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REHABILITATION OF AN ILLEGAL GOLD MINING SITE AFTER EXPLOITATION IN KOUDOUGOU, BOUAFLE DEPARTMENT (COTE D'IVOIRE)

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ABSTRACT

Illegal artisanal gold mining has been around for decades and is practiced by millions of people around the world. In Côte d'Ivoire, it is carried out by poor populations. Gold panning appears to be an effective means of combating poverty and unemployment in Koudougou. The overall objective of this work is to highlight a plan for restoring the site after exploitation by conducting a diagnosis and an assessment of the effects of mining activities with a view to proposing rehabilitation methods. The methodology is based on a field survey approach combining sampling and direct field observation. The results obtained indicate that illegal gold mining activity involves several actors including public administration executives. Although generating income, it negatively affects the health of populations and the bio-physical environments of the environment. There is a need to restore mining sites during or at the end of exploitation. As part of this study, the restoration is carried out at the end of exploitation by the Non-Governmental Organization "Agir pour l'Environnement des industries Extractives" (Acting for the Environment of Extractive Industries) which applied two types of rehabilitation including agriculture and the creation of fish ponds.

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INTRODUCTION

Mining is the activity of extracting precious minerals from the earth, found in a deposit, vein, or placer (alluvial sand). It has always been considered environmentally destructive. The repercussions are significant, so much so that the environmental balance often changes. This activity often develops to the detriment of local populations, who do not always benefit from the economic and financial spinoffs but suffer the effects of land degradation and pollution of all kinds. It is with this in mind that African leaders have been concerned with strengthening the mining sector's contribution to the continent's socio-economic development. Since the fall in the cost of agricultural raw materials in the 1980, on which the Ivorian economy was based, the government has had the industrialization of the country as an alternative (Soro, 2011). Thus, priority has been given to the extractive industry. Since 1990, mining activities have experienced a meteoric rise with the discovery of several gold deposits representing approximately 0.7% of gross domestic product (Yapi *et al*., 2014). Gold mining activity is increasingly increasing, affecting 24 regions (Goh, 2016), attracting many people from all walks of life.

In order to preserve the environment (Hué *et al*., 2021), the restoration of mining sites after the end of activities is essential because it is included in the certification of the operating permit. Generally, complete reclamation is impossible, but rehabilitation and restoration can allow the establishment of a favorable ecosystem (Swapan, 2018). Rehabilitation appears as an alternative to environmental restoration. It is in this context that this study was conducted in Koudougou. The general objective is to highlight a site restoration plan through a diagnosis and an assessment of the effects of mining activities in order to propose rehabilitation methods.

MATERIALS AND METHODS

Presentation of study area : The department of Bouaflé is located in the Marahoué region in the center-west of Côte d'Ivoire between longitudes 5° 15" and 6° 30" West and latitudes 6° 00" and 8° 00" North (Figure 1). The capital city is located 59 kilometers from Yamoussoukro (political and administrative capital) and 306 kilometers from Abidjan (economic capital). The Koudougou study area is located 8 kilometers from Bouaflé on the way to

Yamoussoukro. It is a village populated by Mossi ethnic group (halogens from Burkina Faso) who have been settled there since 1932.

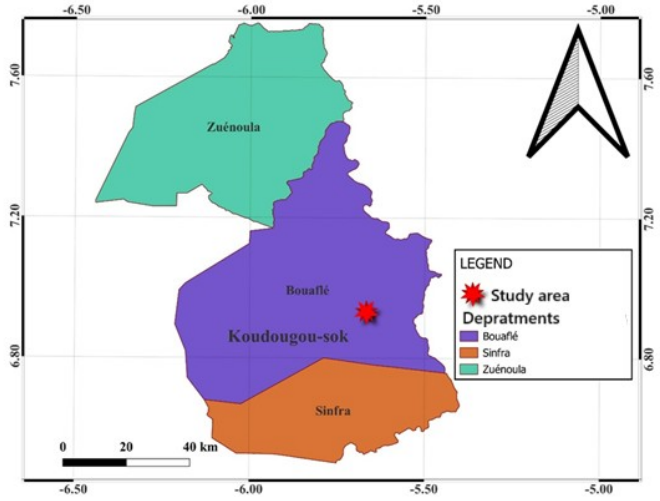

Figure 1. Location of study area

MATERIALS AND METHODS

The methodology focused on the diagnosis of the Koudougou site, the evaluation of the effect of mining activity on the environment and a proposal of rehabilitation techniques. Note that within the framework of this study, the restoration of the site was carried out by the Non-Governmental Organization "Agir pour l'Environnementdes industries Extractives" (acting for the extractives industries) which applied two types of rehabilitation including agriculture and the creation of fish ponds.

Site diagnosis and assessment of the impact of mining activities: The diagnosis was carried out through a field visit to investigate the actors involved in illegal gold mining and to note the damage caused to the environment by photography. Mining activity can disrupt natural environments in several ways, including soil degradation, landscape transformation, solid waste disposal, and the release of liquid and gaseous effluents. Five soil samples were taken and sent to the laboratory to determine some physicochemical parameters (figure 2).

Figure 2. Soilsamples

Site rehabilitation: After assessing the damage caused by illegal gold mining, the excavations were backfilled, filled and levelled (Figure 3). In addition, a fish pond was created and revegetation was carried out through cultivation and tree planting Figure 4).

Figure 3. Machines carrying out backfilling

Figure 4. Nurseries and seeds for growing and planting trees

RESULTS AND DISCUSSION

State of play after illegal gold panning

Actors Involed: The results of the survey conducted in Koudougou show that those involved in illegal gold mining come from all walks of life. They range from the local rural population to public service agents and executives. This contributes to perpetuating it and giving it a certain legality in the eyes of the rural masses.

Impact on the environment: Illegal gold mining in Koudougou has caused enormous disruption to the environment and the health of the population. Indeed, in April 2024, gold wells nearly 12 to 13 meters deep were discovered over an area of 3 hectares caused by gold mining activities. These activities destroyed several cocoa, rubber, and cashew fields. Figure 5 shows the landscape of Koudougou before and after exploitation. Environmental degradation includes fauna, flora, and agriculture. In addition, these illegal activities have contributed to the modification of the ecosystem and microclimate of the area.

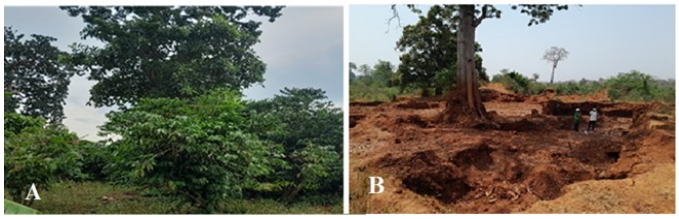

Figure 5. Landscapebefore (A) and after (B) exploitation

Impact on wildlife: These activities have contributed to the disappearance of wildlife due to deforestation and environmental pollution. The degradation of terrestrial habitats, soil excavation and sudden land rearrangement have destroyed the micro-habitats of species such as rodents, insect nests, and burrows. Indeed, deep wells create cold air currents, disrupt the nesting areas of terrestrial birds and alter the activity cycles of insects. The excavations act as death traps for small mammals, reptiles and amphibians.

Impact on flora: The decline in vegetation cover is significant at gold mining sites. The perpetrators of these activities have destroyed entire fields of cocoa and rubber trees. Furthermore, nearly 80% of the root systems of shade trees have been damaged, leading to the imminent disappearance of many plant species. Gold miners use wood to support wells or to build their homes and as firewood for cooking. As

a result, the forest is completely deforested, and around the sites visited, nature is devoid of its vegetation cover.

Physicochemical parameters of soil: The total nitrogen, organic carbon, organic matter and pH values are reported in Table I.

Using shovels and wheelbarrows, the aggregates are collected, dumped into the pits and compacted (Figure 6). Subsequently, backfill materials are added to fill the hollows and faults or ditches in order to level and level the land using machinery (Figure 7). The resulting soils must undergo agricultural restoration in order to regain their fertility.

Table *2.* Results of soil physicochemical parameters

Echantillons	pH	Azote total (NT en %)	Carbone Organique (C en %)	Rapport (C / NT)	Matière organique (MO en %)
1	5,7	0,056	0,82	14,64	1,41
2	5,9	0,07	0,87	12,42	1,49
3	5,6	0,06	0,9	15	1,54
4	5,5	0,04	0,58	14,5	0,997
5	5,4	0,14	1,35	9,64	2,32
Référence d'un sol fertile	6,0-7,0	0,1-0,2	1,5	10-12	2-4

Figure 6. Closing the pits with aggregates

Figure 7. Before and during back filling

Figure 8. Green bean harvest

The analyzed samples show that the soils have lost their fertility following gold panning activities. Indeed, the pH of the soils is acidic and lower than the reference (6 to 7). Only sample 5 still seems close to fertility, despite its acidity with levels of total nitrogen, organic carbon and organic matter consistent with the reference of a fertile soil.

Rehabilitations carried out

Closing and backfilling of excavations: This phase was devoted to the recovery of aggregates leached on site and used to close the pits.

Restoration of fertility through market gardening: The use of legumes allows for reduced fertilizer applications, as nitrogen-fixing bacteria give plant species an undeniable advantage in developing on bare land. They contribute to the fight against erosion and soil depletion, and contribute to environmental preservation and food security. As part of this study, green bean cultivation was carried out, which was a success for the adopted rehabilitation plan. After 3 months, the harvest was satisfactory with a productivity of more than one ton per hectare (Figure 8). The labor came exclusively from Koudougou.

Initially sheltered by a cocoa field, after the green bean harvest, the study area was covered with cocoa trees which today are gradually taking on their former appearance.

Revegetation through tree planting and cash crops: Environmental restoration through revegetation was achieved through the cultivation of acacia, banana, and cocoa (Figure 9). These crops have begun to increase.

Figure 2. Vegetation through plant cultivation

Construction of a fish pond: When it was difficult or even impossible to close certain pits, a dam was built for aquaculture. The pond created has a rectangular shape measuring 170 meters long and 80 meters wide (Figure 10). The bottom is cleaned with the removal of weeds, clay, and aggregates. It contained ten thousand tilapia fries for breeding. Floating cages were installed to separate the fish as they evolved.

Figure 10. Development of a fish pond (start and end of work)

DISCUSSION

This study focused on the rehabilitation of the illegal gold mining site of Koudougou in the Bouaflé department. The results of the survey conducted in Koudougou are consistent with those of Goh (2016) regarding the identification of the actors involved in gold mining. Indeed, the involvement of public service agents and executives in this activity contributes to perpetuating it and giving it a certain legality in the eyes of the rural masses. This explains the persistence of this phenomenon, even though it is illegal. Furthermore, insufficient agricultural income and the collapse of agricultural product prices could be one of the reasons (Soro, 2011). Gold mining seems to be an alternative. Indeed, revenues are shared between gold miners and landowners, in exchange for the right to exploit their land assets. This could also be explained by the jobs generated by the sector and the development of small businesses in the artisanal gold mining area (Affessi *et al*., 2016; Fodé, 2019). However, despite its advantages, gold panning causes environmental destruction, loss of agricultural land, deforestation, and soil degradation. Indeed, Abdou (2020) and Digbo *et al*. (2021) have shown that this activity is the basis of the decline in agricultural activities. Also, the particles mobilized during soil erosion are physical and chemical pollutants of water and affect certain species (Ahoussi and Yapo, 2021). These results are similar to those of Soma *et al*. (2021), who showed that the use of chemicals dangerously compromises the health of water resources. The biological environment is greatly affected. We are witnessing the loss of many fauna and flora species through the destruction of their natural habitat and the regression of agricultural areas (Kouakou*et al*., 2022). Indeed, the installation of gold miners requires clearing land, cutting wood and straw for the construction of houses or sheds for residential use, which could explain this condition (Zadi *et al*., 2019). Many young people prefer to try their luck on gold mining sites rather than pursue studies where the employment and income prospects areuncertain, in their eyes (Mokam*et al*., 2016). However, environmental protection and the fight against poverty mobilize political and institutional actors. Several major global conferences organized by the United Nations (Stockholm, 1972; Rio, 1992; Rio +20, 2012; COP 21, 2015, etc.) have made the issue of the environment a central element of development policies, with the Millennium Development Goals and the Sustainable Development Goals at the heart of it. However, reconciling economic development and environmental protection is not an easy task (Fagnard & Hamaid, 2012). Nevertheless, actions can be carried out through participatory cooperation between the actors involved in gold panning in Koudougou in order to improve the impacts of this activity on the population while reducing risks to the environment. Thus, environmental restoration measures can be adopted. These include the closure and backfilling of excavations, restoration of soil fertility through market gardening of legumes, planting of trees and cash crops (cocoa), and construction of a fish pond. Similar mitigation measures have already been proposed by the "Cabinet d'Etudes, Conseils d'Assistance et de Formation" (Study Assistance and Training Consulting Firm) in 2016 in a study on the environmental and social impact of the Sissingué gold project in Tengréla (far north of Côte d'Ivoire).

CONCLUSION

This study focused on the rehabilitation of the illegal gold mining site of Koudougou in the Bouaflé department. The aim was to demonstrate the influence of this activity and the restoration plan on all environmental entities. To do this, processes were used to identify the impacts on the environment and finally, to propose solutions to try to remedy the harmful effects of the activity. The identification of the actors involved in gold mining made it possible to identify rural populations, wealthy traders, authorities and public service executives. This activity has proven to be destructive to the environment. Nevertheless, the study indicates rehabilitation as an alternative to improve the influence of gold mining, in order to restore the environment to its pre-exploitation state. It has helped to restore degraded soils and create jobs.

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