ANTHROPO-ENVIRONMENTAL IMPLICATIONS OF QUARRYING OF TROPICAL SEDIMENTARY PALAEO-SAND SEAMS OF DOUALA ESTUARINE METROPOLIS, CAMEROON

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Abstract: As an informal and an important but low-keyed economic activity, sand mining in the Douala metropolis is a sector that has remained largely unnoticed. Yet this informal sector is important because it provides an economic life-wire to part of the under privileged and unemployed urban masses who thronged the city in search of better economic opportunities. When the hopes of a brighter economic prospects fail, the less educated who have learnt no proper or specific skills are forced into alternative employment in order to survive the economic and social demands of the Douala Millionaire city. The quarrying finds itself in a double obligation: that of ensuring an acceptable level of hygiene and security for its quarry site actors and that of complying with state legislation which lays emphases on the environmental protection in this economic sector. This problem leads us to the hypothesis that quarry exploitation of sand seams in Douala is an economic visible glory that masks widespread human health insecurity and morpho-environmental deterioration. This paper aims at investigating the magnitude of the quarrying activity in Douala and assesses the environmental and health hazards that result thereof with the objective of determining whether this activity adheres to basic security norms. Field survey conducted between 1997 and 2007 reveal that sand quarrying in Douala is well distributed in the town and its manner of operation fails to meet with security norms which accounts for the multitude of health problems, human losses, morphological disturbances and environmental degradation observed and recorded. This paper advocates a change from an activity-legislation system which has proven its security limits to that of legislation-education in order to raise their health and the environment awareness among the quarry workers.

Keywords: environmental protection, quarrying activity.

Introduction:

The Douala metropolis developed within the Wouri River estuary along the Cameroon coast. Within this sedimentary basin, there has been developed a plethora of quarries in the city centre and suburbs with associated economic and environmental consequences.

The numerous small-scale exploitations result in abandoned craters and ponds of brackish water. This has been accentuated by the wet tropical monsoon climate of the region, Cameroon, that is a population melting point and a heaven for the unemployed who flock the city. The quarry activities that provide one of these openings involve the extraction of earth materials such as sand, gravel, and clay. The large-scale extraction and utilisation of the quarry products provokes detrimental consequences

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on the environment and the health of the actors in this activity.

This activity remains highly unsecured to both urban environment and man despite the Prime Ministerial decree of 26th March 2002, which stipulated the application modalities of law no. 001 of 16th April 2001 related to mining and quarry. This law defines, classifies and elaborates security and hygienic regulations, obligation to the state (tax) environmental protection and other modalities guiding the operation of quarries. Article 88 confines that the potential exploiter should be able to classify if his quarry is temporary or permanent (with a duration of more than two years), if it is a domestic exploitation (where the exploitation is exclusively personal and non commercial) and lastly if the quarry is an artisan one where the methods and procedures are more or less manual and do not use explosives.

Article 90 recommends that the exploitation of any temporary quarry material be subjected to an exploitation permit delivered by the Minister of Mines meaning that no quarry can operate without an authorisation or permit. A visit report of the quarry site has been established by the technical service of the provincial delegation in charge, and the plan of the quarry site to a 1/500e scale. This is not the case of Douala quarry exploiters, especially the artisan exploiters, who possess no plans of the quarry site to a 1/500e scale. Quarry activity has an obligation to conform with the regulations relative to environmental management and protection. Quarry exploiters, particularly those possessing authorisation and exploitation permit, are requested to apply and take measures necessary for environmental protection by using the optimum techniques and methods they know which best reduce environmental degradation. Beside many other reasons, permit holders are expected to control the use of land, water, as well as energy, watch over the protection of flora and fauna, promote or maintain general good health of the population, reduce waste and dust as much as possible, and reorganise the soils of the perturbed zones to steady conditions of security and fertility acceptable by the administrators of Ministry of mines.

Article 120 conforming to Article 91 considers that in the course of obtaining an authorisation or a quarry permit, the exploiter of a quarry site presents an environmental impact study accompanied by an environmental management plan as provided by law. This plan equally describes the rehabilitation programme of the site in the course of exploitation and particularly after exploitation. This is not the case as most quarry sites have been completely abandoned after exploitation with no sign of rehabilitation and no efforts to arrange the land to suit other activities, chiefly farming. The case in point is the quarry site of Champ de Tir in Ngodi, which the “Genie Civile” of the Military department have exploited. This shows that the law was not taken into consideration or was poorly applied on the field.

Quarry exploiters’ attitude towards environmental protection within the urban area shows an insignificantly small acknowledgement of environmental degradation or consequences resulting from quarrying. Quarry exploiters are unaware of the consequences of their activity on the environment, and so reject the responsibility towards protecting or rehabilitating the environment. Worst still the environmental regulations are not stringent and the exploiters follow no particular technical conditions in the course of their exploitation sites. Despite the positive role quarrying plays in providing employment, the life of the workers is constantly at risk, with no appropriate security measures, no efficient tools, no helmet or working boot. Conflicts arise from quarry explorations issues related to land claims, dissatisfaction over compensations, labour disputes over wages, over working conditions or outright disregard for the laws made in this regard. Such conflicts require the implementation or creation of appropriate measures to resolve such conflicts should they occur.

The objective of this article is to show that urban marginal economic operations like sand mining in Douala are informal occupations. They are profitably exploited by people who possess inadequate environmental legislation and security knowledge. The only insight into this activity seems to be the energy to do the hard physical or manual duty. Another objective is to show how this activity comes along with grave environmental and physical health problems on its actors that make the activity unsecured.

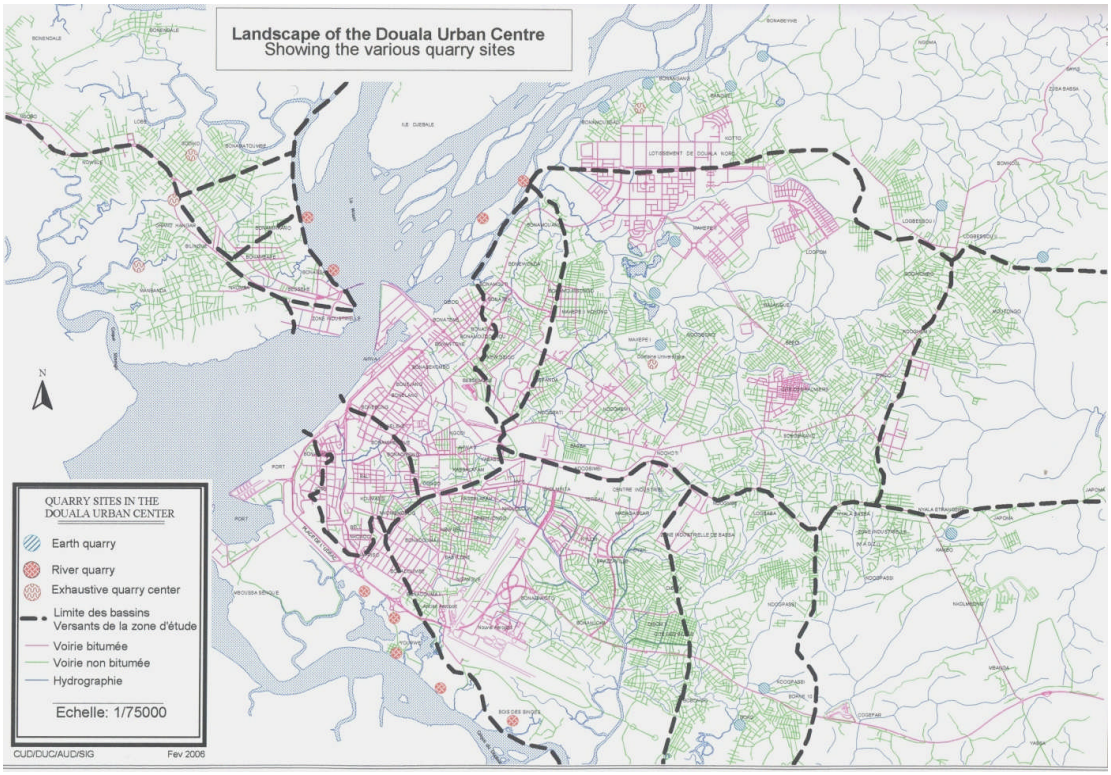
There were undergone visits on the quarry sites of Bonaberi along the Wouri River, areas in Bonamoussadi, Bonagang, Besseke, Bonapriso area, Ngodi during field work that permitted an appreciation of the sites and methods of exploitation and interaction with the workers through interviews and questionnaires in Bonapriso sites, Bonamoussadi and Bonaberi sites, in a random systematic method. Illustrations and photographs were used to underscore field observation.

Results and discussion:

A multitude of quarry activities with indigenous granulometric processes

Quarrying as seen is practised in many areas within the urban area in Douala urban centre (Fig. 1). These quarries have particularities according to the different subdivisions (Tab. 1).

Figure no. 1 The distribution of the quarry sites within the Douala metropoli.



The products of the quarrying include gravel (coarse and fine grain), sand, lateritic hardpans and mud. These basic raw materials constitute the essential elements which

together with sandy-gravel are intensively exploited.

Table no. 1 The distribution of quarry activity sites according to the subdivision in Douala.

Subdivision	Common name	Quarry activity sites
Douala I	Bonanjo	Sites are many Hotel de l'Air, Bois de Singe, Carrière de Bonapriso
Douala II	New-Bell	Youpwe between Pays Content, entrée Marguerite Apollinaire and entrée Dollar Quartier Bafia Carrière Afrique du Sud, Carrière Amérique, Carrière Colombie
Douala III	Bassa	Carrière de l'Axe lourd at Ngodi Bakoko, Champ de Tir, Carrefour Afamy, Carrefour de Billes, Carrière de Terre, Marguerite et Fokou
Douala V		Quartier 14 being North of Akwa otherwise called Carrière de Bonabassem, Bonamoussadi, Bonangham, Carrière Mbangue, Antenne Kotto, six quarry sites called Kuwait, Iraq, Saudi Arabia

Once the raw material has been dug, a systematic separation process is engaged. This material is deposited into a depression measuring about 5m^2 where water (with the use of electric pumps) from nearby streams is pumped towards this material in order to wash out the mud and clay. The residue of this washing made up of gravel or sand is then heaped into mounds in order to drain it of its water contents while anticipating buyers who come to the spot with lorries. The market for these products is thus immediate and on the spot.

Classification of quarrying procedures and quarry forms

The quarrying mechanisms undertaken in Douala are of two types. River quarrying is common within the Wouri River and its tributaries where sand is scooped or dug up from the riverbed. It involves the use of canoes, spades, and buckets as holes are scooped on the floor of the river. The dug-up material is piled into a canoe before being carried to the shore. The work is done during the low tide when the exploiters take advantage of water having receded (Fig. 2).

The open surface earth quarrying method involves cutting and digging up the slopes of small hill or valley bases that are found within the urban centre. The surface exploration method is applied dominantly to valley slopes especially in areas where house construction has not yet completely covered the ground surface. From such potential spots the mining activity progresses towards the raised plateaux. Such progression is through undercutting for sand from below while the upper part that contains less sand and gravel remains unsupported. The unsupported layers that are stressed by gravity suffer from weak particle cohesion and so yield to shear strength and gravity. It therefore collapses into the undercut trench. This produces a quarry cliff which is largely vertical. Once the collapsed rubble has been removed by the miners, for back filling elsewhere, another undercutting phase begins so that the cycle repeats itself. In this way the process continues to produce a parallel quarry cliff slope retreat.

Such a cliff portrays a loosely consolidated sedimentary material which would readily collapse when undercut to produce a near vertical cliff. It uses a wide range of tools and heavy machines such as spades, peak axes, motor-pomp, sifter, trucks in some cases bulldozer and labour (Tab. 2).

The human means of production is vast and the number of people involved tends to vary according to the size of the quarry and so it can be summarised as follows (Tab. 3).

Figure no. 2 Map of river quarry sites in Douala.

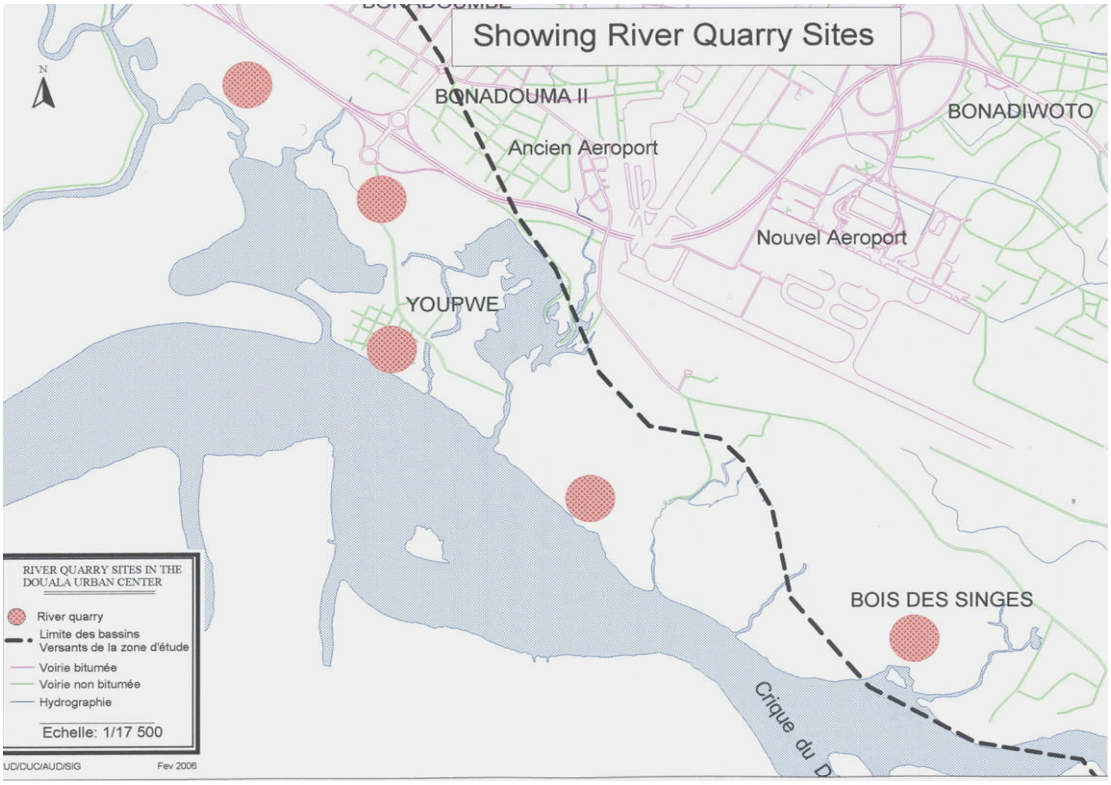


Table no. 2 Equipment and uses of quarrying apparatus.

Ownership	Equipment	Uses in quarries	Quantity/mine(r)
Single	dig axe	digging	1 per miner
	spade	digging, levelling, loading	1 per miner
	bucket and rope	transportation of crude sand	1 per mine
	wheelbarrow	transportation of crude sand	1 per mine
Group	water pump	bring in water from streams to wash the sands	1 per mine
External	lorries	transportation of sand	variable
(Hired)	bulldozers	excavation	variable

In the course of exploitation, the surface area is cleared off its vegetation exposing the top soil. The humus horizon is dug up to expose the gravel, brownish red sand, and then eventually gravel sand and white sand. Next, there is grey sand and white sand together with water accompanying the white sand. In some cases the dug-up earth is directly washed with the help of water sprayed by motor-pomp; furthermore, the final product obtained is siftered and arranged in heaps of various groan sizes.

However, there are levels on which the sand and gravel materials occur in separate

distinct layers. Along the quarry cliff there clearly appear a number of horizons that vary in texture and structure. With the thicker upper layers being silty clay, the base is sand and gravel. There is a general inclination of the horizons with the local depth of the surface of about 5º. The inclination of the surface, as well as the sedimentary strata, is seawards towards the Wouri River. This raises the issue of trying to understand whether these deposits constituted an old Wouri bed or probably a dead palaeo-bed or palaeo-channel. Such occurrence reduces the amount of work to be done in order to obtain the final products, therefore uniform materials are gathered directly without being washed (see Figs. 3 and 4, Annexes).

Table no. 3 Average labour input at various quarries.

Area of quarry (m^2)	Approximate human input				
	Diggers	pit to surface transporters	pit to wash point transporters	sand washers	lorry loaders
01-20	2	1	1	1	4
21-40	3	1	1	2	4
41-60	3	2	1	2	5
61-80	4	2	2	2	6
81 and more	5	2	2	3	7

Two types of open-earth quarries were identified: quarries on valley bottom and quarries along the slopes. The quarries within valleys are found on the outskirts, for instance Bonamoussadi - Logbessou, Antenne Kotto area. The slopes are also dug for sand requiring much water to wash and separate the sand from mud as occurs in the quarry sites of Ngodi Bakoko. The land belongs to the Ministry of Defence called Champ de Tir. This site extends over many hectares with old abandoned trucks and dilapidated quarry machines. The dug up materials are carried to water ditches where they are washed. Water is blocked from flowing out as the material is washed, then eventually the opening is breached for the muddy water to flow away.

The environmental consequences of the excavation of slopes Quarrying in urban Douala which is an element of direct and indirect anthropogenic processes, involving excavation, hydrological interference, acceleration of erosion and sedimentation, subsidence and slope failure. The incidence of these processes on the immediate and distal environment of the quarry presents a complex urban anthropo-geomorphology in Douala. The clearly evident environmental impact of quarrying in Douala town is the rapid displacement of hundreds or thousands of cubic meters of earth seawards so that plateaux are levelled and some raised surfaces are seriously damaged. The large volume of sediments that are sent into the streams and rivers raise their bed levels, thereby the channel configurations are modified. This becomes a leading factor in the evacuation of waste water as well as surface runoff following the frequent storms which are repeated in Douala. Most streams within the quarry areas have their beds raised by about 10-30 cm/year. This has necessitated a repeated dredging of most of the urban water channels (Fogwe and Tchotsoua 2007).

The overall quarry area appears to be severely damaged. Strahler and Strahler (1973) noted that devastation produced by strip mining exceeds in quantity and intensity any of the other varied forms of man-made land destruction. This could take varied forms which may be conical, multiple, high fan ridges, and high plateau mounds, low multiple fan ridges and low ridges by tramways. This then followed by the

development of early symptoms of arroyo trenching which are valley bottom gullies. Where the sand-washed waste water is channelled into nearby streams, there is a surface cut by gullies especially in areas that are desirable for settlements. There is also the accumulation of clay and silt downstream that helps urban farmers at Akwa Nord in the cultivation of vegetables. It may also be possible to suspect that the sedimentation sends the accumulation of debris into the estuary of the Wouri delta. This means that before the quarrying activity ever started, the accumulation of sand, silt, and clay had been much lower and so the dredging of the Douala port was less frequent.

These open cast mines have transformed the landscape into in the Wouri estuary and irreversible forms of advanced and accelerated erosion. Exploiters create lateral cavities on the overlying scarp causing it to often collapse killing the diggers beneath. Tons of unconsolidated matter is removed, washed and carried away, and so large gutters and channels are degraded on these surfaces. In the Bonamoussadi quarry sites, contact with the underlying water table leads potentially to diffused pollution. Due to the fact that most quarries are usually located next to swampy areas, streams or water bodies, large amounts of impurities and mud resulting from the washing process are emptied into them which are then filled with suspensions. This increases sedimentation and aggrades the swamps narrowing the flow and evacuation of runoff or overland flow within the city. This has indirect impacts to swamp plants and micro aquatic organisms.

Quarrying brings about the elimination of the vegetation cover and marine plants, as well as the loss of flora has a direct impact on fauna a reduction in the number of insects and other micro-organisms. Land slides are common occurrences in quarry sites. Quarrying involves cutting the land into very steep slopes. Vertical cuttings of the land usually lead to the development of steep slopes liable to collapse during heavy rains. Water causes a large quantity of loosened slopes prone to sudden sliding. Hence, quarry sides are likely to develop slope movements and thus work accidents occur on the sites. Post quarry scenery resembles badlands located at the fringe zones of the town. Such excavated surfaces which are now exposed are considered by the indigenous as a derelict land surface on which household waste is deposited in large quantities. There is currently a large scale waste disposal in the Makepe area where the urban council collects waste from Sector 13 which extends from Ndogbati to Bonateki and from Makepe I to Ndogbong. The waste collected by the various companies is extremely varied in form and state of degradation. Quarrying is a risky activity for the life of the worker resulting in drowning, skin diseases. Most quarry workers suffer from back and muscular pains due to their tedious activity and blisters on the palms, mosquito bites during the night work.

Conclusions:

Sand quarrying has played a vital role in the economic development as the new urban reconstruction and restructuring of former infrastructure of Douala cannot be over-emphasised. The expansion of former sub-urban zones has used large amounts of sand, propelling this extractive industry to attract increasing attention of the urban unemployed who finds it appealing. This extractive industry, whose raw materials come from nature, is a handsome occupation in the eyes of the clear-sighted investors who, endowed with plenty of economic awareness and business acumen, have appreciated that there are high potential rewards for investment in this sector. Moreover, it is a hidden small scale industry which does not attract the attention of the marauding taxation officers, whose interventions have only gone to stifle economic ingenuity and investments. Cameroon's policy of economic liberalisation and legislation should have given a greater impetus to the opening of new industrial concerns, but the myriads of insecurity facets raised in this paper is a finger pointer to the

fact that more than just legislation is required in this sector. To attain a set of security goals, the way forward is that of educating those who know only about their crude energy exercised in the quarries yet not knowing the risk and hazard vulnerability to which they are exposed.

Rezumat:

IMPLICATII ANTROPOLOGICE ŞI DE MEDIU ÎN EXPLOATAREA NISIPURILOR PALEO-SEDIMENTARE TROPICALE DIN ZONA ESTUARĂ A METROPOLEI DOUALA, CAMERUN

Ca o activitate informală şi importantă, dar puţin adecvată, exploatarea nisipului din zona estuară a metropolei Douala este un sector care a rămas în mare parte neobservat. Şi totuşi acest sector informal este important deoarece oferă o şansă de supravieţuire economică unei părţi a populaţiei urbane subprivilegiate şi şomere care a împânzit oraşul în căutarea unor oportunităţi de lucru. Când speranţele unui viitor economic mai bun eşuează, populaţia fără studii şi fără abilităţi specifice este obligată să opteze pentru o alternativă ocupaţională care să-i asigure supravieţuirea în condiţiile economice şi sociale ale oraşului milionar Douala. Exploatarea nisipurilor impune două obligaţii: de a asigura un nivel acceptabil de igienă şi siguranţă pentru cei care lucrează în zonă şi aceea de a se respecta legislaţia de stat care pune un accent deosebit pe protecţia mediului în acest sector economic. Această problemă ne conduce la ipoteza că exploatarea nisipurilor în Douala este o activitate economică ce maschează o nesiguranţă privind sănătatea oamenilor, dar şi o deteriorare morfologică a mediului. Acest studiu îşi propune să investigheze magnitudinea activităţii de exploatare din estuarul Douala şi să evalueze riscurile de sănătate şi de mediu care rezultă, cu obiectivul de a determina dacă această activitate aderă sau nu la normele bazice de siguranţă. Un sondaj în teren desfăşurat între anii 1997 şi 2007 a relevat că exploatarea nisipului în Douala este bine distribuită în oraş, însă modul său de funcţionare nu întruneşte normele care ţin de multitudinea de probleme privind starea de sănătate, pierderile de vieţi umane, dereglări morfologice şi degradarea mediului, care au fost observate şi înregistrate. Această lucrare susţine necesitatea unei schimbări de la un sistem de activitate legislativă care şi-a dovedit limitele sale de siguranţă, la unul educativ-legislativ, cu scopul de a ridica nivelul de conştientizare asupra problemelor de sănătate şi de mediu printre lucrătorii din exploatare.

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Annexes:

Figure no. 3 Earth quarry site in Bonamoussadi neighbourhood.

Note: Water gushing below the level where gravel is extracted. The motor-pump pipes are used to suck out water from the quarry pit.

Figure no. 4 Quarry products from the slopes of a quarry site.

Note: Worker on site extracting white sand (left). White sand at the base of an earth quarry within a valley in the Bonamoussadi quarry (right).

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