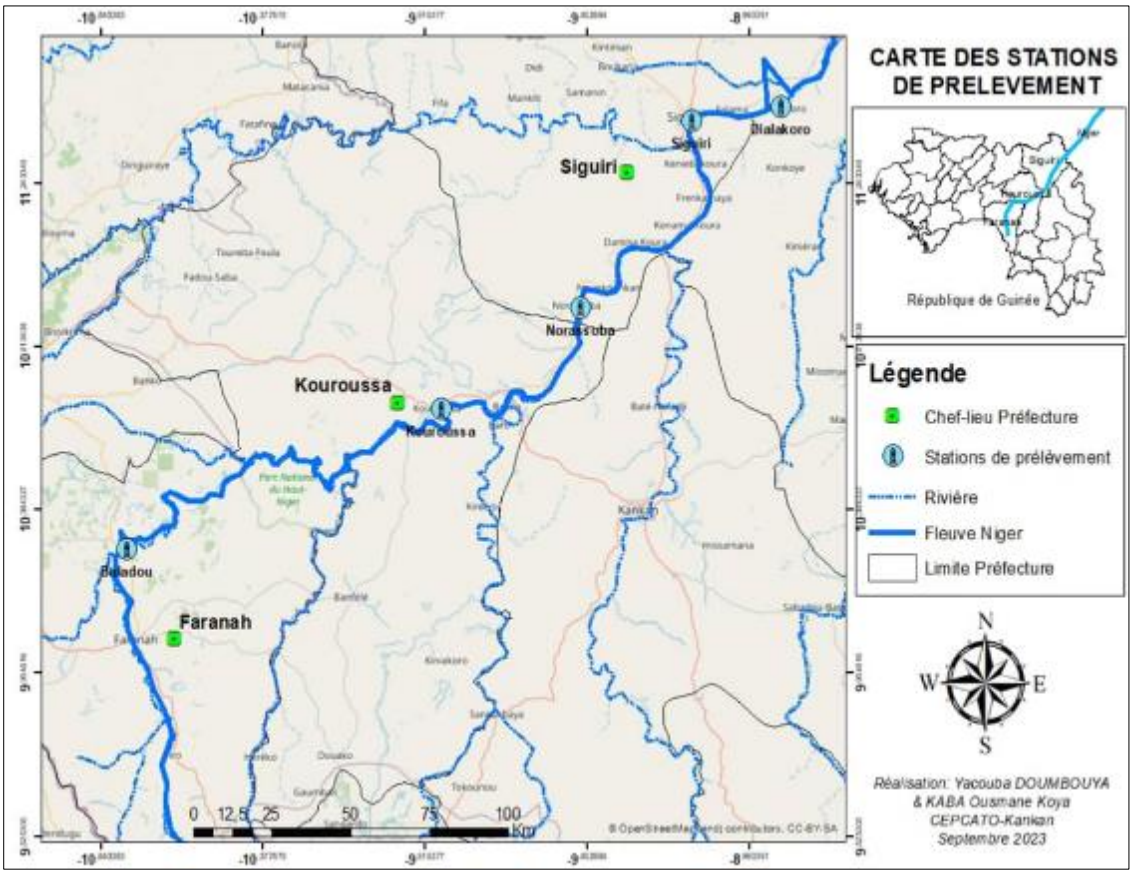

Figure 1 Map of sampling stations on the Niger River in Guinea.

2.2.1. 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. [6].

Nowadays, with the galloping demography and the development of mining, watercourses are savagely assaulted by the population in the pursuit of their daily needs. Both mining industries and traditional operators discharge effluent and ore washing sludge, sometimes containing toxic chemicals such as cyanide, mercury, zinc, lead, arsenic, cadmium, ... etc. These assaults on our waterways can be seen in the destruction of riverbanks and the silting-up of riverbeds by dredgers, resulting in 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. [7]

3. Results

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

Table 1 Human activities detected in the study area.

N°	Prefectures	Locations	Rivers	Activities observed
1	BALADOU(FARANAH)	Baladou	NIGER	Fishing - Farming.
2	KOUROUSSA	Kouroussa	NIGER	Housing - Washing - Swimming.
3	NORASSOBA	Norassoba	NIGER	Market gardening, Washing, Fishing, Farming.
4	SIGUIRI - STATION POMPAG	Siguiri	NIGER	Pumping station - Fish farming Gold mining - Agriculture-Gardening
5	DIALAKORO	Dialakoro	NIGER	Mineral washing - Gold panning.

3.1. Working materials

3.1.1. Methodology

- ¬ Geographical coordinates were determined using a Trimble GeoXM GPS device. [5]
  - PH and temperature were determined potentiometrically using a Multi Parameter Multi 3420 SET G WTW. [4]
  - Electrical conductivity and TDS were determined electrometrically using a Multi Parameter Multi 3420 SET G WTW instrument. [3]
  - Dissolved oxygen was determined potentiometrically using a Multi paramètre Multi 3420 SET G WTW instrument. [11]
  - Turbidity was determined using a TB 210 R instrument. [12]
  - Nitrate was determined photometrically using a Palintest DR 7100 Photometer. [8]
  - Nitrite was determined photometrically using a Palintest DR 7100 Photometer. [10]
  - Phosphates were determined photometrically using a Photomètre DR 7100 Palintest device. [9]
  - Bacteria levels (total coliforms, fecal coliforms and Escherichia coli) were determined using the membrane filtration plating method [13].

3.1.2. Sampling

Sampling consists of selecting locations in the study area according to their relevance upstream, within and downstream of gold panning sites located on average 3 km along the course of the River Niger in Guinea. At these points, water samples will be taken for analysis in the laboratory; it should be noted that certain parameters will be analyzed in situ (PH, conductivity, dissolved oxygen, temperature and turbidity) using the Multi Parameter Multi 3420 SET G WTW and the Turbidimeter TB 210 R.

To carry out this work, we chose five (05) sampling sites, the characteristics of which are given in the table below. These sites were chosen taking into account the intensity of mining activity taking place around them and on the Niger.

- The NIGER at Baladou (Faranah) as the sampling point upstream of the study area. This point, considered as a control, will be unaffected by mining operations, since it is upstream of the study area;
- Four other points will be selected within and downstream of the study area, including:
- The Niger at Kouroussa under the bridge (10°39'8'' N / 9°52'17'' W);
- The Niger at Norassoba (10°55'9'' N / 9°28'25'' W);
- The Niger at Siguiri 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).

Five (5x3=15) water samples will be taken in sterilized bottles, placed in ice chests and cooled to 4°C using ice chips, and returned to the laboratory 72 hours after collection for examination, with the exception of PH, conductivity, turbidity and dissolved oxygen.

For this study, fifteen (15) samples will be taken to the regional water quality laboratory to determine physical parameters (pH, conductivity, turbidity, TDS, dissolved oxygen), nutrients (nitrates, phosphates, nitrites, etc.) and bacteriological parameters (total coliforms, fecal coliforms, Escherichia coli).

Table 2 Sampling sites and their geographical location.

№	SAMPLING STATIONS	RIVERS	GEOGRAPHICAL COORDINATES		OBSERVATION
1	BALADOU(FARANAH)	NIGER	10°16'59'' N	10°46'10''W	Control 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

3.1.3. Analysis of results obtained:

The analysis concerns all the water samples brought to the Laboratory and will focus on bacteriological parameters, metals and cyanide in the water samples.

3.1.4. Results of surface water sample analysis:

Some of the data recorded were measured in the field and subsequently confirmed in the laboratory. These results are shown in tables (3, 4, 5) below:

Table 3 Analyses of bacteriological parameters and free cyanide in surface waters in the study area, sampled from November 18 to 20, 2022

N	SITES	PARAMETERS			
		CT	CF	EC	CN^-
		Col/ 100ml	Col/ 100ml	Col/ 100ml	mg/l
1	BALADOU(FARANAH)	0,00	0,00	0,00	0,00
2	KOUROUSSA	13	9	12	0,00
3	NORASSOBA	3	5	8	0,00
4	SIGUIRI STATION POMPAGE	25	13	18	0,00
5	DIALAKORO	44	21	15	0,00
	STANDARDS	50/ 100ml	20/ 100ml	20/ 100ml	0,07

Table 4 Analyses of bacteriological parameters and free cyanide in surface waters in the study area, sampled from March 14 to 30, 2023.

N	SITES	PARAMETERS			
		CT	CF	EC	CN^-
		Col/ 100ml	Col/ 100ml	Col/ 100ml	mg/l
1	BALADOU(FARANAH)	12	21	11	0,00
2	KOUROUSSA	13	06	44	0,00
3	NORASSOBA	09	34	66	0,00
4	SIGUIRI STATION POMPAGE	12	10	11	0,00
5	DIALAKORO	11	00	15	0,00
	STANDARDS	50/ 100ml	20/ 100ml	20/ 100ml	0.07

Table 5 Analyses of bacteriological parameters and free cyanide in surface waters in the study area sampled from June 06 to 25, 2023.

N	SITES	PARAMETERS			
		CT	CF	EC	CN^-
		Col/ 100ml	Col/ 100ml	Col/ 100ml	mg/l
1	BALADOU(FARANAH)	10	10	32	0,00
2	KOUROUSSA	06	11	31	0,00
3	NORASSOBA	06	21	23	0,00
4	SIGUIRI STATION POMPAGE	15	24	08	0,00
5	DIALAKORO	33	66	09	0,00
	STANDARDS	50/ 100ml	20/ 100ml	20/ 100ml	0.07

Table 6 Analyses of heavy metals - cyanide - bacteriology of surface water in the study area taken from 18 to 20 November 2022.

N°	SITES	PARAMETERS												
		Al	Zn	Cd	K	Ba	Cu	Ni	As	Co	Pb	Mn	Cr	Hg
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
1	BALADOU	0,00	0,00	0,00	7	0,01	0,44	0,00	0,00	0,00	0,00	0,00	0,00	0,00
2	KOUROUSSA	0,01	2,3	0,00	8	0,01	0,04	0,01	0,00	0,00	0,00	0,00	0,00	0,00
3	NORASSOBA	0,00	0,67	0,00	14	0,00	1,25	0,00	0,00	0,00	0,00	0,00	0,00	0,00
4	SIGUIRI	0,00	0,98	0,00	0	0,00	1,53	0,00	0,00	0,00	0,00	0,00	0,00	0,00
5	DIALAKORO	0,02	1,8	0,00	3	0,02	0,82	0,01	0,04	0,00	0,00	0,00	0,00	0,00
	STANDARDS	0,1	3	0,03	12	0,001	2	0,02	0,005	0,01	0,01	0,01	0,1	0,05

Table 7 Analyses of heavy metals - cyanide - bacteriology of surface waters in the study area sampled from March 14 to 30, 2023.

N°	SITES	PARAMETERS												
		Al	Zn	Cd	K	Ba	Cu	Ni	As	Co	Pb	Mn	Cr	Hg
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
1	BALADOU	0,00	0,00	0,00	1,17	0,01	2,93	0,00	0,00	0,00	0,00	0,00	0,00	0,00
2	KOUROUSSA	0,03	2,3	0,00	2,96	0,01	4,24	0,01	0,00	0,001	0,00	0,00	0,00	0,00
3	NORASSOBA	0,00	0,00	0,00	1,19	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
4	SIGUIRI	0,00	0	0	2,27	0,01	2,88	0	0,00	0,00	0,00	0,00	0,00	0,00
5	DIALAKORO	0,08	0,08	0,03	0,00	0,02	4,14	0,01	0,00	0,00	0,00	0,00	0,00	0,00
	STANDARDS	0,1	3	0,03	12	0,001	2	0,02	0,005	0,01	0,01	0,01	0,1	0,05

Table 8 Analyses of heavy metals - cyanide in surface waters in the study area sampled from June 06 to 25, 2023.

N°	SITES	PARAMETERS												
		Al	Zn	Cd	K	Ba	Cu	Ni	As	Co	Pb	Mn	Cr	Hg
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
1	BALADOU	0,00	0,00	0,00	2	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
2	KOUROUSSA	0,03	2,3	0,00	6	0,01	0,02	0,01	0,01	0,00	0,00	0,00	0,00	0,00
3	NORASSOBA	<<	0,33	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
4	SIGUIRI	0,00	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
5	DIALAKORO	0,3	0,08	0,03	3	0,02	0,02	0,01	0,001	0,00	0,00	0,00	0,00	0,00
	STANDARDS	0,1	3	0,03	12	0,001	2	0,02	0,005	0,01	0,01	0,01	0,1	0,05

3.2. Analysis of results obtained:

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

3.2.1. Interpretation

Analysis of the results in tables (3, 4, 5) provides the following information:

PH levels are all within the permitted range (6.5 - 9.5). Although they are almost all slightly basic in the average water period - June 2023 (table 9).

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

Turbidities were compliant at 5 sites (25 NTU) during low-water periods, while at medium-water periods turbidities were exceeded at three of the five sites sampled, namely Baladou upstream of the study area (47.11 NTU), Siguiri (pumping station 44 NTU) within the study area, and Dialakoro downstream of the study area (72 NTU).

As far as temperatures are concerned, it was only during low water that we recorded a slight exceedance of the norm (30°C) at two of the five sites, including Baladou (30.6°C) and Norassoba (31.2°C). This is acceptable according to surface water quality assessment standards (ADOUR – GARONNE Agency).

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

Nitrate meets the standard at all sampled sites. Phosphates are exceeded at Norassoba (table 4), Baladou and Dialakoro (table 5);

Nitrites are also exceeded at Baladou, Kouroussa and Norassoba (table 3) and at Kouroussa, Norassoba and Dialakoro (table 5).

Continuing with these analyses, Aluminium (Al) is present at Kouroussa and Dialakoro (table 6,7 and 8). Barium (Ba) is exceeded at Kouroussa and Dialakoro (table 6) and at trace levels at Dialakoro during the June 2023 mean-water period (table 8). Copper (Cu) is present in all periods, but high levels were observed at low water in March 2023 and the highest peak was measured at Dialakoro (4.14 mg/l vs. 2 mg/l as standard). Zinc (Zn) and cadmium (Cd) were present at all measurement sites except the Baladou control site.

Bacteria are present at all measurement sites, and values are below the norms authorized by the surface water quality assessment standards (ADOUR – GARONNE Agency), with the exception of the Dialakoro site during the average water period in June 2023, where fecal coliforms are exceeded. At the time of our study, no cases of cyanide or mercury were detected in the study area.

4. Conclusion

Ultimately, with population growth, increasing urbanization, industrialization and the intensification of gold mining and agriculture, the number of water users has multiplied and water consumption has grown enormously. This development has been accompanied by an inevitable increase in household, urban, agricultural and industrial discharges into the Niger and its main tributaries in Guinea (the subject of this study): pollution levels in aquatic environments have risen.

The summary of results obtained from November 2022 to June 2023 in the study area generally shows an upward trend in the parameters taken into account (PH, Conductivity and Turbidity), nutrients (phosphates, nitrates and nitrites), heavy metals and bacteria;

Pollutants or mineral salts have taken on a high proportion in Niger waters, influencing Conductivity, water transparency (Turbidity), nutrients and heavy metals;

The washing of ore in riverbeds, the discharge of mining effluents, and the degradation of riverbanks and riverbeds are responsible for the increase in the levels of detected parameters.

This information attests to the fact that gold panning activities are on the increase in the study area. This is evidenced by the multiplicity of anarchic gold panning and ore washing sites along the main tributaries and sub-tributaries of the Niger, and even in the riverbed in some cases in the study area. Laundries have also taken over the banks of these main watercourses, polluting them with washing sludge, which in turn pollutes the Niger downstream (Dialakoro).

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

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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