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Recovery, Utilization, and Environmental Effects

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Some Retrofit Considerations for Revitalizing and Upgrading the Oji-River Coal-Fired Thermal Power Station for Service in 21st Century Nigeria

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The major objective of this article is to show that in the context of sustainable development, coal and its downstream power generation industry could complement petroleum and hydroelectric industries in the national power generation scheme.

The continued utilization of coal in power generation schemes in the world as well as environmental pollution caused by other fossil fuels were examined. These were presented as justifications for the proposed reintegration of coal as a complement to hydropower and oil/gas sources of electric energy in Nigeria.

The scheme of power generation in the Oji-River thermal station was reviewed to enhance the appreciation of the retrofit models to be presented for the revitalization of the plant.

Subsequently, 2 sustainable development retrofit models were considered for the revitalization of the Oji-River thermal power station and enhanced industrial civilization of the Oji neighborhood, as this article will show.

To ensure self-sufficiency, this article will show how the 2 retrofit models will depend on abundant locally available resources, namely, coal, limestone, water, and air.

Keywords downstream power generation industry, revitalization, sustainable development retrofit models, enhanced industrial civilization, self-sufficiency, locally available resources

Introduction

In the ongoing era of economic reform under the names of deregulation, liberalization, and privatization of government monopolies, the 30 MW Oji-River coal-fired thermal power station is a potential investor-attracting power-generation project.

The situation in Oji-River, a town that is about 35 km west of Enugu (Figure 4 in the appendix), the power-generation plant was commissioned in 1956 by the British colonial government. It served the defunct Eastern Nigeria that is currently made up of Enugu,

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Anambra, Ebonyi, Abia, and Imo States. It depended on the coal from the Enugu coal mines that was supplied by a bucket conveyor system that covered about 35 km.

Security consciousness resulting from the Nigerian civil war of 1967–1970 was apparently responsible for stunting the development of coal and its downstream industries by the military and political classes through encouraging the development and domination of petroleum as an alternative source of energy in the 1970s and beyond. This led to neglect of the Oji-River thermal station and its eventual shutdown in 1990 on the grounds of environmental pollution and increasing operational/maintenance costs, while its counterpart, the Ijora power station in Lagos that was also coal fired, was converted to a gas-fired power station. Other coal-dependent industries that virtually died with the plant were the Nigerian cola corporation, the Nigerian cement company Nkalagu, and the Nigerian railway corporation (even the dieselization of the locomotive engines did not save its situation). Thus coal became irrelevant in the Nigerian economy and energy mix.

In recent times, efforts to redress the unfortunate development by diversifying our economic and industrial developments have resulted in the following phenomena:

1. The Ministry of Solid Mineral Development in 2001 signed an agreement with a South African Consortium for the revitalization of Enugu coal mines.
2. During the visit of the president of Nigeria to Enugu State in 2000, the governor took his august visitor to the Oji-River thermal power generating station with a view to restarting the shutdown plant.
3. The vandalization of 330 kV of transmission line in Edo State in 2001, which put all the Eastern States, Taraba, and Benue States to 9 days of power blackout, inspired various levels of governments and well-meaning Nigerians to join in soliciting the federal authorities for the reactivation of the Oji-River plant.

Given the forgone excursion into the trend of events surrounding the Oji-River power station and the need to address multiple energy dependencies as the bedrock of the rapid industrialization and economic-development engine, this article will look at the retrofit considerations necessary to upgrade and put the Oji-River power generation station back into operation. To this end, this article is broken up into the following sections:

1. to justify the need to reintegrate coal into the Nigerian commercial/industrial energy dependencies;
2. to review the thermal power-generating scheme obtainable at the Oji-River plant;
3. to present the retrofit models that ensure sustainable development in the environment;
4. to conclude the paper.

Justifying Energy Dependency on Coal

Contribution of Coal to Electricity Generation

Coal is the most widely utilized resource for electricity generation, as Table 1 shows. It contributes 40% to the total electricity utilization in the world.

Also, Table 2 shows that coal that is being used in high percentages in advanced industrialized countries, namely, the USA and the UK, was neglected and abandoned by federal authorities and that coal's percentage contribution to power generation is zero in Nigeria.

Table 1
World electricity generation resource

Energy resource	Percentage utilization (%)
Coal	40
Hydroelectric	21
Nuclear	17
Oil	11
Gas	10

Source: Iwu, 1998, p. 18.

However, the following sections will show that petroleum development, which the military/political classes undertook with a corresponding de-emphasis on coal usage and development, is not pollution-free.

Oil Spills and Contamination

Oil exploration and exploitation cause some fatalities, spillages, and environmental contamination. One example was on March 24, 1989, when the US experienced one of the worst spillages ever when the Exxon oil tanker Valdez wrecked and spilled 11 million gallons of crude oil, which produced a slick of over 3,000 m^2 along the South Alaskan Coast. Cable News Network (1999) reported that the accident was one of the worst oil spills in US history and that US $3 billion was spent on cleanup of the spill. Despite this accident, the world and Nigeria have not abandoned crude oil.

In Nigeria's Niger-Delta, crude oil production results in sand/oil sludge and oily waste water, which contaminate land, swamps, and seas on which drilling/production rigs are situated.

Oil spillage caused by host-community sabotage, employee error, and facility failure results in contaminated land, soil, and water. Subsequently, expensive cleanup operations are undertaken as remediation measures to restore the contaminated environment and ensure sustainable development. The Shell Petroleum Development Company of Nigeria Limited (SPDC, 2000, p. 36) reported that a total of 340 oil spills were recorded in 2000, accounting for 30,751 barrels of oil spilled.

Table 2
Percentage contribution of coal in power generation

Country	Percentage contribution (%)
China	90
India	90
UK	60
USA	50
Nigeria	0

Source: Iwu, 1998, p. 18.

Gas Flaring and Venting

Routine gas flaring in Nigeria during oil production, which produces a yellow flame plus visible dark-brown smoke, is indicative of incomplete combustion leading to environmental acidification. Oguejiofor (2000b, p. 101) showed the annual levels and trends of the various pollutants poured into the atmosphere by gas flaring by the upstream petroleum industry in Nigeria. Flaring heats up the surrounding environment and causes significant loss in crop yields within 1,000 m of the flare station (Oguejiofor, 2000b, p. 103).

Gas venting pours volatile organic compounds and methane, CH_4, into the atmosphere. CH_4 is known to be a greenhouse gas that has the potential to contribute to the global warming phenomenon.

All of this justifies that coal and its downstream industries are not alone in environmental pollution. However, the need for sustainable development inspired statutory and regulatory authorities to ensure compliance with environmental quality standards put in place to control pollution and contamination during resource exploration and exploitation. Examples are the relevant laws of the land, the regulations of the Federal Environmental Protection Authority (FEPA), the Department of Petroleum Resources (DPR), and the popular International Standard Organisation's (ISO) 14001.

Coal Cleanup Technologies

Enugu is known to have low sulphur content coal and so gaseous emissions from the burning of Enugu Coal is not likely to foul the environment as much as coal with a high sulphur content. According to Atuanya et al. (2001, p. 3), Enugu coal was analyzed and found to have 65.4% of carbon as received and 71.9% as washed, 0.68% of sulphur, 0.008% of phosphorus, specific gravity of 1.3, and a softening point of 365°C. Aside from this, the development of advanced clean coal technologies (ACCT) ensures that all gaseous emissions from coal combustion are reduced to the barest minimum. Models of such technologies that involve particulate removal, gas scrubbing, or fluidized bed combustion that ensures low temperature combustion will be presented later in this article.

Review of the Oji Thermal Power Generation Scheme

Figure 1 is the schematic representation of the Oji-River coal-fired thermal power station shutdown in 1990. Heat needed to convert water into steam is obtained by coal combustion in the boiler. High pressure steam is raised by this means. By charging the high pressure steam to impinge on the blades of the turbine, high-speed rotation of the shaft is obtained. Thus chemical energy is converted to rotary mechanical energy. The rotation of the turbine is transferred to the electric generator coupled to it, thereby converting mechanical energy into electrical energy. The steam is condensed by river water drawn from the river, and the condensed steam (water) is returned to the boiler. About 1.3 kV of electrical energy is generated and transmitted to the generator transformer, where it is stepped up to 330 kV and transmitted to the switching station for connection to the natural grid (see Figure 1).

The review of the scheme of Oji-River power generating station provides a strong basis for enhanced appreciation of the models of retrofit considerations for reactivating the station.

Retrofit Models for Oji-River Plant Revitalization

Burning of coal and other fossil fuels emits pollutants such as SO_2, NO_x, CO_2, and particulate ash. According to Kirkby (1983, p. 192), power plants typically have large

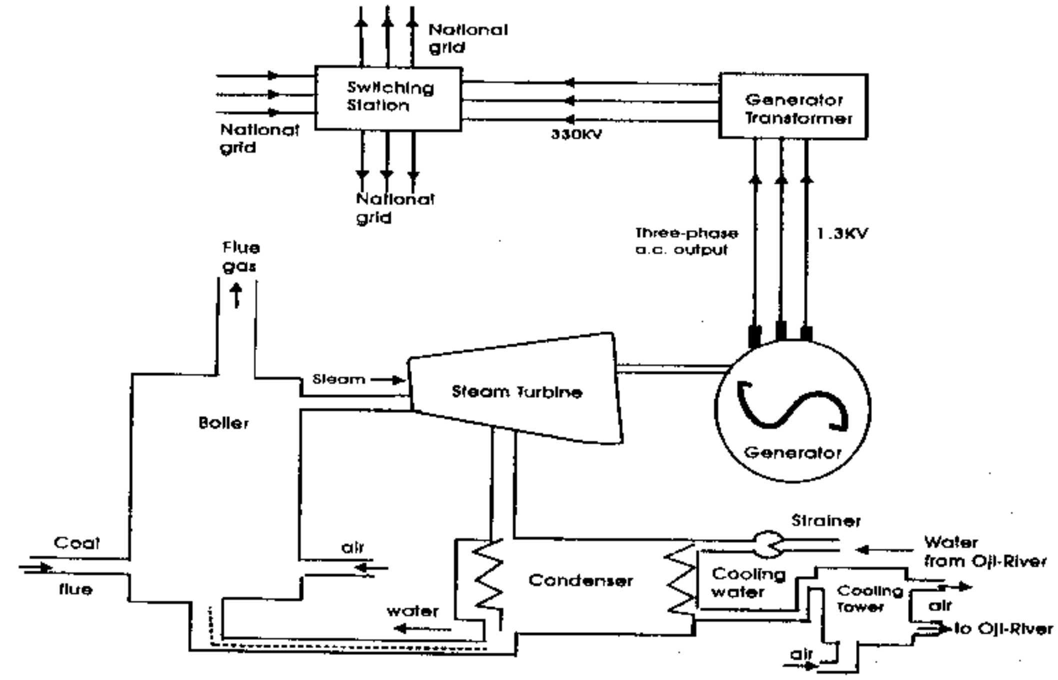


Figure 1. Schematic representation of the coal-fired Oji-River thermal power station. *Source*: Oguejiofor (2002).

volumes of gas and low SO_2 concentrations, while chemical plants such as sulphuric acid units have higher concentrations but lower volumes.

SO_2, NO_x, and CO_2 are acid gases. The transformation in the atmosphere of these oxides into acids give rise to the phenomenon of environmental acidification (Oguejiofor, 2000, p. 101). Environmental acidification leads to acid rain, which attacks everything, namely, vegetation, soils, steel structures, masonry works, and road pavements, and possibly causes hair loss in humans and animals.

Apart from being an acid gas, CO_2 is a greenhouse gas that has global warming potential. Therefore the retrofitting of boilers and furnaces for CO_2 removal is very important.

In view of the foregoing, the removal of the greenhouse and acid gases from the flue gas stream will ensure sustainable development. Sustainable development is achieving economic and industrial advancements without compromising the environment. This definition may have been the vision of Theodore Roosevelt in 1900 when he said, "I recognize the right and duty of this generation to develop and use our natural resources, but I do not recognize the right to waste them, or to rob by wasteful use, the generations that come after us." In the context of this work, sustainable development is therefore the retrofitting of industrial plants for environmental protection. To this end, the retrofit considerations for putting the Oji-River thermal station back into service will present 2 clean-coal utilization technology models plus an alternative option.

Flue Gas DeSO$_2$, DeCO$_2$, and DeNO$_x$ (FGDDD) Model

The acronyms for flue-gas desulphurization (DeSO$_2$), decarbonization (DeCO$_2$), and denitrification (DENO$_x$) may be combined to give the FGDDD model or simply the FG3D model. The scheme of the model is presented in Figure 2.

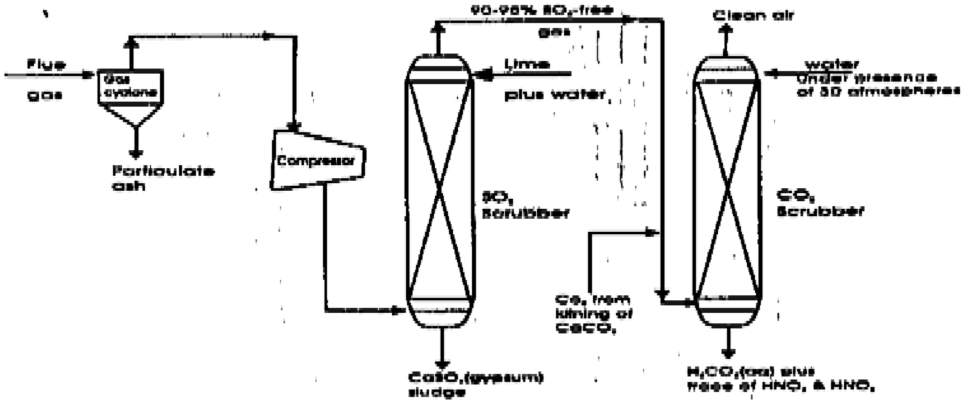


Figure 2. Process diagram of SO_2, CO_2, and NO_x treatment: when Enugu low sulphur content coal and complete combustion are *not* enough.

$DeSO_2$. Flue-gas desulphurization $DeSO_2$ employs a chemistry of reacting gaseous sulphur dioxide, SO_2, with lime (calcium hydroxide $Ca(OH)_2$) in a scrubber (Figure 2) to precipitate insoluble calcium sulphate, $CaSO_4$ (gypsum sludge), as shown in the chemical equation below:

$$SO_2(g) + Ca(OH)_2(l) \rightarrow CaSO_4(s) \downarrow + H_2O(l).$$

The process produces about 90–95% SO_2-free gas, but generates huge quantities of waste $CaSO_4$ and requires a huge supply of lime. This is obtained by quarrying and then kilning (heating) limestone $CaCO_3$, a process that drives off carbon dioxide and produces calcium oxide, CaO:

$$CaCO_3(s) + \text{heat} \rightarrow CaO(s) + CO_2(g).$$

By slaking, a process of reacting CaO with H_2O, lime for SO_2 removal is produced according to the equation below:

$$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(l).$$

$DeCO_2$ and $DeNO_x$. The SO_2-free gas containing CO_2 and NO_x from coal combustion is mixed with CO_2 from kilning and charged to the bottom of the scrubber (Figure 2). Hot water under pressure of 30 atmospheres is fed into the top of the scrubber. The conditions of the reactants (temperature and pressure) enhance the solubility of the gases in water, and dissolution of CO_2 and NO_x is facilitated as the following equations presented by Oguejiofor (2000, p. 101) will demonstrate.

$DeCO_2$ equation:

$$CO_2(g) + H_2O(l) \rightleftarrows H_2CO_3(aq).$$

$DeNO_x$ equations:

NO_x is a mixture of nitrogen monoxide and nitrogen dioxide. The oxidation of nitrogen monoxide by available oxygen to form nitrogen dioxide is shown:

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g).$$

Nitrogen dioxide dissolves in the scrubbing water to give nitrous acid and nitric acid as presented below.

$$2NO_2(g) + H_2O(l) \rightarrow HNO_2(aq) + HNO_3(aq).$$

Economics of the FG3D Model. Such huge quantities of limestone are readily available at cement factory locations in Northern, Eastern, and Western Nigeria that Nigeria could be described as a limestone territory. Large reserves are located at Yandev (Benue State), Ashaka (Bauchi State), Ukpilla (Edo State), Ewekoro (Ogun State), Nkalagu (Enugu State), and Calabar (Cross River State) Odomoke near Abakaliki, and Awgu, to mention just a few locations. The nearest limestone reserve to Oji-River being Nkalagu is currently bedeviled by obsolete mining equipment.

The other naturally-endowed raw material for the Oji-River thermal station is coal. The coal reserve is about 2.75 billion metric tones, but production that is located mainly in Enugu and Okaba (Kogi State) areas is $< 0.01\%$ of the total reserve per year (Iwu, 1998, p. 4). Atuanya et al. (2001, p. 3) states that Enugu coal was analyzed and found to have a gross calorific value of 32.91 MJ/kg°C (dry and ash free) and a net calorific value of 16.00 MJ/kg°C. However, the Nigerian Coal Corporation is currently plagued by obsolete equipment. Of course the river at Oji-River provides the water requirement, while the other raw material, air, is freely available. All of these are pointers to the abundance of raw materials for the economics of the FG3D Model.

The products derivable from the FG3D Model are particulate ash (soot), gypsum, and aqueous carbonic acid. Soot would be useful in making rubber tires, black shoe polish, printer's ink, typewriting ribbons, carbon paper, and toners for photocopiers. Gypsum is usable in cement manufacture, the plasterboard industry, and landfill projects. Carbonic acid is applicable as a chemistry reagent for the teeming school population.

Fluidized Bed Combustion, FBC Model

Another retrofit consideration for revitalizing the Oji-River thermal power station is the fluidized bed combustion (FBC) model. Powdered coal is mixed with powdered limestone or dolomite and the mixture is fed into the combustion chamber (Figure 3). Compressed air is blown into the combustion chamber from below, making the mixture behave like a fluid (hence the name). According to McCormick (1997, p. 43), combustion takes place without visible flames at a temperature of about 850–900°C (1560–1650°F), much less than the 1650°C (3000°F) needed in conventional coal-fired systems. The lower temperature reduces oxidation of elemental nitrogen to nitrogen oxides, and SO_2 emissions are reduced by about 90% by its reaction with limestone to produce dry gypsum. The entrained gas from the fluidized-bed combustion is separated by cyclone. However, for optimum particle sizes $< 1\ \mu$ and optimum gas concentrations > 0.1 grains/ft^3, an electrostatic precipitator is suitable (Oguejiofor, 2000, pp. 108–109).

As shown in Figure 3, fluidized particles circulate between the combustor and the boiler via the cyclone. Steam is raised in the boiler by heat exchange between the hot circulating solid particles and the flowing water. The steam raised is fed into the turbine to generate electricity as shown in the Figure 1 arrangement. To get rid of the CO_2 that is both an acid gas and a greenhouse gas, it is charged to the bottom of the scrubber. A counter current flow of water at about 30 atmospheres dissolves about 95% of the CO_2.

Economics of the FBC Model. Enugu State coal is a cheap fuel and the reserves of 42,670,000 tonnes have been proved by drilling at Enugu, 29,470,000 tonnes at Ezimo, and 32,000,000 tonnes at Awgu Ndeabo Shale (Federal Republic of Nigeria, 1987, p. 47).

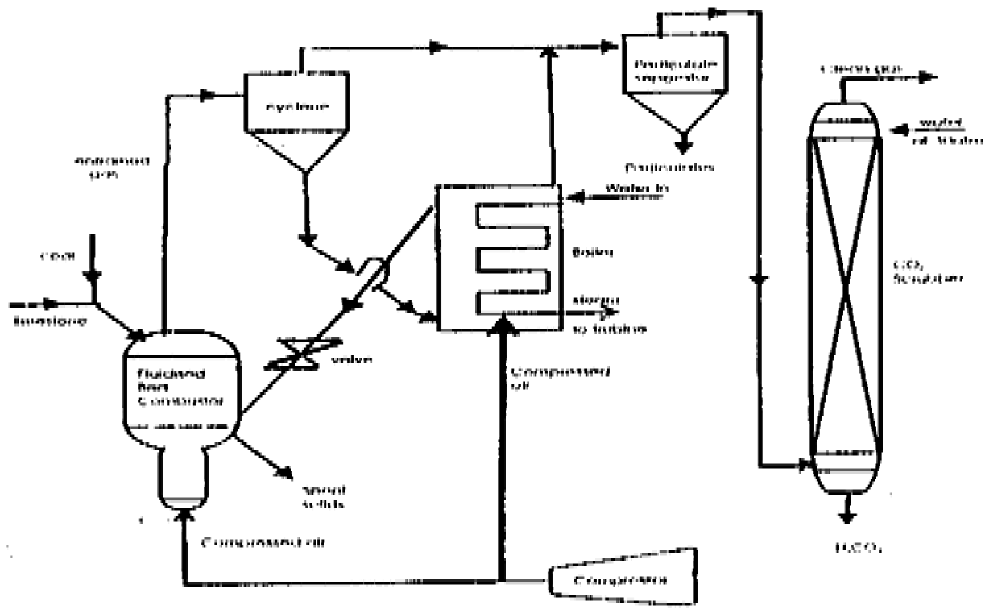


Figure 3. Alternative model for treating gases for sustainable development; when Enugu low sulphur content coal and the efficient fluidized-bed combustion are not enough.

Limestone and dolomite are relatively cheap and available in huge commercial quantities at Nkalagu. According to Berry (1983, p. 195), limestone and dolomite are used in amounts that range from only 5 to 10% of the coal charged.

Gas Utilization Option

Huge natural gas deposits are available at Ugwuoba, Enugu State, a neighboring town to Oji-River. Should the federal authorities follow their earlier precedence whereby the Ijora power station was converted to a gas-fired plant, then the huge gas resources at Ugwuoba should be exploited for the revitalization and upgrade of the Oji-River counterpart. About 15 km of gas pipeline would be required to deliver gas from its deposits at Ugwuoba to the plant location at Oji-River.

Conclusion and Recommendations

The challenge of industrialization and economic development in Nigeria is to exploit endowed abundant resources to produce value-added goods and services within the context of sustainable development. This paper presented 2 clean coal utilization models for retrofitting into the Oji-River thermal power station when revitalizing it.

Therefore in this era of deregulation, emergence of independent power generation, Independent Power Generations (IPG) enterprises, and serious government concern about solid mineral development, the federal government should do the following:

1. revitalize or transfer the Oji-River coal-powered thermal power station to interested investors/entrepreneurs in the power generation industry for subsequent revitalization.

2. build thermal power plants at locations where huge coal deposits, limestone reserves, and rivers are readily available to complement power supply from the nation's hydroelectric and gas/oil sources.

The diversification of power generation suggested above would provide the electricity needed for the following:

1. rapid industrialization and economic advancement and of course the technology transfer needed for coping with events of the modern world.
2. rural electrification, which in turn will check rural to urban migration that plagues rural agricultural production/development on one hand and on the other hand would encourage the menace of the urban motorcycle transport business popularly known as "okada" transport.
3. providing alternative electricity sources on one hand and on the other hand preventing blackouts whenever an accident or vandalization of a major transmission line, such as a 330 kV transmission line, takes place in future.

References

Atuanya, C. U., S. Omenyi, S. I. Okeke, and O. D. Onukwuli. 2001. The effect of methanol on the wetting properties of Enugu coal particulate, Journal of Engineering Technology – The Publication of the Faculty of Engineering and Technology, Nnamdi Azikiwe University, Awka, Nigeria, p. 3.

Berry, R. I. 1983. Fluid-bed gets the nod. In *Process technology and flowsheets*, vol. II, edited by Richard Greene and the Staff of Chemical Engineering. New York: McGraw-Hill Publications Company, pp. 195–197.

Cable News Network, CNN. 1999. Broadcast of the documentaries of the 20th century events.

Federal Republic of Nigeria. 1987. Mineral and industry in Nigeria with notes on the history of geological survey in Nigeria, 2nd ed. Lagos: Government Press, p. 47.

Iwu, G. O. 1998. Coal utilisation in the industrialisation and development process of the nation, paper presented at the *28th Annual Conference of the Nigerian Society of Chemical Engineers*, NSChE Enugu, Nigeria, p. 18, p. 4.

Kirkby, D. R. 1983. Flue-gas desulphurisation produces salable gypsum. In *Process technology and flowsheets*, vol. II, edited by Richard Greene and the Staff of Chemical Engineering. New York: McGraw-Hill Publications Company, pp. 191–192.

McCormick, J. 1997. *Acidearth the politics of acid pollution*. 3rd ed. London: Earthscan Publications Ltd., p. 43.

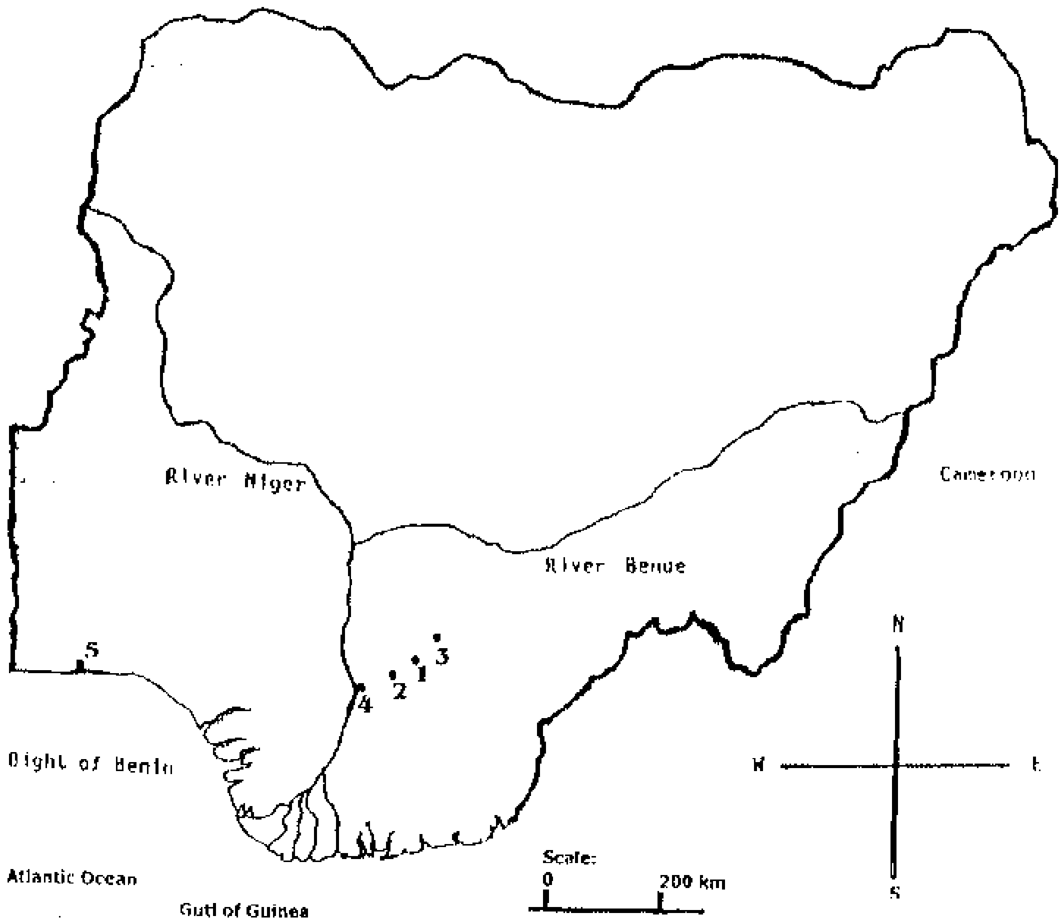
Oguejiofor, G. C. 2000a. Counting the costs of gas flaring and venting for enhanced gas resource management in Nigeria, *Proceedings of the 30th Annual Conference of the Nigerian Society of Chemical Engineers*, NSChE Warri: NSChE Publications, November 9–11, p. 154.

Oguejiofor, G. C. 2000b. Gas flaring in Nigeria: Converting flue gas pollutants into revenue-earning fertilizer by the low-cost retrofitting of flare stations. *International Journal of Environmental Education and Information*, 19(2):99–114.

Oguejiofor, G. C. 2002. Sketch during excursion to Oji-River power plant site, January 7.

Shell Petroleum Development Company of Nigeria Limited, SPDC. 2000. *People and the environment annual report*, p. 36.

Appendix



KEY
- 1 Enugu Coal Mine Location
- 2 Oji - River Power Plant Location
- 3 Nkalagu Limestone Deposit
- 4 Onitsha
- 5 Lagos

Figure 4: Map showing the location of endowed resources for revitalisation and Sustainable - development retrofitting of Oji - River Power Station

Figure 4. Map showing the location of endowed resources for revitalization and sustainable development retrofitting of the Oji-River power station.