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Assessment of the Environmental Impacts of Artisanal Gold Mining in West Mayo-Kebbi/Chad: Gamboke and Mbibou Sites

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Abstract

In Mayo-Kebbi West Province (Chad), artisanal gold mining contributes to the income of rural populations, particularly in Gamboké and Mbibou, but this activity is known to be a source of environmental degradation. Our objective is to assess the impacts of artisanal gold mining on the environment in Gamboké and Mbibou. To identify and quantify the problems, it is important to conduct a combined analysis of surface and groundwater, and soil. The methodology used involves sampling water and soil, then measuring physical parameters. It also uses methods to determine cation and anion concentrations. The results of major elements in soils are normal with an average pH (6.44) which is lower than the limit set by the WHO (6.5 - 8.5). This acidic pH could promote high solubility and mobility of ETMs in soils. In surface and groundwater, turbidity is very high with an average of 18,664 NTU. It appears that water analyses show average levels of heavy metals such as Cd (0.055 mg/l), CN (0.165 mg/l) and Cu (31.1 mg/l) being very high and higher than the standard set by the WHO (0.025, 0.05 and 2 mg/l) respectively. However, our results confirmed the role of gold panning in the excessive degradation of the environment under the effect of uncontrolled chemicals. However, strong measures to regulate traditional gold panning must be taken to reduce the negative impact of this activity on the environment and on the lives of people in the target areas.

Keywords

Gold Panning, Heavy Metals, Evaluation, Environmental Impact, Gamboké, Mbibou

1. Introduction

Gold panning consists of recovering the precious metal, particularly gold, contained in deposits which may be alluvial, eluvial, or vein deposits. This activity can also be practiced in craft form. Artisanal gold panning is the recovery of gold by simple processes, using rudimentary tools. First of all, artisanal mining is any activity by which a citizen from a country goes to gold panning sites, to extract and concentrate mineral substances limited on the surface and in depth, using tools, manual or minimally mechanized methods and processes.

In the sites of Gamboké and Mbibou in Mayo-Kebbi West, gold is found in several types such as that of the Meiganga zone in Cameroon where this metal is discovered in alluvial, eluvial formations and altered quartz veins and at varying depths. It is a non-renewable yellow substance that can be found in traces in green rocks of Proterozoic age. Its exploitation is done in an artisanal manner. According to [1], several thousand people are economically dependent on artisanal mining in most developing countries.

Gold panning is one of the activities that offers employment and several other income-generating activities to millions of people around the world [2]. Indeed, more than 15% to 20% of the gold produced in the world comes from artisanal mining [3]. Gold mining continues to pose many challenges, and with the explosion in the number of artisanal gold mines, its coexistence with agriculture has become increasingly difficult and complex. Pollution from the persistent use of chemicals continues to pose serious problems for freshwater sources used as reservoirs for irrigating fields [4] [5]. According to [6], mining practices are one of the main sources of pollution of surface water, soil, and plantations. Despite these challenges, the artisanal gold sector plays a crucial role in the economy of Mayo-Kebbi West and constitutes a major livelihood for its population, particularly in rural areas where economic prospects and alternatives are considered limited. About 30% of households surveyed believe that artisanal mining is the most important source of income [7]. In the study sites of Gamboké and Mbibou, chosen in this work, this mining activity improves the living conditions of the local population by more than 15% to 20% [8]. Artisanal gold mining is an activity that causes environmental degradation and pollution. The environmental sector is very threatened by the advent of gold panning, especially in its archaic form.

2. Materials and Methods

2.1. The Study Area

Gamboké and MBibou are the two gold panning sites studied which are respectively between 09˚32'37" and 09˚54'38" north latitude and between 14˚82'06" and 14˚98'71" East longitude. Covering an area of 1103.58 km^2, gold mining began on these sites a few decades ago (1930). The hydrographic network is almost invariable in one direction and seems to unify in most cases at NNW-SSE to NNE-SSW. This network is determined by a tropical regime during the maximum rise in rainwater (September-October) and strong interannual fluctuations in flow rates. The relief of the study area is in the form of a plain, which is why the altitudes vary very little, ranging from 342 to 553 m. The area presents a gently undulating landscape due to the phenomenon of erosion, which is alternated by very flat valleys. The soils of this area are favorable for almost all kinds of plantations. The main types of soils are: vertisols, hydromorphic soils, sandy-clayey soils or sandy soils and ferruginous, red soils.

The Mayo Kebbi massif, located in the southwest of Chad between the Congo craton to the south, the West African craton to the west and the Sahara Metacraton to the east. This was formed during the Pan-African orogeny, between 800 and 570 Ma (**Figure 1**). The Pan-African orogenic belts constitute the main segments of a vast Neoproterozoic orogenic belt, associated with the formation of the supercontinent Gondwana between 725 and 550 - 500 Ma [9]. This massif is made up of two series of green rocks which are the Zalbi Series (SZ) to the West of Léré and the Goueigoudoum Series (SGG) to the North of Pala, in addition to the Intermediate Mafic Complex (CMI) (**Figure 1**). These two series and the CMI represent greenstone belts. Everything is covered by Phanerozoic sedimentary deposits [9].

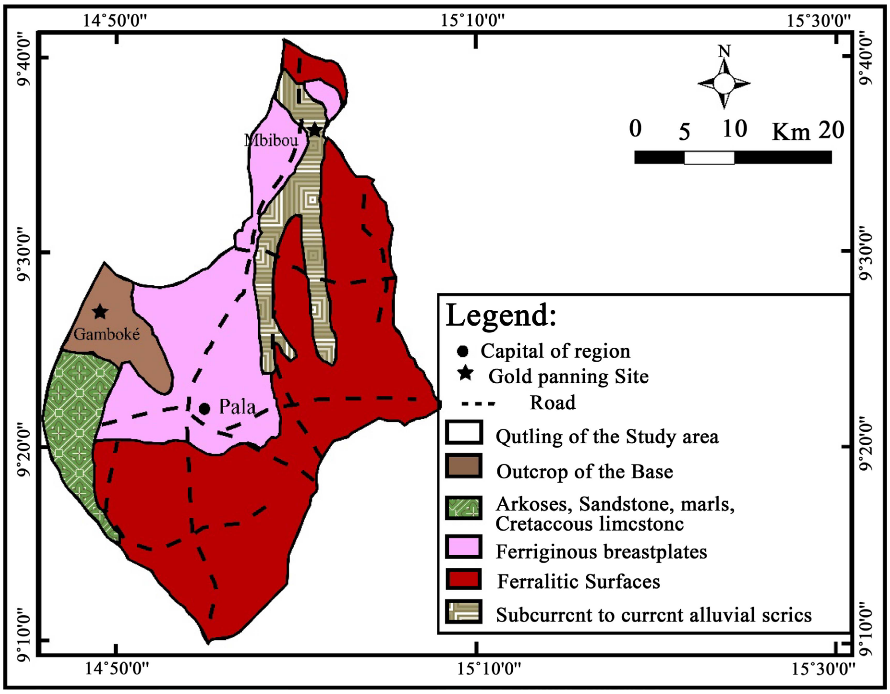

Figure 1. Geological map of Mayo-Kebbi West [10].

2.2. Samples and Preparation

Deep water (wells and boreholes) and surface water (washes and rivers) were sampled during the field campaigns. During this phase, physical parameters of the water were measured, such as hydrogen potential (pH) and electrical conductivity using a multi-parameter instrument. To find normal samples for laboratory analysis, the following steps are taken:

- the preparation of label sheets to attach to the bottles;
- use of latex plastics to avoid sample contamination;
- use of 750 ml and 1500 ml major bottles previously sterilized in sampling for chemical analyzes of cations, anions;
- filling the bottle while ensuring that there are no air bubbles in the bottle when closing the cap to avoid gas exchange with the atmosphere;
- in the case of drilling, the water must be pumped for a while before taking the sample.

2.2.1. Measurements of Physical Parameters

Physical parameters were measured in situ to correlate with the concentration of heavy metals. Physical parameters such as hydrogen potential (pH) and electrical conductivity (µs/cm) were measured in the laboratory using a branded multimeter.

2.2.2. Laboratory Analysis Methods

Analyzes of groundwater samples were carried out at the Hydro-Geosciences and Reservoirs Laboratory (LHGR) of the University of Farcha and at the National Water Laboratory (LNE) for metals: 1) research focused on chemical elements major (cations, anions, alkalinity and heavy metals) and 2) spectrometry by volumetric dosage, molecular absorption spectrophotometer and flame spectrometer (**Table 1**).

The samples taken during the field campaign were analyzed at the National Water Laboratory (LNE). Soil analyzes consist of weighing 10 g of the prepared soil sample and putting it in an Erlenmeyer flask. 100 ml of demineralized water was added to this measured sample for dissolution. Everything is placed on a stirrer under tension for homogeneity and then filtered. For this purpose, measuring devices are used to determine the concentration of the elements sought in the samples.

The analyzes were carried out to meet the expectations of research focused on the major chemical elements: cations (Ca^{2+}; Mg^{2+} Fe^{2+}; K^{+}; Na^{+}; NH_4^+); anions (Cl^-, NO_3^-, HCO_3^-, SO_4^{2-}), alkalinity and heavy metals (CN^-; Zn; Pb and Hg) (**Table 1**).

Volumetric dosing spectrometry is carried out by:

- the DR2800 type molecular absorption spectrophotometer (Fe^{2+}, SO_4^{2-}, NH_4^+, NO_3^-);
- the "BWB-XP" flame spectrometer (K^+, Na^+), (Cl^-, HCO_3^-, Ca^{2+}, total hardness).

Table 1 methods are used to determine the concentration of cations and anions.

3. Results and Discussions

3.1. Physico-Chemical Characteristics

3.1.1. Physico-Chemical Characteristics of Soils

The concentrations of physicochemical parameters determine the quality of a soil **Table 2**.

Table 1. Methods are used to determine the concentration of cations and anions.

Elements	Reactive	Analysis methods	Measuring devices and formulas
Ca^{2+}	Calcon and PH_{12}	**Volumetric Dosages**	TCa = TH-TMg
Mg^{2+}	No reagent		TMg = TH-TCa
HCO_3^-	PH		TitraLab AT1000 Series
Cl^-	Ca^{2+}		Burettes
SO_4^{2-}	Sulfaver	**Spectrometry**	DR2800 Spectrophotometer
NO_3^-	Nitraver		
Pb	pPb-1, pPb-2, pPb-3, pPb-4, pPb-5, pPb-6		DR6000 Spectrophotometer
CN^-	Cyaniver		DR2800 Spectrophotometer
Cu	Cu-1, Cu-2	**Spectrometry/method 8506 and 8026**	DR/890 Colorimeter
As	Powder sachet A1 and one tablet A2	**Wag-WE10500**	Arsenator
Cd	Solutions: A (1 ml) and B (0.4 ml); pretreated sample (4 ml)	**LCK/TNT plus**	DR1900 Spectrophotometer

Table 2. Result of elementary statistics of physico-chemical parameters of soils.

Noms	**Ca^{2+} (mg/l)**	**Mg^{2+} (mg/l)**	**HCO_3^- (mg/l)**	**Cl^- (mg/l)**	**SO_4^{2-} (mg/l)**	**NO_3^- (mg/l)**	**pH**
Minima	6.27	0	0	0	0	3	4.52
Maxima	27.44	10.9	503.7	72	31	114	7.18
Moyenne	13.44	3.23	150.91	19.14	6.57	27.63	6.44
Ecart-type	8.50	4.48	234.77	25.11	12.14	40.65	0.88
Normes OMS/TCHAD 2017	**200**	**250**	**?**	**250**	**250**	**50**	**$6.5 < pH < 8.5$**

3.1.2. Physical Characteristics of Soils

Hydrogen potential (pH) of soils

The pH of the soils ranges from 4.52 to 7.18 with a mean of 6.44 and a standard deviation of 0.88. Its average, slightly below the WHO standard, attests that the soils in the study area are acidic (Figure 2). Soil acidity is believed to be due to the precipitation of hydroxides, increasing the acidity of the environment and consuming metals.

3.2. Chemical Characteristics of the Major Elements: Cations and Anions

- The Calcium (Ca^{2+}) concentrations of the analyzed soils are around 6.27 mg/l and 27.44 mg/l with an average of 13.44 mg/l and a standard deviation of 8.50 mg/l. It appears that these levels are below the WHO/Chad standard (200 mg/l) (Figure 3(a)), which could explain the low production of calcium by carbonate deposits.
- The Magnesium (Mg^{2+}) contents vary between 0.00 mg/l and 10.9 mg/l for an

average of 3.23 mg/l) and a standard deviation of 4.48 mg/l. In addition, the magnesium concentration in soils is very low compared to the [11] standard (250 mg/l) (**Figure 3(b)**).

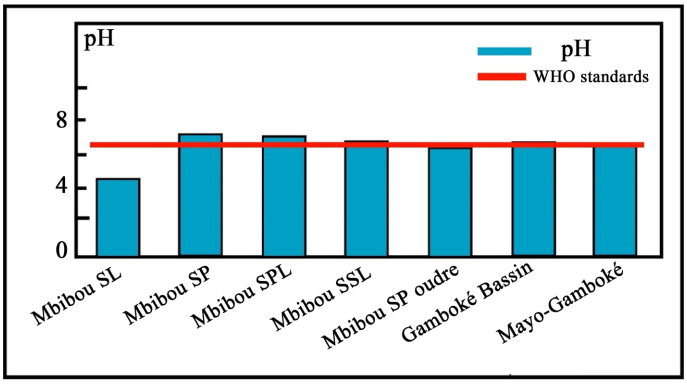

Figure 2. Variations in soil pH.

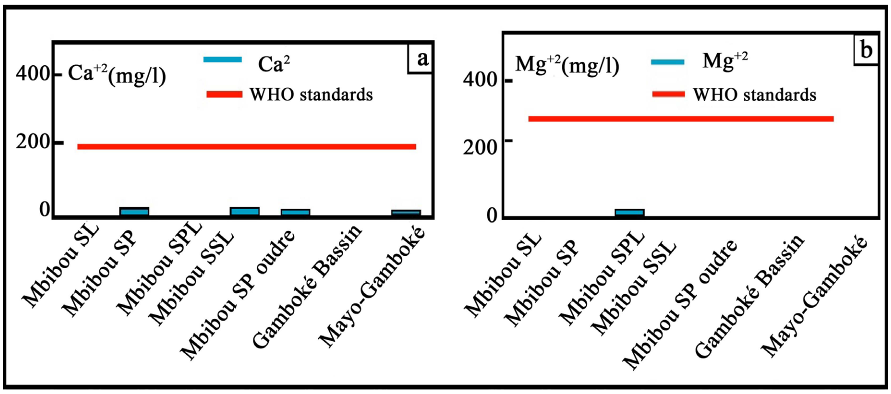

Figure 3. Variation in cation contents: (a) in Calcium; (b) in Magnesium.

The bicarbonate (HCO_3^-) content of soils is between 0.00 mg/l and 507 mg/l, with an average of 150.91 mg/l and 234.77 standard deviation. The Gamboké soil samples analyzed show an absence of bicarbonate (0.00 mg/l), but on the other hand those from MBibou show a very high concentration (503.7 mg/l), (**Figure 4(a)**).

- The chloride (Cl^-) concentration of the soils has a minimum of zero and a maximum of 72 mg/l with an average of 19.14 mg/l and a standard deviation of 25.14 mg/l. These soils are poorly concentrated in this element in the mining area studied compared to the WHO standard limited to 250 mg/l (**Figure 4(b)**).
- Sulfate (SO_4^{2-}) concentrations in soils vary greatly. They are of the order of 31 mg/l for an average of 6.57 mg/l with a standard deviation of 12.14 mg/l. It was noted that the soil samples from the Gamboké site have almost zero sulfate content compared to those from Mbibou which contain sulfate with a content of 31 mg/l, being below the standard set by [1] (250 mg/l) (**Figure 4(c)**). The origin of sulfate in these waters could be explained either by the presence of evaporitic

sedimentary rocks, notably gypsum ($CaSO_4$) or sulfur is present in sphalerite, chalcopyrite ($CuFe_2$), galena (PbS) and pyrite (FeS_2), the alteration of which is considered the reason for their presence in the environment [12]. The mineralization in the gold veins comes from quartz veins, which would support the high probability of the presence of sulfur according to [13].

- The soils analyzed recorded nitrate (NO_3^-) contents between 3 and 114 mg/l for an average of 27.63 mg/l and a standard deviation of 40.65 mg/l (**Figure 4(d)**). The presence of nitrate in these soils was due to the discharge of wastewater from gold miners or by leaching of fertilizers spread in the agricultural fields neighboring the mining sites. Their measured contents remain below the [1] standard (50 mg/l),

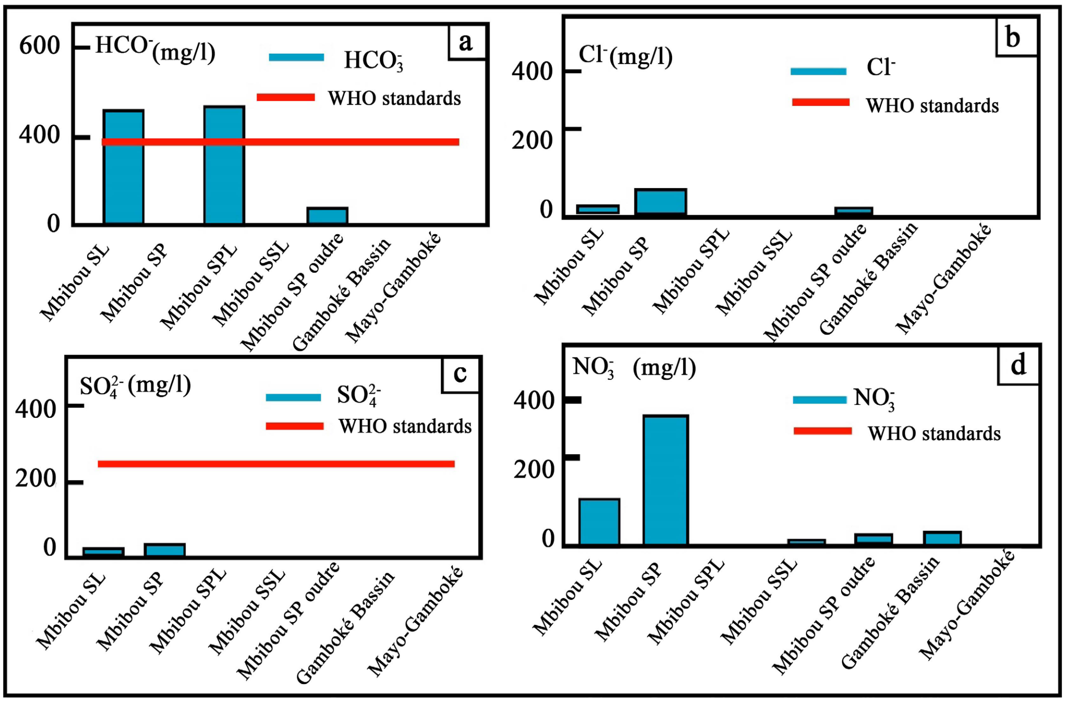

Figure 4. Variations in anion contents: (a) Hydrogen carbonate; (b) Chloride; (c) Sulfates; (d) Nitrates.

Soil pH values indicate high pollution in our study areas, because lowering pH increases the solubility and mobility of heavy metals in the soil. The pH value of the samples is acidic, so there could be a source of pollution that could extend from the sites through the flow of water and production of dust. This justifies the Cu, Cd and CN contents below in waters which are beyond the WHO standard.

3.3. Physico-Chemical Characteristics of Water

Physical Characteristics of Water

The quality of water is based on the concentration of physicochemical parameters. The result of the elementary statistics of the physical parameters (pH, conductivity and turbidity) made it possible to determine these different values (minimum and maximum), averages and standard deviations in the table below. (**Table 3**)

Table 3. Basic statistics result of physical water parameters.

Physical parameters	MINIMA	MAXIMA	AVERAGE	STANDARD DEVIATION	WHO/Chad STANDARDS
pH [H_3O^+]	7.40	8.00	7.71	0.18	$6.5 \leq pH \leq 8.5$
CE (µs/cm)	300.0	830.0	491.0	177.5	≤2500
STD (mg/l)	151.3	418.5	248.5	89.1	≤1300
Turbidity (NTU)	10.1	116000.0	18664.0	35523.2	≤5

EC: electrical conductivity; STD: total dissolved solids.

1) Hydrogen potential (pH) of water

Hydrogen potential (pH) indicates the acidity or basicity of water. The pH of the water analyzed varies from 7.40 to 8.00 with an average value of 7.71 and a standard deviation of 0.18. Its average value shows that these waters have an alkaline pH and comply with the WHO standard.

In a gold panning area, pH is one of the most important factors controlling the mobility of ETMs at the water-sediment interface and plays an important role in the adsorption of metals on the soil surface. An acidic pH promotes the high solubility of heavy metals and their mobility in the soil, particularly through the dissolution of metal salts or the destruction of the retention phase. Conversely, an alkaline pH limits or immobilizes the transition of metals from the solid phase to the aqueous phase [14] (**Figure 5**).

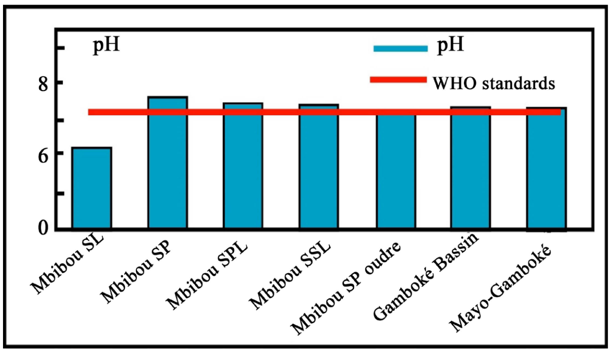

Figure 5. Variations in water pH.

2) Electrical conductivity (EC)

The electrical conductivity of water is the expression of its mineralization and is expressed in microsiemens per centimeter (µs/cm). It is a measure of ability to conduct an electric current. It varies from 300 to 830 µs/cm on the two gold sites, for an average of 491 µs/cm. Compared to the WHO standard (≤2500 µs/cm), the waters are weakly mineralized. This low mineralization could be explained by the fact that the waters of the sites studied do not contain enough dissolved mineral salts, such as chlorides, sulfates, etc. High conductivity reflects either normal pH or high salinity [15] [16].

Water turbidity is the determination of water clarity. Turbidity has a minimum value of 10.1 NTU and a maximum of 116,000 NTU, with an average of 18664.0 NTU and a standard deviation of 35523.2 NTU. The average turbidity is above the 2017 WHO standard (≤5 NTU), and the water quality is very poor. This abnormal variability in surface water turbidity is due to ore processing activities. According to Vigouroux *et al.* (2005 and 2006), high turbidity contributes to the disruption of photosynthesis and reduces the dissolved oxygen content of waters caused by particles suspended in the water. Likewise, high turbidity reduces water transparency and pollutes the environment by affecting aquatic species.

3) Chemical characteristics of water with heavy metals

In order to determine pollution, the levels of heavy metals in the water are compared to current standards (WHO standards).

The heavy metals present in waters, on the one hand, come from the heritage of the geochemical background and on the other hand from the accumulation of anthropogenic contributions. The heavy metal contents of water, the values of which are recorded in the table below. (**Table 4**)

Table 4. Result of elementary statistics of heavy metals in waters.

Physical parameters	MINIMA	MAXIMA	AVERAGE	STANDARD DEVIATION	WHO/Chad STANDARDS
Copper	0.9	47.6	31.1	14.171	2
Lead	0	0.021	0.007	0.008	0.01
Arsenic	0	0.011	0.002	0.004	0.01
Cadmium	0.01	0.221	0.055	0.004	0.005
Cyanide	0.001	0.453	0.165	0.18	0.05

After observing the analysis results of 10 water samples including 5 heavy metals (Cu, Cd, CN, Pb and As), we note that the concentration of Cu, Cd and CN in surface water is high compared to (Pb and As). Half of the samples have a high cyanide content, Cu and Cd are observed in all samples, Pb is obtained in 2 samples and As is present at very low content in all samples. Taking into account the results of the water analyzed, the Pb and As present a low content which is below the limit values set by the WHO for drinking water; on the other hand, the contents of Cu, Cd and CN exceed this standard.

- Copper (Cu) contents vary from 0.9 to 47.6 mg/l for an average of 31.1 mg/l and a standard deviation of 14.17 mg/l (**Figure 6(a)**). All samples analyzed have a content higher than the limit set by the WHO (2 mg/l). The high Cu contents of the waters are not surprising because this heavy metal is present in abundance in the gold ores chalcopyrite ($CuFe_2$), galena (PbS) and pyrite (FeS_2), the alteration of which is considered to be the because of their presence in the environment [17] and in the soil [18] [19]. During gold extraction, an acid attack on the ore facilitates their mineralization, solubilization and mobility in surface waters. As and Cu have a common source, gold ore.
- Arsenic (As) concentrations in water samples (**Figure 6(b)**) vary from 0.00

mg/l to 0.011 mg/l with an average of 0.002 mg/l and a standard deviation of 0.004 mg/l. The maximum was obtained in the Mbibou mining well, where the water from this artesian well is also used for gold miners' consumption. The average is below the WHO standard (0.01 mg/l).

- The Lead (Pb) content varies from 0.00 to 0.021 mg/l, the average is 0.007 mg/l and the standard deviation is 0.008 mg/l (**Figure 6(c)**). The average is below the WHO standard (0.01 mg/l).

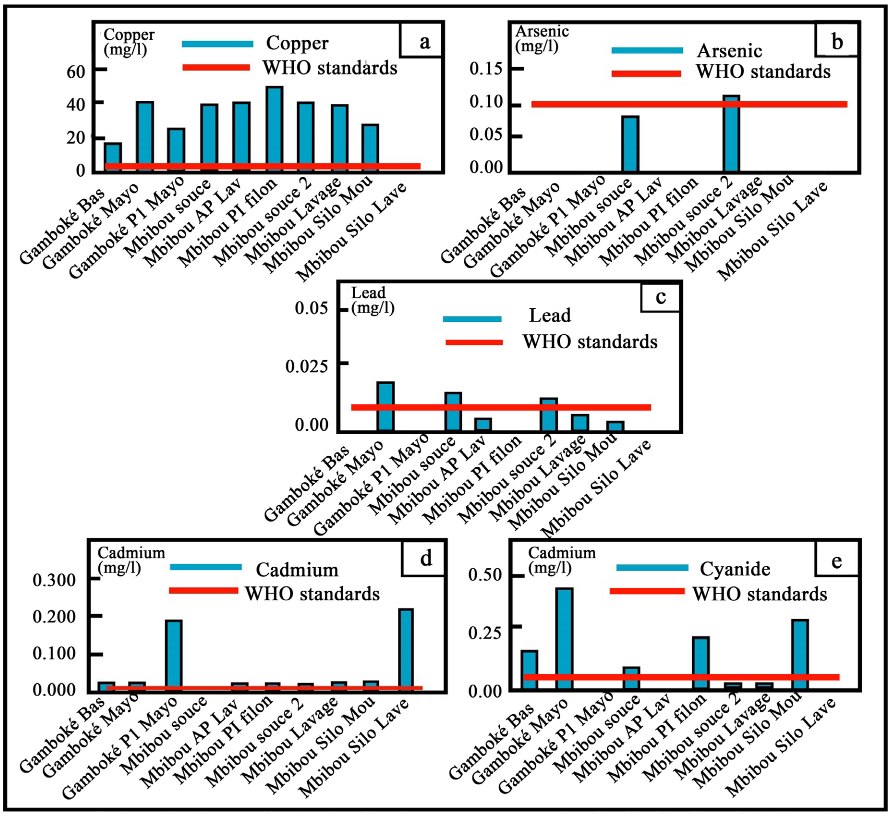

Figure 6. Variations in heavy metal contents: (a) Copper, (b) Arsenic, (c) Lead, (d) Cadmium and (e) Cyanide.

- The concentrations determined in Cadmium (Cd) (**Figure 6(d)**) present extreme values of 0.01 mg/l to 0.221 mg/l with an average of 0.055 mg/l and a standard deviation 0.004 mg/l. The maximum value was observed in the Mbibou gold ore crushing silo. The average content is higher than the limit of the [1] standard at 0.005 mg/l.
- The concentration of Cyanide (CN) is around 0.001 to 0.453 mg/l with an average of 0.165 mg/l and a standard deviation of 0.18 mg/l. The average level determined is above the 2017 WHO limit value set at 0.05 mg/l (**Figure 6(e)**).

Cadmium, copper and Cyanide, very toxic, are discovered in surface and underground water (mining wells) at concentrations higher than the limit values set by the WHO. They are a source of concern since gold miners and animals consume water. Their accumulation in the body leads to kidney (Pb, Cd), neurological

(Pb, As, Cd), hepatic (Cd) problems and causes cancer [20].

3.4. Impacts of Artisanal Mining on the Environment

Mining activities pose a threat to natural ecosystems, particularly in protected areas and areas of high conservation value. Artisanal mining sites produce mining waste which can pollute the soil and waterways that subsequently pass through protected areas. Finally, like any human settlement, we observe on artisanal mining sites, environmental pollution by waste and organic matter and a significant accumulation of rubbish and batteries from the torches used by gold miners in the mines.

3.4.1. Impact on Soil and Food Insecurity

Mining activity impacts the soil at all stages. In Gamboké, as in Mbibou, the sites are dotted with holes, often shallow or very deep, creating small reliefs on the surface and modifying the natural landscape. Digging effectively contributes to the degradation of the soil which leads to infertility and intensive erosion processes. This imbalance is at the origin of alluvial deposits in the valleys. These uncontrolled activities can cause disruptions in the natural drainage of watercourses.

Indeed, gold panning is the cause of soil degradation which is a factor in the reduction of cultivable areas and also a factor in the search for more fertile land. It is the result of a reduction in food production and the emergence of conflicts following the occupation of land. This artisanal activity makes it unsuitable not only for agriculture but also for grazing. In addition, soil pollution is caused by the discharge of solid and liquid waste on sites. According to [21], these extraction procedures are not reversible in most cases and can be catastrophic on a generational scale.

3.4.2. Impact on Water Resources

The movement of "waste rock by runoff water, the erosion of hillsides, and ore washing residues lead to the silting of rivers during the rainy season. During low water periods, the watercourses are mostly dry. The abnormally high content of suspended matter in these watercourses is manifested by the muddy and turbid appearance of the watercourses" [22] (**Figure 7(a)**, **Figure 7(b)**). Water is used throughout the chain of gold panning activities. During sinking, the free water table is reached, and the gold miners use motor pumps to evacuate large quantities of water, contributing to the reduction of the level of the groundwater table.

Gold processing activities with mercury consume a lot of water. For example, it takes around 200 liters of water to process a 50 kg bag of gold ore. The chemical products, solid waste (used batteries) and liquids (used oils) used contaminate surface and groundwater by leaching or infiltration. Furthermore, the use of mercury in the purification of gold and certain chemical particles contained in the subsoil leads to sedimentary deposits that pollute aquatic and atmospheric environments (**Figure 7(c)**, **Figure 7(d)**). In Guyana, research carried out by [23] on the biochemical cycle of mercury highlighted the aggravating role of gold panning activity, through additional releases of metallic mercury, through certain soil erosion which promotes the mobilization and transport of metallic mercury to the lowest points (shallows, watercourses). The results of these authors are confirmed in the present research.

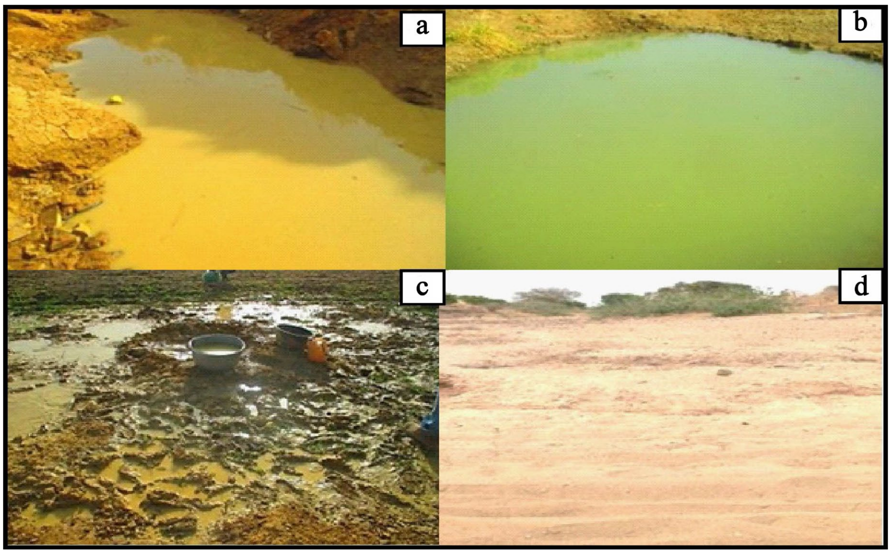

Figure 7. Water pollution induced by gold panning: (a) and (b) Surface water, (c) Discharge of processing water and (d) Silting.

3.4.3. Impact on Wildlife

In Gamboké, as in Mbibou, these mining activities have led to the escape or death of animals on the sites. This is due to excessive tree cutting and sound production. Gold miners use a lot of wood during digging, which quite destroys ecological niches and reduces the number of certain animals. On the gold panning site, the digging and installation of miners are activities that have a very negative impact on wildlife.

3.4.4. Impact on Flora

To reach gold horizons, excavations often require clearing which results in the significant loss of plant species, notably tree savannahs and grassy savannahs [23]. Indeed, the clearing operations carried out by gold miners on the activity sites gradually contribute to the destruction of the plant cover. Deforestation exposes the soil, facilitates the infiltration of rainwater [23] and erodes the soil. In traditional gold panning techniques, the risks and dangers for the physical environment generally result in deforestation, destruction of plant cover and soil. The destruction of plants is also reinforced by the search for nuggets which are known to be found especially between the roots of certain plants. The installation of mining shafts also requires clearing and deforestation to reinforce the walls of the shafts and prevent landslides. As no monitoring is put in place, the savannah is almost destroyed. The destruction of trees contributes to the destruction of wildlife habitat (migration or loss of certain animals) and a loss of tree species useful to humans. The progressive loss of flora (**Figures 8(a)-(c)**) gradually impacts the climate of the site: an increase in wind speed, high evaporation and thermal variabilities. A reduction in vegetation leads to drought and a reduction in agricultural yield. High flow turbulence leads to the transport and deposition of sediments in streams, which reduces stream beds and their flow [24]. (**Figure 8**)

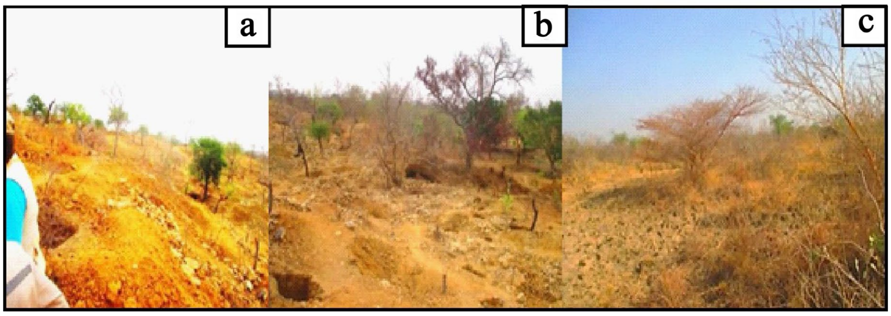

Figure 8. Degradation of the plant cover of gold panning sites: (a), (b) of Gamboké and (c) of Mbibou.

4. Conclusions

In summary, artisanal gold mining constitutes a significant source of wealth and an undeniable component of the economy of Mayo-Kebbi West province for a growing population. Gold panning is the main activity of the population and is considered an income-generating activity for the community, contributing both to income for gold miners and to financial support for local authorities. Over time, gold panning has become an undeniable activity in Mayo-Kebbi West, contributing significantly to the economic and social development of the province. Unfortunately, the development of this sector is based, in the current context, on unsustainable exploitation and production systems, including the use of harmful chemicals, which have considerable negative consequences leading to degradation, air and water pollution, the scarcity of certain forest species, the loss of arable land, the disappearance of fauna and flora, which leads to the loss of biodiversity.

These negative impacts directly affect the system and production capacities of the agricultural sector, one of the most important pillars of development. This activity remains a source of many pathologies and respiratory diseases such as irritations of the eyes, lungs, throat and coughs. Faced with the dichotomous realities (positive and negative aspects) presented by artisanal gold mining, the potential actors, include gold miners, customary chiefs, the local population, and not forgetting the decision-makers. These people must work for a good organization of this activity in order to mitigate and warn the populations about the harmful impacts on man and his environment; its advantages should not lead to losing sight of the serious consequences of such an activity.

Conflicts of Interest

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

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