



Restoration of Degraded Illegal Gold Mining Site in the Sub-prefecture of Kokoumbo (Central Côte d'Ivoire) Through Economically Important Forest Species

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ABSTRACT

Background: In Côte d'Ivoire, in the sub-prefecture of Kokoumbo, mining activities are causing enormous damage to the environment. The vegetation cover and soil at the sites are degraded by excavation. One solution to repair the effects of mining on the environment is restoration. This study was conducted with the aim of highlighting the impacts of illegal gold mining on the soil and revegetating it with six economically important forest species.

Methods: Soil pits were dug and soil profiles were described at sites affected and unaffected by gold panning. The organic matter content was analyzed. The soil was then leveled and six economically important forest species were planted according to the one tree plot design in order to study their ability to grow on this soil. The seedlings of these plants were 1 month old at the time of planting and the data were collected 1 year later. These plants are: *Terminalia ivorensis*, *Tectona grandis*, *Mansonia altissima*, *Garcinia kola*, *Acacia mangium* and *Milicia excelsa*. The observed parameters were Stem height growth, diameter of roots collar, the number of leaves, Mortality rate.

Result: Gold mining has promoted the formation of technosols. The highest mortality rate among the planted species was recorded for *Garcinia kola* with 78.5%. The species *Tectona grandis*, *Acacia mangium* and *Terminalia ivorensis* recorded no mortality. The average height of *Tectona grandis*, at 316.11 cm, is greater than that of *Acacia mangium*, which is 247.89 cm and that of all other cultivated plants. Their agronomic parameters were significantly different from those of the other tree species. They can be recommended for reforestation of sites or former gold mining sites.

Key words: Illegal gold mining, Mortality rate, Revegetating, Technosols.

INTRODUCTION

Mining activity is growing significantly in Côte d'Ivoire and now accounts for 4% of gross domestic product (GDP). It is a sector that provides many direct and indirect jobs (Thilo, 2018). In Côte d'Ivoire, industrial gold mining coexists with illegal gold panning. Illegal gold mining appears to be motivated solely by the desire to earn significant financial gain quickly. At the end of 2016, the Ministry of Mines counted 187 illegal gold mining sites, including 142 former sites that had been recolonized and 47 new sites. Today, that number has risen to more than 241 illegal sites, with an estimated population of 23,400 gold miners (CNDH, 2022). This situation is becoming increasingly alarming and appears to be a cancer for the government and for Côte d'Ivoire as a whole. Experts estimate that artisanal production, which escapes the state, amounts to around 30 tons of gold per year, depriving the state of significant revenue (UNOCI, 2010) estimated at nearly 479.22 billion CFA francs. The development of this economic activity also raises many problems, including the degradation of the environment and natural resources. Abandoned sites are devoid of vegetation, abiotic and likely to pollute larger areas. One solution for repairing the effects of mining on the environment is restoration. This mitigates most of the negative impacts

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of mining (Thomas, 2012). Work on the rehabilitation of mining sites has been carried out in America and Europe (L'Huillier *et al.*, 2010; Bailly *et al.*, 2021). However, in Côte d'Ivoire, work related to mining restoration is virtually non-existent. Resolving the environmental problems associated with artisanal mining remains a major concern. The objective of this study is to highlight the impact of illegal gold mining on vegetation cover and to carry out revegetation of a site.

MATERIALS AND METHODS

Geographic location

The study was conducted in the subprefecture of Kokoumbo. This sub-prefecture is located in central Côte d'Ivoire (Fig 1). It is bordered to the north by the sub-prefecture of Yamoussoukro, to the west by the sub-prefecture of Oumé, to the east by the sub-prefectures of Toumodi and Djekanou and to the south by the sub-prefecture of Bonikro. This sub-prefecture is located approximately between latitudes 6°21' and 6°40' north and longitudes 5°08' and 5°19' west. Rainfall can reach 1,200 mm per year (Gnangoun *et al.*, 2023). The climate is Baouléan, characterized by four seasons, including two dry seasons and two rainy seasons. Relative humidity varies between 70% and 85%.

Plant material

The plant material consisted of a regenerative plant species for degraded soils and five economically important forest species exploited for their wood for a total of six forest species. Seedlings of these six species were planted when they were one month old. They are: *Acacia mangium* (Mimosaceae), *Tectona grandis* (Verbenaceae), *Milicia excelsa* (Moraceae), *Terminalia ivorensis* (Combretaceae), *Mansonia altissima* (Malvaceae), *Garcinia cola* (Clusiaceae). The field equipment included a digital camera for taking photographs as needed. Machetes, shovels and

picks were used to dig soil pits. Ropes, a tape measure and stakes were useful for revegetation.

Methods

Soil survey at the study site

Site delimitation and landscape identification

The soil survey began with a reconnaissance of the site, followed by the opening of a path running southeast-northwest. The plot was delimited and its geographical coordinates recorded using a GPS with 5 m accuracy. The landscape was identified through field observations. The working scale used in the field was 1/2500, meaning, one observation every 25 m.

Opening of soil pits, description of soil profiles and soil sampling

The opening of soil pits was carried out according to the homogeneity or heterogeneity of terrain. Thus, every 25 m along the strip, an auger was used to assess certain morphological characteristics of the soil (texture, color and depth). The soil pits opened were 1.20 m deep if there were no constraints (hardened layer, crust, *etc.*); 1 m long; and 0.80 m wide. The different soil profiles were described, based on the observation of morphological characteristics such as: The depth or thickness of the horizon, the color of the soil, the presence or absence of organic matter, the moisture content of the soil, the texture of the soil; the content and different types of coarse elements, the general structure and flow structure, the general cohesion and cohesion of aggregates, the general porosity and pore size; the abundance of roots, their size and preferred orientation; the drainage class, determined by observing hydromorphic spots; the transition between one horizon and the next. Soil samples were taken from each surveyed plot from the horizons for various laboratory analyses. Samples were taken from the 0-20 cm, 20-40 cm, 40-60 cm and 60-120 cm

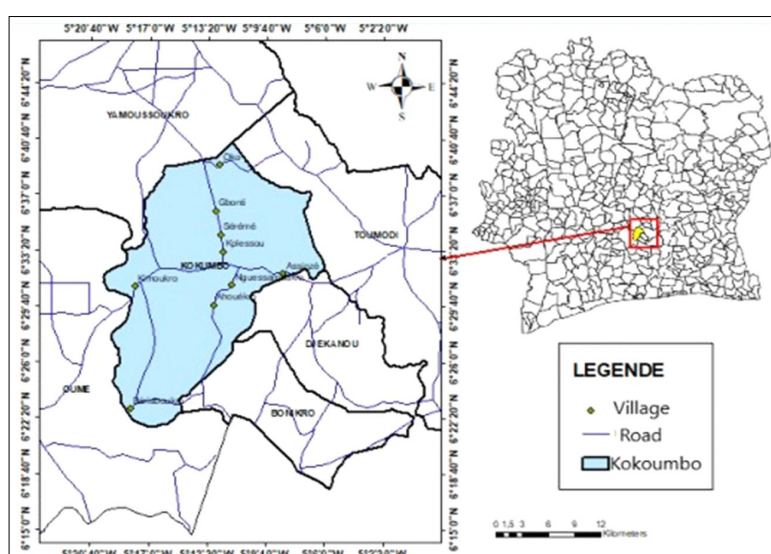


Fig 1: Map showing the location of the study area.

horizons and then combined into composite samples according to the different soil types observed. The sampling depths were determined by the rooting depth of the crops (citrus fruits, food crops and market garden crops).

Revegetation technique

The study area, which has been severely degraded by gold panning, is leveled using a Poclain machine to make the ground surface horizontal. A baseline serving as a reference for determining the other lines is created using a rope and two stakes. A rope and stakes are used to establish all other lines. Stakes are placed at 3 m intervals along this baseline. The method used is the same as that applied during reforestation 3-4-5. Lines perpendicular to the baseline are drawn using a rope. On these perpendicular lines, stakes are spaced 4 m apart so as to form triangles from the baseline. Then 20 cm holes are dug at each stake. Seedlings of these species are planted in each hole and then watered. Parameters such as stem height, collar diameter, number of leaves and changes in height and mortality rate were observed and studied.

Statistical analysis

The experimental design was a one-tree plot design (one tree constitutes one repetition) and the treatments were the different tree species. To carry out this experiment,

17 trees were chosen at random and numbered. Monthly measurements were taken on these trees. The data collected were subjected to a one-way analysis of variance (ANOVA) using STATISTICA 8.1 software. This analysis made it possible to compare the plants in terms of their agronomic parameters. The averages of the measurements were discriminated using Newman-Keuls tests at a 5% threshold.

RESULTS AND DISCUSSION

Leveling the ground created a flat surface where stakes were planted. These stakes will be replaced by forest species (Fig 2).

Type of soils surveyed

Two types of soils are observed in areas not affected by mining activity. These are cambisols, which represent low-slope soils and are distributed across the plot in two variants based on a few distinctive properties. Petroplinthic cambisols: These types of soils are found on the upper slopes of the plot (Fig 3).

They have a humus horizon (horizon A) on the surface, with relatively average drainage (2-3). This profile is relatively humic over approximately 15 cm at the surface layer, very clayey, very cohesive and polyhedral to compact



Fig 2: A and B: Leveling a gold panning site.



Fig 3: Petroplinthic cambisol.

in structure, highly developed throughout the profile, with a fine texture and patches of hydromorphism from the surface. At depth, this profile has a hardened layer due to iron and aluminum hydroxides (horizon B). These observations are similar to those of Koffi (2023) in his study titled Agro-pedological characterization and mapping of soil suitability for cultivation in new rubber-producing Areas in Côte d'Ivoire: The Case of the Departments of Man, Toumodi and Prikro. He showed that in the Department of Toumodi, where the subprefecture of Kokoumbo is located, the soils belong to the Cambisols class. In conclusion, these soils are shallow, moderately humic in the surface layers, rich in clay, with low porosity and numerous patches of hydromorphism, a crusted layer and numerous concretions.

Ferric Cambisols (Humics): These soils are another variant of Cambisols and occupy a quarter of the plot (Fig 4).

They are characterized by brown to reddish-brown horizons with hydromorphic patches and humus in the surface horizons. The texture in the underlying layers is silty-clayey, with a lumpy and fibrous structure at root level. The underlying horizons are of the B1, B11 and B (fe) types with reddish patches. They are poor in humus and have a fresh, silty-sandy texture that is cohesive and very low in porosity, which is induced by coarse elements and marked by the phenomenon of hydromorphism. Ultimately, these soils are moderately deep, relatively humic in the surface layers, rich in clay, with low porosity and numerous patches of hydromorphism and a crusted layer, numerous ferruginous concretions. These results are consistent with those obtained by Kouakou *et al.* (2013) in their study of the macromorphological characteristics of soils developed on volcanic-sedimentary substrates at Blafo-Gueto (Toumodi) in south-central Côte d'Ivoire.

Technosols

Technosols cover the entire surface area of this locality. These degraded soils are generally the result of frequent deposits of sandy, organic and coarse materials (pebbles, gravel and stones). They come in two varieties: Fluvic Technosols (Arenic) and Anthraquic Technosols. Anthraquic technosols cover the middle, central and northeastern and southeastern ends of the lowlands. These soils (Fig 5), far from being stratified, are also reworked and the profile is characterized by anthraquic horizons. These soils are derived from sludge waste, the materials of which are produced by mining activities. These results are identical to those reported by Rodríguez-Espinosa *et al.* (2025), who restored soils derived from technosols formed during mining operations.

Fluvic Technosols are soils that cover the northwestern and southwestern ends of the lowlands, which have been disturbed by various cycles of fluvial deposits (Fig 6) caused by washing the soil samples. These soils are stratified and the profile shows several fluvic strata with distinct colors and properties.

Prospecting has revealed changes to the soil and the emergence of fluvic technosol. At first glance, the soil

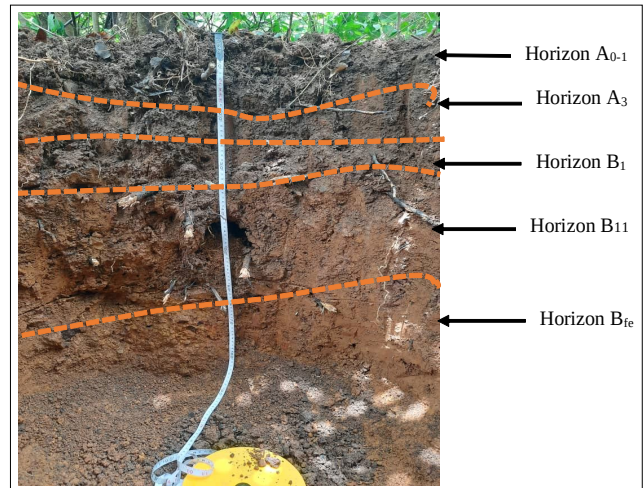


Fig 4: Ferric cambisols (Humics).



Fig 5: Anthraquic technosols.



Fig 6: Fluvic technosols.

appears to be significantly affected. In fact, the soil is affected in one way or another at every stage of mining. The physical impacts left behind after the completion of pits, the formation of spoil heaps and deforestation have a negative impact on soil quality. The solid and liquid waste left behind leads to a loss of soil fertility, this situation that is particularly problematic in developing countries. In these countries, the total concentration of heavy metals is generally much higher in soils around mining sites compared to that recorded in developed countries (Narendrula *et al.*, 2013). This is due to variations in the level of socioeconomic development and the strictness of regulatory enforcement. In addition, soil eroded upstream is carried downstream by runoff into marshes, where it accumulates through sedimentation, leading to the formation of fluvic technosols.

Environmental diagnosis of soil organic matter and phosphorus quality

Table 1 shows organic matter content, organic matter mineralization rate and assimilable and total phosphorus content. These results show that soil organic matter and assimilable phosphorus content are relatively low.

The carbon and nitrogen content of the soils is optimal to high. As for the mineralization rate, the values obtained

for the soils are normal to high. Ultimately, the soils are poor in organic matter and assimilable phosphorus, rich in nitrogen and carbon, with relatively slow decomposition of organic matter. Thus, the suitability of the soils is marginal in terms of biological activity, especially in compacted and gleyic sites. These results are consistent with those Fahikasari *et al.* (2025) in their study Impact of Underground Gold Mining on Soil Chemistry and Biology: Indigenous Microbe-Driven Rehabilitation? These authors showed that gold mining has a negative impact on soil organic matter.

Evaluation of agronomic parameters of planted forest species

Stem height growth

The evolution of height growth in different forest species is shown in Fig 7. The height growth of *Garcinia kola* did not change during the nine months of our study, while that of *Mansonia altissima* was very slow during the same period. The forest species *Tectona grandis* grew slowly and gradually from the first to the third month, then experienced rapid growth from the third to the ninth month.

Terminalia ivorensis also experienced gradual growth from the first to the third month, then recorded higher growth

Table 1: Organic matter and phosphorus content of soils at the Kokoumbo site.

Soil classification (Typology)	Soil layer	Organic matter (%)			Level of mineralization	Phosphorus (g/kg)	
		Org C	Tot N	OM	Ratio C/N	P sample	P Tot
Petroplinthic cambisols	PKB1H1	1	0,1	17,24	12	< 0	476.4
	PK1H2	1	0.1	10	13	< 0	454.9
Ferric cambisols (Humics)	PKB2H2	0.9	0,09	18	13	14.3	389.1
	PKB2H3	1,3	0.11	19	12	19.8	286
	PKB2H4	1,9	0.17	14	12	33.8	418.3
	PK2H5	1,1	0.1	9	12	< 0	171.5
	PKB3HAP	1.4	0.1	13	12	< 0	306.9
Anthraquic technosols	PKB4HAP	1.9	0.2	11	13	8.2	49
Fluvic technosols (Arenic)	Surface (Composite sample)	1.8	0.2	19	13	< 0	471.9
Composite sample	Critical threshold	1.0-1.5	> 0.08	20-30	9.0-12	> 20	25-50

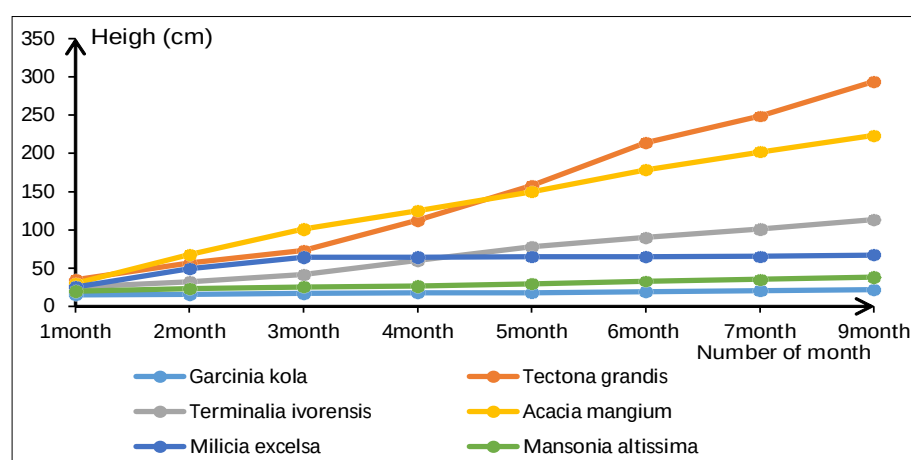


Fig 7: Curve showing the evolution of stem height for the six forest species.

from the third to the ninth month. The forest species *Acacia mangium* grew gradually throughout the study period. The highest growth rate was recorded for *Tectona grandis* and the lowest growth rate was observed for *Garcinia kola*.

Changes in collar diameter

The collar diameter varied according to species over the study period (Fig 8). *Tectona grandis* and *Acacia mangium* grew slowly during the first three months and began to grow rapidly during the third and ninth months. The collar diameters of the forest species *Garcinia kola*, *Terminalia ivorensis*, *Milicia excelsa* and *Mansonia altissima* changed slowly and gradually.

Changes in the number of leaves

The number of leaves on *Mansonia altissima* remained static from the first month of planting to the seventh month, then increased slightly from the seventh to the ninth month, while *Garcinia kola* showed a slight increase in the number of leaves (Fig 9). The number of leaves on *Tectona grandis* increased slowly and gradually. In the forest species *Milicia excelsa*, the number of leaves increased from the first to the third month, then decreased from the third to the ninth month. The number of leaves increased rapidly in *Acacia mangium* throughout the study period, while in *Terminalia ivorensis* the number of leaves increased moderately from the first to the seventh month and rapidly

from the seventh to the ninth month. The most rapid change in the number of leaves was observed in *Acacia mangium*.

Determination of heights, collar diameter, average number of leaves and mortality rates of the six forest species

During this experiment, the highest mortality rate was observed in *Garcinia kola*, at 78.5%. *Mansonia altissima* recorded a mortality rate of 10% and *Milicia excelsa*, a rate of 8% (Table 2). The mortality rate was 0% for the three other species, *Tectona grandis*, *Terminalia ivorensis* and *Acacia mangium*.

The highest stem height was observed in *Tectona grandis* and the smallest height was recorded in *Garcinia kola*. *Mansonia altissima* and *Garcinia kola* had the smallest number of leaves. The highest number of leaves was observed in *Acacia mangium*. The largest collar diameter was recorded in *Tectona grandis*, while the smallest diameters were recorded in *Garcinia kola*, *Mansonia altissima*, *Terminalia ivorensis* and *Milicia excelsa*. The findings that the agronomic parameters of *Garcinia kola* are significantly lower than those of other plants are corroborated by M'Bo *et al.* (2026), who show that the growth of *Garcinia kola* is enhanced on favorable soils when soil amendments are applied.

The height of the stems, the collar diameter, the high number of leaves observed in *Acacia mangium* compared to other plants and the zero mortality rate demonstrate this

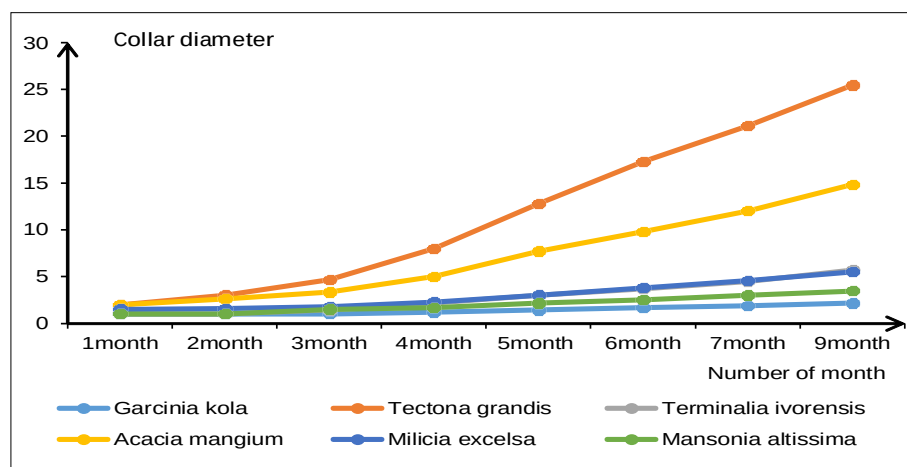


Fig 8: Evolution of diameter of roots collar for different forest species.

Table 2: Average height, collar diameter, number of leaves and mortality rate of six forest species.

Plants	Heigh average (cm)	Number of leaves	Collar Diameter	Mortality rate
<i>Acacia mangium</i>	247.89±38b	185.44±31.72a	14.83±5.92b	0
<i>Garcinia kola</i>	21.43±2.95f	9.14±1.36e	2.14±0.33c	78.5
<i>Mansonia altissima</i>	36.00±15.82e	8.11±4.91e	3.28±1.48c	10
<i>Milicia excelsa</i>	66.89±28.51cd	29.11 ±8.67dc	5.61±5.40c	8
<i>Tectona grandis</i>	316.11±97.91a	40.56±20.65c	25.44±7.54a	0
<i>Terminalia ivorensis</i>	104.22±40.91c	85.00±62.31b	5.44±1.67c	0

The means marked with the same letters do not differ significantly according to ANOVA tests at the 5% level.

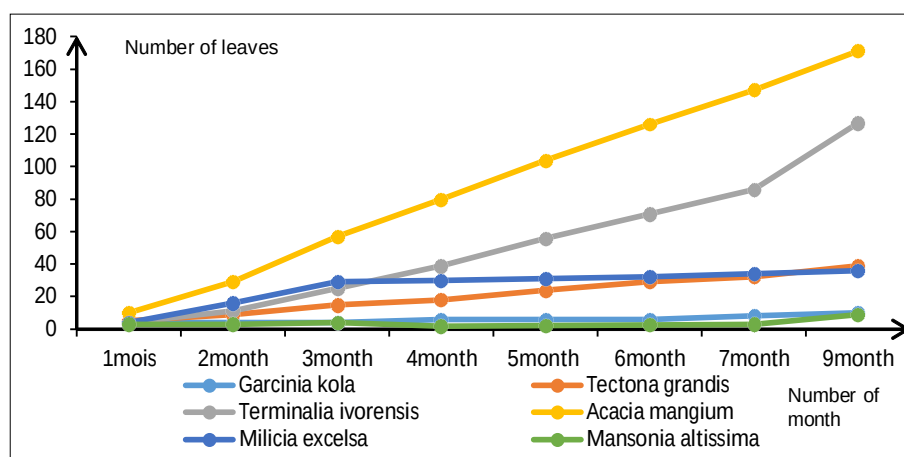


Fig 9: Change in the number of leaves of different forest species.

species' ability to adapt to degraded soil. This potential has been highlighted by reforesters (Zo-bi *et al.*, 2012). It is an undemanding species that adapts to poor environments thanks to the presence of rhizobia on its root system. This plant also has phytoremediation capabilities. In fact, Koffi *et al.* (2022) highlighted this potential when they studied the remediation potential of *Acacia mangium* on the soils of the M'Ploussou de Bonoua Park landfill. These authors have shown that this plant can remove up to 100% of nickel, 93% of lead and 74% of chromium. It thus helps to improve soil fertility. *Tectona grandis* has adapted to this environment because it is a hardy species that is easy to plant. It is the main species used for reforestation in Côte d'Ivoire because it adapts to almost all environments. These claims were corroborated by N'guessan *et al.* (2015) when they studied plantation teak in Côte d'Ivoire.

These researchers assert that this plant is one of the best species used for reforestation. Olusegun *et al.* (2024) showed that *Tectona grandis* can accumulate heavy metals, functioning as a phytoremediation plant. *Milicia excelsa* exhibited low stem heights; these observations contradict those of Ambassa *et al.* (2021), who reported rapid height growth in the plants. They state that when the soil is fertile, *Milicia* plants can reach 1.5 m in a year. In fact, a plant species may grow differently depending on the nature of the environment in which reforestation takes place and the plants with which it is associated during cultivation (Bihua *et al.*, 2022). The ability of the *Terminalia* genus to adapt and grow in an unfavorable environment containing heavy metals while accumulating these metals was highlighted by Aruwajoye and Olajuyigbe (2014). This genus grows that this can be explained by the fact that this plant is used for reforestation due to its edaphic resilience. The height and collar diameter of the three plant species; *Milicia excelsa*, *Garcinia kola* and *Mansonia altissima* are lower than the average values observed in reforestation plantation, according to studies conducted by Kasso *et al.* (2021).

CONCLUSION

Gold mining has severely degraded the soil, leading to the formation of fluvic and anthraquic technosols. Revegetation using forest species shows that three species have adapted to fluvic and anthraquic technosols. These plants are *Acacia mangium*, *Tectona grandis* and *Terminalia ivorensis*. They can be used in agroforestry for their remarkable agronomic characteristics and their ability to capture heavy metals. The three other species, *Garcinia kola*, *Mansonia altissima* and *Milicia excelsa*, have difficulty growing on these soils with low organic matter content. Revegetation using economically important forest species is an alternative because it restores vegetation cover and can be a source of income for the owners of these former gold mining sites.

Conflict of interest

We, authors of this article, hereby declare that there are no financial, personal, professional, or institutional conflicts of interest that could have influenced the conduct of this study, the analysis of the data, the interpretation of the results, or the writing of this article. We also certify that the work presented in this article is original; all authors have contributed significantly to the design, conduct and payment of the publication costs of the article; no commercial, financial, or other relationship could be perceived as influencing the scientific content of this article.

REFERENCES

- Ambassa, N.V., ANABA, M.D. and BIYE, E.H. (2021). Régénération assistée de *Milicia excelsa* (Welw.) C.C.Berg avec des boutures et graines dans la Région du Centre au Cameroun. *Afrique Science*. **18**: 1-12.
- Aruwajoye, D. and Olajuyigbe, S.O. (2014). Phytoremediation of diesel-contaminated soils using seedlings of two tropical hardwood species (*Khaya senegalensis* and *Terminalia superba*). *International Journal of Scientific and Engineering Research*. **5**: 1067-1078.

- Bailly, F., Amir, H., Bart, F., Fogliani, B., Forlacroix, V., Ititiaty, Y.F., L'Huillier, L. and McCoy, S. (2021). Environment and Restoration of Mining Sites. pp. 231.
- Bihua, C., Juan, Z., Weiwei, X. and Hein, S. (2022). *Betula alnoides* admixed with *Castanopsis hystrix* or *Cunninghamia lanceolata* from two reforestation case studies in southeast china. *Indian Journal of Agricultural Research*. **56(5)**: 557-561. doi: 10.18805/IJARE.AF-732.
- CNDH. (2022). Redefining Priorities to Consolidate the Effectiveness of Rights. pp: 303.
- Fahikasari, I., Dewi, W., Happy, W. and Zarate, J. (2025). Impact of underground gold mining on soil chemistry and biology: Indigenous microbe-driven rehabilitation? *Journal Biologi Papua*. **17**: 37-49.
- Gnangouin, A.Y.J., Kouassi, A.M. and Diarrassouba, K. (2023). Impacts of climate change on future climate patterns in West Africa: The case of the N'zi River basin (Bandama, Côte d'Ivoire). *Bulletin of the Association of French Geographers*. **100**: 92-111.
- L'Huillier, L., Jaffré, T. and Wulff, A. (2010). Mining and the Environment in New Caledonia: Ultramafic Substrate Environments and Their Restoration. IAC Publishing, Nouméa, New Caledonia. pp. 412.
- Kasso, D., Félicien, T., Charles, B., Nils, B. and Eric, F. (2021). Guide pratique des plantations d'arbres des forêts denses humides d'Afrique. Presses agronomiques de Gembloux. pp 322.
- Koffi, A.L., Bongoua-Devisme, A.J., Konan-Kan, K. and Konate, A. (2022). Remediation potential of *Acacia mangium* on the soils of the M'Ploussou de Bonoua public landfill site (Ivory Coast). *The Journal of Animal and Plant Sciences*. **54**: 9989-10000.
- Koffi, A. (2023). lorsqu'il étudiait Caractérisation agro-pédologique et cartographie de l'aptitude culturale des sols de nouvelles zones de production hévéicole en Côte d'Ivoire: Cas des départements de Man, Toumodi et Prikro. Thèse de doctorat. Université Jean Lorougnon Guédé de Daloa. pp. 209.
- Kouakou, Y.K.N., Yao, G.F., Nangah, K.Y., Baka, D., Adingra, A. and Yao-Kouame, A. (2013). Caractères macromorphologiques des sols développés sur fonds volcano sédimentaires au Blafo-gueto (Toumodi) dans le centre sud de la Cote d'Ivoire. *European Scientific Journal*. **9**: 18-30.
- M'Bo Kacou, A., Kanigui, I.S., Kouakou, T.d'A. and Kouamé, C. (2026). Effect of biological amendement on the agromorphology of cocoa companion species (*Irvingia gabonensis*, *Garcinia kola*, *Tieghmella heckelii* and *Beilschmiedia manii*) at the nursery stage. *Indian Journal of Agricultural Research*. **60(3)**: 359-367. doi: 10.18805/IJARE.AF-944.
- Narendrula, R., Nkongolo, K.K., Beckett, P. and Spiers, G. (2013). Total and bioavailable metals in two contrasting mining regions (Sudbury in Canada and Lubumbashi in DR-Congo): Relation to genetic variation in plant populations. *Chemistry and Ecology*. **29**: 111-127.
- N'guessan, K.A., Noël Boué, V.B.B., Soulemame, T. and Tapé-Bi, F.A. (2015). Maximum productivity and technical exploitable age of *Tectona grandis* (teak) according to site fertility in Côte d'Ivoire. *Journal of Applied Biosciences*. **95**: 9003-9014.
- Olusegun, O.A., Olubukola, T.O., Layade, K.T., Onafurume, O.M., Ayanniyi, O.A. and Murtala, M.O. (2024). Bioaccumulation and health risk assessment of heavy metals in *Tectona grandis* LINN and *Gmelina arborea* Roxb around the Ratcon quarry site in Ibadan, Oyo State, Nigeria. *Journal of Forestry Research and Management*. **20**: 47-57.
- Rodríguez-Espinosa, T., Pérez-Gimeno, A., Almendro-Candel, Navarro-Pedreño, J. and Gregorio, G.F. (2025). Technosols for mine restoration: Overcoming challenges and maximising benefit. *Appl. Sci.* **15(21)**: 11664-11672.
- Thilo, S. (2018). Young Perspective: Political Analysis on Ivory Coast. pp. 30.
- Thomas, S. (2012). Vegetation Restoration Methods in the Ecological Restoration of Mining Sites: A Comparison between Quebec and Peru. Thesis submitted to the Department of Biology and the University Center for Environmental Training. University of Sherbrooke. pp. 116.
- UNOCI. (2010). Report on violations of human rights and international humanitarian law committed in western Côte d'Ivoire. pp. 20.
- Zo-bi Irié, C., Foua, A., Tape-Bi and Ouhonlé, J.M.G. (2012). Evaluation of the physical characteristics of twenty clones of teak [*Tectona grandis* (L.) f. Verbenaceae] in central-western Côte d'Ivoire. *Rev. Ivoir. Sci. Technol.* **20**: 147-161.