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Assessment of Metal Pollution in Drinking Water in the Localities East of the Ity Mine (Côte d'Ivoire)

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Abstract In Côte d'Ivoire, the Ity mine is a major economic hub, yet it can generate significant environmental impacts. The aim of this study was to assess the compliance of drinking water in the Est-Cavally communities neighboring the Ity mine with WHO standards following a technical incident. Twenty water samples from streams, wells, and hand-pumped boreholes were collected and analyzed using AFNOR methods. Physicochemical parameters generally fell outside standard limits, notably showing excessively acidic pH (4), high turbidity (29.3 NTU), and high organic matter content (12.84 mg/L). Microbiological pollution was significant in the majority of wells (total coliforms, *Escherichia coli*, *Entercoccus faecalis*), indicating fecal contamination. Severe metal contamination dominated by lead (Pb) and arsenic (As) was observed in almost all water sources (backwater, hand-operated pump, and wells). None of the analyzed samples met potability criteria. Urgent measures regarding treatment, protection of water sources, and analytical monitoring are essential to safeguard public health

Keywords: *drinking water potability,mining pollution,heavy metals*

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1. Introduction

Human activities, particularly mining operations, are a major source of heavy metal release into the environment, leading to the contamination of soil, water, and sometimes the air through direct emissions, atmospheric deposition, and the discharge of mining residues. [1,2,3].

In West Africa, numerous studies conducted in gold mining areas in Ghana, Senegal, Nigeria, and Côte d'Ivoire show recurring contamination of soil, sediment, water, and sometimes crops by elements such as arsenic, mercury, lead, and cadmium. [4,5,6].

Around the Ity mining complex, located in western Côte d'Ivoire, environmental pressure has intensified over the years due to increased mining and cyanidation activities. This situation was recently exacerbated by a technical incident at the site, raising concerns about the potential release of metallic contaminants into the water supply used by local communities. Some of the heavy metal contaminants in gold mines that have been shown to cause adverse health effects in humans as a result of prolonged exposure through drinking water are: lead, copper, cadmium, mercury, chromium, arsenic, and so on [7].

This study aims to assess the impact of gold mining activities on the quality of drinking water in villages located in the eastern Cavally area, surrounding the Ity mine.

2. Materials and Methods

2.1. Equipment and Supplies

The equipment used for the analyses included a atomic absorption spectrometer Agilent 55 AA, hydride generator Agilent VGA 77, a probe pH meter (Hanna®, United Kingdom), a WAGTECH 7100 Se® photometer (UK), a TURB 430 IR® turbidimeter (France), a HACH HQ 11d® probe pH meter (France), a HACH HQ 14d® probe conductivity meter (France), a SARTORIUS Goethingen® filtration manifold (Germany), and a LABNET® incubator (USA).

The glassware used was of analytical grade quality.

2.2. Reagents

All reagents used were of analytical grade. The reagents used included distilled water, concentrated nitric acid 65%, concentrated hydrochloric acid 37% and stock standard solutions (Hg, Pb, Co, As et Cd) 1000 mg/L. Nitratest and Nitricol tablets, zinc powder, and Ammonia No. 1 and No.

2 tablets were used for the determination of nitrates, nitrites, and ammonium; these were Wagtech® (UK) products. Culture media comprising Rapid *E. coli* 2 Agar, Bile Esculin Azide (BEA) Agar, and used for the respective cultivation of coliforms, **Enterococcus faecalis**, and **Pseudomonas aeruginosa**; these were Bio-Rad® (France) products.

2.3. Sampling

Water samples were collected from wells (10), hand-operated pumps (6), and backwaters (4) in villages located around the Ity mining area .In total of 20 sampling sites.

• For physicochemical and microbiological analyses:

- One (1) 1000 mL Pyrex glass bottle filled to the brim for physicochemical analyses;

- One (1) 500 mL Pyrex glass bottle filled three-quarters full for microbiological analyses. Sampling was carried out in accordance with the AFNOR FD T90-520 standard (October 2005), which defines the conditions for the sampling, preservation, and transport of water samples. The water samples were placed in a cooler for transport to the laboratory, maintaining the cold chain using ice packs to prevent microorganism proliferation. The collected samples were transported away from light at a temperature between 4°C and 8°C. Upon arrival at the laboratory, the samples were either processed immediately or stored in a refrigerator at 4°C to 8°C.

• For metal analyses

The samples were stored in 1 L polyethylene containers and preserved in situ by the addition of 10 mL of concentrated nitric acid (HNO_3) to prevent physicochemical alterations before laboratory analysis.

2.4. Methods

The physicochemical parameters of the water samples specifically pH, electrical conductivity, and turbidity were determined in accordance with standardized AFNOR methods [8,9,10,11].

Concentrations of nitrates, nitrites, ammonium, chlorides, manganese, aluminum, fluorides, organic matter, and iron were measured using a photometric method. For each parameter, a 10 mL volume of the water sample was placed in an analysis tube, and a specific reagent tablet was added. After thorough mixing with a glass rod to ensure the reagent dissolved, the tube was placed in a photometer. The program corresponding to the parameter being analyzed was selected, and absorbance was measured at a wavelength of 520 nm.

Microbiological analysis focused on total coliforms, *Escherichia coli*, *Enterococcus faecalis, and Pseudomonas aeruginosa*. The samples underwent membrane filtration, and the membranes were then placed onto appropriate culture media. Following incubation for 18 to 24 hours, bacterial colonies were counted in accordance with reference protocols [11,12].

The data obtained were subsequently subjected to statistical analysis using methods described in the literature [12].

The following parameters total mercury, arsenic, lead, cadmium, cobalt, and cyanide were analyzed using atomic absorption spectrometry. The collected data were compared to drinking water standards.

3. Results

Table 1 shows the precise locations of the drinking water abstraction points in the East Cavally area, as well as the type of water source.

Table 1. Samples water sources from localities in the East-Cavally area of the Ity mining zone

Number	Sample localisation	Water sources	Sample Name	GPS Localisation Longitude	GPS Localisation Latitude
1	Camp Kompouleu	Backwater	B1	06°51’00.17"	08°60’00.27"
2	Camp Kouegonopleu	Backwater	B2	06°51’06.76"	08°04’18.09"
3	Camp Tieupleu	Backwater	B3	06°52’15.04"	08°04’29.57"
4	Camp Tolegbepleu	Backwater	B4	06°51’40.06"	08°03’27.97"
5	Village Csr Tiepleu	Hand -operated pump	PH1	06°51’51.10"	08°02’38.93"
6	Camp Gouepleu	Hand -operated pump	PH2	06°51’06.43"	08°03’55.79"
7	Camp Tiakpaloupleu	Hand -operated pump	PH3	06°52’20.38"	08°04’38.19"
8	Village Tiepleu	Hand -operated pump	PH4	06°51’59.56"	08°02’29.54"
9	Camp Tobopleu	Hand -operated pump	PH5	06°52’03.14"	08°03’06.44"
10	Camp Yassetouo	Hand -operated pump	PH6	06°53’02.08"	08°03’51.98"
11	Village Tiepleu	Well	W1	06°52’09.38"	08°02’27.49"
12	Village Tiepleu	Well	W2	06°51’56.52"	08°02’24.82"
13	Camp Tiakpaloupleu	Well	W3	06°51’13.76"	08°05’39.94"
14	Camp Tiakpaloupleu	Well	W4	06°52’19.36"	08°04’48.65"
15	Camp Declipleu	Well	W5	06°52’38.15"	08°05’16.78"
16	Camp Doukpapleu	Well	W6	06°52’23.11"	08°05’43.78"
17	Camp Gouepleu	Well	W7	06°51’03.23"	08°03’57.98"
18	Camp Kouégonopleu	Well	W8	06°51’11.59"	08°04’29.08"
19	Camp Simonepleu	Well	W9	06°52’14.39"	08°05’52.72"
20	Camp Yassetouo	Well	W10	06°52’55.69"	08°03’52.06"

Table 2 lists the minimum and maximum values for the physicochemical and bacteriological parameters of drinking water in the East-Cavally localities of the Ity mining zone

Table 2. Results of physicochemical and bacteriological parameters for drinking water in the East-Cavally localities of the Ity mining zone

Parameter	Norme	Backwaters	Hand-operated pumps	Wells
Turbidity	≤ 1 UNT	1.88-15.7	0.37-8.13	2.73 - 29.3
Temperature	≤ 25	26-29.1	23.1-28.1	26.4-28.5
pH	6.5-8.5	4.1-5.4	4.2-6.5	4-6.1
Nitrites	≤ 0.1 mg/L	0.02-0.06	0-0.02	0.01-0.06
Nitrates	≤ 50 mg/L	0.40 -1.06	0.48-0.68	0.32-1.26
Ammonium	≤ 1.5mg/L	0.03-0.0.09	0.01-0.07	0.01-0.74
Organic matter	≤ 5 mg/L	1.62-11.34	0.86-18.26	3.16-12.84
Iron	≤ 0.3mg/L	0.01-0.50	0-1.45	0.10-0.55
Manganese	≤50 mg/L	0.006-0.21	0.003-0.036	0.011-0.038
Fluorides	≤1,5 mg/L	0.1	0-0.19	0.01-0.03
Total coliforms	0 CFU/100 mL	200-700	0-1200	0-3250
Escherichia coli	0 CFU/100 mL	0	0-100	0-350
Entercoccus faecalis	0 CFU/100 mL	0	0-100	0-200
Pseudomonas	0 CFU/100 mL	0	0	0

The three water sources (backwaters, hand -operated pumps, wells) showed significant non-conformities with regard to potability standards, both physico-chemically and microbiologically.

Backwaters were the most degraded overall, followed by wells, while hand pumps showed a slightly better physico-chemical quality but sometimes severe microbiological contamination.

Table 3. Results of heavy metal concentrations in drinking water from localities in the East-Cavally area of the Ity mining zone

Heavy metals	Norme	Backwaters	Hand-operated pumps	Wells
Hg	6µg/L	<0.3	<0.3	<0.3
As	10µg/L	1.7856-3.1008	0.3032-3.1008	0.2873-1.4785
Pb	10µg/L	38.65-150.44	30.93-177.71	<1-151.09
Cd	1µg/L	<1	<1	<1
Co	2mg/L	0.0837-0.3189	0.1735-0.3772	0.1132-0.33181
Cyanures totaux	50µg/L	2-51	0-51	0-27

The three water sources had very contrasting profiles.The most problematic metals were lead (Pb) and, to a lesser extent, cyanides.Mercury (Hg), cadmium (Cd) and arsenic (As) remain globally compliant, while cobalt (Co) was present at low but not negligible levels.Backwaters and wells showed the highest concentrations of lead, indicating significant contamination.Manual pumps were not free from risks, with Pb values far exceeding the standard.

4. Discussion

In localities located near a gold mine, this water quality profile is explained by the combination of three types of pressures:metal contributions related to mining activities,physicochemical degradation of surface waters and wells,fecal contamination of water sources used by the population.Studies published between 2018 and 2026 generally confirm this pattern: surface water and wells are the most affected, while boreholes and hand pumps often have better quality. However, their vulnerability remains high and depends closely on the protection of the structure and the proximity of discharges from mining activities [13,14,15].

The high turbidity observed in backwaters and wells is consistent with studies conducted in gold-bearing zones, which attribute these exceedances to erosion, sedimentation, and the resuspension of particles from mining sites [15,16]. In the Oda River in Ghana, the turbidity reached 694 to 1755 NTU and was accompanied by an excess of fecal coliforms, E. coli, and iron, showing that particulate loading is a central marker for degradation in mine waters [16]. A positive relationship between turbidity and bacterial contamination has also been observed in rural Nigeria, which reinforces the idea that waters with higher particulate matter levels are also those most exposed to microbiological risk [18].

The acidic pH measured in the three types of sources, especially in backwaters and wells, is also compatible with gold-bearing contexts. Work in Ghana and Cameroon reports pH between 5.1 and 6.5 in mining communities, with acidity attributed to local mineralization and, in some cases, hydrolysis of sulfates and minerals accompanying gold [14,19,20]. This acidity is important to discuss because it promotes the corrosion of structures and can increase the mobility of certain metals, as has also been shown with degraded groundwater in other contamination contexts [21].

Nitrites, nitrates, ammonium, and fluorides were compliant. This contrast with Pb, turbidity, and microbiology is common in studies where several major ions remain acceptable while a few critical parameters are sufficient to degrade the water [16,18,20].

Lead is the chemical contaminant of most concern, with exceedances sometimes very significant in all three sources, which is consistent with mining areas where Pb is often enriched by extractive activities [23,24].

Arsenic remains below your standard of 10 µg/L, but its repeated presence confirms a possible geological or mining influence; in some contexts, As remains moderate while other metals dominate the risk [24,25].

Mercury is below the measured threshold, which is reassuring locally, but studies in gold-rich areas show that Hg can vary greatly depending on the distance to the site, the compartment studied, and the season [15,26].

Iron also exceeded the standard in some samples, especially pumps and wells. In mining districts, elevated

Fe often accompanies turbidity and degrades water acceptability, even when it is not the main driver of toxicological risk [13,15].

Total cyanides reached 51 µg/L, so above or in direct contact with the 50 µg/L standard for backwaters and pumps. The literature is more nuanced here: a study in the ASGM area did not find a general contribution of cyanide to water pollution, while other studies show that certain point sources may remain critical [15,21].

Backwaters have consistently positive total coliforms, wells have the highest spikes, and pumps show intermittent contamination by E. coli and Enterococcus faecalis, indicating recent fecal pollution [18,21,22]. Backwaters presented the best consistency: their quality typically reflected surface water altered by runoff, sediments of mining origin and diffuse inputs [15,25]. Wells, by contrast, showed much higher variability and were frequently the most bacteriologically problematic sources [19,27]. Although hand pumps performed better on average, studies conducted in Africa reveal that approximately 21% of boreholes equipped with hand pumps still failed to meet microbiological criteria [22].

5. Conclusion

In conclusion, the quality of the water analyzed in localities near the gold mine appears generally degraded. The main non-compliance issues relate to turbidity, acidic pH, microbiological contamination, and above all high lead levels, indicating that several sources are unfit for consumption without prior treatment.

Backwaters and wells are the most affected, whereas hand pumps offer relatively better water quality, though they remain susceptible to sporadic contamination. These results highlight the likely influence of the mining environment and the need for regular monitoring, as well as measures for water protection and treatment.

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