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Limestone quarrying : the impact on the vegetation and landform of sagamu cement factory site, Sagamu, Southwestern Nigeria

S. O. OKE*, and G. A.O. IBHANESEBHOR

Department of Botany,Obafemi Awolowo University,Ile-Ife,Nigeria.
**Corresponding author, E-mail:* soke@oauife.edu.ng ; +234 08035803308

ABSTRACT

Species composition of the vegetation of several sites (worked; unworked; spoil heap in the quarry and its environs) in a cement manufacturing town, Sagamu, Southwestern Nigeria, was studied. The aim was to document the plant species compostition (biodiversity) of the quarry sites and its environs, which will provide baseline data for assessing the impact of limestone quarrying on the vegetation of the area. Two sampled plots, each measuring 25 m x 25 m, were studied in each site by complete enumeration of all the woody species and their girth measured at breast height. Limestone excavation in the area has altered the landform by creating new and varied habitats, namely, ponds and spoils heaps, which were not originally in the area. The spoil heaps have provided a haven for *Pinus caribaea*, a rare species of the vegetation of the area while *Typha australis* and fern are peculiar to the ponds and their banks.The original vegetation of the area has been greatly disturbed by agricultural activities and limestone quarrying. The present vegetation is a regrowth as evidenced by the small girth sizes of the woody species. Three distinct vegetation types, namely, gallery forest along water course, spoil heap vegetation dominated by *Pinus caribaea and Terminalia catapa*, and lowland secondary grasslsand vegetation dominated by *Anthocleista vogelli, Alchornea spp* and *Spondia mombin* .The spoil heap vegetation has fewer woody species but higher density than lowland secondary grassland vegetation with several species.The dominant grass species across all the sites were *Andropogon tectorum, Panicum maximum, Penisetum purpureum and Sorghum bicor, and* forb species were *Aeschynomene cristata, Chromolaena odorata* and *Ipomea spp.*

Keywords: Environment, excavation, quarrying, biodiversity, vegetation, species.

INTRODUCTION

Mineral exploration directly affects plant biodiversity through both physical and chemical modification of the environment, and indirectly in a variety of ways (Ratcliffe, 1974). The most obvious impact of mineral exploitation is that of physical change to the land surface, with its cover of soil and vegetation. Through this process, habitats can be altered or destroyed. The quarrying sector's primary impact on biodiversity is through the removal of surface features during the extraction of minerals (BBRC, 2012). One of the biggest negative impacts of quarrying on the environment is the damage to plant biodiversity (Sustainable floor, 2009). Quarrying carries the potential of destroying habitats and the species they support.

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Secondary effects of the quarrying process, such as noise, dust, pollution and waste removal can also impinge on plants and animals population. Usually these effects include a combination of changing land forms and disturbance, for instance through sedimentation which may arise through excavation and disturbance to land or water through the activities themselves. (BBRC, 2012). Disturbance to an ecosystem means any discrete event that disrupts the ecosystem, community or population structure, or the physical environment (Pickett and White, 1985). Species composition, community dynamics and human welfare services of ecosystems become adversely affected by disturbances of both natural and anthropogenic origin (Sousa, 1984). Habitat destruction is the leading cause of species extinction and biodiversity loss in natural ecosystems (Pimm and Raven, 2000; Koh et al., 2004).

The nature of the extraction is inherently damaging to the environment not just because of the production process but also because the end products serve to increase greenhouse gas emissions, waste energy, and discourage recycling of resources. Vegetation removal also accounts for part of the world's greenhouse gas emissions. Prevention of natural forest from being removed, is protecting carbon stores vital in the fight against climate change. In addition, promotion of the regeneration of degraded forest leads to active uptake of carbon.

In reality, many quarries provide wild life havens in areas where biodiversity is otherwise limited by other forms of land-use such as farming. Through careful management, quarries can significantly enhance the biodiversity of an area and provide much needed habitats such as small cliffs, arid environments and ponds.These areas can encourage certain species to become established. Quarrying provides a unique opportunity to enhance the nature conservation.

Many quarries are also important reservoirs of biodiversity. Many quarries aim to increase biodiversity and an index to measure the biodiversity in these quarries is important. Ecosystems can contribute to mitigation of climate change in the tropics. To preserve the biodiversity and carbon values, the forest can be managed for ecosystem restoration by replanting with native trees. Restoration is a major opportunity for the industry to enhance biodiversity.

Understanding of forest processes is necessary for assessment of impacts, the amelioration of effects of disturbance, optimisation of productivity and rehabilitation of ecosystem (Congdon and Herbohn, 1993). In 1976, the West African Portland Cement Company, Sagamu (WAPCO) was incorporated in Nigeria and started commercial production of cement in 1978. In dry and rainy season 2009, field trips were made to the factory site to study the vegetation of the area and study sites were established within and outside the factory with a view to assessing the impact of cement manufacturing on the vegetation of the area. This paper reports the existing plant biodiversity of the area.

MATERIALS AND METHODS

Study area

The study area is a cement-producing town of Sagamu (Latitude 06^0 48' N Longitude 003^0 37'E) in Sagamu local Government area in Ogun State. It is in the derived Savanna zone of Nigeria (Keay, 1959). White (1983) has described the vegetation as mosaic of lowland rain-forest and secondary grassland of Guinea-Congolian type. The soil developed over sedimentary rocks and is a well-weathered well drained

soil with deep profile.The rainy season lasts from April to November while the dry season prevails for the remaining months. The wettest month is September and approximately 90% of the rainfall occurs between April and October.The temperature ranges from mean minimum of 21.1 °C to mean maximum of 31.7 °C.

Sampling procedure

The vegetation of three sites in the quarry area (worked; unworked; spoil heap) within the factory premises and another three sites outside the factory premises (Sotubo, Atoyo and Senior Staff Quarters) were sampled. Two sampled plots, each measuring 25 m x 25 m, were studied in each site.Worked area refers to area where limestone excavation has been carried out, while in unworked area there is no excavation. The sample plots were chosen systematically based on the sites where excavation has been carried out or not been carried out within the factory site. The same procedure was adopted in sites outside factory but here the choice of sample plots was based on sites where there was no evidence of recent farming.

In each site and within each plot, all the woody plants were enumerated and identified to species level. Their girths were measured at breast height. All herbaceous species within the sample plots were identified and their abundance visually estimated and classified as abundant, common or scarce. Species nomenclature is according to Hutchinson and Dalziel (1972). Descriptive statistics involving the use of mean, standard deviation and standard error was used to analyse the data.

RESULTS

Species composition of the vegetation

A total number of 141 plant species belonging to 121 genera, and 49 families were recorded from all the sites (Spoil heap, worked, unworked and outside the factory premises) of study area.

Spoil heap sites

The older spoil heaps were dominated by *Pinus caribaea* and *Terminalia catapa*. Other common woody species are *Albizia zygia, Albizia lebbek, Allophyllus africanus, Ficus exasperata, Mallotus oppositifolia and Leea guineensis*. The older spoil heaps consist of all these species while the recently deposited spoil heaps are dominated by *Elaeis guineensis*, *Lantana camara* and herbaceous species such as *Aeschynomene cristala, Calopogonium mucunoides, Ipomea spp* and *Physalis angulata* and grass species such as *Andropogon spp* and contains sapplings/seedlings of other species at very low frequency.

Worked sites

The vegetation of most of these sites was dominated by herbaceous species. The vegetation of the ponds created by limestone excavation are dominated by *Typha australis* while the banks of the ponds are dominated by fern and grass species such as *Panicum maximum, Cynodon dactylon, Sorghum bicolor* and *Andropogon spp*.

Unwoked sites

The vegetation of these sites has been greatly disturbed with farming activities. The present vegetation consists of regrowth woody species interspersed in herbaceous ground layer. Evidence of some of the woody species of the original vegetation is manifested by big stands of *Melicia excelsa, Ceiba pentandra, Cola gigantea, Ficus spp* left standing during land preparation which dot the terrain. The common regrowth woody species encountered consist of *Anthocleista vogelli, Azadiractha indica, Delonix regia, Lecaniodiscus cupanoides, Musanga cecropoides, Psidium*

guajava, Solanum torvum and *Spondias mombin.* The common woody species encountered along the water courses consist of *Alchornea s*pp and *Bambusa vulgaris*.

The dominant herbaceous species consist of *Chromolaena odorata and Ipomea spp* while *the* common species consist *Ageratum conyzoides, Calopogonium mucunoides, Combretum nigerica* and *Phyllantus amarus* and dominant grass species consist *Andropogon spp, Panicum maximum, Penisetum purpureum and Sorghum biclor.*

Sites outside the factory premises

The vegetation of these sites had been greatly disturbed by farming activities. It consisted of regrowth woody species interspersed in a ground herbaceous layer. The woody species composition of the regrowth vegetation consists of *Azadiractha indica, Cassia siamea, Cleistopholis patens, Cocos nucifera, Cola spp, Morinda lucida, Newbouldia laevis* and *Trema orientalis.*

The grass species were *Andropongon spp., Panicum maximum, Penisetum purpureum, Sorghum bicolor* while the forb species *were Aspilia africana, Ageratum conyzoides, Chromolaena odorata, Euphorbia heterophylla* and *Phyllantus amarus. Cleistopholis patens were* the common plant along the water course. Around the settlement are planted *Anarcardium occidentale, Bauhinia monandra, Ceiba pentadra, Citrus* species and *Elaeis guineensis*.

Woody species density and girth sizes

In the spoil heap sites, *Pinus caribaea* had the highest density of 528 plants ha^{-1}, followed by *Terminalia catapa* which had the density of 176 plants ha^{-1} while *Albizia lebbeck* had the lowest density of of 16 plants ha^{-1} should be ha^{-1} (Table 1). In unworked site *Anthocleista vogelli* had the highest density of 144 plants ha^{-1} while *Bombax buonopozense, Cola gigantea and Ceiba pentandra,* had the lowest density of 16 plants ha^{-1}. The unworked sites had the highest mean woody species density followed by the spoil heap sites and the sites outside the factory premises (Table 1). Though the soil heap sites had high plant density, it was made up of individuals contributed by only few species adapted to the sites. The woody species of the sites (within the quarry) had small girth sizes (Table 2) except some woody species of the original vegetation. This indicates that the vegetation is made up of regrowth woody species. Also of note is the lowest plant density of sites outside the factory premises.

Changes in the landform in the quarry site

The quarrying of limestone deposits has created large man-made ponds whose sizes vary with the extent of quarrying (i.e.depth and area covered) and hills of spoil heap made up of soil, shale and rocks poor in limestone content.These have created new habitats which now support fauna and flora species not found in the other sites in the area.Workers in the factory (personal communication) reported that there are different fish species in these ponds which are now perennial water bodies. *Pinus caribaea and Terminalia catapa* growing on the spoil heaps were introduced and *Typha australis* and ferns growing in the ponds were invasive.

Table 1: Mean density of woody species ± standard error of the mean in the study plots in Sagamu, Southwestern Nigeria.

Species	Density ha^{-1}			
	Spoil heap	**Worked site**	**Unworked site**	**Outside factory premises**
Albizia adantifolia	-	-	16	-
Albizia lebbeck	32	-	-	-
Albizia zygia	16	-	32	16
Alchornea cordifolia	-	-	64±28	32
Alchornea laxiflora	-	-	80 ± 48	32
Allophylus africanus	16		-	-
Alstonia boonei	-	-	-	32
Anacardium occidentale	-	-	-	32
Anthocleista vogelli	-	-	144±48	-
Azadiractha indica	-	-	64±28	48 ± 32
Bambusa vulgaris	-	-	80±48	-
Baphia nitida	-	-	32	-
Bauhinia monandra	-	-	32	32
Brachystegia eurycoma	-	-	32	-
Canarium schwinfurthii	-	-	-	32
Cassia siamea	-	-	32	48±32
Ceiba pentandra	-	-	16	-
Cleistopholis patens	-	-	-	48± 32
Cola acuminata	-	-	-	48±32
Cola gigantea	-	-	16	-
Cola nitida	-	-	-	16
Cocos nucifera	-	-	-	48±32
Delonix regia	-	-	48 ± 32	-
Dialium guineensis	-	-	16	16
Elaeis guinensis	48 ± 32	-	-	-
Ficus capensis	-	-	48 ± 32	-
Ficus exasperata	16	-	16	-
Ficus sur	-	-	48 ± 32	-
Icacina tricantha	-	-	16	-
Lantana camara	48 ±32	-	-	-
Lecaniodiscus cupanoides	-	-	48 ±32	-
Leea guineensis	16	-	16	-
Leucaena leucocephala	-	-	-	16
Lonchocarpus cynanceus	-	-	16	-
Ludwigia spp	-	-	32	-
Mallotus oppositifolia	32	-	16	-
Manihot esculenta	-	-	32	-
Margaritaria discoides	-	-	-	32
Milicia excelsa	-	-	16	-
Morinda lucida	-	-	-	48±32
Musanga cecropoides	-	-	16	-
Newbouldia laevis	-	-	-	80±32
Pentaclethra macrophylla	-	-	16	-
Pinus caribaea	528± 80	-	32	-
Psidium guajava	-	-	48±32	-
Pterocarpus spp	-	-	32	-

Pycnanthus angolensis	-	-	32	16
Raphia venifera	-	-	32	-
Rauvolfia vomitoria	-	-	32	16
Ricinodendron heudelotti	-	-	16	16
Securinega virosa	-	-	16	-
Senna occidentale	-	-	32	-
Solanum torvum	-	-	48±32	-
Spondias mombin	-	-	80± 48	-
Spondiathus preussii	-	-	16	-
Sterculia tragacantha	-	-	32	-
Symphonia golubifera	-	-	16	-
Tephrosia braceolata	-	-	-	16
Terminalia catapa	176±48	-	32	-
Treculia africana	-	-	16	-
Trema orientalis	-	-	-	64 ± 48
Triumphetta corymbosa	-	-	32	-
Urena lobata	-	-	32	-
TOTAL	928 ± 56	-	1616±2.8	784±5.7

Table 2: Mean girth size of woody species ± standard error of mean in the study plots in Sagamu, Nigeria. .

Species	Mean Girth size (cm)			
	Spoil heap	**Worked site**	**Unworked site**	**Outside factory premises**
Albizia adantifolia	-		31.6	
Albizia lebbeck	33.5 ± 3.9	-	-	-
Albizia zygia	37.5 ± 6.4	-	23.7 ± 2.3	26.5 ± 7.3
Alchornea cordifolia	-	-	4.0±0.8	4.2± 0.7
Alchornea laxiflora	-		6.3 ± 1.7	5.8 ± 2.8
Allophylus africanus	18.6 ± 3.1	-	13.2 ±1.6	-
Alstonia boonei	-	-	-	28.5 ± 3.9
Anacardium occidentale	-	-	-	38.3 ± 12.3
Anthocleista vogelli	-	-	16.0±3.7	-
Azadiractha indica	-	-	28.0±7.8	28.5 ± 2.9
Bambusa vulgaris	-	-	16.0±3.8	-
Baphia nitida	-	-	4.2 ± 0.6	-
Bauhinia monandra	-	-	13.6 ± 2.3	11.8 ± 5.7
Brachystegia eurycoma	-	-	15.3 ± 4.5	-
Canarium schwinfurthii	-	-	-	17.0 ±4.8
Cassia siamea	-	-	32.5 ± 8.2	38.0±13.2
Ceiba pentandra	-	-	56.5 ± 11.3	-
Cleistopholis patens	-	-	-	37.4± 12.8
Cola acuminata	-	-	-	32.7± 5.9
Cola gigantea	-	-	98.7 ± 18.8	-
Cola nitida	-	-	-	16.8 ± 4.6
Cocos nucifera	-	-	-	34.9 ± 4.3
Delonix regia	-	-	36.4 ± 6.5	-
Dialium guineensis	-	-	13.2 ± 2.7	18.3 ± 7.3
Elaeis guinensis	46.6 ± 4.2	-	28.8 ± 2.8	-
Ficus capensis	-	-	34.8 ± 3.9	-

Ficus exasperata	16.5 ± 2.5	-	48.0 ± 4.9	
Ficus sur	-	-	14.4 ± 2.8	
Icacina tricantha	-	-	8.6	
Lantana camara	8.3 ± 1.3	-	-	-
Lecaniodiscus cupanoides	-	-	21.2 ± 8.8	-
Leea guineensis	11.2±		8.7	
Leucaena leucocephala	-	-	-	12.5 ±2.4
Lonchocarpus cynanceus	-	-	13.2 ±3.6	-
Ludwigia spp	-		9.2 ± 2.2	
Mallotus oppositifolia	12 ± 2.2		6.3	
Margaritaria discoides	-	-	-	32.3 ± 4.8
Milicia excelsa	-		56.8	
Morinda lucida	-	-	-	24.8±3.2
Musanga cecropoides	-		29.8 ± 4.5	
Newbouldia laevis	-	-	-	28.2± 3.9
Pentaclethra macrophylla	-	-	14.0	-
Pinus caribaea	28.5± 8.0	-	16.5±3.2	-
Psidium guajava	--	-	10.8 ±4.9	-
Pterocarpus spp	-		12.3 ±1.3	-
Pycnanthus angolensis	-	-	25.0 ± 4.9	23.3 ± 8.8
Raphia venifera	-	-	22.6 ± 4.5	-
Rauvolfia vomitoria	-	-	11.9 ± 3.7	19.0 ± 1.4
Ricinodendron heudelotti	-		32.8 ± 2.8	46.0 ± 11.2
Securinega virosa	-	-	15.7±5.8	-
Senna occidentale	-	-	13.2±3.7	-
Solanum torvum	-	-	9.8±3.2	-
Spondias mombin	-	-	28.0± 4.8	-
Spondiathus preussii	-	-	12.7	-
Sterculia tragacantha	-	-	32.5 ±5.5	-
Symphonia golubifera	-	-	16.8	-
Tephrosia braceolata	-	-	-	5.2 ±2.2
Terminalia catapa	37.6±4.8	-	32.4 ±6.5	-
Treculia africana	-	-	19.4	-
Trema orientalis	-	-	-	18.6 ±3.8
Triumphetta corymbosa	-	-	13.2 ±3.3	-
Urena lobata	-	-	8.3 ±1.8	-

DISCUSSION

Limestone excavation in the area has altered the land form of the area and created new and varied habitats – ponds and spoil heaps. These habitats now support fauna and floral species not found in any other sites in the area. The spoil heaps provide a haven for *Pinus caribaea* a rare species of the vegetation of the area not found in any other site in the study area. *Pinus caribaea and Terminalia catapa* are species of wide adaptation and which are normally planted as ornamental trees in the area and also occur in large natural population on the heaps and in other sites indicating their adaptation for the general habitat conditions including the heaps. These plants being fast growing woody species, valuable for the protection of the soil surface from erosion, useful for massive reforestation programme and the conversion of heavily eroded lands on which nothing else could be grown. These plants have been so far successfully used to clothe barren eroded and denuded lands with a tree cover (Lamb and Ntima, 1971; Hayward 1990). These species may be possible candidate species for the revegetation, reclamation and stabilization of quarry sites in cement producing towns of this

country. The few number of woody species found on the spoil heap vegetation in this study compare to those found on the other locations in the study sites is in agreement with the observations on spoil heap vegetation by Muoghalu (1996) in Nkalagu and Oke and Ibhanesebhor (2010) in Ewekoro. These few woody species are those adapted to the sites. The aquatic habitat provided by ponds created by limestone excavation has also provided refuge for fish species and some plant species including ferns.There is need to assist the natural development of the vegetation of these new habitats (ponds and spoil heaps) which have provided ecologically refuge to rare animal and plant species in the area. Presence of *Typha australis* and ferns in the pond is an indication of commencement of succession in the area.

The original vegetation of the study area has been completely destroyed by agricultural activities and limestone quarrying. The present vegetation is a regrowth as evidenced by the size of the woody species which are generally small. It is made up mainly of regrowth woody species and some big trees left standing during the land preparation which dot the terrain forming the open upper layer while the herbaceous grass and forb species form the ground cover. The dominant grass species are *Panicum maximum, Sorghum bicolor, Andropogon gayanus* and forb species are *Aeschynomene cristata, Chromolaena odorata, Physalis angulata, and Calopogonium mucunoides.* Three distinct vegetation types currently exist in the area; gallery forest along perennial waterbody course, spoil heap vegetation and lowland secondary grassland vegetation, each with distinct species composition.

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