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An Integrated Reclamation Scheme to Ensure Good Mining and Mineral Processing Practices in the Niger Delta Area of Nigeria

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Abstract: This study examines the environmental conditions of mining and mineral processing sites in the Niger Delta Area of Nigeria with special reference to Ondo State, Nigeria. For the purpose of the study, field data were collected on the location, locality, mining status and environmental conditions of solid mineral deposits in the states that make up the Niger Delta area of Nigeria. Hand-held Global Positioning System (GPS) receivers were used to determine the location of each site visited. Physical assessment of the environmental degradation as a result of oil and gas exploitation and unfriendly mining and mineral processing practices was done. The area was characterized by great biological diversity with sensitive and fragile ecosystem resulting from dangerous mining and mineral processing practices. To ensure good mining and mineral processing in the area, an integrated reclamation scheme has been developed.

Keywords: Environment, mining, processing, reclamation, remediation

INTRODUCTION

The Niger delta area of Nigeria is not only endowed with abundant oil and gas but with several solid mineral deposits. However, only very few of these minerals are currently being exploited. Others, which have the potential of being exploited on a commercial scale, are yet to be mined. The Niger Delta area comprises of immensely rich mineral deposits with close to one third of known solid minerals available in Nigeria (Daniel and Walker, 2004). Spreading over a total landmass of about 70,000 sq km, the region was inhabited by an estimated population of 20 million Nigerians in 2000 communities. The tribes that inhabit the area include the Ogonwas, the Ikwerres, Ekpeyes, Ogbas, Egbemas, Engennes and the Abuas of Ahoada division as well as the Obolos and the Opobo people (Williams, 2005; Jackson, 2003). In addition to the Ijaws of Western Delta were the Urhobos, Wasokos, the Itsekirwas and part of Kwale. In its present composition, the Niger Delta covers the 6 states of the South-South namely Akwa-Ibom, Bayelsa, Cross-River, Delta, Edo and Rivers. However, the legislation on the Niger Delta Development Commission (NDDC) in 2000 has further extended the frontiers of the Niger Delta to include Abia, Imo and Ondo States, thus making the political map of the Niger Delta to comprise 9 states out of 36 in the Country. According to Douglas (2002), the nine states of the Niger Delta region accounts for about 90 % of oil and gas export earnings accruing to the federation's account of the Federal Republic of Nigeria. The Niger Delta communities have settled in the area for several millennia, (Okonta and Osadebe, 2003)

Extraction and development of minerals are closely interlinked with other natural resources like land, water, air and forest. The area in which mineral occurs often have other resources thus presenting a choice of utilization of the available natural resources. According to David (2001) such areas are usually ecologically fragile while some are biologically rich. It is necessary to take a comprehensive view of these environmentally related issues in order to facilitate the choice of order of land use, keeping in view the need for technological development as well as need to protect the forests, environment and ecology of the area. These two aspects have to be properly coordinated to facilitate and ensure a sustainable development of mineral resources in harmony with environment. Mining activity often leads to environmental problems like land degradation particularly in open cast mining, land subsidence in underground mining, deforestation, atmospheric pollution, disposal of solid wastes, pollution of rivers and streams (Wilson, 2004). These phenomena usually affect the ecological balance of the area. Opencast mining in areas with actual forest cover leads to deforestation. Prevention and mitigation of adverse environmental effects due to mining and processing of minerals and restoration of the affected forest areas in accordance with the prescribed norms and

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Table 1: Location, classification and environmental conditions of identified solid minerals in the. Ondo state, Niger delta area of Nigeria

Mineral		Location	GPS readings									
NameLocal		government authority	Locality	Easting X	Northing Y	Elev. (m)		Mining status	Land use	Environmental condition		
Barite		Ose	Ifon	326274	369177	147		Undev.	Agric.			
Granite/ dimensional stone		Akoko South West	Oba (outskirt) Akoko	373107	363110	306		Aband.	Agric. alteration	Land scape		
			Oba town Akoko	373206	363308	313		Undev.	Agric. vegetation	Thick		
			Iwaro-oka Akoko	378416	369235	392		Being mined.	Agric. alteration	land scape		
			Supare akoko	384108	358039	359		Being mined	Agric. alteration	Land scape		
			Supare akoko	381818	357142	352		Being mined	Agric. alteration	Land scape		
		Akoko South East	Epinmi akoko	383233	381575	400		Abandd.				
								Agric.	Land scape alteration			
			Ipe-akoko	379466	378708	477		Undev.	Agric.	Thick vegetation		
		Ifedore	Igbara oke	290257	377098	352		Abandd..	Agric.	Land scape alteration		
Clay	IM4	Ose	Omialafa	330572	364821	165	7	Industrial	Undev. _			
		Akoko NW	Erusu	398095	374951	391	8	Industrial	Being mined	Open pit		
Filter sand	IM8	Okitipupa	Ode aye	294239	256285	29	9	Industrial	Undev ._			
Granite/ aggregates	IM9	Ose	Ori-ohin	328226	364207	149	10	Industrial	Being mined.	Quarry		
			Elegbeka	362769	334350	195	8	Industrial	Being mined.	Quarry		
			Afo isale	372658	375093	333	10	Industrial	Abandd..	Quarry		
			Afo oke	375757	373412	385	8	Industrial	Abandd..	Quarry		
		Akoko NW	Ise akoko	390954	382800	374	8	Industrial	Abandd..	Quarry		
		Akure North	Akure	357449	289695	295	9	Industrial	Being mined.	Quarry		
		Ifedore	Ijare	302255	371252	392	9	Industrial	Undev.	_		
		Ondo East	Ita Nla	346667	268824	257	8	Industrial	Undev.	_		
		Ondo West	Oka	340421	262728	246	10	Industrial	Undev.	_		
		Odigbo	OtuCostain	307945	275305	74	9	Industrial	Abandd.	Quarry		
		Ileoluji	Ileoluji	352358	268720	277	10	Industrial	Undev.			
Gravel/ sandstones	IM10	All except riverine	Widespread	Industrial	mined	Open	pit	Agric.		Land scape alteration		
Kaolin	IM12	Ose	Ute	315461	352117	136	8	Industrial	Undev._	Agric.		Thick vegetation
		Okiti pupa	Abu soro	292320	240513	51	10	Industrial	Aband.	Opein pit alteration	Agric.	Land scape
Laterite	IM13	All except riverine	Widespread					Industrial	mined	Opein pit	Agric.	Land scape alteration
Limestone	IM14	Ose	Okeluse	308655	351382	82	9	Industrial	Undev.	_	Agric.	Thick vegetation
			Okeluse	30906	351350	82	10	Industrial	Undev.		Agric.	Thick vegetation
			Okeluse	309053	351352	83	9	Industrial	Undev.	_	Agric.	Thick vegetation
			Okeluse	308563	349091	69	9	Industrial	Undev.	_	Agric.	Thick vegetation
			Ute	315986	350363	80	8	Industrial	Undev.	_	Agric.	Thick vegetation
			Arimogija	313131	361924	80	10	Industrial	Undev.	_	Agric.	Thick vegetation
River sand	IM19	Ilaje	Orere Ara	26021	253556	70	10	Industrial	Undev.	_	Agric.	Thick vegetation
		Okiti pupa	Igbotako	284077	242997	75	10	Industrial	mined	Dredging	Agric.	Erosion
Shale	IM20	Ose	Okeluse	308563	349091	69	9	Industrial	Undev.	_	Agric.	Thick vegetation
			Okeluse	312160	354608	87	8	Industrial	Undev.	_	Agric.	Thick vegetation
Silica / glass sand	IM21	Ilaje	Igbokoda	261930	261369	15	9	Industrial	Being Mined	Dredging	Agric.	Erosion
			Zion Pepe	238761	255609	32	9	Industrial	Undev.	_	Agric.	Thick Vegetation
			Iloro	259650	263360	16	10	Industrial	Undev.		Agric.	Thick Vegetation
			Aboto	256241	256384	30	9	Industrial	Undev.	_	Agric.	Thick Vegetation
			Akata (Igbala)	264250	241549	24	9	Industrial	Undev.	_	Agric.	Thick Vegetation
			Atijere	269134	230770	25	10	Industrial	Undev.	_	Agric.	Thick Vegetation
Iron ore	MMI	Akoko NE	Akunnu	401993	388047	399	9	Metallic	Undev.	_	Agric.	Thick Vegetation
Pyrite coal (lignite)	MM2	Odigbo	Agbabu	264686	289216	35	8	Metallic	Undev.	_	Agric.	Thick Vegetation
	CM1	Ose	Ute	345681	313651	393	8	Carbonaceous	Undev.	_	Agric.	Thick Vegetation
Tar sand / bitumen	CM2	Irele	Loda	271235	294556	66	10	Carbonaceous	Undev.	_	Agric.	Thick Vegetation

Table 1: (Continue)

Odigbo	Ofosu	305475	299960	69	11	Carbonaceous	Undev.	_	Agric.	Thick Vegetation
	Agbabu	264707	287852	36	10	Carbonaceous	Undev.	_	Agric.	Thick Vegetation
	Agbabu	264664	290579	34	10	Carbonaceous	Undev.	_	Agric.	Thick Vegetation
	Ago Alaye	292881	223582	81	9	Carbonaceous	Undev.	_	Agric.	Thick Vegetation
	J4 Junction	303875	208359	60	8	Carbonaceous	Undev.	_	Agric.	Thick Vegetation
Ose	Ute	350363	315986	80	8	Carbonaceous	Undev.	_	Agric.	Thick Vegetation

established forestry practices, should form integral part of mine development strategy in every instance. Mining operation should not ordinarily be undertaken in identified ecologically fragile and biologically rich areas. The objective of this paper was to examine the environmental conditions of mining and processing of solid mineral deposits in the Niger Delta Area of Nigeria with special reference to Ondo State. This was with the aim of developing an integrated reclamation scheme that would ensure best mining and processing practices.

MATERIALS AND METHODS

Field data on the location, locality, mining status and environmental conditions, of solid mineral deposit in the Niger Delta area of Nigeria were collected for the purpose of building an integrated reclamation scheme. The study was conducted in 36 locations in different local authorities of the region in the period from 17 June to 18 august 2007 (Table 1) Additional data and available records on exploration, mining and processing of solid minerals from libraries, relevant Government offices and agencies were also reviewed for the purpose of this study. These include State Mine Offices, Geological Survey offices, Federal and State Environmental Protection Agencies, companies involved in mineral exploration, mining and beneficiation, individual professionals and specialists in the mineral industry. A list of specific locations and places visited was prepared for field data collection on the environmental conditions of mining and processing practices in those places where there had been mining activities. Table 1 shows the data collected with respect to location and environment condition of identified solid minerals in Ondo State. Similar data were collected for other eight States. Hand-held Global Positioning System (GPS) receivers (Gamin 12XL) were used to record Eastings. Northings and the elevation of earth location visited. Data were also collected from field location where there were no mining activities but where a mineral occurrence had been indicated.

RESULTS AND DISCUSSION

General environment condition in the Niger delta area: The primary occupations of the people in the Niger delta area include fishing, farming, forest product gathering, craft, etc. usually at subsistence level. It was therefore no surprise that the flora and fauna of this area was rich. The higher-lying plains experience 5-7 months of flooding in the year, resulting from the overflowing waters of the lower Niger River in which whole communities and farmlands were invariably submerged. Flooding of river-banks and coastal erosion were common phenomena. The region was difficult if not an inclement terrain. The Niger Delta region has the world's third largest mangrove forest with the most extensive freshwater swamp forest and tropical rainforest (Van de Ban and Hawkins, 2001). The land was characterized by great biological diversity. Along the immense potential for agriculture, the region also has vast reserves of non-renewable resources, particularly hydrocarbon deposits in oil, gas and bitumen. Others were clay and silica. Because of these abundant natural resources, it can be said that the Niger Delta area has a sensitive and fragile ecosystem.

The complex environmental challenges of the Niger Delta area can be categorized into two:

- The difficult terrain,
- The menace of environmental degradation posed by prospecting for solid mineral, oil and gas.

The area represents an array of seemingly insurmountable physical constraints for human habitation. As with most deltas of the world, the region was fragmented into countless islands surrounded by an intricate network of rivers, rivulets and creeks. This would definitely make infrastructural development capital-intensive in such an environment.

The physical environment was mostly water with very low elevations, decreasing to below sea-level was some parts of the coastal arrears, thus, bringing about flooding in which the rivers over run their banks and the flooding-waters spread and deposit their sediments in the swamps.

Present mining and processing practices: The present state of exploration, mining and beneficiation of solid minerals in the Niger Delta state follow the general state of neglect of the solid minerals business in Nigeria as enumerated below.

Mining: Mining, especially surface mining which was common in all the places visited was generally environmentally unfriendly. Granite and marble quarrying for aggregates as dimension stones, clay, gravel and sand mining were the common mine quarry sites. Explosives were used almost on daily basis in some mining sites. The vibration and noise generated in some of these places (though basement) was observed to have reduced wildlife population in addition to weakening of the ground and

initiation of erosion. Landscape alteration and deforestation were common features in many of the abandoned and existing mine sites. Most of the existing mining companies do not have plans for restoration and reclamation of mine sites, judging from the conditions of abandon mine sites.

Although the miners claimed they had plans for restoration they were likely going to follow the trend unless adequate commitments were made. Indiscriminate borrows of laterite by some construction companies were observed to have caused serious erosion that was difficult to control in some areas. Mining, like mineral exploration, has affected all levels of local occupation in some places with illegal mining having the greatest noticeable impact on the environment. Some clay and sand mining sites were dotted with pits while erosion initiated by local mining have eaten up some farmlands. Some local mining practices were even very dangerous. For example, a clay mining site in Akwa Ibom State for example was at the base of a deep valley. The walls of the mining faces were almost vertical over 10m high in some places with heavy log trees hanging almost above the mines. Caving, sloughing and sometimes massive wedge and circular failures were observed to occur frequently and this was dangerous to the local miners. Field report from a sand mining site in Abia State also indicates a dangerous practice in which local miners make long shovels to undermine a sand deposit beneath a heavy overburden. This too was very dangerous as caving can lead to disaster.

It was also observed that the mine officers in most states were not adequately mobilized to monitor and control mining activities. The consequence of this was that mining activities were carried out without consideration for the environment. Pollution of the environment was also a common feature in places where clay mining was been done as dust was seen covering parts of some tarred roads. Continuous dust inhalation will undoubtedly lead to some health hazards. Some roads (especially in Ondo North Senatorial District) were said to have been damaged by heavy duty trucks used in transporting dimension blocks.

Mineral processing/beneficiation: Processing practices follow mining practices pattern. Since only a few of the identified minerals were actually mined for industrial purposes by truly mechanized and standard methods these few were also those processed by standard beneficiation techniques. The rest that were mined by local practices were processed locally or used as-mined. The standard processing practices seen in most of the states were those applied in:

- Glass sand processing for glass making.
- Granite/marble quarrying for aggregates and dimension stone production.
- Clay processing for various industrial uses.
- Pebbles processing for construction and decoration.

The crude processes seen in most of the places visited were applied to minerals /aggregate such as gravel, sand, clay and some times granite

Glass sand processing: The standard processing techniques seen were those employed by glass companies like Oluwa Glass Company at Igbokoda in Ondo State and Delta Glass Company at Ugheli in Delta state. Both employ gravity Processing using spirals and hydrocyclones to wash off impurities from the sand. Depending on the level of impurity in mine run-off, washing may be done in stages with batteries of spiral separators and cyclones.

Sand materials used by the local people were not seriously processed other than removing chaff by sorting since the normal use was for local building construction.

Aggregates and dimension stones: In aggregates processing, the fragmented rocks from the mine or quarry were crushed and then passed through screens of different sizes to classify them into size ranges such as 3/8, 3/4, 1/2, 1/4, 1 inches, hardcore and stone dust, which were used for various purposes. In dimension stone processing, the rock material would be blasted into blocks which were then cut into slabs of specified dimensions using gang saw machine or a wire saw. The cutting material (especially the wire) was equipped with hard carbide or diamond teeth. The slabs were then shaped ground and polished. In most of the dimension stone quarries visited, the latter part of the processing (i.e., shaping, grinding and polishing) was not done. The rock materials were either transported or exported as dimension blocks or as slabs. A crude process of making dimension stone was common in Ondo, Edo and Cross River States.

Clay processing: Presently in most part of the Niger Delta, clay is widespread. Some companies sometimes use standard methods like centrifugal classification to degrit the clay for paint and ceramic production. Processing for local uses involves manual digging and removal of the plant clay would then be polished or smoothen by hand and marked with a sharp object. In some places the polished and marked products were smoked to dry and then taken to the market. Some natives claimed that this was used for medicinal purposes. The most common local use of the clay was in making mud blocks, in plastering and painting of houses. When intended for plastering and painting, the clay was simply degritted by sedimentation. Some clay materials had less gritting inclusions and these were used as mined.

Gravel processing: Gravel in most of the areas where it was widespread was processed by sorting and jigging. The choice between the two depended on whether the gravel was mined in the waterbed or as an unconsolidated

deposit. When found in river bed, hand jigging with baskets was often used. Gravels processed in this manner were purer than those processed in places where there was limited supply of water. In this case, processing was done by hand sorting with a large number of women and children picking. Small ponds of water were made where the sorted product was washed. When the impurity was predominantly fine grained sand with little or no water content hand jigging was used most time with baskets but sorting was predominant in most of places that were visited. These practices were common in Akwa-Ibom state.

Environmental effect of mining: Environmental problems that may be caused by mineral exploitation include air, water pollution and soil pollution; quality alteration of landscape and ecological alteration which may involve extinction of some biological species. The nature and extent of environmental damage induced by mining will depend on the mining method employed and the nature of minerals being mined. Mining has two broad areas namely surface mining and underground mining. There were several methods under each of these that were applicable to mining different mineral types. The choice between surface and underground mining depends on the stripping ratio of a deposit and will be determined during the design of the mine. A surface mining method can also translate to underground mining at a depth when stripping for surface mining becomes uneconomical. Surface mining methods include open pit, open cast mining, strip mining, quarrying, alluvial mining, placer mining and solution mining. Surface mining methods were generally environmentally unfriendly than underground mining methods.

Quarrying, open pit and open cast mining and striping mining involves the use of explosives in excavation. So, in addition to altering the landscape, employing these mining methods create other disturbances like noise generation, dust generation, damage to building causing landside, induce erosion, disturb local occupation like hunting, farming fishing etc. surface mining can produce noxious wastes, that pollute water sources, drive some plants and animals into extinction or drastically reduce their population.

Environmental impact of mineral processing/ beneficiation: Processing or beneficiation was another important aspect of solid minerals development. Without processing, the crude ores were not useful in any industrial plant or process. Beneficiation helps to contrite mineral values from the low grade to higher percent composition of the valuable mineral. For instance, the Nigeria Iron ore Mining Company at Itakpe in Kogi State supplies iron ore concentrates to Ajaokuta and Aladja Steel Plants. The average grade of Itakpe iron ore as-mined was about 35% which must be upgraded through beneficiation to 65% and about 70% for Ajaokuta and Aladja Steel plants respectively. The purpose of processing may also be to remove colour or some minor impurities that affect the service properties of the mineral concentrate. An example of this was the presence of very small quantity of iron or other metal oxides in glass sand. If not removed, these will induce various colours in the glass produced from such sand. So, to concentrate mineral values, various techniques were used. Among these were: magnetic separation, Heavy Medium Separation (HMS), electrostatics and high-tension separation techniques, classification, gravity concentration methods, floatation and some hydrometallurgical processes. These processes have their environmental impact which should be minimized.

Like mining mineral processing or beneficiation can also be environmentally unfriendly. The level of environmental impact depends on the processing technique used. However, the major environmental problem of mineral processing considered here include air and water pollution that could result from tailing disposal and noxious particulates and gaseous emission from the mills, separators and material handling equipment. The toxicity of tailing and waste fluids depends on the processing technique employed. For instance, floatation, leaching and some colour removal processes employ chemicals, liquids suspensions and gases that leave toxic fluid which must be treated at the end of the separation processes. Some radioactive ores produce radioactive tailings and fluids, which must be treated before disposal. Similarly, processing mills and materials handling systems do generate dust which depends on the nature of the ore being processed. These products of processing, if not well contained and treated before disposal, can serve as pollutant to the air and water sources affecting both human and animals lives; and the ability of the land to sustain agriculture and other human activities.

Consideration of environmentally friendly/approaches to mining and mineral processing:

Mining: Environmental approaches to mining were usually more of remediation and minimization than total avoidance. Whichever mining technique was employed in the exploitation of a mineral deposit however, an environmentally friendly approach should be adopted and followed to minimize any adverse effect of such operation on the environment. Such should take into consideration the following which were fundamental to developing comprehensive and functional environmental remedial strategies:

- The resident and national interest.
- The legal regulatory problem.
- The baseline study and project design problem.

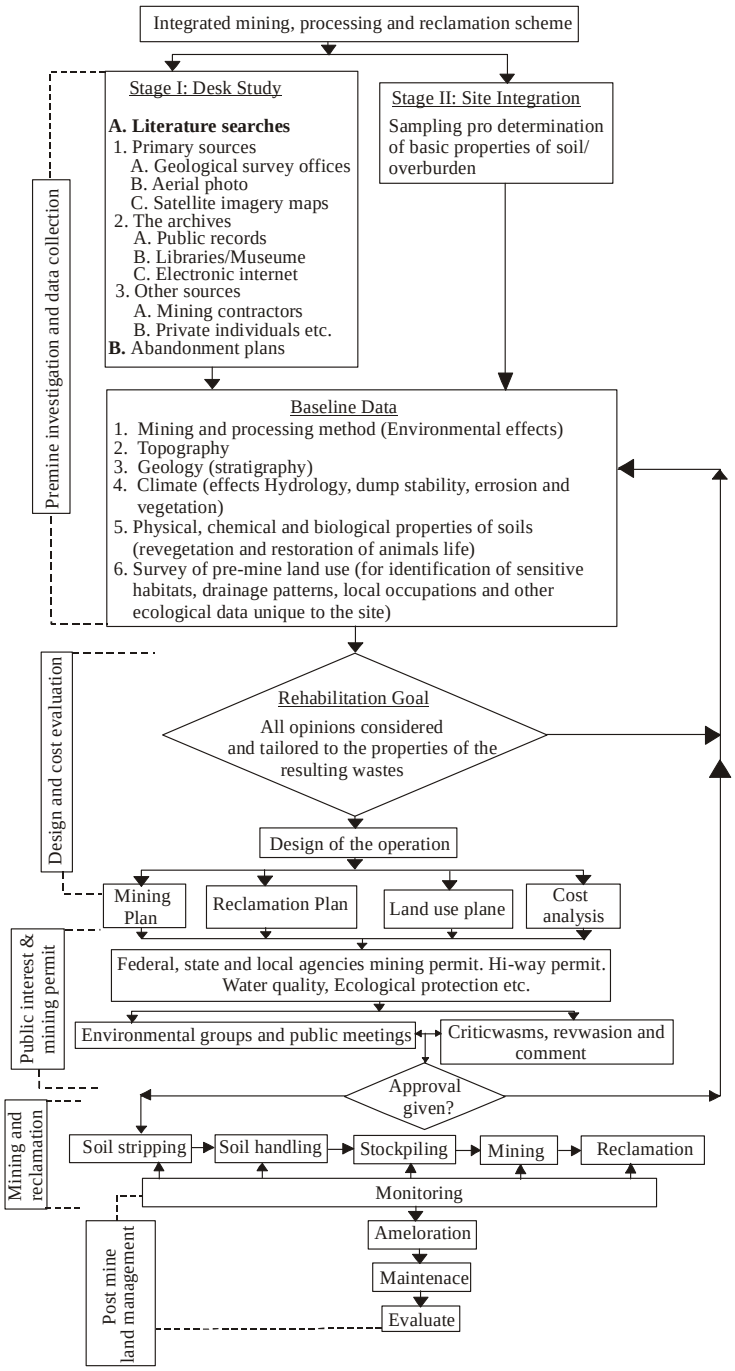

Fig. 1: Integrated mining, processing and reclamation Scheme

All of these were closely related and form the basis for ensuring environmentally friendly approaches to mineral exploitation. Generally, these problems can be solved through the development of an integrated reclamation scheme which kick-off immediately at the beginning of mining operations. Figure 1 shows an integrated mining and environmental remediation scheme that will ensure good mining and mineral processing practices. The reclamation scheme involves the following steps.

(1) Conduct a comprehensive Environmental Impact Assessment (EIA) of the entire area to generate a baseline data for subsequent assessment of the

environment during and after mining. Such baseline data should include information on the ecosystem the pre-mining landscape, hydrologic conditions; air purity or pollution status, survey of local occupations, soil and water pollution status, health status and demographic information. Continually assessing the environment on the basis of this information will ensure that any adverse effect on the environment was quickly identified and checked before it becomes a nuisance.

(2) Use available baseline data in project design and environmental impact simulation. The project design should be an integrated mining and environmental remediation scheme which should include:

- A programme for preservation of soil, plant and animal species (both terrestrial and aquatic) prior to mine development for use during restoration.
- A programme for air quality monitoring and fugitive particulates control.
- Water quality monitoring, waste treatment and disposal scheme.
- A programme for vibration and noise monitoring and control during mining.
- A programme for land restoration which should state specially the type of restoration, time and sequence of restoration operations.
- A programme for containment of any toxic product prior to their treatment.

Figure. 1 Shows an integrated mining and environmental remediation scheme which if strictly implemented will enhance an environmentally friendly exploitation.

(3) Details of exploration data should be used during the mine design stage (with a sufficiently powerful GWAS software), to create a perspective view of the area after the life of the mine. This will help in drawing restoration plan for post-mining land use.

(4) Other available baseline data should also be used in the same manner as above to simulate other possible environmental problems such as erosion, subsidence in adjoining land, hydrologic disorder and local occupation disorder.

(5) The available data with the results of 3 and 4 should be used to determine the type of land use and hence restoration and treatment plans to be adopted, If the land will eventually be used for any of agriculture, forestry, housing, industry, amenity, sport, water sport, conservation (nature) waste disposal or combinations of these.

(6) Enact necessary legislation to protect the environment; and if adequate law exists for protection of the environment and indigenes of places where mineral deposits were found, such should be enforced.

(7) Ruling authority through appropriate ministry and agencies should have blue print of the operations of any mine and its environmental restoration plan before issuing license for development of such mines. To be effective, such plan should be submitted with application for issuance of lease or license. This implies that each application should be accompanied by a perspective view of the area after the life of the mine

(8) Proper monitoring of the mines operations either directly by the ministry and agency or through a competent consultant should be adopted in order to ensure compliance with environmental plan.

(9) Caving patterns in underground mines should be such that their effects do not transmit to the surface otherwise slurry pumping should be used to fill abandoned or worked underground sites.

(10) Where chemicals were used in solution mining underground or used to aid coal gasification, wells should be located in such a way that their fluid emission does not affect nearby aquifers or any source of underground water.

(11) Capacity development training should be undertaken for all mines officers and mines offices adequately equipped with necessary tools and mobility.

Mineral processing/beneficiation: The most environmentally friendly approaches to Mineral processing/ beneficiation were in all respects similar to those of mining and exploration. However the following were suggested in addition to any applicable approach from mining and exploration:

- Environmental baseline data on Streams, Rivers and other sources of water for human and animal consumption should be made handy and used as a basis for monitoring water quality during mineral processing.
- Rivers, streams, air and other water bodies (including water wells and boreholes) within 50 km radius of the plant should be constantly sampled and analyzed to determine their effects on both surface and underground water.
- Waste dumps and tailing dams should be located such that rivers and streams were not easily contaminated by effluents and spillages from them.
- Grinding mills should be controlled to prevent dust, pulp and oil from spilling into the environment.
- A reputable consultant in mining and metallurgical processing environment should be appointed to

monitor both the plant and the mine where these were located close to each other. Alternatively, the appropriate ministry or government agency could be empowered to constantly monitor plant operations by taking samples of plant products and water from streams and rivers around and analyzing them to determine any change in the characteristics of the particular environment. Also a combination of the expertise of a consultant and appropriate ministry or agency may be more effective.

- Capacity development training should be frequently organized for all those involved in environmental monitoring and these adequately equipped with necessary tools and mobility.
- Toxic and radioactive waste products (where produce) should be temporarily stored in a safe place before their treatment and final burial in an impermeable ground.
- Legislation should ensure that all environmental indices affected by the mineral processing plant operation were adequately internalized and plant operators encouraged to implement it.

CONCLUSION

Resulting from the general description of the environmental conditions of the Niger Delta region was the fact that the region was endowed with abundant mineral resources which, no doubt can contribute immensely to the socio-economic development of the region, reduce poverty and raise the living standard and quality of life of the people. However, before this can be achieved, the minerals ought to undergo two major stages of development i.e mining and processing. These two stages could cause different types of environment damage which included ecological disturbance, erosion of river banks, destruction of natural flora and fauna, pollution of air, land and water, geological hazards due to instability of soil and rock masses, landscape degradation and radiation hazards. The environmental damage caused by small-scale mining activities of laterite, clay, kaolin, gravel and sandstone by private entrepreneurs was far much less, buy more difficult to control. Mining of most minerals were characterized by unsightly debris of rock wastes, pits associated with construction works and some of which were turned into unsightly refuse dumps, particularly in the urban areas, there were evidence of environmental degradation related to mining of these mineral resources. Characteristic of most mineral deposits in the study area was lack of accessibility to the locations of the deposit, which could make mining capital intensive. Since damage to the environment was inevitable, therefore both the government and the mineral industry must be involved in precautionary and remedial measures that can minimize the environmental impacts of mineral development. Government should provide the regulatory legislation with appropriate sanctions, while the mineral producing companies were to carry out mandatory precautions, remedies or compensation for the damage done. Mining and mineral processing plan should only be approved only when accompanied with comprehensive time and financial bound reclamation programme.

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