

The Extraction of Geomaterials and The Degradation Of The Environment

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Abstract: *Anxious to be mentioned among the great industrialized or developed nations say, developing countries such as Côte d'Ivoire invest significant financial and human resources in the construction and development of social infrastructures. These works which are meant architectural gems, the expression of prestige and greatness of the country, gobble up massive amounts of natural resources (gravel, sand, laterite ...), and this in total disregard to the nuisance they cause on the environment. In this article, the impact of these operations on the lives and health of the population, fauna, flora and ecosystems are analyzed from the data collected on the field. It is an estimation of the noise, vibration, dust, gas and changes in the space. Thus the quarries for the extraction of Geomaterials are installed haphazardly wherever the need arises without a prior study or request in accordance with the mining code. These workings, whether they are "illegal" or not, whatever sometimes lasting for a short time, generate noise of over 55 decibels, raise a dust made of gas from the combustion of fuel, and severely degrade the ecosystem. To reduce these nuisances, we should consider an intelligent resource management that will take into account the economic aspects on the one hand, and lead to sustainable development and the risks of global warming on the other hand.*

Keywords: Geomaterials, management of the environment, nuisance, intelligent management, ecosystem.

1. Introduction

The environment is the set of physical, impacts of these operations on the environment. Instead, they are limited to the fact that non-metallic minerals in general and in particular Geomaterials are reusable several times so concerned about the preservation of the environment. Other studies show that such concrete can be recycled and so they help preserve the environmental [2], [3].

chemical, biological and socio-economic, moral and intellectual factors that may have a direct or indirect influence over the development of the dwelling place of living-beings and human activities. The environment then has to do with the overall element (biotic and abiotic) that surrounds a species and allow him to live. It is therefore the life support. So all beings therefore operate in a space that is their environment where they draw all the elements necessary for their psychological and physiological development while changing that space perhaps consciously or unconsciously.

The environment can thus be divided into two large domains (i) the human environment regarding the living environment and spatial planning; and (ii) the natural environment including soil, sub-soil, water resources, air, biodiversity, landscapes, etc [1]. The natural environment, the key to the survival of beings is dangerously affected by their activities. Indeed, man for example, in his ever increasing desire to submit and mark his territory need to use various materials to build his home place. Some of these materials, such as wood come from forest. This therefore leads to the destruction of the forest. Meanwhile, plants recycle the most important part of carbon produced by

human activities. Other materials are extracted from the large reserve of non-metallic minerals that form soil and sub-soil.

Even though these operations are necessary, because they are important tools for the appreciation of the dynamism of an economy, but if we don't take heed may cause serious and irreversible damage to the balance of the environment. In addition, all lectures and writings on the environment omit the

This article aims to analyze the impacts of Geomaterials extraction over the degradation of the environment. It is meant to be an alarm bells for a rational exploitation and upgrading of former mining quarries in Côte d'Ivoire.

2. Geomaterials

According to [4], all materials made of complex chemical elements comprising one or more mineral phases, of which raw material is a component of the earth are Geomaterials. Therefore the term Geomaterials gather all construction materials such as cements, concrete, bricks and blocks, tiles and glasses; and other products from industrial activity using as raw material, raw or manufactured products extracted from the earth such as paper, paint, plastic, cast iron.

The Geomaterials are paramount in the social, economic, intellectual and health development of people and countries. The construction industry is one of the largest in the world. About 90% of rocks and minerals in the world are employed by the construction industry. Table 1 shows different areas of activity in which minerals are used in Europe: construction and types of industrial activity [5].

Table (1): Proportion of minerals in various industrial products

Building and construction industry			Others industrial activities		
Application	Value (x 10 ⁶ €)	Proportion of natural mineral (%)	Application	Value (x 10 ⁶ €)	Proportion of natural mineral (%)
Concrete	38 600	100	Abrasive	9 300	100
Aggregates	-	100	Plastics	95 300	< 50
Fine ceramics	20 000	100	Painting	26 000	< 70
Bricks and tiles	6 600	100	Special ceramics	-	100
Ciment, lime, plaster	38 600	100	Refractory	-	100

Construction industry contributes by its mass consumption of the Geomaterials to the flourishing of all men by creating job, financial means, a decent living place and a favorable environment for his life.

There are a wide variety of Geomaterials so we can classify them into two main categories according to their ability to burn (fuel Geomaterials) or not to burn (non-fuel Geomaterials). These non-fuel Geomaterials are distributed into industrial minerals (minerals and other materials used at low levels in the industry) and non-industrial minerals (rocks, clay, sand for glass, aggregates, laterite, limestone). Non industrial minerals typically used in large quantities in the construction industry are considered environmentally friendly materials apart from the products they are associated with them or not during construction. The addition of these supplements requires the burning of a significant amount of fossil fuels thence a high production of CO₂ [6].

An earthen construction for example gives many advantages in the fight against environmental degradation:

- The earth is reusable several times to build houses; the use of clay as a binder in the development of these products allows to recycle that earth more than once. So there is no waste at all.
- A low thermal inertia: when it is hot outside, the interior of the building is at a moderate temperature (lower than the outside) [7], [8].
- A no adverse effect of these materials on the health of the dwellers of those earthen houses.

However, achieving such construction requires generally extraction of the large volumes of materials in the immediate vicinity of the cities and homes, in order to reduce transportation costs. This can cause a substantial nuisance on the environmental balance. Unfortunately, no article care about this reality. So to assess the effects of increasing pressure from the exploitation of Geomaterials on the environment that this contribution was written. It analyses the relationship between Geomaterials exploitation and the environmental protection in the particular case of Côte d'Ivoire.

Indeed, the extension of the city of Abidjan causes a strong pressure on the extraction of Geomaterials. In 1998 statistics showed increasing volumes extracted up to 2001[9]. Today, despite the crisis, these quantities might be multiplied by a factor of 5. Are the advantages of Geomaterials based constructions not questioned by their exploitation?

3. The different sorts of Geomaterials exploitation in Côte d'Ivoire

In Côte d'Ivoire, specifically in Abidjan and its suburbs, exploitation of Geomaterials when outside the city are within 5 to 10 km far from the last homes. Three types of materials are used by the construction industry; they are: the crushed rock, sand and laterite.

3.1 Crushed Rock

The crushed rock is artificial aggregates produced from alluvial or massive rocks. They are used in construction for producing concrete, achieving railway ballast, making road bed and surfacing.

The crushed rock is sold according to the size range (d / D). Their mechanical characteristics are summarized in Table 2.

Table (2): Mechanical features of crushed granite in Côte d'Ivoire

Features	values
Absolute density	2,62
Los Angeles coefficient	>30 %
Equivalent of sand	>90 %

Production of crushed rock has two large main operations that are: extraction (discovery and extraction) and treatment (removal of impurities, primary storage, crushing, screening, washing, storage and shipping). Between these two main phases an intermediate phase may occur: loading and transportation. The discovery is the identification of the batholith in the underground by geophysical methods. This is followed by the step of stripping the vegetation and the soil cover. After the batholiths are exposed, comes the step of extraction. The extraction is based on the use of explosives. The blasts of mines lead to the bursting of the rock. They are a function of several interrelated parameters but also processing operations. In addition, the shots are causing different types of nuisances: noise, vibrations and projections. The transfer of blocks from the mining place to the treatment place is done through device such as dumpers or trucks already loaded by excavators or loaders. Treatment involves several operations including crushing and screening. The operation of the various devices used in the treatment is provided by the combustion of fossil fuels. The finished products are finally transported out of the factory to the users in town at an average frequency of 2 trucks per hour. A working day is about 7 hours. Mining craters may have diameters of more than 100 m and depths of 50 to 150 m.

3.2 Sand

The sands are generally natural aggregates which size is between 80 µm and 5 mm. It is a loose material derived from the deterioration of rocks. They are used for the manufacture of mortars, concretes and the embankment.

The sand used in construction in Côte d'Ivoire comes primarily from the lagoon bottom. Figure 1 shows the particle size characteristics of the sand. They consist mainly of quartz minerals with fragments of mollusc shells.

The extraction of sand on the lagoon cord that runs through the city of Abidjan is done with suction dredges. They suck water and sand at the bottom of the lagoon and they spill over a dam

built on the shore. The water gradually returns to the lagoon leaving behind the sand that accumulates in the form of dune. After several days of drying, a loader with tyres collects and fills the dry sand on Benes trucks that convey it to the different sites of use. The maximum depth reached before stopping drag is about 18 m. The dredge is powered with diesel oil and the workday is last for 8 hours. The frequency of shuttle of the transportation cargoes is highly variable depending on the amount of the daily demand for sand and the number of companies (2-5 trucks per hour). A dozen companies are involved in that activity on the banks of the lagoon.

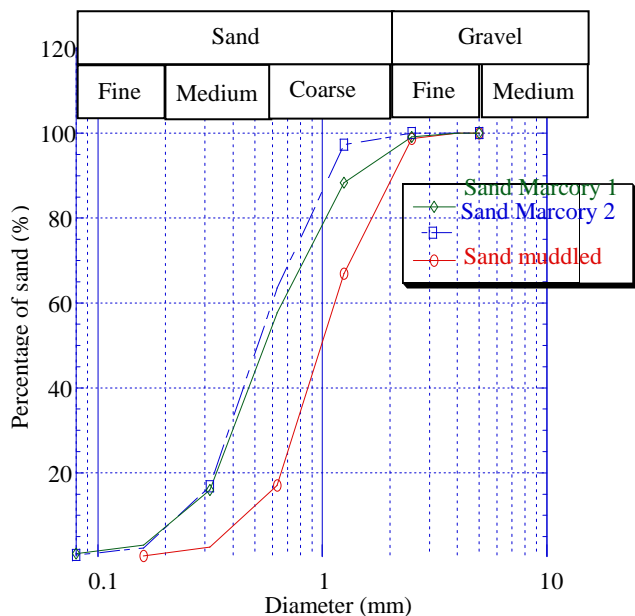


Figure 1: Size analysis of the lagoon sand grains

3.3 Laterites

Laterites are highly altered lands, found abundantly in the tropical and subtropical belt, usually just below the surface of vast plains or clearings in areas with significant precipitation [10]. They contain very variable but substantial proportions of iron and aluminum oxides with quartz and other minerals. Laterites are used for earth construction but mostly as embankment materials and to build seating or to repair roads. According to [11], [12] laterites from Côte d'Ivoire are clayey sand with about 30% of clay content. It mainly consists in quartz, kaolinite and illite. Its content in iron oxide and in oxide of titanium is more than 9%.

The extraction of laterite is done either with a shovel or by using machines on the hillsides. It usually takes place very close to the last homes. Laterite is carried into the city with Benes trucks.

4 Nuisances related to the use of these materials

The extraction of Geomaterials produces environmental changes related to use of machineries and products and also to the changes in the ecosystem (natural environment). To understand more about these changes, we have analysed the direct and indirect, temporary and permanent effects of the settlement of quarries on the environment. That analysis concerned sites and landscapes, fauna and flora, natural environment and biological balances, convenience with the vicinity (noise, vibration, odor, light emissions) or agriculture, hygiene, health and public safety.

4.1 Noise

According to AFNOR, noise is an inappropriate tone. It is also a complex blending of sounds producing an auditory sensation deemed as inconvenient or dangerous. Noise can be characterised by its frequency (low or high), noise level (also called intensity) and duration (short or long). The volume is measured in decibels (dB).

Noise affects our well being like our health. It is the source of stress, aggression, violence, disturbance of sleep and depression [1]. Exposure to high noise levels leads to the destruction of the auditory system that is ill-suited to bear it for long periods. This is mainly due to the degradation of some of the haired cells in the inner ear, fragile cells, few in number and not renewing, resulting in a permanent loss of hearing. The higher the noise level, the higher the risk is great and it likely leads to rapid degradation. However, some high noise level (night clubs, concerts, high power music players) usually cause no hearing damage or just temporary problems. But the auditory system undergoes premature aging, which can lead to early deafness. But, low volume levels may also cause disturbances which consequences are important, including much fatigue, a decreased of alertness and efficiency at work or learning abilities along childhood.

Noise is usually measured with a sound meter. Since we don't have a sound meter, it has been estimated on the different Geomaterials extraction sites from the noise level of a brand new Benes truck, from the average age of the equipment used and level of maintenance. The values considered are those obtained from the extraction sites within a radius of 100 meters in the surrounding. The results shown in Table 3 are the averages registered for seven days.

Table 3: Measurement of noise on different quarries

Type of quarry	Quarries of crushed granite	Sand quarry	Laterite quarry
Noise level (dB (A))			
Close to the work place	> 90	> 90	> 90
100 meters from the work place	88<NS<75	86<NS<65	85<NS<60

NL=noise level

This table shows that regardless of the type of quarry, the noise level goes down as you walk far away from the work place because of the attenuation of the sound intensity. Moreover, the values vary in the same range because it is the same machines that are used. According [13], a noise level equal to or higher than 85 dB (A) is harmful to human beings as well as to animals. Likewise, sound levels between 45 and 55 dB (A) result in an increase of certain pathologies such as hypertension and myocardial infarction over a longer term. Moreover, for the same exposure time, the amount of noise that reaches the ear doubles when the noise level increases for 3 decibels. This also creates a disorder on the environment, lifestyle and animals reproduction.

4.2 Dust and gases generated by machines

Dust and gas that are produced by machines during Geomaterials extraction consist of solid or liquid particles resulting, either from the spreading of clayey particles found in

soil or generated by the extraction into the air or from gases produced by the combustion of hydrocarbons or metals wear. These particles pollute the air or the ether thence affecting the quality and the purity of the air. This degradation occurs when the degrees of concentration and the presence of these particles last long enough to cause toxic or an ecotoxic effects.

The pollution of the ether brings about symptoms such as breathing difficulties, coughing, throat sore, headache, eye irritation etc. It may trigger asthma attacks in people with asthma or decrease the functioning of children respiratory system. The pollution of the air may also trigger cardiovascular problems, such as myocardial infarction, and to a lesser extent, chest angina or heart troubles. In some cases, it may lead to premature death. It may also cause allergies. To animals and plants, the air pollution affects the health of many evolved living beings, and even to well-known primitive and resistant species like lichens, algae, invertebrates so on and so forth. Pollution can directly kill organisms (for instance, lichens are sensitive to the acidic pollution of the air). It also has indirect impacts (by degrading odors, floral fragrances, hormones or pheromones before they reach their targets), this phenomenon may partly explain the decline of some pollination populations (including some birds, bats nectarivore) noticed in all industrial and agricultural countries. It may also explain the difficulties that individuals of some species (lizards, snakes, amphibians, some mammals) have to breed (males and females cannot meet very well as formerly) or the difficulties some species have to feed themselves (the individual can no longer feel very well the smell that will lead him to his food source) [14].

The pollution of the air has been appreciated from the dust on the trees. This usually red dust is easily identifiable on plants leaves. The degree of pollution fades when you move far away from the production site or from sites access roads. The extent of the affected area depends on the direction and the speed of winds. It varies from 10 meters to several hundred meters. This dust can be found in homes, on clothes, on food and beverages. It falls on the uncovered food we buy at the roadside and eat. The duration of exposure, and the amount of physical activities are factors accounting for the consequences of this air pollution on the surrounding people health. However, surveys carried out over some populations indicate that children often feel colds.

An important part of air pollution on Geomaterials extraction sites comes from the use of fossil fuels. Burning diesel oil generally releases large quantities of air pollutants such as NO_x (nitrogen oxide), CO (carbon monoxide), HC (hydrocarbon), Pb (lead). These gases are usually greenhouse gases responsible for the global warming and the destruction of the ozone layer. Some are carcinogenic and others are toxic that is they lethal in closed environments.

4.3 Vibrations

A vibration is a very fast reciprocating movement around an equilibrium position. It is a wave that propagates without displacement of matter but carries energy. Vibrations are associated with many types of equipment used in the quarry or mining fields and extraction with explosives is considered to be the most important source of vibration.

Vibrations affect the stability of infrastructure, buildings and houses, and of people living near the extraction sites. They also lead to the destruction of structures in the surrounding uninhabited areas and disturb animal life.

Vibration is measured with a vibrometer. We can also measure it by: (i) determining the level and the duration of exposure; (ii) the nature and the condition of the machines and devices that

generate vibration, and the duration of their work. In this work, nuisances related to vibrations were assessed from surveys conducted on the field with people living around the extraction sites. The processing of these informations establishes that the sensitivity of vibration depend on individuals, on activities undertaken, on the frequency and the amplitude of vibrations.

The vibrations produced by the equipment used in extracting Geomaterials have a high frequency although the amplitudes seem weak. They are sensitive over a relatively small radius of 30-50 meters around the site. The relatively high frequency and duration of those repetitive and regular vibrations that is from 7 to 8 hours per day bring about muscular, vascular and neurological disorders. This may also lead to back pain and micro traumatism to the spine. Underground vibrations lead animals to run and dig their holes far away. This changes the natural balance of the area.

Moreover, the higher amplitudes of vibrations are registered during extraction with explosions performed generally in the quarries of crushed granite. These levels of vibration are very sporadic and instant (once or twice a month). They shake houses, and sometimes cause cliffs to collapse and certain trees to fall down.

4.4 Ecosystem

The ecosystem here refers to the natural environment: vegetation and soil. Degradation of the ecosystem leads to the proliferation of various parasites in the soil, the imbalance in the aeration of roots and to the disruption of agricultural lands.

We took photographs to study ecosystem degradation.

Figure 2 shows:

- In pictures **a** and **b**, a laterite mining quarry. They display a large gash of nearly 20 meters deep, made in a hill near buildings. Frequent landslides occur along the cliff.

- In pictures **c** and **d**, respectively the shore after dredging and collecting of the lagoon sand, a pit filled with polluted water and covered with grass after the extraction of clay in the area of Dabou.

- In pictures **e** and **f**, an open pit and another one covered by clay operators in the region Bingerville.

- In pictures **h** and **g**, a cut of more than 30 meters deep made on crystalline fields, an area of several acres and a pit of 50 meters deep filled with water.

All these photos show that the vegetation has been completely destroyed, and the soil has been scattered or taken away and pickled on the surface. In these areas, the soil can no longer play its role as a filter very well that is its renewal and protective function of the underground water. The disruption of life environment and the development of thousands of invertebrates and micro organisms in the soil disturb its full development. Moreover, according [15] the sediment balance of the lagoon is very sensitive to any changes that may occur in the immediate vicinity. So sand dredging affects the balance of lagoon biotope. These impacts result in the:

- Disturbance of sediment transport
- Weakening and erosion of shoreline
- Collapses and landslides on the bank
- Far going of the aquatic fauna.

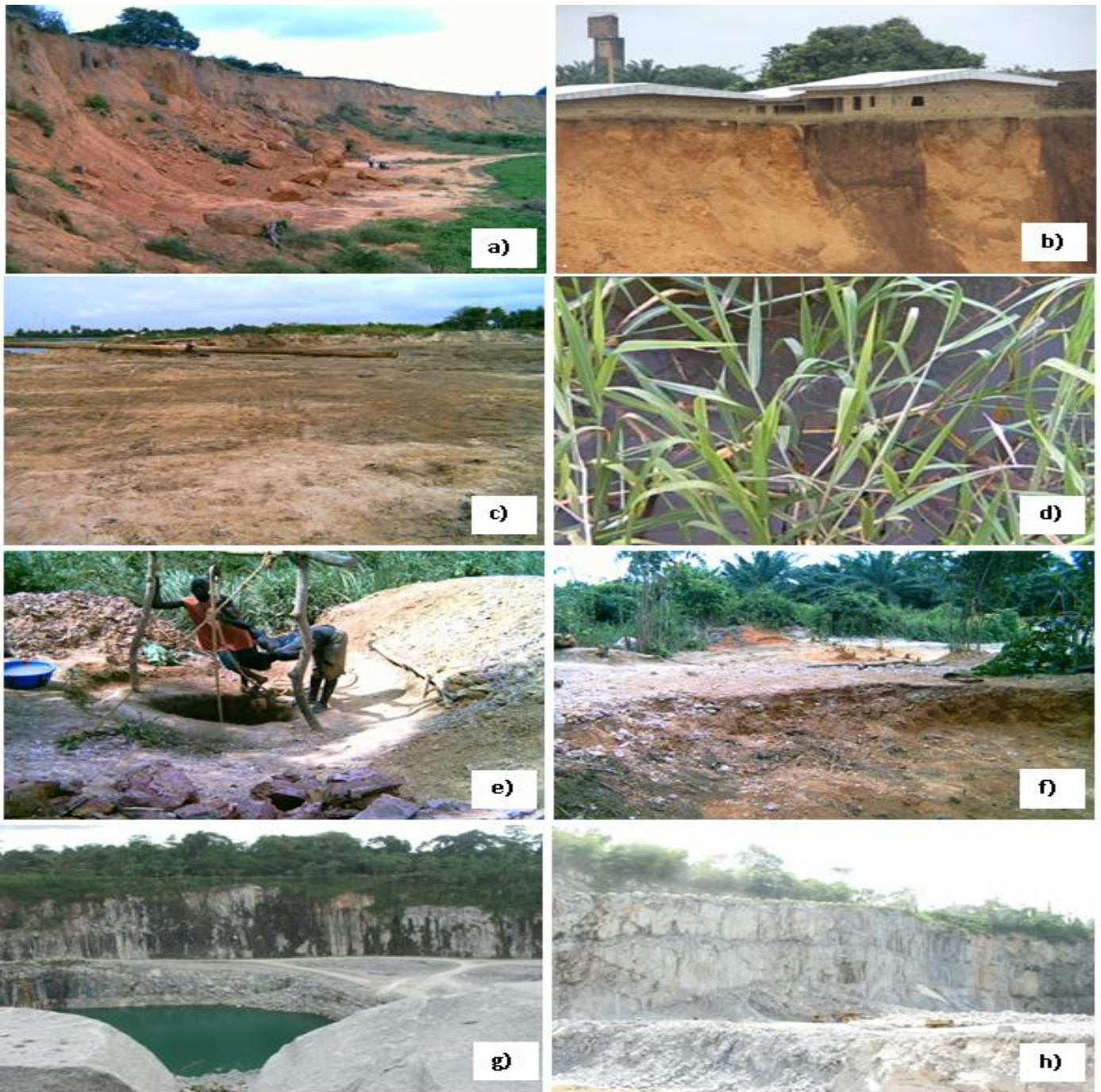


Figure 2: Overview of Geomaterials extraction sites in Côte d'Ivoire

a) and b) development of laterite; c) use of the lagoon sand d) clay extraction in Dabou; e) and f) clay extraction in Bingerville g) and h) extraction of crushed granite

5 Control of the impact of Geomaterials use

The use of Geomaterials is essential for the development of men's daily life. However, these extractions cause directly or indirectly adverse environmental changes. This is why it is so important to set up a system of supervision and control meant to gradually reduce or eliminate negative actions created by those adverse effects on the environment.

Moreover, building materials extraction and competitiveness over financial markets are closely related to what they are used

for. This is why, natural resources and environmental protection programs have to be considered through economic parameters. Indeed the costs of production, raw materials availability, the many processings and wastes from production, to say in short, the costs of Geomaterials are correlated to the respect for products quality and the regulations of the environment. So, the implementation of a strong managerial system for these economic and human factors will likely reduce negative environmental changes.

The construction industry is the world's largest energy consumer. According to [16] production and transportation alone use a quarter of the energy. This increases the risk of global warming, which is not conducive to sustainable development.

To control these factors indirectly related to the extraction of Geomaterials, it is compulsory to have a quarry management concept respectful of the environment, of social justice and economic profitability.

In Côte d'Ivoire, to control the impact of Geomaterials extraction, political and economic measures have been implemented to lessen the impact on the environmental elements, such as terrain, flora and fauna. For instance, in the mining code, Article 77 of Act N°. 95-553 of July 18th 1995 requires each applicant for a mine working or a quarry running license to submit a comprehensive environmental impact assessment survey and an environmental management program, including a plan of rehabilitation of the sites as well as the estimation of costs. However, the actual monitoring of the rehabilitation and environment management plans on the field raises many concerns. Each quarry being unique in its kind, it must achieve the desired profitability within reasonable ecological conditions. So then, the management of quarries should keep a balance between the precepts ruling the local environment and the operator's local initiative along his activity. The technicians in charge of that balance checking must follow a strong training in order to complete this mission mindfully.

6 -Conclusion

The extraction of crushed granite, laterite, lagoon sand and clay, even on a very short-term, causes significant damage on the environment at different levels.

- The noise generated by the machines affects animals as well as people living in the vicinity of sites. This affects their health and their social behavior.
- The vibrations related to the use of explosives, along with the movements of machines and culls may cause muscular troubles and stress, according to the amplitude and the frequency of their actions.
- Dust and gases spread over large areas where they may cause respiratory problems and allergies.
- The ecosystem including the flora and the earth is deteriorated. The soil function as natural filter is disturbed and that brings about pollution of underground water or lessens the renewal of underground water stores.

By looking at the extent of negative impacts generated by Geomaterials working on the environment, it is necessary to control extraction business because the environment is not replaceable. We should create programs for the management of natural resources and the environment in accordance with the economy and a strict enforcement of regulations.

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