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Community Perception on Environmental Impacts of Artisanal Gold Mining: a Case Study from commune of Fourou, Republic of Mali

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Abstract

Artisanal gold mining (AGM) is one of Mali's most significant economic activities. This activity become a serious environmental concern because of the chemicals used for AGM. The artisanal gold processing method uses a significant amount of water. The operating waste, often toxic by chemical mercury, is discharged or drained into watercourses. This study describes the main actors and the different methods of exploration, extraction, and processing of gold by artisanal miners, as well as their perception of environmental impacts. The methodology adopted is based on surveys and observations conducted at the Lollè and Sinty sites. The results show that no mining legislative rules were applied. Still, non-standard customary rules for a very long time. AGM has a particular organizational chart that actors manage. This study shows that AGM can cause health and environmental problems, especially with the use of chemicals, contamination of water resources, land degradation, and destruction of fauna and flora. Analysis of water samples shows that the mercury concentration at Lollè exceeds the WHO standard, while most mercury concentrations at Sinty are below this standard. The geomorphology of the study area shows a watershed with an area of 88.40 km2 with four orders of the hydrographic network in Lollè and 404.02 km2 with five orders in Sinty. While the slopes range from very weak to strong, and the study areas are practically flat. This study will provide accurate information to policy-makers for implementing environmental management strategies in a manner that miners can understand and evaluate.

1. Introduction

Nowadays, gold is important in the international system and the general economy. The gold reserve of any nation preserves the strength and stability of a country's wealth [1]. Artisanal gold mining (AGM), or gold panning is practiced for centuries and affects millions of people worldwide. Ten to fifteen million people are involved in this activity in more than 70 countries [2]. Gold panning, although often rudimentary and poorly mechanized, contributes significantly to the global gold market, representing 15 to 20% of global production [3]. In developing countries, this activity is an essential source of income for millions of people, providing jobs and supporting the fight against poverty and rural exodus [4,5]. Artisanal mining is defined as small-scale mining operations that are often informal and characterized by low levels of mechanization [6]. Sana *et al.* [7] highlighted the lack of knowledge of the miners on the health and environmental impacts of artisanal gold mining. While Cuya *et al.* [8] indicated that miners that economically rely on informal ASGM are aware of and concerned about the associated environmental problems and generally have positive perceptions of nature. However, Araujo *et al.* [9] emphasized the importance of formalizing gold mining operations, organizing social activities around cooperatives, and continuously pursuing technical and educational efforts.

In Mali, traditional mining is defined as any small-scale operation that consists of extracting and concentrating mineral substances from primary

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and secondary outcropping or sub-outcropping deposits and recovering marketable products using manual or traditional methods and processes, including artisanal gold panning [10]. According to Hussein [11], traditional mining was widely used worldwide in the early 1900s. In sub-Saharan Africa, most of the population is poverty-stricken and supports themselves by exploiting nearby natural resources such as gold. Gold panning is an activity often considered ancestral and intensified in recent decades, especially in West Africa, creating significant challenges for the environment. In the Kayes, Koulikoro, Sikasso, Gao, and Kidal administrative regions, artisanal mining of gold is much more coveted than agriculture. It provides more than 500,000 people, according to estimates by the international NGO Human Rights Watch (HRW) with employment [12]. However, it is difficult to give exact statistics on the population of gold miners with the involvement of other foreign nationals. The Sikasso region records 92 active sites, according to the 2017 mapping report by the National Service of Geology and Mines, including 13 in the commune of Fourou [13]. According to statistics from the Ministry of Mines presented on February 2, 2021, the total production of gold panning in 2020 in Mali was 6 tons, and it is exploited on dry land or in river beds. In both cases, water and chemicals are involved, which are very dangerous for human, animal, and environmental health [12]. This polluted water, considered to be the source of life, is used for domestic, industrial, and irrigation purposes.

Uncontrolled exploitation of mineral resources such as gold can lead to severe disruptions in the natural drainage of watercourses and seriously pollute groundwater. It destabilizes the hydrographic network by the presence of multiple exploitation holes in the beds [14]. The artisanal gold processing method requires the use of a significant amount of water. The operating waste, often toxic by chemical elements (cyanide, mercury), is discharged or drained into watercourses that can penetrate and reach the water tables [14]. AGM is an activity that denudes areas and promotes water erosion, reducing water infiltration that ensures the recharge of water reservoirs [15]. Several studies have been conducted in Mali in gold mining areas [13-16, 17, 18,19, 20, 21]. These studies were based on the impact of gold mining, specifically on the environment (water, soil, vegetation) and job creation in the country. The dual effect of artisanal mining and its morbidity was also studied [22].

In a context where extractive activities continue to grow, it is crucial to commensurate the voices of affected communities to promote sustainable gold mining practices that respect the rights of local populations. Such an approach could promote harmonious development that balances the need for economic resources with the preservation of the environment and community well-being. Sidibe and Camara [23] worked on the socio-economic effects of gold mining areas in the Kadiolo counties in Mali. Their results indicated that the gold mining sites have positive and negative effects on the population and the environment. Also, Keita [18] worked in artisanal mines in Mali and found that the gold mining must be promoted to increase its positive impacts and reduce its harmful effects. Keita *et al.* [24] investigated the socio-economic causes that pushed farmers to abandon agriculture in favour of gold panning at the Farabacoura site, Sikasso region in Mali. As for Sissoko *et al.* [19], they analyzed the negative and positive environmental effects of gold panning in Kéniéba, Kangaba, and Yanfolila, in Mali. Their findings showed that gold panning is a beneficial activity to reduce unemployment and migration but is harmful to health and children's education. Teschner [20] studied the role of artisanal gold mining in the commune of Yallankoro-Soloba during the transitional period in Mali and show that the gold panning activity has a positive effect on the community. Toure [25] studied the trauma of gold miners during their gold panning activities in the Emergency Department of the Gabriel Touré University Hospital in Mali. Konaté *et al.* [26] analyzed child labor in the artisanal gold mines in the rural commune of Fourou, cercle de Kadiolo, and revealed that children start work at a very early age in order to contribute to family income and they are involved in all stages of gold extraction.

Most of these studies focused on the socio-economic impacts of gold panning. Previous studies successfully used surveys in artisanal gold mining areas. However, no study conducted on the assessment of the impact of artisanal gold mining on the environment in the commune of Fourou in the Republic of Mali. It is the second region where gold panning activity is more practiced, with 40.4% after the Kayes region [27]. This study aims to understand the perception of artisanal gold miners and the impacts of their activities on the environment. The knowledge produced and data collected will serve as the basis for environmental policies to protect local communities.

2. Materials and Methods

2.1. Presentation of studied area

The Rural Commune of Fourou was created by Law No. 96-059 of 04/11/1996. It comes from the former Arrondissement of Fourou, following the territorial division of 1996 as part of the implementation of decentralization. The commune of Fourou is located in the circle of Kadiolo, Sikasso region in Mali. It is located to the West of the Circle of Kadiolo at 55 km from the city and approximately 155 km from Sikasso, the regional capital. It is located between -6° and -6° 30 West and 10° and 10°30 North. A former village of the Senufos, the rural commune of Fourou covers an area of 1,400 km^2. Figure 1 presents the study area.

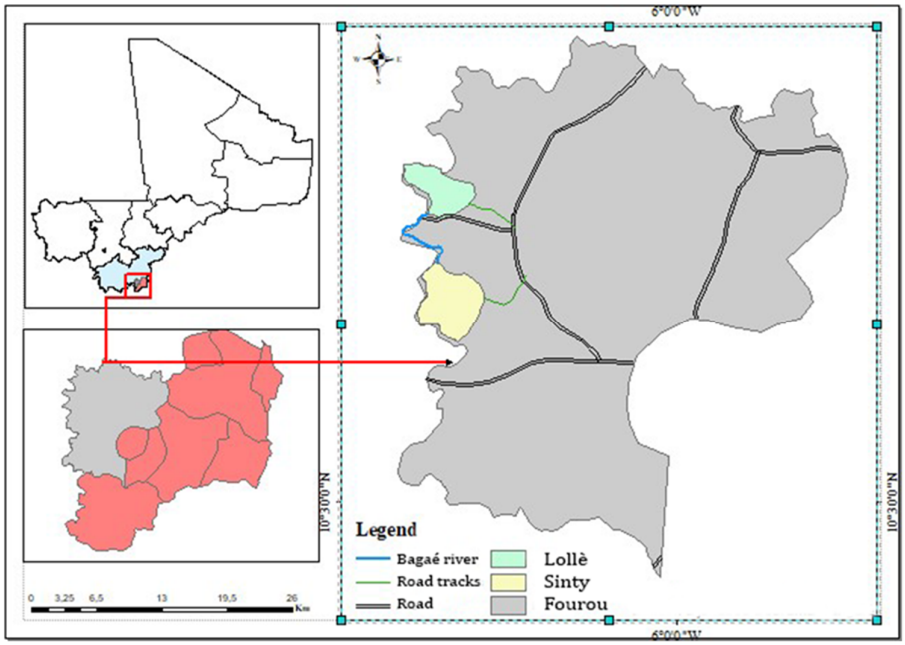

Figure 1. The localization of the studied area.

The commune of Fourou consist of 23 villages and 06 hamlets [28]. It has experienced a huge population increase in the last decade due to the exploitation of the Syama gold mine by SOMISY and 13 gold panning sites. The population is estimated at 47,492 inhabitants, including 24,680 men and 22,812 women, and the growth rate was 3.6% [29]. The population is composed of the Senufo and Samogho ethnic groups, with some minorities of Malinké, Fulani, Bambara, Minianka, Sonrhaï, Dogon, Bozo, Mossi, Kassonké, Sarakolé [16]. At present, gold panning is the primary source of the economy, plus agriculture, livestock breeding, gathering, fishing, trade, and crafts. The socio-cultural organization is dominated by the traditional chieftaincy in the villages [28]. Formally, the management of artisanal mining of mineral substances falls under the jurisdiction of local authorities. The following texts govern artisanal mining:

- Law No. 2023-040 of August 29 on the mining code in the Republic of Mali. According to the mining code, artisanal gold mining or traditional gold panning is carried out within an exploitation corridor by holders of an artisanal mining authorization. This authorization is materialized by the issuance of a gold panning permit exploitation by local authorities (art. 64; 65). The artisanal mining permit is granted to individuals and groups of natural persons of Malian nationality or nationals of countries granting reciprocity to Malians (Art 66). The duration of this permit is three years, renewable for periods of three (3) years (Art 67). The code prohibits the use of explosives and dangerous chemical substances, including cyanide, mercury and acids, in artisanal mining activities (Art 67). Holders of artisanal or semi-mechanized mining permits are required to carry out their activities in accordance with the legislation and regulations in force on environmental protection. Artisanal mining is submitted to the environment and social impact assessment (Art 64).

- Decree No. 2017-0555 /PRM of June 29 on the transfer of powers to local authorities in the field of Mines allows the Municipality to exercise its powers concerning traditional gold panning.

- Law No. 2021-032 of May 24, 2021, relating to pollution and nuisances, which makes environmental assessments mandatory for any activities likely to

harm the environment and the quality of the living environment).

The commune of Fourou is watered by the Bagoé River, which separates it from the Republic of Côte d'Ivoire and the Banifing, and serves the communes of Tiongui (Kolondiéba circle), Fourou (Kadiolo circle) and Lobougoula (Sikasso circle). The Bagoé River is the main water channel in the south of Mali [30]. The two rivers (Bagoé and Banifing) are confluences of the Bani (900 km long), which is the major tributary of the Niger River in Mali [31]. These rivers help facilitate gold processing in the commune. The Bagoé River is very turbid due to the increase in the sediment rate. The most important ponds are Lollè, which is 7 km far from Fourou, and the second one is Diéou, 12 km to the North East.

2.2. Data collection

Interviews were conducted, and observations were made to identify beliefs, values, and social dynamics that influence communities' behaviors and attitudes toward the changes brought by gold mining. AGM often results in the degradation of the environment (water resources, soil, vegetation), and is crucial for local communities.

2.2.1. Direct observations

During this observation, the investigator must focus not only on a person's statements but also on their behavior. Direct observations on gold panning sites made it possible to examine the perception of the population studied in usual situations and to identify their behavior towards the environment. It enables to visualize the artisanal mining sites, the waterways, the flora, and the state of soil degradation, as well as to observe the different techniques and technologies applied by the actors in the artisanal exploitation of gold. Several photographs of gold miners during their routine work (digging; raising, screening, washing and processing of ore) were taken.

2.2.2. The interviews

The non-directive interview (or "free interview") is a qualitative study research method that allows data to be collected. It is used to obtain detailed information on a general subject and allow an investigation to be carried out. The field interviews were conducted to examine the gold panning sites and their environment, and understand the technique, technology, perception, environmental aspects, and consequences on biodiversity. To this end, interviews were performed with the gold panners and households. The interview questions were developed using the koobotoolbox and the kobotoolcollect tools. Thus, 30 people from Lollé and Sinty agreed to participate in the interviews as people in the gold mining areas are very suspicious of surveys. Questionnaires were administered by trained research students from the High Institute of Mines and Geology of Boké, Guinea. The language used for interviews was the local language (Bambara). Informed consent was sought from the respondents, and data were handled following the General Data Protection Regulation [32].

2.2.3. Group discussion

According to Cissé [33], the idea of the group discussion is to confront the perceptions of the actors to gather a large amount of information. This discussion concerned landowners, women, and men gold miners active in the gold panning sector (Figure 2.a and Figure 2.b) to understand the genesis of the gold panning activity, gold panning techniques, technology, and their perception of the impacts of gold panning, the difficulties encountered and the solutions they propose.

2.3. Data analysis

Descriptive statistics were used to summarize the responses from the different participants. The responses obtained were analyzed using Microsoft Excel. This software facilitated the presentation and visualization of the obtained data in a more meaningful way, which allows for more straightforward and more accurate interpretation.

3. Results and Discussion

3.1. The actors and stages of gold panning

3.1.1. The main actors

In Mali, artisanal mining takes place on land belonging to the land heritage of a family or village. The village chief or landowner monitors this activity. During the opening, no mining legislative rules were applied, but non-standard customary rules existed for a very long time. This activity has a particular organization chart managed by actors. Among these actors, we have:

3.1.1.1. Chief of the village

According to chieftaincy rules, he is generally the oldest in the village. According to the mining regulations adopted by the villagers, the village chief does not receive his percentage of the gold

mined but benefits from the savings from the tickets sold. He is the final decision-maker after consulting with his council.

3.1.1.2. The village elders

The village elders are respected and listened to figures within the community. They have a deep knowledge of the authorship of the land and the history of gold panning in our study region. The customary chief, a leading traditional authority, is among these wise men. At the start of the dry season, a period conducive to mining activity, gold miners often request access to new mining sites. In this study, it was observed that the *"Damantigui",* representative of the local administrative authorities, systematically consults the village elders to obtain their support before authorizing mining in new sectors. After a careful study carried out by the customary chief, the *Damantigui* obtains the approval of the elders, who thus play an essential consultative role in the decision-making process. In addition, they participate in determining an auspicious day for the opening rituals of the new gold panning campaign by consulting the *"Tombolomas",* specialists in traditional calendars.

(a) **(b)**

Figure 2. Data collection with stakeholders; a) Discussion with the men's group; b) Discussion with the women's group.

3.1.1.3. The good managers "Damantigui"

There are generally two to five people in charge of the *"Damantigui".* The group is made up of an individual who invests in the well by paying the cost of the access ticket (10,000 CFA) for 15 days, renewable, and who also ensures the daily supply of food for the miners. This sponsor receives its share when the profits are distributed. In addition, there are two to four people who dig and bring the ore up from the shaft. These workers may also be the ones financing the operation.

3.1.1.4. Artisanal mining polices “Tombolomas”

Tombolomas, or artisanal mining police, are indigenous men selected by village elders. The head of the police, called "Tomboloma *koutigui* ", is designated by consensus by the village chief based on criteria such as courage, trust and dedication to the community. The role of *Tombolomas* includes selling tickets, distributing extraction areas, maintaining order and safety of miners, and respecting local traditions. They direct the extraction process.

3.1.1.5. Hunters "Donsos"

The *Donsos* of the site are volunteer hunters determined to help the village. They have the same role as the *Tombolomas*, acting as intermediaries between the workers and the *Tombolomas*. They stand guard to secure people and their property.

3.1.1.6. Diggers "Farassena"

The *"Farassena*" are the people responsible for digging the mining shafts. Their job is to dig from the opening of the well until reaching the gravel or ore containing gold, using a unique pickaxe called *"Kalassourouni".* When they encounter difficult areas, they may resort to using a jackhammer or chisel for lack of anything better. To extract gold ore, they use a pickaxe called a *"Kaladian",* which allows them to follow the direction of the deposit. In the event of flooding, they use a motor pump to evacuate the water. In poorly ventilated areas,

ventilation devices are installed by those who work outside the wells. During the digging, the *"Kaladjanti"* use tree trunks to support the walls in case of risk of fall.

3.1.1.7. Researchers “appareils Tiguiw”

These are gold miners who use electromagnetic devices to search for gold. These device users limit themselves to the surface or a shallow depth. When the device detects metal or another object, it alerts.

3.1.1.8. The charge shooters "Djouroussamana."

They are the people who pull the loads from the depths to the surface using a bucket, a cut can, or a rope, using a winch system or a pulley.

3.1.1.9. Carriers

As for them, they transport the sediments to the washing basin with a metal bucket, a can, or a three-wheeled motorcycle.

3.1.1.10. Caterers "Farakolaw"

They are usually women who wash the sediment to obtain the gold using gourds and rubber cups. Strangers can also wash away the sediment with a slice and spittle.

3.1.1.11. Businesses "Djatiguiw"

Businesses are people who buy gold from artisanal miners to resell it. They are located on the site or in the village. This step in the artisanal gold mining process involves bringing the ore to the surface. This is done by tying a bucket or cut drum to a rope and then using a winch or pulley to pull the ore up. Generally, this task is carried out by men. The individuals responsible for this activity are called "rope pullers" (*Djouroucountigiw*). They also play a role in sharing the profits generated in the exploitation process.

3.1.2. Transporting the ore

It is the third step, which consists of transporting the ore to the watercourse or the basin set up near the wells. These basins are supplied with water by transferring old wells to the basins through a pipe and a motor or by irrigating water from the river to the basins. In these sites, the shooter sends the ore directly to the edge of the basin, which is close to the well. As for the spitter, their transport is done by men using three-wheeled motorcycles.

3.1.3. Ore processing

The techniques used on-site to process gold ore are panning/simple washing, sluice washing, spitter washing, and mercury recovery:

3.1.3.1. Panning or simple washing

Figure 5 shows the ore washing by panning or simply. This gold ore processing operation is done by women using a calabash in a shallower washing hole supplied with water from rivers or old mining wells or at the edge watercourses. This washing occurs following numerous rotational movements of the calabash currently replaced by basins. During these centrifugal movements, all the light minerals are carried away by the water. At the bottom of the calabash, only gold remains (if there is any) mixed with heavy minerals, generally black *"Bli"* in colour. This concentrate is put in a small bowl or a small gourd, and the process continues until it goes down and the mixture is taken to their business client. According to our findings, this *Batée* method is very rudimentary and tedious; however, it is less expensive and the least damaging to the environment because it does not use any chemicals [34].

3.1.3.2. Sluice treatment

According to Sanoussi [35], the sluice is a device used to concentrate gold. Figure 6 shows an overview of gold ore sluice processing. The sluice is an inclined plane covered with a railing carpet. The ore is mixed with water and poured little by little into the sluice. The gold in the ore is trapped in the grooves of the mat, and the water drains away the other less dense particles. The mat is lifted after a few minutes of work to wash in a container, finally obtaining the mud containing gold and processing it to obtain pure gold nuggets. Next, they add mercury to concentrate.

3.1.4. Operating stages and technology applied in the commune of Fourou

Artisanal mining is carried out in several stages, which are:

3.1.4.1. Prospecting

The prospecting of the artisanal mine is done differently from that of the industrial mine. This prospecting was done after the consensus of the village chief, the councilors, and the Tombolomas. Several wells are dug in different places for tests to do this prospecting. The part of the wells that will

produce more gold will be the new area to be exploited by the community called *"Béen"*.

3.1.4.2. Digging or sinking

It is the very first and most challenging step in artisanal mining. The hole is dug using a pickaxe, hammer, small shovel, and a motor for complex parts (pickaxe) (Figure 3).

These wells can include hard and soft parts depending on the nature of the site. The gold prospector digs a vertical hole using a digging pickaxe. When he finds signs of the presence of ore, the gold prospector follows the direction of the ore using a cutting pickaxe. When digging, the digger leaves some parts (pillars) or uses tree trunks for support. After the subsoil has been exhausted, the digger goes to the surface with a torch attached to his forehead, which serves as lighting for the hole. The depth of the hole varies depending on its ore content, which ranges from three to twelve meters for alluvial and eluvial deposits and tens of meters for vein deposits. In the commune of Fourou, an exploitation well belongs to at least three people. There is one person who finances the work and pays the ticket but does not participate in the activity. After exploitation, the money is divided into two parts after subtracting the price of the motor pump if it was used. One part is shared equally between the three owners and the second between the others who participated in the work from digging to washing. The T*ombolomas* collect the price of the gold drilling ticket (10,000 CFA francs). This money is presented to the village chief and his advisers as well as to the youth of the village, and it is used as part of local development.

Figure 3. Sinking a well.

3.1.4.3. Raising the sediment

After extraction, Figure 4 shows an overview of the sediment rising from a well.

Figure 4. Removal of sediment from a well.

3.1.4.4. Transporting ore

This is the third step which consists of transporting the ore to the watercourse or the basin set up near the wells. These basins are supplied with water by transferring old wells to the basins through a pipe and a motor or by irrigating water from the river to the basins. In these sites, it is the shooter who sends the ore directly to the edge of the basin which is close to the well. As for the spitter, their transport is done by men using three-wheeled motorcycles.

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The techniques used on-site to process gold ore are: panning/simple washing, sluice washing, spitter washing, and mercury recovery:

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Figure 5 shows the ore washing by panning or simply. This gold ore processing operation is done by women using a calabash in a shallower washing hole supplied with water from rivers or old mining

wells or at the edge watercourses. This washing occurs following numerous rotational movements of the calabash currently replaced by basins. During these centrifugal movements, all the light minerals are carried away by the water. At the bottom of the calabash, only gold remains (if there is any) mixed with heavy minerals generally black *"Bli"* in color. This concentrate is put in a small bowl or a small gourd and the process continues until it goes down and the mixture is taken to their business client. According to our findings, this *Batée* method is very rudimentary and tedious, however, less expensive and the least damaging to the environment because it does not use any chemicals [3].

Figure 5. Panning or simple treatment by women.

3.1.4.5.3. Spitting treatment

The spitter is a mill equipped with a water pump grinding and washing the ore. Figure 7. shows an overview of the processing/washing of gold ore with a spitter in the Commune of Fourou. The ores processed by the spitter are dug or excavated with the devices. The mixture of ore and water produces mud that crosses a layer of gold reservoirs and goes towards the bed of waterways or old wells. The carpet is lifted and washed afterward. In the gold panning sites of the commune of Fourou, this technique is generally used by "*Burkinabè*" foreigners. For the head of the *Tombolomas*, this technique is a way to close the old wells. However, it can also obstruct waterways and make the area unclean with mud and the elements accompanying gold.

3.1.4.5.4. Recovery and sale of ore

At the end of the daily activity, the mixture of gold and black metal in the small container is treated with great care to reduce impurities. Then it is put into the *"Fanfan",* which is in the form of a

3.1.4.5.2. Sluice treatment

According to WHO [4], the sluice is a device used to concentrate gold. Figure 6 shows an overview of gold ore sluice processing. The sluice is an inclined plane covered with a railing carpet. To use this device, the ore is mixed with water and poured little by little into the sluice. The gold in the ore is trapped in the grooves of the mat and the other less dense particles are drained away by the water. The mat is lifted after a few minutes of work to wash in a container finally to obtain the mud containing gold and process it to obtain pure gold nuggets. Next, they add mercury to concentrate.

Figure 6. Sluice treatment.

metal spoon (Figure 8.a), and added mercury (Figure 8.b) for those using it before placing it on a butane gas to dry (Figure 8.c). After drying, the concentrated gold is purchased by businesses who have a balance *"Dia"* scale in their possession which is used to weigh the gold. Before weighing, the "business" removes the rest of the impurities with a magnet. Mercury is used very little in the processing of ore in the commune. The majority of users are foreigners.

Figure 7. Spitting treatment.

(a) (b) (c)

Figure 8. Ore recovery and sales equipment. a) Electronic balance and metal spoon; b) Mercury; c) Butane gas for drying gold.

3.2. The Perception of gold miners on the impacts linked to the activity on the environment

3.2.1. General information about the respondents

The data collected on artisanal mining sites in the commune of Fourou provide information on nationality, level of education, and the practice of gold panning and its effects. Table 1 presents the nationalities of traditional gold miners on artisanal mining sites. Analysis of this table reveals a diversity of nationalities from the West African sub-region.

The results indicate that 81.08% of individuals are Malians. In addition, we observe the presence of Ivorians (8.11%), followed by Burkinabè and Guineans, each representing equally 5.41%. The strong growth of foreigners on these gold panning sites in the commune of Fourou can be explained by several factors, namely, the quantity and quality of gold on these sites. The massive concentration of gold miners on the sites and the use of chemical products causes health problems and negatively impact the quality of fauna, flora, soil, and water resources [21]. However, it is also the source of income for many families. Unlike Cissé [33], the author asserts that the arrival of many foreigners, notably Burkinabé gold miners, has caused a transition in technique and technology.

Table 1. Nationality of traditional gold miners

Native country	Percentage
Burkina Faso	5.41
Guinea	5.41
Ivory Coast	8.11
Mali	81.07

Table 2. Level of education of traditional gold miners.

Level of studies	Language of study	Percentage
Koranic	Arab	8.11
Secondary school	French	8.11
Primary school	French	18.92
University	French	5.41
Nothing	Nothing	59.45

The analysis of Table 2 reveals the level of education of traditional gold miners in the commune of Fourou: 59.46% of gold miners did not attend school. However, 8.11% followed Koranic education. Furthermore, 18.92% have reached the basic level, while 8.11% have a secondary education level. Finally, 5.41% of gold miners have a higher education level.

Table 3. presents the distribution of traditional gold miners according to their marital status and the participation of members of their households in gold panning activity in the commune of Fourou. The results show that 94.59% are married, while 5.41% are single. In addition, 97.30% of households have members who practice gold panning. The development of several gold panning sites could explain this sharp increase in the rate of households practising gold panning. It is considered the primary economic activity of the population. Authors such as [36, 37, 38, 39] came to the same conclusion. Several people engage in gold panning either temporarily (often after wintering and until the next rainy season) or permanently.

Table 4. illustrates the impact of population growth due to gold panning activities in the commune of Fourou. Analyses show that 35.14% of those questioned believe that population growth has a positive impact on the development of the village. On the other hand, 29.73% think that population growth harms the development of the village. In addition, 32.43% of respondents believe

that population growth could have both a positive and negative impact on the development of the village. Finally, 2.70% of respondents chose not to give their opinion.

3.2.2. Degrees of use of chemicals by respondents

Table 5. The following presents the use of chemicals in the processing of gold during gold panning activities in the commune of Fourou. It reveals that 27.03% of respondents use chemicals, including mercury, in the gold processing process, especially during amalgamation. Furthermore, 43.24% do not use chemicals. However, 29.73% of respondents chose not to answer this question.

3.2.3. Perception of gold miners of the impact of the activity on the environment

Table 6. shows the impacts of gold panning on natural resources, particularly water resources, fauna, flora, tree cutting, and soil degradation in the commune of Fourou. Surveys reveal that 24.32% of gold miners cut down trees during their gold panning activities. Figure 9 shows the impact AGM on tree cutting.

Table 3. Distribution of traditional gold miners on their marital status and participation of household members in gold panning activity.

Marital status	Percentage	Household participation	Percentage
Married	94.59	Gold mining households	97.30
Single	5.41	Non-gold miners' households	2.70

Table 4. The impact of demographic growth due to gold panning activities.

Nature of impact of growth	Growth reviews	Percentage
Positive impact on growth	Yes	35.14
Negative impact on growth	Yes	29.73
No positive or negative impact	Yes and No	32.43
No idea	NIL	2.70

Table 5. Chemicals are used in the processing of gold during gold panning activities.

Use of chemicals	Nature of products	Percentage
User group	Mercury	27.03
Non-user group	Nothing	43.24
Neutral group	No idea	29.73

Table 6. Impact of gold panning on natural resources.

Nature of impact	Qualification of gold miners on impact	Percentage
Deforestation/cutting of trees or wood	Tree cutter	24.32
	No tree cutter	37.84
	Neutral	37.84
Destruction of fauna and flora	Reduction of vegetation	70.27
	No decrease	29.73
Water supply source	Irrigator of the ancients	2.70
	Home shipments	5.41
	Irrigate watercourses	2.70
	Old wells or streams	2.70
	Did not respond	86.49
Contamination of water resources	Change in water quality	75.68
	Quality is not changed	18.92
	Did not respond	5.41
Degradation of soil/cultivable land	Impact of activity on the soil	81.08
	The soil is not impacted	13.51
	Did not respond.	5.41

Regarding water supply, the results show that 2.70% get their supplies by irrigating old wells, 5.41% from their homes, 2.70% from rivers, and 2.70% use either old wells or waterways. However, 86.49% did not answer this question. On water quality, 75.68% of respondents believe that artisanal mining has had a negative impact, 18.92% think that water quality has not changed, and 5.41% did not respond. Figure 10. shows the impact of AGM on water resources.

Regarding the impact on the soil, 81.08% of respondents affirm that gold panning has

significantly degraded or even impacted the soil, while 13.51% believe that the soil is not affected. Additionally, 5.41% did not answer this question.

Figure 9. The impact of AGM on tree cutting.

Figure 11. shows the impact of AGM on soil degradation.

Finally, regarding the destruction of fauna and flora, 70.27% of respondents noted a significant decrease in vegetation due to the opening of multiple gold panning sites. In comparison, 29.73% did not notice this change. The degradation of the fauna and flora is explained by the increase in the number of artisanal gold mining sites and by the influx of foreigners into the area. These new arrivals put pressure on nature for their settlement, contributing to the deterioration of forest and wildlife resources in the region studied [33, 40].

According to our surveys and observations made on the different sites, the physical impacts left, such as digging holes, forming piles of earth, and deforestation, have negatively influenced the quality of the soil. These physical changes have contributed to the decrease in the density and biological diversity of the locality. This degradation is manifested by the loss of the surface horizon (very marked water and wind erosion) and Figure 11shows the impact of AGM on soil degradation.

Figure 10. Impact of AGM on water resources.

the reduction of nutrients (decrease in fertility and loss of organic matter in the soil), as well as by reducing water infiltration. AGM is generally located along watercourses. The process of mechanically treating mineralized gravels using washing tools such as "sluice" or "washing ramp" requires a permanent flow of water. The movement of gold miners to a new, more prosperous site by abandoning many exploitation wells offers the soil a process of intensive erosion, leading to the destruction of the surface soil. This imbalance can cause over-alluviation of the valleys and their more or less profound asphyxiation. These processes are almost irreversible and can become catastrophic on the scale of a few generations. Alluvial mining, which is frequently accompanied by the destruction of the banks and massive sediment inputs, can locally disrupt the balance of rivers.

The two sites studied are crossed by the same river, the Bagoé river (see Figure 1). The main morphometric characteristics of the watersheds were determined by analyzing the watershed from SRTM images. The Lollè watershed has an area of 88.40 km², while that of Sinty covers 404.02 km². Tables 7 and 8 present the statistics of the Lollè and Sinty watershed maps. It emerges from the analysis of Tables 7 and 8 that the slopes of the villages of Lollè and Sinty are divided into three classes: very low slope, low slope and steep slope. The different slopes are identifiable by distinct colors: very gentle slopes are designated by the color yellow, weak slopes by the color light green and steep slopes by the color dark green (Figure 12). The study areas are almost flat. Figure 13 shows the map of the hydrographic networks of the commune of Fourou, including the villages of Sinty and

Lollè. It can be seen in Figure13 that the hydrographic network of Lollè has four orders, while that of Sinty has five. In addition, we can also observe the direction of water flow towards streams or rivers. This information is crucial for understanding the hydrological dynamics and erosion processes in the studied region.

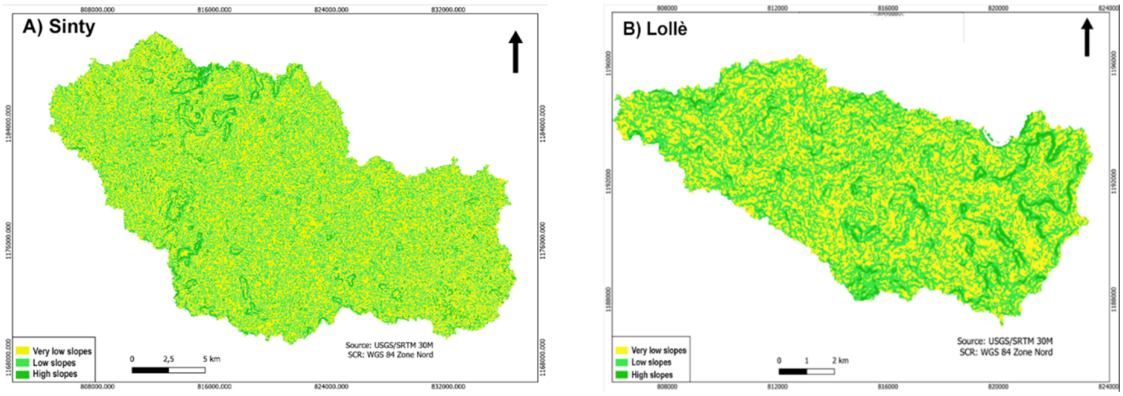
The soil in the commune of Fourou is poor due to water erosion. The commune includes clayey soils, sandy soils, gravelly soils, loamy soils, clayey loamy soils, and clayey sandy soils. The soil and subsoil are greatly affected by AGM removing the topsoil, and exposing the saprolite substrates to the outside. Artisanal extraction wells are generally the cause of water erosion during the dry season [16].

Table 7. Statistics of Lollè watershed maps.

Watercourses	km ^{2}	Slopes	km ^{2}
1	1.2447	Very gentle slopes	38.5
2	0.6507	Low slopes	42.2415
3	0.3141	Steep slopes	5.5215
4	0.2394		

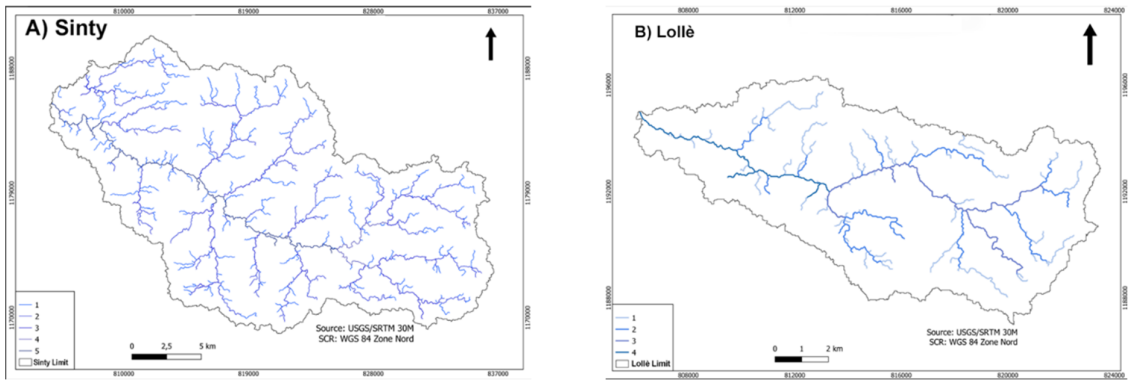
Table 8. Statistics of Sinty watershed maps.

Watercourses	km ^{2}	Slopes	km ^{2}
1	5.0184	Very gentle slopes	38.5002
2	2,733	Low slopes	42.2415
3	1.8135	Steep slopes	5.5215
4	0.2727		
5	0.8847		



(a) (b)

Figure 12. The slopes of the villages: (a) Sinty; (b) Lollè. The slope is classified according to the classification of [41].



(a) (b)

Figure 13. The hydrographic network: (a) Sinty; (b) Lollè.

The watersheds of the rivers were delimited with the hydrographic networks on the basis of the digital terrain model (DTM).The hydrographic networks were classified according to the Stralher classification [42]. This classification assigns values to each of the branches of the network. The value of 1 is assigned to any drain that has no tributaries and a drain of order n+1 comes from the confluence of two drains of the same order n. In addition, if a lower order joins a higher order in a confluence, then it is the value of the higher order that is attributed to the drain

The creation of turbidity and the contamination of water by sludge can lead to an impoverishment of aquatic fauna. Watercourses can also be contaminated by heavy metals from ore washing. Gold miners' use of mercury constitutes the most significant impact on human and environmental health at mining sites [18]. Mercury is the chemical used in the various gold mining sites studied in the commune of Fourou. Surface water samples collected at the Sinty and Lollè sites and analyzed at the Analytical chemistry laboratory of the Faculty of Science and Technology of Bamako in Mali reveal a constant mercury concentration in all samples from Lollè (0.01 ppm).

In comparison, Sinty's mercury concentration varies between 0 and 0.007 ppm. The mercury concentration at Lollè is significantly higher than at Sinty, indicating more significant mineralization. The mercury concentration at Lollè (0.01 ppm) exceeds the WHO standard (0.006 mg/L), while most mercury concentrations at Sinty are below this standard.

The gold panning sector operates with customary village rules even if it is governed by various texts that are not in force. In Mali, part of the power of the Ministry of Mines over artisanal mining is conferred on local authorities for its management and the application of the texts. The mayor of the commune thinks that the texts must be applied and wants the establishment of sales counters to have an environmental protection fund. Those responsible for artisanal mining believe that the application of the regulations in the commune is complex. Nowadays, with the presence of multiple gold panning areas, the commune faces a great environmental danger. This problem is explained by the population growth in the commune by nationals and foreigners. Through our surveys and studies carried out by other authors such as [21,43,44,45,46], it emerges that the artisanal mining sector can cause health and environmental problems, especially with the use of chemicals. However, gold panning is also a source of income for many families. The chemicals and explosives used by gold miners are prohibited in Mali, according to the mining code (Art 50). The state is considering solutions to this issue. These solutions consist of informing the actors on the texts of the mining code and raising their awareness of the good practice of this activity. In this work, the state is supported by NGOs such as the FDS (Foundation for Development in the Sahel), which plays a huge role in environmental management, raising awareness, and training the actors in the commune of Fourou.

4. Conclusions

In the artisanal mining sites of the commune of Fourou, more particularly on the sites of Lollè and Sinty, gold is mined in an artisanal manner with the use of chemicals that are dangerous to human and environmental health by miners. Artisanal mining has contributed to the development of the living environment of gold miners (construction of permanent houses, purchase of equipment, marriage, etc.) and villages by creating jobs. The results of this study show that no mining legislative rules are applied, but non-standard customary rules have existed for a very long time. Artisanal gold mining has a particular organizational chart that actors manage. This study shows that the AGM can cause health and environmental problems. However, The State must set up a mechanism for the correct application of the mining code on the sites through monitoring and environmental protection services.

Analysis of water samples shows that the mercury concentration at Lollè exceeds the WHO standard, while most mercury concentrations at Sinty are below this standard. The geomorphology of the study area shows a watershed with an area of 88.40 km^2 with four orders of the hydrographic network in Lollè and 404.02 km^2 with five orders in Sinty. While the slopes range from very weak to strong, and the study areas are practically flat.

Communities that remain accessible, members are often unfamiliar with researchers and may be hesitant to participate in studies. This hesitancy limited the strength of this present study, as greater community involvement could have significantly improved data collection and outcomes. Future studies can overcome these barriers by building trust through long-term engagement, and involving communities in the research design process especially to ensure communities are fully aware of the importance of the research. To improve current study, specific studies on the impact of gold

panning on health, soils, aquatic flora, and fauna should be encouraged.

Conflicts of Interest

The authors declare no conflict of interest.

Ethical Statement

The authors state that the research was conducted according to ethical standards.

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References

[1]. Onjaniaina, S.C. (2021). L'or : Un patrimoine national mal maitrise. Etude faite à travers le fokontany ambatomandidy-ferme, Commune Ambatolampy, district Tsiroanomandidy., Mémoire. Antananarivo, Madagascar.

[2]. United Nations Environment Programme (UNEP) (2014). Annual report, https://www.unep.org/resources/annual-report/unep-2014-annual-report

[3]. United States Agency International Development (USAID) (2017), Directive environnementale sectorielle : Exploitation minière artisanale et à petite échelle, 2017. http://www.usaidgems.org/sectorGuidelines.htm.

[4]. World Hralth Organization (WHO) (2017). World health statistics 2017: monitoring health for SDGs, Sustainable Development Goals. https://creativecommons.org/licenses/by-nc-sa/3.0/igo

[5]. Tomicic, C., Vernez, D., Belem,T., and Berode, M. (2011). Human mercury exposure associated with small-scale gold mining in Burkina Faso, *Int Arch Occup Environ Health, 84(5)*, 539–546.

[6]. Toledo, O.Z., & Arce, M. (2024). Informal, Legal, or Illegal? Varieties of Artisanal Mining in the Global South. *World Politics*, *76(4)*, 697–734.

[7]. Sana, A., De Brouwer, C., & Hien, H. (2017). Knowledge and perceptions of health and environmental risks related to artisanal gold mining by the artisanal miners in Burkina Faso: a cross-sectional survey. *Pan Afr Med J.* 27:280.

[8]. Cuya, J.A., Glikman, J., Groenendijk, *et al.* (2021). Socio-environmental perceptions and barriers to conservation engagement among artisanal small-scale gold mining communities in Southeastern Peru, *Glob. Ecol. Conserv.*, 31 , 2351-9894.

[9]. Araujo, C.H.X., Ullah, I., & Tomi, G. (2025). Challenges in artisanal small-scale gold mining: perspectives and transformations to sustainability along BR-163 in Brazil, *Journal of Sustainable Mining*: 24 : 2 , Article 11.

[10]. Code Minier (2019), Journal officiel de la République du Mali, Secrétariat du Gouvernement. Mali.

[11]. Hussein, S.O. (2020). Assessment of urban vegetation changes on different scales in a semi-arid region using satellite imageries, Faculty of Science and Informatics, Szeged, Hungary.

[12]. Cenozo (2023). Orpaillage au Mali : un tueur silencieux. https://cenozo.org/orpaillage-au-mali-un-tueur-silencieux/

[13]. Guindo, S. E. M. H. A. (2020). Plan d'Action National pour l'Extraction Minière Artisanale et à Petite Échelle d'Or au Mali Conformément à la Convention de Minamata sur le Mercure, Mali.

[14]. Amoakwah, E., Ahsan, S., Rahman, M.A., Asamoah E., Essumang D.K., & Ali M. (2020). Assessment of Heavy Metal Pollution of Soil-water-vegetative Ecosystems Associated with Artisanal Gold Mining, *Soil and Sediment Contamination: An International Journal*, *29(7)*, 788–803.

[15]. Niane B., Guédron S., Feder F., Legros S., Ngom P. M., & Moritz R., (2019). Impact of recent artisanal small-scale gold mining in Senegal: Mercury and methylmercury contamination of terrestrial and aquatic ecosystems, *scitotenv,* 669, 185–193.

[16]. Dembele, A., (2022). L'orpaillage, la population et l'environnement dans la commune de Fourou. www.delta-c.net

[17]. Fane, S., and Samake, I. (2019). Entités Territoriales Communales Décentralisées et Gouvernance des Ressources Foncières : L'exemple de l'or dans le Ganadougou/Région de Sikasso au Mali, *ESJ*, *15(29)*, 117–137.

[18]. Keita, S., (2001). Study on Artisanal and Small-Scale Mining in Mali, Minerals and Sustainable Development (MMSD), Working Paper 80. https://www.iied.org/g00726

[19]. Sissoko, M., Smale, M., Castiaux, A., & Theriault, V. (2019). Adoption of new sorghum varieties in Mali through a participatory approach, *Sustainability (Switzerland)*, *11(17)*, 1–15.

[20]. Teschner, B.A. (2014). Orpaillage pays for everything: How artisanal mining supported rural institutions following Mali's coup d'état, *Futures*, *62*, 40–150.

[21]. Ndiaye, K., (2020). Le développement de l'orpaillage, son impact environnemental et sanitaire dans le sud-est du Sénégal : Exemple du site aurifère de Bantako. https://lib.uliege.behttps://matheo.uliege.be

[22]. Karembe, M.S. (2020). Extraction minière artisanale et à petite échelle de l'or et morbidité à kénieroba Thèses d'exercice de médecine générale. Faculté de Médecine et d'Odontostomalogie ; Université des Sciences, des Techniques et des Technologies de Bamako. https://www.bibliosante.ml/handle/123456789/3978

[23]. Sidibe, M. A. H. M., & Camara M. (2020). Impact socioéconomique de l'orpaillage dans le cercle de Kadiolo au

Mali, *Revue Malienne de Science et de Technologie*, *1(24)*, 91–103. https://www.revues.ml/index.php/rmst/article/view/194

[24]. Keita, M. M., Owuor, G., and Ogendi, G. M. (2018). Drivers of Participation in Artisanal Gold Mining and its Effect on Agriculture in Mali, *ADRRI Journal of Agriculture and Food Sciences*, *41(3)*, 1–16. https://www.journals.adrri.org/

[25]. Toure, H.H. (2022). Etude de la prescription médicale dans le cadre de la mutualité dans le centre de santé «MIPROMA» à Bamako. Thèses d'exercice en Pharmacie. Faculté de Pharmacie. Universite des Sciences, des Techniques et des Technologies de Bamako, Mali. https://www.bibliosante.ml/handle/123456789/3867

[26]. Konate, F.O., Traore, S., Yattara, B., & Konate, M. F. (2024). Analysis of Child Labor in Artisanal Gold Mines in the Rural Commune of Fourou, Cercle De Kadiolo, Sikasso Region, Mali. *International Journal of Research in Humanities and Social Studies*, *11(2)*, 1-8.

[27]. Plan d'Action National (PAN) (2020). Plan d'Action National pour l'Extraction Minière Artisanale et à Petite Échelle d'Or au Mali Conformément à la Convention de Minamata sur le Mercure.

[28]. Mairie de Fourou (2022). Rapport annuel 2021, Mali. www.bvg-mali.org

[29]. Service Local de la Planification de la Statistique de l'Information de l'Aménagement du territoire et de la Population (SLPSIAP) de Kadiolo, (2017). Bulletin trimestriel de l'activité statistique au Mali « KHI-DEUX », Mali.

[30]. Sanogo, Y., Samake, F., Kone, A., &Traore, D. (2015). Diversité du peuplement ichtyologique de la rivière Bagoé (Bassin du Niger, Mali), *Agronomie Africaine*, *27(1)*, 47–56.

[31] ABFN (2018). L'état du fleuve Niger au Mali. https://q-eau-mali.net/wp-content/uploads/sites/53/2019/08/rapport_etat_fleuve_niger.pdf

[32]. Frankenfield, A. M., Fernandopulle, M.S., Hasan, S., Ward, M. E. and Hao L. (2020). Development and Comparative Evaluation of Endolysosomal Proximity Labeling-Based Proteomic Methods in Human iPSC-Derived Neurons, *Anal Chem, 92(23)*, 15437–15444.

[33]. Cissé, F.B. (2019). Étude des impacts de l'exploitation artisanale de l'or en république de Guinée (cas de la préfecture de Siguiri), Mémoire. Montréal (Québec, Canada), Université du Québec à Montréal, Maîtrise en sciences de l'environnement.

[34]. Aline, D.S.L. and Souza M.B. (2018). Os benefícios apresentados na utilização da terapia assistida por animais: revisão de literatura., *Revista Saúde e Desenvolvimento*, *12(10)*, 224–241.

[35]. Sanoussi, A.A. (2020). Evaluation des impacts de l'exploitation artisanale de l'or sur le site d'orpaillage de Komabangou (Liptako, NIGER).

[36]. Sambiénou, W.G., Gourcy L., Alassane, A., Kaki, C., Tossou, Y.Y.J., & Mama, D., (2018). Flow Pattern and Residence Time of Groundwater within Volta River Basin in Benin (Northwestern Benin)," *JWRAP*, *10*, 663–680.

[37]. Yaou, KF. (2019). Caractérisation hydrogéologique et hydrogéochimique des nappes souterraines de la Zone Minière d'Arlit au Niger. http://lib.uliege.be

[38]. Ngouala M.M. (2020). Caratérisation des eaux souterrainnes du moyombe au sud-ouest de la République du Congo par les méthodes géochimiques et statistiques,*Rev. Ivoir. Sci. Technol*, *35*, 446–461. http://www.revist.ci

[39]. Kouadri, S., & Samir, K. (2021). Hydro-Chemical Study with Geospatial Analysis of Groundwater Quality Illizi Region, South-East of Algeria, *J. Chem. Chem. Eng, 40(4)*, 1315–1332. www.SID.ir

[40]. Kouassi, S.G., Séraphin, K.K., Lazare, K.K., Alexis, B.L., Félix K.K., & Dongui, B.K., (2020). Evaluation de la Contamination Chimique des Eaux Souterraines par les Activités Anthropiques : Cas de la Zone d'Ity-Floleu Sous-Préfecture de ZouanHounien, Ouest de la Côte d'Ivoire," *ESJ*, *16(6)*, 247–274.

[41]. Dembélé, N.J. (2012). Drainage network and geomorphological evolution of the three gorges area, 156p. Doctorat: Quaternary Geology: China University of Geosciences: Chine.

[42]. Strahler, A.N. (1952). Dynamic basis of geomorphology. *Geological Society of America Bulletin, 63*, 923–938.

[43]. Maman Illatou, E. F. O. (2022). Impacts de l'orpaillage et de l'agriculture sur la qualité des eaux du Liptako nigérien : identification des hots spots des pollutions métalliques et organiques, transferts de connaissances entre recherche et terrain," Thèse. Institut Mines-Telecom (IMT) / École Nationale Supérieure des Mines d'Alès (IMT Mines Alès) / Universite Abdou Moumouni de Niamey, France.

[44]. Affessi, A.S., Gnamien, J.K. K., & Moussa, S., (2016). Impacts sociaux et environnementaux de l'orpaillage sur les populations de la region du Bounkani (Cote D'ivoire), *ESJ*, *12(26)*, 288.

[45]. Huisa-Mamani, F., Arizaca-Avalos, A., & Lanque-Maquera, O.E. (2024). Mercury pollution in water, soil, and biota induced by artisanal gold mining: A case study from Ananea District, Puno, Peru. *Journal of Degraded and Mining Lands Management, 12(2)*, 7159-7171.

[46]. Akpanowo, M.A., Benson, N., Ekong, G.B., Umaru, I., Iyakwari, S., & Yusuf, S. D. (2025). Effect of artisanal mining on water quality: An assessment of water sources in local communities in Anka, Northwest Nigeria. *ISABB Journal of Health and Environmental Sciences*, *10(1)*, 1-13.

درک جامعه از اثرات زیست محیطی استخراج طلای دستی: مطالعه موردی از کمون فورو، جمهوری مالی

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چکیده:

استخراج دستی طلا (AGM) یکی از مهم‌ترین فعالیت‌های اقتصادی مالی است. این فعالیت به دلیل مواد شیمیایی مورد استفاده برای AGM به یک نگرانی جدی زیست‌محیطی تبدیل می‌شود. روش فرآوری دستی طلا از مقدار قابل توجهی آب استفاده می‌کند. زباله‌های عملیاتی، که اغلب به دلیل جیوه شیمیایی سمی هستند، به درون آبراه‌ها تخلیه یا زهکشی می‌شوند. این مطالعه، بازیگران اصلی و روش‌های مختلف اکتشاف، استخراج و فرآوری طلا توسط معدنچیان دستی و همچنین درک آنها از اثرات زیست‌محیطی را شرح می‌دهد. روش اتخاذ شده بر اساس بررسی‌ها و مشاهدات انجام شده در سایت‌های Lollè و Sinty است. نتایج نشان می‌دهد که هیچ قانون قانونی برای استخراج اعمال نشده است. با این حال، قوانین عرفی غیر استاندارد برای مدت زمان بسیار طولانی اعمال شده است. AGM دارای یک نمودار سازمانی خاص است که بازیگران آن را مدیریت می‌کنند. این مطالعه نشان می‌دهد که AGM می‌تواند باعث مشکلات بهداشتی و زیست‌محیطی شود، به ویژه با استفاده از مواد شیمیایی، آلودگی منابع آب، تخریب زمین و نابودی جانوران و گیاهان. تجزیه و تحلیل نمونه‌های آب نشان می‌دهد که غلظت جیوه در Lollè از استاندارد WHO فراتر می‌رود، در حالی که بیشتر غلظت‌های جیوه در Sinty کمتر از این استاندارد است. ژئومورفولوژی منطقه مورد مطالعه، حوزه آبخیزی با مساحت ۸۸.۴۰ کیلومتر مربع با چهار رده شبکه هیدروگرافی در لوله و ۴۰۴.۰۲ کیلومتر مربع با پنج رده در سینتی را نشان می‌دهد. در حالی که دامنه‌ها از بسیار ضعیف تا قوی متغیر هستند و مناطق مورد مطالعه عملاً مسطح هستند. این مطالعه اطلاعات دقیقی را برای سیاست‌گذاران جهت اجرای استراتژی‌های مدیریت زیست‌محیطی به شیوه‌ای که معدنچیان بتوانند آن را درک و ارزیابی کنند، فراهم می‌کند.

کلمات کلیدی: اثرات زیست‌محیطی، معدنچی طلا، لوله و سینتی، غلظت جیوه.