Biodiversity and Potential Socio-Economic Importance of Abandoned Quarry Sites in Abeokuta Area, Ogun State, Nigeria

D. O. Odulate[1], J. A. Soaga[2]*, S. A. Onadeko[2] and Y. Akegbejo-Samsons[1]
[1] *Department of Aquaculture and Fisheries Management*
[2] *Department of Forestry and Wildlife Management*
University of Agriculture, Abeokuta, Ogun State, Nigeria
** Corresponding author; Email: soagaj@yahoo.com*

Abstract

The study evaluated the biodiversity status of abandoned quarry pits in 'Aro' in Abeokuta, Ogun State in Nigeria. The site was 1800 m^2 in area. A total of 80 pits were inundated in the area. Stratified sampling was used to select 30 pits, ranging from small to medium and large pits. Twenty-eight per cent of the inundated pits were selected. A total of 26 aquatic plants were identified. *Nymphae lotus* had the highest occurrence (90%) while others with least occurrence had 2.3%. The study area was a good location for game animals, thus, animal species such as weaver birds (*Ploceus* spp.), hawks (*Eremopterix leucotis*) and water ducks (*Dendrocygna viduata*) were found to occupy some of the niches. A socio-economic assessment of the inundated pits in the area revealed that pit users made financial gains from the biological resources of the pits when exchanged in market places under direct use value of the resources. The biological resources entered into human preferences and, therefore, users generated income. Estimates from a small pit with stocking density of 791 fingerlings showed that N59,219 could be generated annually and in multiples if the pits are many. The management method excludes supplementary feeding in such pits but polyculture could be adopted with species such as *Clarias gariepinus* and *Oreochromis niloticus*. There were also indirect values (non-marketed resources) from the pits, including environmental functions such as recycling of nutrients and gases, aesthetic and water for domestic uses. These also require valuation to appreciate economic values of the pits.

Introduction

The term "biodiversity" has been defined as "the variety and variability among living organisms and the ecological complexes in which they occur" BRAAF, 1999; WCMC, 1992; OTA, 1987. Humans rely on the earth's biodiversity for sustenance and development. Current estimates of the earth's total species diversity range from 10 to 100 million species of plants, animals, fungi and micro-organisms (Baumgartner, 2006). There is no doubt that biotech-nological advancement could not have been possible without the diverse living resources within the environment. Tropical parts of the world have the highest biological diversity. According to Boussienguet (1994), tropical rainforest, which constitutes only 6% of the earth's surface, contains at least 50% of all the earth's biodiversity. Tropical countries are, thus, the main centres of the world's biological diversity. Accordingly, WCMC (1992) maintained that tropical forest is a source of ecological benefits and material wealth, having undisputed value from the concept of total economic value (TEV) of the forest to the society.

Biodiversity in abandoned pit locations, especially quarry sites, could be linked with suitable habitats for floral and faunal in such locations. Quarrying is an economic activity which contributes to environmental degradation through damage to the landscape and the creation of pits, which may later be

inundated and gradually become habitat for species from adjoining forest. However, Areola (1991) maintained that rock quarrying is less damaging to the landscape and vegetation than the quarrying of earth materials. This could be explained in terms of confinement of extraction to the rocky areas which are bare of vegetation and marginally suitable for agriculture. Man and environment, therefore, relate with each other dialectically. There is no doubt that mining operations lead to scarification of the land surface resulting in the existence of numerous mine pits of various sizes. Some of the pits when abandoned contain permanent water bodies which become breeding grounds for mosquitoes. NEST (1991) maintained that such pits could be dangerous for both humans and livestock.

The presence of water bodies in the abandoned pits often initiates succession and eventual colonization by aquatic flora and fauna. Such pits become economically useful, because aquatic macrophytes grow within the pits. Apart from their ecological role, aquatic macrophytes contribute greatly to the economic, scientific, and recreational importance of water-bodies (Ita, 1994). Bennet (1985) noted that the aesthetic values of inundated pits are among the most attractive waters found in lake State in United States. Pit water has economic significance that could be utilized to the advantage of the pit users. Inundated pits were equally classified by Edwards (1986) as wetlands which form part of a terrestrial habitat submerged or saturated with water. Despite the vast literature on wetlands, little attention has been given to the diversity and income potential of aquatic ecosystems formed as a result of mining activities. The objectives of this paper were, therefore, to determine the (1) diversity of fish, aquatic plants and other life forms that colonize abandoned pits after quarrying, and (2) socio-economic importance of the pits in support of livelihoods of the local people.

Materials and methods

Study area

The study area was in Abeokuta North Local Government area of Ogun State, Nigeria (7° 15' N, 3° 25' E), which is located between River Ogun and Olumo rock. The rock is a massive granite outcrop of primitive formation forming part of a plateau from which the town derived its name, Abeokuta (under the rock). The area is situated in the rainforest belt of Nigeria with annual rainfall of 1000–1500 mm (Iloeje, 1978; Oyesiku, 1992), and is characterized by two distinct seasons, the longer wet season lasting for eight months (March–October) and the shorter dry season of four months duration (November–February). The relative humidity is high all the year round, and generally above 80% during the wet season and between (60–80%) during the dry season. Major economic activities in Abeokuta include quarrying, sawmilling, block making, dress making and pottery making. The abandoned quarry sites in 'Aro' Abeokuta have a total land area of about 1,800 m^2. There are 114 dug pits out of which 80 are permanently inundated and 34 inundated only during the wet season.

Sampling procedure and sample sizes

Stratified sampling was used to select pits with 38% sampling intensity. The inundated pits were divided into three strata, small, medium and large. The division was based on the different sizes of the pits. Small pits

varied from 1–300 m^2 in area, medium 301–600 m^2 and large 601–1500 m^2. From each stratum, inundated pits were selected randomly. In stratum 1 (small), over 50% of the pits were selected with a total of 16 small sized pits. In stratum 2 (medium) and stratum 3 (large), 20% of the pits were selected with seven pits from each stratum. A total of 30 pits were selected out of the 80 inundated pits based on predetermined sampling frame. Parameters recorded in each sampled pit included (i) faunal species, (ii) aquatic floral species, and (iii) water quality, specifically temperature (^{0}C), *p*H, conductivity (µs/cm), dissolved oxygen (mg/l), alkalinity (mg/l), total hardness and carbon, and (iv) oxide (mg/l).

Classification of organisms

Observed organisms were classified as aquatic plants and animals. Plants were identified (Polumin & Walters, 1985; Tarver *et al.*, 1986) and categorized into emergent, sub-emergent, floating and algae. Animals were grouped as fishes, amphibians, birds and reptiles. Direct drive count method was used for the birds and reptiles. Enumeration was done during the hours of 16–20 GMT daily for 5 days.

Evaluation of income potential

Budgetary analysis was used to evaluate income potential in abandoned quarry pits. Profitability of economic activities within the pit was determined. Gross profit (GP) was given by Gross Annual Return (GAR) less Variable Cost (VC). Other budgetary terms used in this study include Gross profit (GP) = GAR–VC, Total cost (TC) = TVC + TFC, Total variable cost (TVC), Total fixed cost (TFC), Net profit (NP), and Fixed cost (FC).

The cost and return analysis showed the profitability of a small sized inundated pit by users. The assumptions made in the analysis were (1) No feeding of the fish species within the inundated pit for the period of the study. (2) Polyculture was adopted for the pit at a stocking rate of 5 fingerlings/m^2 and stocking density of 791 fingerlings for 158.2 m^2 sized pit. (3) Stocking ratio was 3:2 of *Claries gariepinus* and *Oreochromis nitolicus*, respectively.

Results and discussion

Table 1 shows the categorization of the inundated pits into small, medium and large pits. Small pits varied from 1–300 m^2 in area, medium (301–600 m^2) and large (601–1500 m^2). Table 2 reveals common aquatic plants and their frequencies of occurrence in the pits. *Nymphaea lotus* had the highest percentage of occurrence (90%) while species with least occurrence (3.3%) were *Alternanthera philoxeroides, Ageratum conyzoides, Sporobolus pyramidalis,*

TABLE 1
Categories of inundated pits and their dimensions

Categories	*Area (m^2)*	*Volume (m^3)*	*Number sampled*	*Mean depth (m)*
Small	1 – 300	84 – 225	16	0.64
Medium	301 – 600	127 – 570	7	0.56
Large	601 – 1500	362 – 1885	7	0.71

TABLE 2
Aquatic plants in sampled inundated abandoned quarry pits

Species	*Family*	*Common name*	*Percent frequency of occurrence*		
			Small pit	*Medium pit*	*Large pit*
Emergent species					
Ipomea digitata	Convolvulaceae	Morning glory weed	3.3	4.9	5.1
Ipomea aquatica	Convolvulaceae	Swamp morning glory	1.9	2.0	3.0
Ipomea asarifolia	Convolvulaceae	Swamp morning glory	12.4	14.2	10.1
Nymphaea lotus	Nymphaeaceae	Water lily	36.1	23.2	31.7
Typha latifolia	Tyhacea	Cat-tail	28. 4	30.6	24.2
Ludwigia octovalris	Onagraceae	Primose-willo	4.2	11.1	3.4
Ageratum conyzoides	Asteraceae	Goat weed	-	-	3.3
Alternanthera philoxeroides	Amaranthaceae	Alligator weed	-	-	3.3
Sporobolus pyramidalis	Poaceae	Cat's tail grass	-	-	3.3
Oryza barthii	Poaceae	Grass	-	-	3.3
Cyperus difformis	Cyperaceae	Sedge	-	5.4	7.9
Cyperus odoratus	Cyperaceae	Flat sedge	-	-	3.3
Fuirena ciliaria	Cyperaceae	Sedge			
Digitaria horizontalis	Cyperaceae	Sedge	-	2.4	4.3
Hyperrhenia	Poaceae	Jamaican	-	-	3.3
Kyllinga	Cyperaceae	Sedge	2.5	4.6	5.2
Paspalum virgatum	Poaceae	Razor/sword grass	4.3	5.9	6.5
Sphenoceae zeylanica	Sphenocleaceae		-	6.5	6.8
Leonotis nepetifolia	Limiaceae		-	-	6.7
Submergent species					
Najas minor	Najadaceae	Brittle waternymph	4.1	9.5	13.1
Utricularia gibba	Lentibulaviaceae	Bladderwort	9.3	12.7	18.0
Floating species					
Azolla africana	Azollaceae	Water velvet	7.2	14.7	18.1
Azolla caroliniana	Azollaceae	Water fern	2.3	5.3	6.4
Lemna minor	Lemnaceae	Common duckweed	1.1	2.9	2.7
Spirodela polyrhiza	Lemnaceae	Giant duckweed	-	-	3.3
Algae					
Spirogyra punctata	Zygonemataceae	Water silk	4.2	5.1	7.4

Oryza bartii, Cyperus odorantus, Hyparrhenia spp. *and Spirodela polyrhiza*.

Animals recorded from the inundated pits are listed in Table 3. Three classes of animal fauna were discovered in the inundated pits, and they ranged from insects to amphibians and fishes. Different fish species were found in almost 91% of the pits followed by insects (23.3%) and amphibians (20%).

Other animals found within and around the inundated pits are presented in Table 4, which shows that weaver birds had the highest abundance of 60.14% and snakes the least (0.17%). The implications of the presence of these animals in the pits are that food and water were readily available, triggering a process of succession with buried propagules germinating and developing into matured plants.

Physical and chemical parameters of the water measured in the inundated sampled pits were presented in Table 5. The values of physico-chemical parameters obtained indicated that they were within the range of acceptable values suitable for fish culture. Accordingly, Moyle & Leidy (1992) reported that such pits could support other aquatic life. Thus, fish could, therefore, be used as an indicator of aquatic biodiversity in the existing inundated pits.

Socio-economic importance of the inundated quarry pits

The economic values of the pits may be expressed in direct and indirect use values. The direct use value of the inundated pits is the socio-economic importance of the floral and faunal species which are exploited for food, medicine and income. Ita (1994) reported that in a balanced environment, aquatic plants have recreational, aesthetic and medicinal values. *Nymphaea lotus* (water lily) stems and roots are traditionally used for treatment of eruptive fevers and urethral discharges, and as emollients and diuretics while the decoction of the flower is narcotic and sedative (Ita, 1994).

Kio & Ola-Adams (1987) reported that the rhizome, flora, receptacle and fruits of *Nymphaea lotus* are either eaten raw or cooked. Also, *Ludwigia stolonifera* is used as an ingredient/condiment of soup in the Yelwa area of Kebbi State (Obot & Ayeni, 1987). Thus, there could be direct transaction between the people and the biological resources of the pits, since the biological resources generate products which are exchanged at the market place. Products such as game animals, frogs and water ducks are only consumed at subsistence level mostly by pit users as sources of supplementary protein. Biological resources of the pits that enter into the market economy include different fish species and water spinach, harvested as animal fodder for rabbits and pigs.

The indirect use value resources of the pits are non-marketed resources such as environmental assets of clean air and water, and nature preservation which do not have financial value but are also important to society by making indirect contributions to the welfare of the people. These resources promote good output of flora and fauna resources of the pits by encouraging environmental functions. Nutrients as well as carbon and oxygen are recycled between the pits and the environment. Attempts must, therefore, be made to place values on these resources. Other indirect values include habitat and food for game animals including fish fry, waste receptacle for clothes washing, body cleaning and aesthetic uses (relaxation and swimming).

TABLE 3
Aquatic fauna observed in the sampled inundated abandoned quarry pits

Species	*Family*	*Common name*	*Percent frequency of occurrence*		
			Small pit	*Medium pit*	*Large pit*
Gerris lacustris	Gerridae	Pond skater	1.2	1.9	3.1
Dolomedes aquaticus	Pisuaridae	Water spider	3.5	4.3	4.7
Rana rugosa	Amphibiaceae	Toad/frog	5.4	7.3	13.3
Parachanna obscuta	Channidae	Snake head fish	1.3	3.0	4.0
Synodontis clarias	Synodontidae	Synodontis	–	–	2.1
Hemichromis faciatus	Cichlidae	Tilapia	4.7	6.0	14.3
Clarias gariepinus	Clariidae	Mud cat fish	3.7	7.1	10.0

TABLE 4
Estimate of birds and reptiles observed in and around the inundated pits

Species	*Common name*	*Family*	*No. observed*	*Percentage distribution*
Dendrocygna viduata	Water duck(white-faced)	Anatidae	47	7.70
Ploceus spp.	Weaver birds	Cuculidae	347	56.89
Eremopterix leucotis	Hawk	Alaudidae	16	2.62
Streotopelia vinacea	Venaceous dove	Columbidae	33	5.41
Agama agama	Agama lizard	Aganidae	166	27.21
Natrix natrix	Grass snake	Acrochordidae	1	0.17
Total			610	100.00

Table 5
Physico-chemical parameters of water samples from abandoned inundated quarry pits.

Parameter \ Pit size	*Small*	*Medium*	*Large*
Temperature (°C)	23.0	25.0	24.0
Dissolved oxygen (mg/l)	6.0	7.0	8.0
Alkalinity (mg/l)	171.0	19.7	171.0
*p*H	6.2	6.4	6.8
Total hardness (mg/l)	188.1	119.7	136.8
Conductivity (µs/cm)	322.0	264.0	329.0
Carbon iv oxide (mg/l)	35.0	30.0	35.0

In view of the significance of the pits to the community, it was estimated that a small-sized pit of 158.2 m^2 could generate revenue for pit users. Such pits could be stocked with 791 fish fingerlings at a stocking rate of 5 fingerlings/m^2 for a period of 1 year. Estimated net profit per annum from such a pit without supplementary feeding was N59,219.00 (Table 6) using the sum of the net profit of the two species. Species of fish

TABLE 6
Estimated income and return analysis of 158.2 m^2 (small sized) inundated quarry pit

Description	C. gariepinus	O. niloticus
	N	*N*
Gross annual return	64,050.00	10,224.00
427 qty @ N300.00 and N120.00 (287) qty		
Stocking ratio	3	2
Variable cost		
Input cost (fingerlings)	11,875.00	1,580.00
Transport cost	800.00	500.00
Tax/Permit	-	-
Total variable cost	12,675.00	2,080.00
Gross profit	51,375.00	8,144.00
Fixed cost		
Depreciation (5%)	150.00	150.00
Total cost (TC) = TVC + TFC	12,825.00	2,230.00
Net profit (NP = GP – FC)	51,225.00	7,994.00
Ratio analysis (GP/TC)		

Source: Field Survey, 2006.

NB: The minimum weight after 12 months when the pit was ready for cropping was 0.5 kg for *C. gariepinus* and 0.3 kg for *O. niloticus*. 5% depreciation was calculated using price of shovel and headpan used in construction for silted pit (N300.00) per annum.

such as *Oreochromis niloticus* (Nile tilapia) and *Clarias gariepinus* (Mud catfish) were combined to obtain the net profit.

Conclusion

The paper focused on the biodiversity of abandoned mined pits for income generation by pit users. There is no doubt that mining renders areas unsuitable for agriculture, settlement and industrial development, and such areas are abandoned as unusable. However, recent trends in development had shown that such abandoned sites, especially mined pits, could be profitably utilized for fish culture as a viable economic activity. Such pits when inundated can be economically utilized for aquacultural activities rather than abandoning them. The appropriate culture method for such inundated pits is mostly polyculture to promote conservation and ensure efficient utilization of available resources. The inundated pits in 'Aro' Abeokuta yielded additional income to the users of the pits.

World Bank (1982) reported that an additional income to a group of people will create additional social welfare to the group regardless of the income level of the group. Thus, the pits contributed to the economic growth of the area through trade stimulation and additional income to the people involved. Economic activities through the utilization of the pits, therefore, guarantee employment at a tolerable wage level and represent a method of poverty reduction and employment generation at subsistence level. This trend justifies and calls for more baseline information on biodiversity in abandoned inundated pits. Ogwumike & Ozughalu (2001) reported a linkage between poverty and environmental degradation. Thus, the poor will continue to struggle for survival, often at the expense of many things, especially the environment. The inundated pits, therefore, offer solace to the poor.

Aquatic plants such as *Ipomea asarifolia, Nymphae lotus, Ipomea aquatica, Azolla africana, Alternanthera philoxeroides* and *Spirodela polyhprhiza,* with significant economic value, especially as animal fodder, could further be harvested, processed and marketed to increase income levels of pit users. Accordingly, Diversitas (2001) reported that humanity depends on animal, plant, fungal and microbial species for food, fuel, fibres, medicines, drugs, and raw materials for the manufacturing industry. Therefore, the employment problems of the working poor members of the society could be resolved by using abandoned quarry pits along with other poverty-alleviating methods to ensure income redistribution for better standard of living.

References

Areola O. (1991). *Ecology of natural resources in Nigeria*. Avebury Academic Publishing Group City, England.

Baumgartner S. (2006). *Why the measurement of species diversity requires prior value judgements.* Working paper, University of Heidlberg, Germany. 23 pp.

Bennett G. W. (1985). Managements of Lakes and Ponds, 2nd edn. R. E. Krieger Publishing Company. Malaba, Florida.

Boussienguet J. (1994). Problems of assessment of biodiversity. In *The biodiversity of micro-organisms and invertebrates: Its role in sustainable agriculture. Proceedings of the 1st workshop on the Ecological Foundations of Sustainable Agriculture (WEFSA), London, 26 - 27 July, 1990.* CASAFA Report series No.4 (D. L Hawksworth, ed.), pp 31–35.

BRAAF (1999). Biodiversity inventory of Omo Biosphere Reserve, Nigeria. *Country report on Bio-*

sphere Reserve for Biodiversity Conservation and Sustainable Development in Africa (BRAAF) Project. 26 pp.

Diversitas (2001). Diversitas Science Plan. In *Biodiversity Focus*. (M. H Wake, ed.), pp. 10–22. Biology International. No 42. IUBS

Edwards A. W. A. (1990). Wetlands in Southern Nigeria. In *Nigeria Wetlands.* (T. V. L. Akpata and D. U. U Okali, eds), pp 27–34. MAB State of Knowledge Workshop on Nigeria Wetlands, Rivers State. August 27–29, 1986.

Iloeje N. P. (1978). *A New Geography of Nigeria*. Fletcher and Sons Ltd., Norwich. 191 pp.

Ita E. O. (1994). Aquatic plants and wetland wildlife resources of Nigeria. *CIFA Occasional Paper. No. 21., FAO,* Rome. 52 pp.

Kio P. R. O. and **Ola-Adams B. A.** (1987). Economic Importance of Aquatic Macrophytes. In *Ecological Implications in the Development of Water Bodies in Nigeria*. (C. Iloba, ed.) National Institute for Freshwater Fisheries Research Institute, New Bussa.

Moyle P. B. and **Leidy R. A.** (1992). Loss of Biodiversity in Aquatic Ecosystems. Evidence from Fish Fauna. In *Conservation Biology, the Theory and Practice of Nature Conservation, Preservation and Management.* (P. L. Fieller, and S. K. Jain, eds), pp. 127–169. Chapman and Hall City, USA.

NEST (1991). *Nigeria Threatened Environment. A National Profile*. Nigerian Environmental Study Team. Ibadan, Nigeria. 288 pp.

Obot E. A. and **Mbagwu I. G.** (1988). Macrophyte flora of the newly impounded Jebba Lake, Nigeria. *Afr. J. Ecol.* **24** (3):195–198.

Office of Technology Assessment (OTA) (1989). *Technologies to Maintain Biological Diversity.* OTA – F – 330, Washington DC, USA.

Ogwumike F. O. and **Ozughalu U. M.** (2001). Growth, Poverty and the Environment. In *Natural Resource Use, the Environment and Sustainable Development.* Selected Papers for the 2001 Annual Conference of the Nigerian Economic Society.

Oyesiku O. O. (1992). Ogun State in Nigeria. In *Ogun State in maps.* (Onakomaya *et al.,* ed.) Rex Charles Publication, Ibadan, Nigeria. 6 pp.

Polumin O and **Walters M**. (1985). *A Guide to the Vegetation of Britain and Europe.* Oxford University Press, Oxford. 238 pp.

Tarver T. P., Rodgers J. A., Mahler N. J. and **Lazor R. L.** (1986). *Aquatic and Wetland Plants of Florida.* Bureau of Aquatic Plant Res. and Control, Florida Dept of Nat. Res., Tallahassee, Florida 32303. 127 pp.

World Bank (1992). Dimensions of Poverty. In *Leading Issues in Economic Development,* 4th edn. (G. M. Meier, ed.), pp 20–25. Oxford University Press, London.

World Conservation Monitoring Centre (WCMC) (1992). Global Diversity: Status of the Earth's Living Resources. Chapman and Hall, London. pp 434–438.