TECHNOSCIENCE REVIEW

(An international science, engineering, technology & development academic research journal)

Volume 1, Numbers 1&2, November 2010

Welfare & Industrial Promotions (WIPRO) International
The Eastern Nigeria Industrial Estate
30 Zik Avenue, Uwani
P.O. Box 9060, Enugu.
www.wiprointernational.org

TECHNOSCIENCE REVIEW

(An international science, engineering, technology & development academic research journal)

The **aim** of the ***Technoscience Review (TR)*** derives from the **mission** and **objective** of the Publishers, ***Welfare & Industrial Promotions (WIPRO) International,*** as follows:
Mission: Confronting the abounding development challenges in developing countries;
Objective: Using research, publication, conference, enterprise development and awareness creation to develop the total man in developing countries.

BETTERING THE LOTS

Welfare & Industrial Promotions (WIPRO) International

The Eastern Nigeria Industrial Estate, 30 Zik Avenue, Uwani, P.O. Box 9060, Enugu
Phone: +234-805-315-2828, +234-803-338-7472, *www.wiprointernational.org*

Published by
Welfare & Industrial Promotions (WIPRO) International
The Eastern Nigeria Industrial Estate
30 Zik Avenue, Uwani
P.O. Box 9060, Enugu
Phone: +234-803-338-7472, 805-315-2828
www.wiprointernational.org

Cover, Design & Concept: Rowland Egolum & Felix Ezeh

CONTRIBUTORS

Nnaji, Chidozie Charles
Lecturer, Department of Civil Engineering, University of Nigeria, Nsukka

Ozougwu, Patrick
Department of Civil Engineering, University of Nigeria, Nsukka

Augustus O. Atubi (Ph.D.)
Senior Lecturer and Head, Department of Geography and Regional Planning, Delta State University, Abraka, Nigeria.

Onyenekenwa Cyprian Eneh
Senior Research Fellow, Institute for Development Studies, Enugu Campus, University of Nigeria, Nsukka.

Isife, Chima Theresa (Mrs.)
Research Fellow, Institute for Development Studies, Enugu Campus, University of Nigeria, Nsukka.

CONTENTS

Editorial … … … … … … … … … … 1

Comparative Analysis of Sewage, Abattoir Wastewater and Cassava Wastewater
- *Nnaji, Chidozie Charles and Ozougwu, Patrick* … … … … 3

Effects of Petroleum Refinery Effluents on River Iffie Water in Delta State, Nigeria
- *Atubi, Augustus O. (Ph.D.)* … … … … … … … 11

The Chemist and environmental sustainability
- *Onyenekenwa Cyprian Eneh* … … … … … … … 19

ICTs for sustainable development in Nigeria
- *Isife, C.T.* … … … … … … … … … … 25

Book Review … … … … … … … … … 35

Call for articles … … … … … … … … … 39

EDITORIAL

For many centuries, technological advances of great significance were made without benefit of knowledge from science. The iron production, printing, and hydraulic engineering, including dams, canals, irrigation systems, water wheels, canal locks, barbed wire, food preservation, fermentation and many metallurgical processes are instances where technology ran ahead of science. The steam engine was commonplace before the science of thermodynamics elucidated the physical principles underlying its operations.

With the growth of the chemical and electrical power industries in the 19th century, scientific knowledge was of direct use in solving of problems and the development of products, although it was rarely sufficient on its own. Later, the communication and electronic industries manifested the effectiveness of a close relationship between science and technology, as indeed did the experience of World War II and subsequent more local military conflicts. By the second half of the 20th century, much modern technology was intimately related to scientific knowledge, and science itself had become increasingly linked to technology through its dependence on complex instrumentation to explore the natural world. More similarities than differences can be found between science and technology. Both terms imply a thinking process, both are concerned with causal relationships in the material world, and both employ methodology that results in empirical demonstrations that can be verified by repetition. The symbiotic and synergistic relationship between modern science and modern technology has thrown up the term "technoscience" to describe the essentially merged, even hybrid, enterprise.

So far, academic journals appear to dissect and concentrate on various aspects of technoscience, rather than them together. Thus, there are journals of science, technology, engineering, etc. There is the need for an academic research journal of technoscience, to integrate the various aspects of technoscience, which have become hybridized, especially at the rapid rate of technoscience development and growth. This has birthed this *Technoscience Review*.

This maiden edition focuses on Environment and ICTs. In the first article, Charles Nnaji and Patrick Ozougwu of the Civil Engineering Department, University of Nigeria, Nsukka report on comparative analyses of sewage water, abattoir wastewater and cassava wastewater in Nsukka area. Sewage, cassava wastewater and abattoir wastewater were subjected to different temperatures for a period of six days and analyzed for BOD on a daily basis. Cassava and abattoir wastewater needed even more severe treatment than sewage before disposal. BOD constant k'_1 for sewage at 15^0C was found to be less than those of cassava and abattoir wastewater at the same temperature. However, above 15^0C, k'_1 for sewage was found to be more than those for cassava and abattoir wastewaters. The values k'_1 for cassava and abattoir wastewaters were found to be close (between 0.397 day^{-1} and 0.44 day^{-1}) for all temperatures investigated. Arrhenius constant was found to be 1.194, 1.002 and 1.004 for sewage, cassava wastewater and abattoir wastewater respectively. The study also shows that the conventional 5-day BOD at 20^0C is probably being overrelied on as cassava wastewater and abattoir wastewater were found to attain maximum BOD_5 removal at 27^0C.

The second article by Atubi, Augustus O. (Ph.D), senior lecturer and head of the Department of Geography and Regional Planning Delta State University, Abraka, Nigeria, examined the effects of Warri refinery effluents on river Iffie and its environs. It ascertained the nature of effluents released from the refinery into the water body and also the effect on the water quality. Data were generated from direct field measurement of pH, Conductivity, Total

Hardness, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Turbidity and heavy metal profiles (Mg, Zn, Cr, Ni, Cl, Cu, H_2S, P) of water samples from river Iffie collected at three different points: Iffie, Ubeji and Ughoton. Turbidity, Hydrogen Sulphide, Total Suspended Solids (TSS), Copper, and Chromium records for water samples from Iffie and Ubeji points were found to be higher than the WHO and FEPA standards, thereby making the water in these areas not suitable for consumption. Based on the findings recommendations were proffered.

In the third article, Onyenekenwa Cyprian Eneh, senior research fellow with the Institute for Development Studies, Enugu Campus, University of Nigeria, Nsukka submits that sustainable development advocates environmental sustainability, which requires some roles of the chemist to achieve. These roles, as captured in the review paper, include prevention and protection against environmental degradation and its monitoring, recycling of wastes, making packages from 100% renewable resources, production of agrochemicals for aforestation and biodiversity and food security, production of renewable energies, production and application of water treatment and sanitation chemicals, chemical control and recycling of automobile exhaust emissions. The paper recommends more serious measures at national and international levels to encourage the study of chemistry and to enhance the regulation of its practice.

In the fourth article, Mrs. Chima Theresa Isife, a research fellow with the Institute for Development Studies, Enugu Campus, University of Nigeria, Nsukka notes that most African countries, including Nigeria, are not on course to realize the millennium development goals (MDGs) by 2015. Poverty level towers higher, as well as income inequality. This is not the case in the "information-rich" developed countries, where socio-economic sustainable development is powered by information communications technologies (ICTs). The paper argues that ICTS will provide the targeted tools for and facilitate sustainable development in Nigeria, if adopted faster than the progression shown for earlier technologies.

The book review column looks at the economic and social impacts of privatization of state-owned enterprises. This topic is of relevance, since enterprises are driven by technology and impact the environment.

Guide to authors is provided in the column on 'Call for articles.'

Professor Ignatius U. Obi
Editor-in-Chief
Department of Crop Science, University of Nigeria, Nsukka.

COMPARATIVE ASSESSMENT OF THE BIODEGRADABILITY OF SEWAGE, ABATTOIR WASTEWATER AND CASSAVA WASTEWATER

Nnaji, C.C.* and Ozougwu, P.

Department of Civil Engineering, University of Nigeria, Nsukka

E-mail: episcopal2k@yahoo.com, chidozie.nnaji@unn.edu.ng

Tel.: *+234-803-894-8808*

* *Author for correspondence.*

ABSTRACT

Sewage, cassava wastewater and abattoir wastewater were subjected to different temperatures for a period of six days and analyzed for BOD on a daily basis. Results obtained show that cassava and abattoir wastewater need even more severe treatment than sewage before disposal. BOD constant k'_1 for sewage at 15^0C was found to be less than those of cassava and abattoir wastewater at the same temperature. However, above 15^0C, k'_1 for sewage was found to be more than those for cassava and abattoir wastewaters. The values k'_1 for cassava and abattoir wastewaters were found to be close (between 0.397 day^{-1} and 0.44 day^{-1}) for all temperatures investigated. Arrhenius constant was found to be 1.194, 1.002 and 1.004 for sewage, cassava wastewater and abattoir wastewater respectively. The study also shows that the conventional 5-day BOD at 20^0C is probably being overrelied on as cassava wastewater and abattoir wastewater were found to attain maximum BOD_5 removal at 27^0C.

INTRODUCTION

The developed world may have succeeded at proper management of toxic waste from complicated industrial processes, but many developing nations still battle with such basic issues as treatment and disposal of sewage and other wastes from domestic activities or cottage industries. In rural and semi-urban areas all over Africa and Nigeria in particular, wastewaters are allowed to flow from homes and small food processing plants directly into streams and rivers. Unfortunately, people still rely on these streams for potable water.

Cassava wastewater is usually a by-product of the production of *garri*, starch, tapioca, cassava flour, etc. Many village dwellers ferment and wash cassava in their streams[1] without being aware of the harm they might be doing to people who fetch the water a few meters downstream. Table 1[2] shows the heavy bioload of cassava wastewater from starch production. It has been reported that in the region of the Cauca Valley (Colombia), wastewaters generated from the starch extraction process by about 250 existing small-scale plants are directly discharged into rivers without any treatment[3] . There is no doubt that this observation rings familiar to anyone who has been to a rural area.

Although it has been reported that fermentation reduces the cyanide content of cassava, a significant reduction is only achieved if the soaking water is routinely changed[4] . Unfortunately the practice of routine change of soaking water is hardly done partly due to ignorance and partly due to water scarcity in some areas. Cassava wastewater can be put to use by holding it in a tank to allow organic matter and suspended solids to settle and thereafter used for irrigation[5]. Treatment of cassava wastewater need not involve an imported complex technology beyond the reach of the individual. Researchers have shown that cassava wastewater can be treated using a filter bedpacked with bamboo which is a locally available material[1].

Cassava wastewater is of foremost significance in this research because many people have died after meals prepared from cassava.

Table 1

Main characteristics of the cassava starch extraction wastewater

Parameter[a]	Range	Average value[b]
pH	3.6–6.5	5.3 ± 0.7
Chemical demand for oxygen, COD	4200–7000	4800 ± 810
Soluble COD, SCOD	3500–6100	3850 ± 740
Biochemical demand for oxygen, BOD	1100–3900	1680 ± 755
Total solids, TS	2300–6600	3800 ± 1305
Total suspended solids, TSS	700–2200	1350 ± 440
Volatile suspended solids, VSS	600–2050	1200 ± 560
Total carbohydrates	330–400	365 ± 19
Lactic acid	1200–2000	1400 ± 240
Acetic acid	330–400	350 ± 19
Total nitrogen	80–150	105 ± 16
Total phosphorus	20–35	25.1 ± 8.1
Cyanide	3–5	3.5 ± 0.5
Water used/ton of cassava proceeded (m^3)	10–14	11 ± 1.1

[a] All parameters except pH are in mg/L.
[b] Average value was taken from 12 starch extraction plants. All analyses were carried out with three replicates.
[c] Results were means of 26 analyses with three replicates.

Abattoir wastewater is another wastewater that is usually discharged into the environment without any treatment. Wastewater from most slaughter houses in the country are conveyed by drains to the nearest roadside channel from where they flow to streams and rivers, thereby leading to high organic load in the affected water bodies. This practice has contributed further to the degrading and fouling of the natural environment. Abattoir wastewater has a complex composition and is very harmful to the environment[6] . Previous researches have shown that untreated abattoir wastewater can cause severe deoxygenation of streams and groundwater contamination[7,8] .

METHODOLOGY

Sewage was collected from the inlet of the University of Nigeria, Nsukka waste stabilization pond. Abattoir wastewater was collected from Ogige Abbatoir in Nsukka, Enugu State, Nigeria. Cassava wastewater was collected from a garri processing firm along Ochumba Street, Achara Layout, Enugu. The wastewaters were characterized and then incubated for BOD at different temperatures as follows: 15^0C, 27^0C and 35^0C for six days. The samples were tested for BOD everyday for the six days. It should be noted that fresh samples of the three categories of wastewater were collected for each temperature. The same sample should have been used for each category were it not for frequent power outage which made preservation of samples very difficult. Moreover, there were not enough incubators to run the experiments concurrently.

The values of k' were obtained for the different wastewaters at different temperatures using Thomas method. Thomas[9] using common logarithms, transformed the BOD equation into a linear form as follows:

$$\left(\frac{t}{BOD_t}\right)^{1/3} = \left(2.3k'_1 L_0\right)^{-1/3} + \left(\frac{k'^{\,2/3}_1}{3.43L_0^{1/3}}\right)t \quad \dots \quad \dots \quad \dots \qquad (1)$$

where BOD_t = Biochemical oxygen demand required by micro-organisms at any time t, L_o = ultimate BOD, k'_1 = BOD rate constant.

Equation (1) is a straight line of the form $y = a + bx$

If $\left(\frac{t}{BOD_t}\right)^{1/3}$ is regressed or plotted against t, the slope (b) will be equal to $\left(\frac{k'^{\,2/3}_1}{3.43L_0^{1/3}}\right)$ while the intercept (a) will be equal to $\left(2.3k'_1 L_0\right)^{-1/3}$. Hence $k'_1 = 2.61(b/a)\, and\, L_0 = \left(2.3k'_1 a^3\right)^{-1}$ (see Figs. 2-4). The values of k'_1 obtained for each type of wastewater at different temperatures were used to obtain the Arrhenius constants for cassava wastewater, abattoir wastewater and sewage. In order to obtain Arrhenius constant for each wastewater, Arrhenius equation was transformed as follows:

$$Logk_T = Logk_0 + (T - T_0)Log\theta \dots \quad \dots \quad \dots \quad \dots \quad \dots \qquad (2)$$

where k_T = BOD rate constant at T ^{0}C, k_0 = BOD rate constant at base temperature usually 20 ^{0}C, θ = Arrhenius constant, T_0 = 20 ^{0}C for wastewater.

Hence, equation (2) can be rewritten thus:

$$Logk_T = Logk_{20} + (T - 20)Log\theta \dots \quad \dots \quad \dots \quad \dots \quad \dots \qquad (3)$$

$Logk_T$ was plotted (regressed) against $(T - 20)$ so that the slope yields Logθ while the intercept yields $Logk_{20}$.

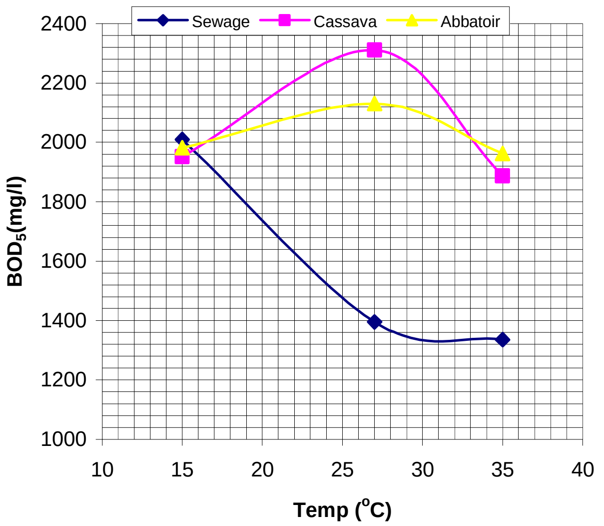

Fig 1: BOD_5 versus Temperature

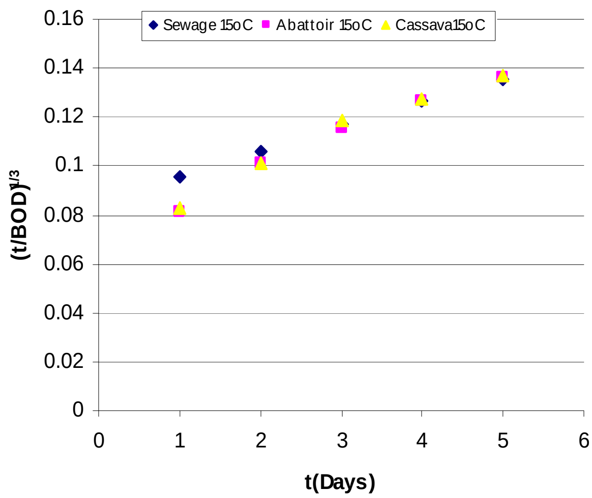

Fig 2: $(t/BOD_5)1/3$ versus Time for 15^{o}C

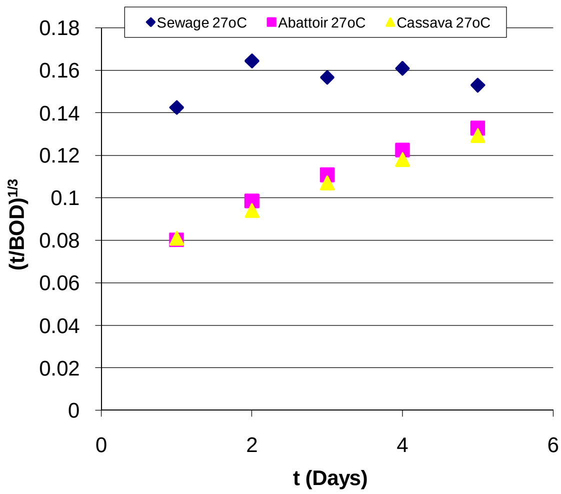

Fig 3: $(t/BOD_5)1/3$ versus Time for 27°C

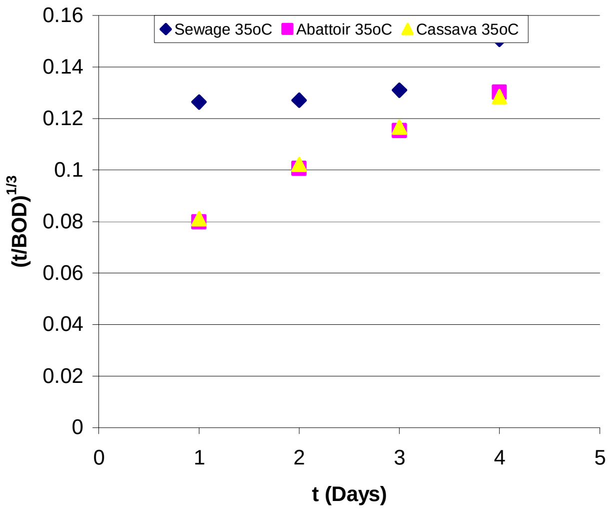

Fig 4: $(t/BOD_5)1/3$ versus Time for 35°C

RESULTS AND DISCUSSION

Preliminary results obtained show that cassava wastewater is richer in COD than the other two, while abattoir wastewater has more suspended solids than others. Figures 6-9 show that at lower temperatures (about 15^0C), k'_1 values for the three wastewaters were close while at higher temperatures (about 35^0C), the k'_1 values for sewage increases exponentially. Also, at lower temperatures, the *k* values for sewage were lower for both cassava and abattoir wastewater. At 15^0C precisely, the k'_1 value for sewage (0.27 day^{-1}) was found to be about half the values of cassava and abattoir wastewater with k'_1 values of 0.42 day^{-1} and 0.44 day^{-1} respectively at the same temperature. Furthermore, the k'_1 values for cassava and abattoir wastewater remained fairly constant with change in temperature.

This observation suggests that the biodegradation of cassava and abattoir wastewater were affected by temperature to a much less degree than it affected that of sewage, though Figure 2 (a plot of BOD_5 versus temperature) shows that for cassava wastewater and abattoir wastewater, the optimum temperature for the biodegradation was 27^0C. The BOD test was first used in the late 1800s by the Royal Commission on Sewage Disposal as a measure of the amount of organic pollution in British rivers[10]. At that time, the test was standardized to run for 5 days at 18.3"C.

These numbers were chosen because none of the British rivers had headwater-to-sea travel times greater than 5 days, and the average summer temperature for the rivers was 18.3"C. Accordingly, this should reveal the "worst case" oxygen demand in any British river. The BOD incubation temperature was later rounded to 20"C, but the 5-day test period remains the current, if somewhat arbitrary, standard. So it can now be seen that, while 5-day BOD at 20^0C may give a good approximation of the organic load of sewage, for abattoir and cassava wastewater, 5-day BOD at about 27^0C will give a better estimation. Higher temperature could kill off active micro-organisms while lower temperatures could immobilize them. Bacteria in sewage are more sensitive to temperature because sewage is a milder waste than abattoir wastewater and more especially cassava wastewater. Hence sewage can sustain a wider range of micro-organisms than cassava wastewater and abattoir wastewater.

Arrhenius constant was obtained for the three categories of wastewater (see Fig. 5 and table 3). The Arrhenius constant obtained for sewage, cassava wastewater and abattoir wastewater are 1.194, 1.002 and 1.004 respectively. Hence, Arrhenius equation can be written thus:

For sewage, $k_{20} = k_T\,(1.194)^{T-20}$ … … … … … (4)

For cassava wastewater, $k_{20} = k_T\,(1.002)^{T-20}$ … … … (5)

For abattoir wastewater, $k_{20} = k_T\,(1.004)^{T-20}$ … … … (6)

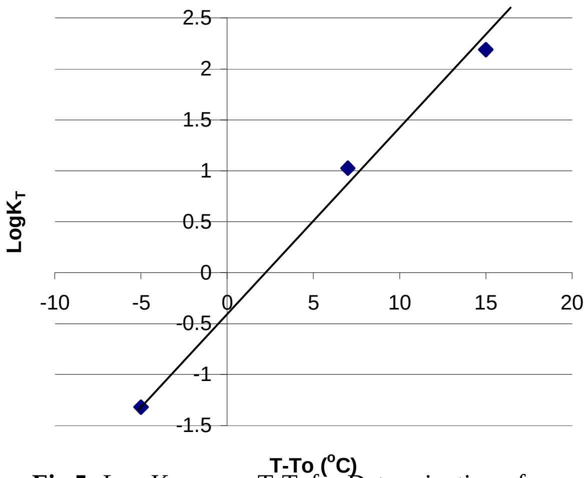

Fig 5: Log K_T versus $T\text{-}T_0$ for Determination of Arrhenius Constant for Sewage

Table 2: Arrhenius Constants for Different Wastewater

	Arrhenius Constant
Sewage	**1.194**
Cassava	**1.002**
Abbatoir	**1.004**

The constants were then substituted into the Arrhenius equation and the resulting equations were used to predict the k'_1 values. It was also observed that the predicted value of k'_1 using Arrhenius equation agreed well with the observed values for sewage, but not so well for cassava wastewater and abattoir wastewater (see Figs. 6 to 9 and Table 3).

Table 3: Calculated and Observed Values of K

Wastewater	K	15°C	27°C	35°C
Sewage	$K_{calculated}$	0.289144	2.331728	9.376775
	$K_{observed}$	0.266784	2.78921	8.93303
Abattoir	$K_{calculated}$	0.429344	0.450412	0.465029
	$K_{observed}$	0.440426	0.42295	0.487419
Cassava	$K_{calculated}$	0.409885	0.419831	0.426595
	$K_{observed}$	0.420036	0.397135	0.441604

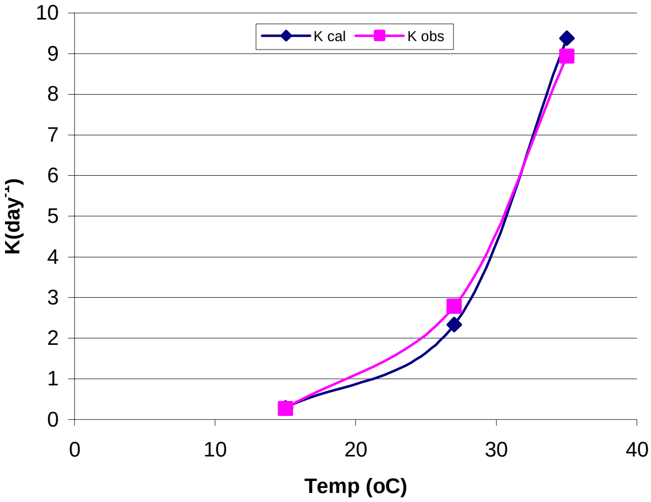

Fig 6: Calculated and Observed Values of K for Sewage

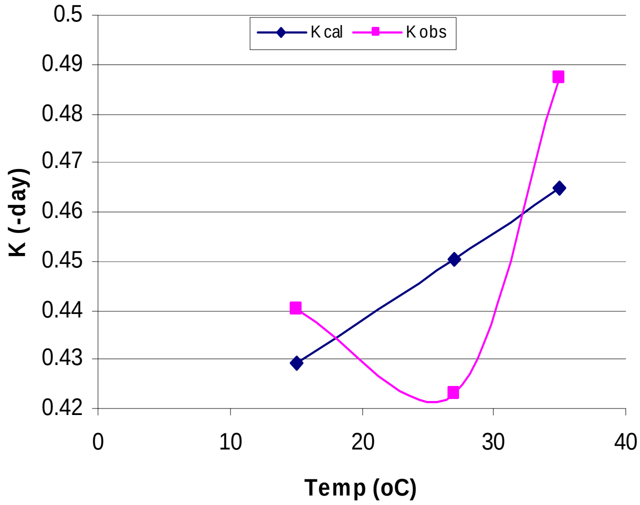

Fig 7: Calculated and Observed Values of K for Abattoir

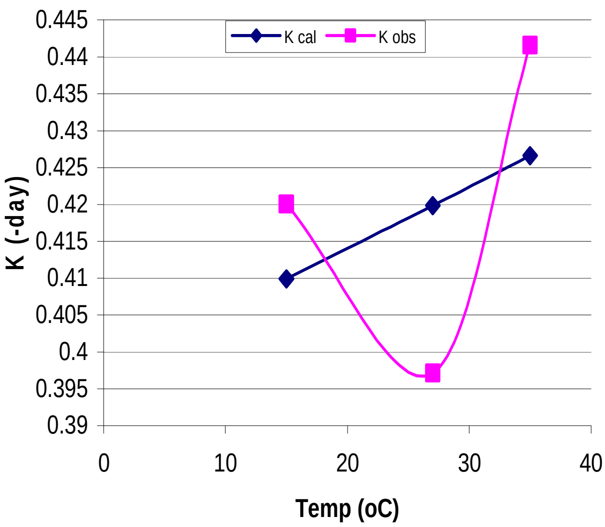

Fig 8: Calculated and Observed Values of K for Abattoir

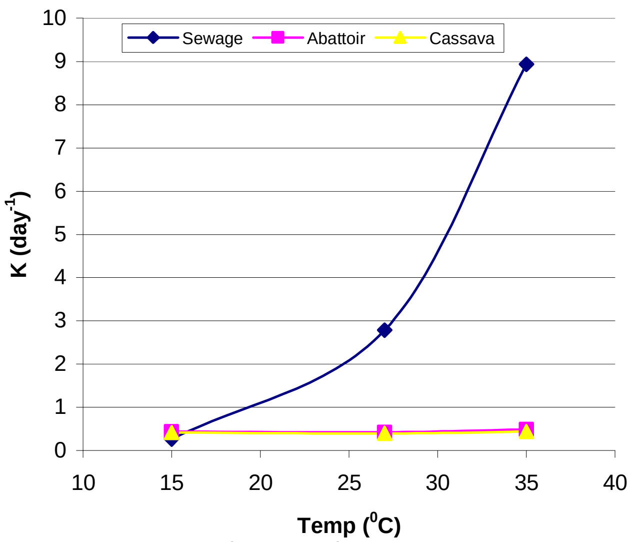

Fig 9: Comparison of *k* values for sewage abattoir and cassava

CONCLUSION

It can be clearly seen from this study, that the value of k'_1 is not the same for all kinds of wastewater. Obviously, activities of bacteria in cassava wastewater are usually inhibited by the presence of cyanide which will, in turn, affect the *k* value. It is therefore pertinent to employ the appropriate k'_1 values in the design of treatment plants for different categories of wastewater. It can also be inferred that sewage is easier to treat and degrades faster than abattoir wastewater and cassava wastewater.

RECOMMENDATION

Cassava wastewater and abattoir wastewater must be given a substantial level of treatment before being discharged into the environment.

REFERENCES

1. G. Oboh (2006), "Nutrient enrichment of cassava peels using a mixed culture of *saccharomyces cerevisae* and *lactobacillus spp*," *Solid Media Fermentation Food Chem*. 82(4): 91-8.
2. X. Colin, J. L. Farinet, O. Rojas, and D. Alazard. (2007), "Anaerobic treatment of cassava starch extraction wastewater using a horizontal flow filter with bamboo as support," *Bioresources Technology*, 98: 1602-1607.
3. R. D. Cooke (1985), "Cassava, an enzymatic assay for total cyanide content of *Manihot Esculenta Crantz*," *Journal of Science Food Agric*, 18: 130-145.
4. N. Okafor, C. Umeh, and C. Ibenegbu (1998), "Amelioration of *garri*, a fermented food derived from cassava, *manihot esculenta crantz*, by inoculation into cassava mask of micro-organisms simultaneously producing amylase, linamarase and lysine," *World J. Microbiol*, 19: 217-23.
5. C. Polprasert, P. Kemmadamrong and F.T. Tran (1992), "Anaerobic baffle reactor (ABR) process for treating slaughterhouse wastewater," *Envi. Technol.*, 13: 857-865.
6. J.M. Quinn and P.N. MacFariane (1989), "Effects of slaughterhouse and diary factory wastewater on Epilithon: A comparison in laboratory streams," *Water Research*, 23: 1267-1273.
7. A.Y. Sangodin and O.M. Agbawhe (1992), "Environmental study of surface and groundwater pollutants from abattoir effluents," *Bioresources Technology*, 41: 193-200.
8. H.A. Thomas, Jr. (1950), "Graphical Determination of BOD Curve Constants," *Watersewer Works*, 97(123): 67-72.
9. R.F. Weiner and R. Matthews (2003), *Environmental Engineering*, New York, Elsevier Science.

EFFECTS OF PETROLEUM REFINERY EFFLUENTS ON RIVER IFFIE WATER IN DELTA STATE, NIGERIA

Atubi, Augustus O. (Ph.D)
Department of Geography and Regional Planning
Delta State University, Abraka, Nigeria

ABSTRACT
This study examined the effects of Warri refinery effluents on river Iffie and its environs. It ascertained the nature of effluents released from the refinery into the water body and also the effect on the water quality. Data were generated from direct field measurement of pH, Conductivity, Total Hardness, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Turbidity and heavy metal profiles (Mg, Zn, Cr, Ni, Cl, Cu, H_2S, P) of water samples from river Iffie collected at three different points: Iffie, Ubeji and Ughoton. Turbidity, Hydrogen Sulphide, Total Suspended Solids (TSS), Copper, and Chromium records for water samples from Iffie and Ubeji points were found to be higher than the WHO and FEPA standards, thereby making the water in these areas not suitable for consumption. Based on the findings, recommendations were proffered.

INTRODUCTION
Petroleum refineries and petrochemical plants are important sectors of the petroleum industry. While the petroleum refinery and petrochemical industries are most desirable for national development and improved quality of life, the unwholesome and environmentally unacceptable pollution effects of the waste from these industries have become something to contend with. This is because in the process of converting crude oil into petroleum products (liquefied petroleum gas, naphtha, kerosene, diesel oil and residual oil) and petrochemical products (polypropylene, polyethylene), wastes of different kinds are generated. The wastes can be broadly categorized into oily materials, spent chemicals, spent catalysts and other residuals. These wastes are released to the environment in the form of gases, particles, and liquid effluent (consisting of surface runoff water, sanitary wastewater, solid waste and sludge)[1].

The wastewater released from the refineries are characterised by the presence of large quantity of crude oil products, polycyclic and aromatic hydrocarbon, phenols, metal derivatives, surface active substances, sulfides, naphthalene acids and other chemicals[2]. As a result of ineffectiveness of purification systems, waste water may become seriously dangerous, leading to the accumulation of toxic products in the receiving waster bodies with potentially serious consequences on the ecosystem[3,4].

The uncontrolled disposal of waste into water renders water unsafe for economic use, recreational use and poses a threat to human life. It is also against the principle of sustainable development. More so, water-borne diseases and water-related health problems are mostly due to incompetent management of water resources[1]. Safe water for all can only be assured when access, sustainability and equality can be guaranteed. Urban areas generally have a higher coverage of safe water than the rural areas. Even, within the urban area, there are variations in the quality of water, as much of the water get contaminated in many different ways, through industrial effluents and untreated municipal sewage[5,6].

Refinery effluents contaminated by aromatic hydrocarbons produce poor health and lethal toxicity in fishes and two species of tilapia[7]. Similarly, the accumulation of heavy metals with accompanying histopathology in *oreochronmis niloticus* exposed to treated petroleum refinery effluents from the Kaduna refining and petrochemical company had been reported[8]. These and other studies agree that petroleum refinery effluents pose serious problems to both aquatic and human life forms.

Drinking contaminated water can cause various diseases, such as typhoid fever, dysentery, cholera and other intestinal diseases[9,10]. Human beings are made up of water, in roughly the same percentage as water in the surface of the earth[11]. Their tissues and membranes, brains, hearts, sweat and tears, all reflect the same recipe for life. Water is essential for the development and maintenance of the dynamics of every ramification of the society[12]. Water is indeed life and thus the most important natural resource without which life would be non existent. Availability of safe and reliable source of water is an essential prerequisite for sustained development[13].

Nigeria is regarded as the greatest gas flaring country in the world, and in the process of flaring, carbon dioxide, sulfur dioxide and nitrous oxides are released into the atmosphere, where they mix with rain to produce toxic acid rain, which causes damages to vegetation and aquatic life[6,14]. Oil prospecting has brought with it untold hardship to the environments in Nigeria. Dwellers of the oil producing areas are generally suffering from scarcity of farmlands, as their lands have been made unproductive due to constant oil spillages and wastes dumps[15].

One of the most visible consequences of the numerous oil spills had been the loss of mangrove trees. The mangrove was a source of both fuel woods for the indigenous people and a habitat for the area's biodiversity, but is now unable to survive the toxic oil spills. Oil spills also pose serious health risks to people when they consume sea foods contaminated by oil[16,17].

Nigeria has experienced increased pipeline vandalisation, kidnapping, and militant take-over of oil facilities in the Niger Delta region. As of April 2007, an estimated 587,000bbl/d of crude production was shut-in. Since December 2005, Nigeria has lost an estimated 16 billion dollars in export revenues due to shut-in oil production. The Shell B.P. has incurred the majority of shut-in oil production (477,000 bbl/d), followed by Chevron (70,000 bbl/d) and Agip (40,000 bbl/d) [18].

Oil in the aquatic environment may be damaging in a variety of ways. It may involve changes in the composition of aquatic communities, leading to inability to survive, permanent damage and in some cases massive mortalities. Odour, taste and colour are present in oil polluted water. Oil pollution of water also constitutes a potential health risk to human beings who use such water for domestic and drinking purposes and consume fishes found there-in[19-21].

The Study Area

Warri Refining and Petrochemical Company, Ekpan located in Delta State is a subsidiary of the Nigerian National Petroleum Corporation (NNPC), an oil company involved in the refining of crude petroleum oil into fuel, kerosene and other by-products. The refinery is bounded by three communities, namely Ekpan, Jeddo and Ubeji. Iffie is next to Ubeji (Fig.1). The study area is located around latitude $5^0$31'N and $6^0$11'N and also between longitude $5^0$44'E and $5^0$47'E. The area is approximately 100 square kilometers and it is bounded by other communities. The human activities are mainly primary occupations, such as fishing, crop farming, vegetable farming and little of petty trading. The economy is agriculturebased.

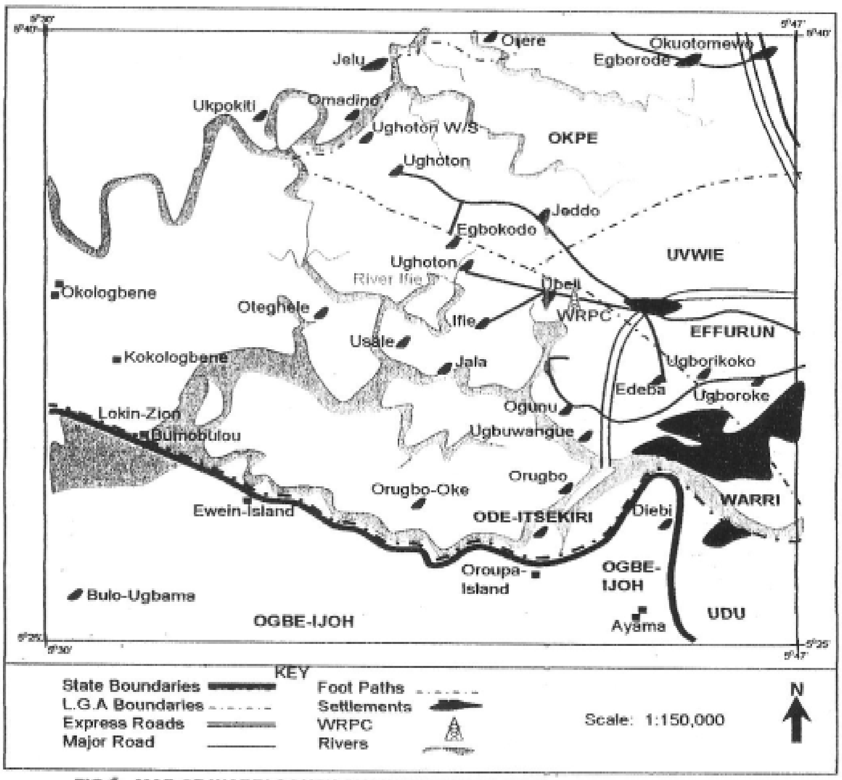

FIG 1: MAP OF WARRI SOUTH SHOWING STUDY AREA

11

Fig. 4.1: Map of study area

METHODOLOGY

This research work is an experimental research with a survey on river water samples. The locations of the various sampling points are at Iffie River, Ubeji River and Ughoton River. These stations were established to cover possible affected area along the river course based on an earlier field reconnaissance survey. The three (3) locations are equi-distanced from discharge point. Iffie River and Ubeji River were divided into ten sites and Ughoton River into three sites. Running water samples from the three (3) rivers were carefully collected with sterilized plastic containers, fitter and with information tags for identification. These were then assessed immediately for physical characteristics, such as pH, conductivity and turbidity. Laboratory analyses of the water samples followed.

Thirty water samples were collected from the three locations (equi-distanced from the polluted point) with container. All samples were allowed to settle down before any laboratory analysis. This is to eliminate any form of turbidity influences on the tests. One dependent control source at Ughoton was established. The control sample served as standard characteristics of the nature of river water in the neighbourhood and from which variations were identified.

Instrumentation

The instruments used in this study include Bulk Scientific Atomic Absorption Spectrophotometer (AAS) Computerized Model 210VGP with Epson Printer LX300+ and replaceable lamp holder. This was used to measure the heavy metals. The pH was measured with H tester 1 Tm, Model cole Planner (R), conductivity was measured with the suntex conductivity meter, the Total Dissolved Solids (TDS) was measured with the Hatch TDS meter, model CO20, Total Suspended Solids (TSS) was determined using weight loss technique and turbidity was measured with hatch spectrophometre, model DR2010.

Statistical analysis

The mean and range of the data as well as the analysis of variance, ANOVA, were used for analyses.

RESULTS AND DISCUSSION

From the water analysis (Tables 4.1 and 4.2), it was observed that a lot of chemicals, such as chloride, phosphate, oil and grease, chromium, hydrogen sulphide, magnesium, copper, zinc, nickel are released into the river and the major ones are heavy metal, such as chromium, phosphate, chloride, copper, zinc and nickel. These effluents released into the river make the water unsafe for domestic purpose, recreational purpose and agricultural purpose.

In Table 4.1, the pH values recorded in Iffie River are generally within the WHO acceptable limits of 6.5-9.2 thresholds. This is evident from 6.53 mean pH value that is within the 6.5-9.2 WHO threshold. However, the lowest pH value of 6.21 and 6.29 were recorded in Iffie 5 and Iffie 6 respectively, which fall outside the WHO acceptable limit. The low pH values recorded in Iffie 5 and 6 could be attributed to the effluents that enter the river from the Warri petrochemical company. This low pH values increase the concentrations of some dissolved metals in the water, increasing the toxicity of these metals.

The total hardness values of water samples analysed were within the maximum limits of WHO standards of 100mg/L. This is seen from the mean of 36.49 total hardness recorded in Iffie river with Iffie 9(48) and Iffie 7(42) being the highest and lowest total hardness being recorded in Iffie 1, Iffie 2, Iffie 3, Iffie 4, Iffie 6, Iffie 8 and Iffie 10. The magnesium hardness values of the water samples collected from Iffie River were within the WHO acceptable limit of WHO standards 250mg/L. This is seen from the mean value of 15.72 magnesium hardness that was recorded in Iffie 1, Iffie 2, Iffie 3, Iffie 4, Iffie 6, Iffie 7, Iffie 8 and Iffie 10.

The turbidity values of the water samples collected from Iffie River are generally higher than the maximum limits of WHO acceptable standard of 25NTV. This is evident from the mean turbidity value 144.2NTU recorded in Iffie river with the highest being recorded in Iffie 5 (282) and Iffie 9 and the lowest turbidity was recorded in Iffie 1 (109), Iffie 2 (124), Iffie 3 (118), Iffie 4 (76), Iffie 6 (129), Iffie 7(116), Iffie 8 (78) and Iffie 10 (130).

Total Dissolved Solids (TDS) concentration in Iffie River had a mean of 60.09 which is within the maximum limits of 1000mg/L acceptable by WHO. However, the highest concentration of total dissolved solids value of 98 was recorded in Iffie 1 and Iffie 6 (87.8) being the points with highest concentration of total dissolved solids. On the other hand, the lowest concentration of total dissolved solids was recorded in Iffie 2, Iffie 3, Iffie 4, Iffie 5, Iffie 7, Iffie 8, Iffie 9 and Iffie 10.

Water samples analysed in Ubeji River showed that the conductivity level in the ten points were below the 500µs/cm limits of WHO standards. This is evident from the mean of 63µs/cm recorded in Ubeji.

Table 4.1: ***Physiochemical Characteristics and Some Metals in River Iffie***

Parameters	Iffie 1	Iffie 2	Iffie 3	Iffie 4	Iffie 5	Iffie 6	Iffie 7	Iffie 8	Iffie 9	Iffie 10	Mean	Range	
												+	-
pH	6.7	5.59	6.53	6.55	6.21	6.71	6.52	6.5	6.29	6.7	6.53	6.7	6.2
Conductivity	196	85.5	84.5	112	91	177.8	84.1	110	96	178	121.49	196	84
Total Hardness	40.8	41	41.2	40.9	0	32	40	42	48	39	36.49	48	0
Magnesium Hardness	15.8	16.2	16.3	15.9	0	22	17	17	28	9	15.72	16.3	9
Chloride (mg/L)	23.1	23	23.4	23.09	16.89	19.55	22.4	23.01	17	19.12	21.06	23.4	17
Turbidity	109	124	118	76	282	129	116	78	280	130	144.2	28.2	76
Phosphate	3.46	4.43	4.05	2.43	6.48	5.61	5.01	4.98	4.56	5.12	5.61	16.5	2.4
Hydrogen Sulphide (H_2S)	2.89	2.62	2.07	0.19	9.46	0.13	2.11	2.2	1.99	2.5	2.01	3.5	0.13
Total Dissolved Solid (TDS)	98	41.9	41.1	54.6	44.8	87.8	78	50	55.2	49.5	60.09	98	41.1
Total Suspended Solid (TSS)	91	96	98	52	72.8	106	98.4	76	97	94	88.12	106	52
Zinc (mg/L)	0.054	0.041	0.018	0.04	0.023	0.06	0.84	0.03	0.054	0.034	0.043	0.08	0.018
Nickel (mg/L)	0.055	0.014	0.008	0	0.02	0.019	0.021	0.024	0.023	0.026	0.021	0.06	0
Copper (mg/L)	0.29	0.017	0	0	0.001	0	0.014	0.016	0.018	0.017	0.037	0.04	0
Chromium	0.074	0.061	0.078	0.045	0.057	0.045	0.046	0.048	0.058	0.049	0.056	0.08	0.05

Source: Field survey, 2009

The highest conductivity of 85.8µs/cm was recorded in Ubeji 1 and 62µs/cm in Ubeji 10 and the lowest conductivity values in Ubeji 2 (57.4µs/cm), Ubeji 3 (60.8µs/cm), Ubeji 8 (59.8µs/cm), Ubeji 9 (59.3µs/cm) and Ubeji 6 (61.6µs/cm).

Total hardness concentrations in Ubeji River were generally within the maximum 100mg limits of WHO standards. This is seen from the mean of 31.1mg recorded in Ubeji River. The highest total hardness concentration of 34.1mg and 32.9 was recorded in Ubeji 6 and Ubeji 8 respectively and the lowest total hardness concentration of 31.7mg was recorded in Ubeji 1, and Ubeji 2 (25mg), Ubeji 3 (31mg) and Ubeji 10 (30.3mg).

Table 4.2: ***Physiochemical Characteristics and Some Metals in River Ubeji***

Parameters	Ubeji 1	Ubeji 2	Ubeji 3	Ubeji 4	Ubeji 5	Ubeji 6	Ubeji 7	Ubeji 8	Ubeji 9	Ubeji 10	Mean	Range	
												+	-
Ph	6.5	5.93	5.93	5.96	5.8	6.3	6.9	6.82	5.94	6.87	6.19	6.9	5.8
Conductivity	85.8	57.4	60.8	61.4	60.7	61.6	60.8	59.8	59.3	62.1	62.97	85.8	57.4
Total Hardness	31.7	25	31	31.9	31.1	34.1	3.19	32.9	30.1	30.3	31.1	32.9	25
Magnesium Hardness	22.7	9.8	21	22	20	23	21.1	20.3	19.9	20.6	20.04	23	9.8
Chloride (mg/L)	19.5	10.67	19.5	19.4	16.9	18.2	17.9	19.2	18.6	19.6	17.94	19.6	10.7
Turbidity	115	50	29	87	79	89	99	95	106	110	85.9	115	29
Phosphate	5.62	1.56	2.04	2.92	2.56	2.45	2.67	1.98	2.01	2.1	2.59	5.6	1.6
Hydrogen Sulphide (H_2S)	0.16	0.11	0.18	2.42	0.68	0.59	0.55	0.43	0.4	0.2	0.57	0.68	0.2
Total Dissolved Solid (TDS)	41.6	69.3	28.2	29.5	40.2	39.8	45.7	45.6	45.9	50.3	43.57	50.3	6.9
Total Suspended Solid (TSS)	93	54	20	61	69	70	57	58.4	61	63	60.64	93	20
Zinc (mg/L)	0.017	0.013	0.017	0.025	0.024	0.021	0.029	0.019	0.02	0.023	0.02	0.029	0.02
Nickel (mg/L)	0.029	0.0029	0.019	0.041	0.034	0.028	0.035	0.036	0.032	0.031	0.031	0.036	0.019
Copper (mg/L)	0	0	0	0	0.013	0.017	0.012	0.01	0.011	0.014	0.007	0.017	0
Chromium	0.05	0.043	0.039	0.04	0.053	0.049	0.049	0.051	0.038	0.042	0.045	0.053	0.04

Source: Field Survey, 2009

Turbidity recorded in Ubeji river ranges between 29NTU-115NTU with a mean of 85.9NTU with the highest turbidity duty of 115NTU and 110 being recorded in Ubeji 1 and Ubeji 10 respectively while the lowest turbidity were recorded in Ubeji 2, Ubeji 3, Ubeji 4, Ubeji 5, Ubeji 6, Ubeji 7, Ubeji 8 and Ubeji 9. Turbidity recorded in Ubeji River were generally higher than the 25NTU maximum limits of WHO and Federal Environmental Protection Agency (FEPA) standards.

Total suspended solids concentration in Ubeji river were higher than the maximum limits of <30mg/L and FEPA standards. This is seen from the mean of 60.64mg/L total suspended solids recorded in Ubeji River. The highest total suspended solids of 93mg/L was recorded in Ubeji 1 and the lowest total suspended solids of 20mg/L was recorded in Ubeji 3.

In Table 4.3, the pH concentration in Ughoton River was generally below 6.5-9.2 maximum limits of WHO and FEPA standards. This is evident from the mean of 5.74 observed in Ughoton River during the period of observation. The highest pH concentration of 5.98 was observed in Ughoton 3 and Ughoton 2 (9.95) respectively and the lowest pH concentration of 5.31 in Ughoton 1.

Turbidity values in Ughoton River were generally higher than the maximum 25NTU limits of WHO and FEPA standards. This is evident from a mean of 66.33NTU recorded in Ughoton River the highest turbidity value was recorded in Ughoton 2 and the lowest in Ughoton 1 (61).

Total suspended solids concentration in Ughoton river were generally higher than the maximum limits of <30mg/L WHO standards. This is evident from the mean of 53.33mg/L observed in Ughoton River. The highest total suspended solids concentration of 58 was recorded in Ughoton 2 and the lowest total suspended solids concentration of 48mg/L was recorded in Ughoton 1.

Table 4.3: ***Physiochemical Characteristics and Some Metals in Ughoton River***

PARAMETERS	CONTROL 1	CONTROL 2	CONTROL 3	MEANS	WHO LIMIT
pH	5.31	5.95	5.98	5.74	6.5-9.2
Conductivity	60.1	61.2	62	61.1	500
Total Hardness	41	40	39	40	100
Magnesium Hardness	25	23	21	23	250
Chloride (mg/L)	19.49	19.3	19.48	19.42	250
Turbidity	51	70	68	66.33	5.82
Phosphate	2.52	2.49	2.46	2.49	5.82
Hydrogen Sulphide (H_2S)	1.88	1.98	1.89	1.91	0.1
Total Dissolved Solid (TDS)	30	36.6	40.1	35.56	100
Total Suspended Solid (TSS)	48	58	54	53.33	30.
Zinc (mg/L)	0.041	0.044	0.023	0.036	0.05
Nickel (Mg/L)	0.054	0.045	0.05	0.049	0.61
Copper (Mg/L)	0	0.015	0.041	0.009	0.02
Chromium	0.048	0.043	0.041	0.044	0.05

Source: Field survey, 2009

In Table 4.4, the calculated F-value of 153.463 at 0.05 significant level is greater that the critical F-value of 2.21. Thus, it can be concluded that the quality of water from river Iffie is significantly dependent on effluent from the Warri petrochemical company. From the result, it is observed that the effluent (waste water) from the refinery has a significant effect on the water and lives of the people of Iffie community and its environs.

Table 4.4: ***Summary of ANOVA Explaining the Quality of Water from the River***

Model	Sum of squares	df	mean square	F	Sig.
Regression	7693.813	2	3846.906		
Residual	275.741	11	25.067		
Total	7969.553	13			

a. *Predictors (constant) Ubeji, Iffie*
b. *Dependent variable, Ughoton.*

Policy Implications/Recommendations

Based on the findings of this study, the following recommendations are proffered:

1. The Warri petrochemical refinery should adhere to remediation policies.
2. The Warri petrochemical refinery company should ensure that their effluent is properly treated before discharge into the river. The Federal government agencies responsible for the proper discharge of this effluent should monitor them properly without compromise. There is also the need for the government of Delta State to provide pipe born water in these communities and revive the state of water board.
3. There is also the need for rural dwellers to be educated on the danger of using contaminated water.

CONCLUSION

This study his shown that the higher values of metals obtained at the effluent zones implicate the industry adjacent to the area as one of the sources of heavy metals in the river Iffie and Ubeji.

REFERENCES

1. World Bank (1998), *Petroleum Refining: Pollution Prevention and Abatement Handbook,* Washington, D.C.: World Bank, 377-380.
2. A.Y. Suleimanov (1995), "Conditions of Waste Fluid Accumulation at Petrochemical and Processing Enterprise Prevention of their harm to water bodies," *Meditsina Truda Promyswe Nnaia Ekologila*, 12: 31-36.
3. M.U. Beg, T. Saeed, S. Al-Muzaini, K.R. Beg and M. Al-Bahloul (2003), "Distribution of Petroleum Hydrocarbon in Sediment from Coastal Area Receiving Industrial Effluents in Kuwart," *Ecotoxical Environ Saf,* 54: 47-54.
4. S.O. Aghalino and B. Eyinla (2009), "Oil Exploration and Marrine Pollution: Evidence from the Niger Delta, Nigeria Kamla-Raj," *Journal of Human Ecology*, 28(3): 177-182.
5. P.A. Oluwande, M.K.C. Sridhar, A.O. Bammeke and A.O. Okubadejo (1993), "Pollution Levels in some Nigerian Rivers," *Water Research*, 17(9): 957-963.
6. A.O. Atubi (2009), "Environmental Risk Assessment (ENRA) for sustainable Development: An Overview," *Journal of State and Society*, 1(1): 127-136.
7. R.K. Kuehn, K.D. Berlin, W.E. Hawkins and G.K. Ostrander (1995), "Relationships among Petroleum Refining, Water and Sediment Contamination and Fish Health, *Journal of Toxicology and Environmental Health*, 46: 101-116.
8. B.G. Onwumere and A.A. Oladimeji (1990), "Accumulation of Metals and Histopathology in Oreochrimise Niloticus Exposed to Treated NNPC Kaduna (Nigeria) Petroleum Refinery Effluent," *Ecotoxicology and Environmental Safety*, 19: 123-134.
9. R.K. Udoh (1987), *Geographical Regions of Nigeria*, Ibadan: Heinemann.
10. O.T. Adeyemi (2004), "Oil Exploration and Environmental Degradation: The Nigerian Experience," *Environmental Informatic Archives,* **2:** 389-393.

11. A. Gore (1993), *Earth in the Balance Ecology and the Human Spirit,* New York: Penguin Book, 105-109.
13. C.C. Asonye, N.P. Okolie, E. Okenwa and U.G. Iwuayanwu (2007), "Some Physico-Chemical Characteristics and Heavy Metal Profiles of Nigeria Rivers," Retrieved on 11/11/2010 from *http://www.academicjournals.org/AjB*
14. A.B.A. Egborge (1991), "Industrialization and Heavy Metal Pollution in Warri River," 32-1, *Inaugural Lecture,* University of Benin, Benin City, Nigeria.
15. FEPA (1991), National Environmental Protection (Effluent Limitation) Regulations, Abuja: FEPA.
16. E.W. Bogardy (2004), "A Biological Measurement of Copper Complexation Capacity in Sea Water," *Limnol. Oceanography*, 18: 993-117.
17. F.C. Onuoha (2007), "Poverty, Pipeline Vandalisation/Explosion and Human Security: Integrating Disaster Management into Poverty Reduction in
12. United Nations Development Programme (2006), *Niger Delta Human Development Report,* Abuja: UNDP.
Nigeria," *African Security Review,* 16(2): 94-108.
18. EIA (Energy Information Administration) (2007), *Nigeria Country Analysis Brief,* Abuja: Energy Information Administration.
19. P.C. Novi and O.T. Badejo (2001), *Impacts of Oil Spills along the Nigeria Coast;* The Association for Environmental Health and Sciences, Retrieved on 12/12/2007 from http://aehsmag.com/issues/2001/October/impacts.htm
20. M. Helmer (2006), "Natural Disasters and Climate Change," *Disasters*, 30(1): 1-4.
21. A.O. Atubi (2009), "Implications of Oil Spillage for Environmental Management in the Niger Delta Area of Nigeria," *Nigerian Sociological Review,* 4(1&2): 269-280.

THE CHEMIST AND ENVIRONMENTAL SUSTAINABILITY

Onyenekenwa Cyprian Eneh
Institute for Development Studies, Enugu Campus
University of Nigeria, Nsukka
Tel.: *+234-803-3387472*
Email: *esccha@yahoo.com*, *onyenekenwa.eneh@unn.edu.ng*

ABSTRACT

Sustainable development advocates environmental sustainability, which requires some roles of the chemist to achieve. This review paper captures these roles, including prevention and protection against environmental degradation and its monitoring, recycling of wastes, making packages from 100% renewable resources, production of agrochemicals for aforestation and biodiversity and food security, production of renewable energies, production and application of water treatment and sanitation chemicals, chemical control and recycling of automobile exhaust emissions. It recommends more serious measures at national and international levels to encourage the study of chemistry and to enhance the regulation of its practice.

INTRODUCTION

As an aftermath of the Brundtland Commission of 1987, the concept of development based on conquest and wrecking of the world for increased economic productivity has been replaced with the paradigm of development based on sustaining the environment for all generations of people. Depleting the planet in the name of economic development that seeks to maximize economic production, only to deny the future generations the resources bequeathed to the present generation as well as the future generations of the earth's inhabitants, is unacceptable[1].

Sustainable development is a mainstream recognition of a link between development and environment. It advocates meeting the economic, environmental, political, social, cultural and health needs of the present without compromising the ability of the future generations to meet their own needs. It seeks to minimize waste by maximizing recycling and discouraging the use of non-renewable resources, encourage sustainable use of finite renewable resources, discourage overtaxing the capacity of ecosystems to absorb or break down wastes, protect natural processes and climatic systems, including not overtaxing the capacity of global ecosystems to absorb or dilute wastes without adverse effects, and mobilize political and institutional structures within nations and internationally to support the achievement of these goals[2].

Before creation, the earth was void, empty, a formless mass cloaked in darkness. It would have remained most uneventful, dull and dumb to date, but for creation. Creation obviously involved lots of reactions of chemical elements. Hence, the Creator has been described as the First Chemist. He performed the first chemical reaction in creating light. Next, he reacted the chemical and biochemical elements (e.g. hydrogen, oxygen, etc.) to form water, land, vegetations and animals. He formed man from the dust. Thus, he set the pace and empowered the chemist with the knowledge and the skill to create one material substance from others. It has been said that the power of creation belongs to God, who gave to the chemist the next power to change matter from one form to another[3-5].

Chemistry has been defined as the branch of science studying the properties, composition and structure of matter, which comprises all things that have mass and occupy space, together with the associated chemical and/or physical changes and how such changes impact on the welfare of man and society. Chemistry is the study of everything. Indeed, what on earth is not chemistry? Chemistry is the heart of science, which is the foundation on which technology for national development is built. Remove science and technology, mankind will revert to the Stone Age[6].

Thus, the chemist plays vital and strategic roles in the health sector. He is actively involved at every stage of the search for drugs - biologically active substances of known or unknown structure, compounds which affect life processes. Both pharmacokinetics (absorption, distribution, biological transformation and excretion) and pharmacodynamics (biochemical and physiological effects and their mechanism of action) of drug are directly related to the chemistry of the drug. Chemistry is deployed in the isolation (extraction, phytochemical screening, separation and purification, and analysis) of drugs. Similarly, chemistry plays very crucial roles in effective agriculture for sustainable food production, processing and preservation. From the determination of the soil nutrient status through the production and choice and application of fertilizers and pesticides and preservatives to food processing and preservation, chemistry plays indispensable roles. Thus, chemistry addresses food and drug availability and affordability, thereby enhancing both the quality of life and life expectancy of a nation's citizenry. Chemistry is applied to natural resources to release the potential in the flora and fauna, converting them into raw materials and wealth for the welfare of the citizens[6].

A chemist is a graduate of chemistry or chemistry-related discipline from a recognized university or polytechnic. He was trained in the area of chemical handling, usage and management. He practices in the industry, government ministry or agency, school, etc.[7]

This paper is a review of the relevance of the chemist in achieving environmental sustainability. His key roles include the prevention of and protection against environmental degradation, recycling of waste matters and sewage, making packages from 100% renewable resources, production of agrochemicals and fertilizers for aforestation and biodiversity and food security, production of renewable energy to replace the fossil fuels and other non-renewable energies, production and application of water treatment and sanitation chemicals, chemical control and recycling of automobile exhaust emissions, and monitoring of environmental degradation. It recommends the encouragement of the study of chemistry and the enhancement of the regulation of its practice in order to maximize the services of the chemist in environmental sustainability.

THE ROLE OF THE CHEMIST IN ENVIRONMENTAL SUSTAINABILITY

The modern utilization of biomass (organic matter) involves the large-scale coppicing of rapidly growing trees (such as various types of willow), the harvesting of rapidly growing trees (e.g. eucalyptus), or the conversion of crops into fuels (e.g. sugarcane into ethanol)[8].

Geothermal energy projects may release carbon dioxide, hydrogen sulphide, and mercury. Tidal power projects, especially tidal barrages, may destroy or fundamentally change estuarine habitats. Emissions, notably sulphur, oxides of nitrogen, suspended particulate matter, and other noxious emissions, such as benzene and volatile organic compounds, having harmful local and regional effects, are a problem with secondary forms of fossil fuels in particular[8].

Greenhouse effects arise from carbon "sequestration," the absorption of carbon dioxide that occurs when new tree or other plant growth follows modern biomass processing. Greenhouse gases are emitted into the atmosphere by the conversion and use of fossil fuels and by the burning of biomass. Some of this is absorbed in the oceans, and some on land, but the rest – for varying lengths of time – goes to increase the atmospheric concentration of these gases, which is widely believed to have a global warming effect. Increasing atmospheric concentrations of these gases resulting from human activity raise the mean temperature of the Earth's atmosphere, causing global mean sea level to rise, and having both widespread and localized climatic effects[8].

In general, coal emits the greatest quantity, weight for weight, carbon dioxide (the most significant individual greenhouse gas), followed by oil and natural gas. Coal, crude oil, natural gas, biomass, hydroelectric power, solar energy, wind energy, and heat all provide primary energy, which are recovered or gathered directly from natural resources. Primary energy usually, though not always, needs to be converted into secondary energy: electricity, petrol for cars, jet fuel for aeroplanes, paraffin and diesel oil for lighting and heating, charcoal, etc. Conversion requires plants and technologies: oil refineries, coal-fired or gas-fired electricity-generating stations, nuclear power stations, photovoltaic cells, etc. [8]

Distribution of the final form (electricity through the grid, petrol in delivery vehicle) follows, to be applied in an end-use technology (a cooker, a light bulb, a furnace, a car, an aircraft) to provide the energy service required (heating, lighting, mobility, etc.) The final transformation of energy by the end-use device to the energy service required is termed conversion to useful energy. Effective energy use is of practical, technical and policy concern, and could have a significant impact on world energy supply requirements. Various estimates place end-use efficiency as "exergy", at well under 10%, both in industrialised and other countries[8].

Environmental pollution (noxious and greenhouse gas emissions), global warming, ozone-depleting, deforestation and threat to and extinction of wildlife, and urban degradation are some of the manifestations of environmental degradation with disastrous consequences. The concept of 'environmental space' per person per country measures environmental degradation due to human activities. Environmental space is the sustainable rate at which we can use environmental resources without causing irreversible environmental damage, depriving the future generations of the earth's inhabitants of the resources they will need[8-10].

Massive pollution of the biosphere must be controlled in order to survive the crisis of environmental degradation and maintain the earth as a place for human habitation. The chemist is central to the basic techniques for pollution reduction, including precipitation, dispersion, treatment, cyclones, wet scrubbers, absorption, etc. To control air pollution by exhaust he introduces direct after-burner in the exhaust system, catalytic after-burners and exhaust cooling. He also controls the sulphur dioxide emitted by coal-fired plants by analyzing and selecting low-sulphur coal, desulphurising of coal and fuel-gas, stacking and dispersing sulphur dioxide, etc. [11]

The chemist is increasingly engaged in the research for recycling of waste matters and sewage, making packages from 100% renewable resources, production of agrochemicals and fertilizers for aforestation and biodiversity and food security, production of renewable energy to replace the fossil fuels and other non-renewable energies, production and application of water treatment and sanitation chemicals, environmental chemical control and recycling of automobile exhaust and other emissions of dangerous chemicals, and monitoring of environmental degradation[12-23].

CONCLUSIONS AND RECOMMENDATIONS

The roles of the chemist in environmental sustainability are as crucial as they are diverse. This paper has attempted to review them, but not exhaustively, especially as new areas are being exploited by the day.

It is recommended that more serious measures should be taken at national and international levels to encourage the study of chemistry and to enhance the regulation of its practice in order to maximize the services of the chemist in environmental sustainability, which is a milestone in the new global paradigm of sustainable development.

REFERENCES

1. Nigel Cross (2002). "Sustainable Development," *developments,* the international magazine, 18, p. 3+.
2. O.C. Eneh and N.J. Owo (2008). "Sustainable Development – A Review." *International Journal of Development Studies*, 3(3), 100-103.
3. The Holy Bible (1996). New Living Translation. Genesis Chapter 1 verse 2a. Wheaton, Illinois: Tyndale House Publishers Inc.
4. G.E. Eke (2007). "Time to arise and shine." *ICCON News 2007*, a newsletter of the Institute of Chartered Chemists of Nigeria, 2(2), p. 2.
5. D.A. Akoh (2007). "Evolution of chemistry profession in Nigeria." *ICCON News 2007*, a newsletter of the Institute of Chartered Chemists of Nigeria, 2(2), p. 5+.
6. F.E. Okieimen (2007). "The role of chemistry in national development." *ICCON News* 2007, a newsletter of the Institute of Chartered Chemists of Nigeria, 2(2), 7.
7. H.C. Okolo (2007). "Governing Council visits media houses." *ICCON News* 2007, a newsletter of the Institute of Chartered Chemists of Nigeria, 2(2), 4.
8. Microsoft Encarta Kids (2007).
9. I.R. Ejilah, L. Adejuyigbe, A.A.G. Olorunnishola and S.I. Ige (2007). "Characterisation of exhaust pollutants emitted from a two-stroke spark ignition engine." Programme and Book of Abstracts of the First International Conference on Sustainable Development, held 14-15 November 2007 at the University of Abuja, Nigeria, p.83.
10. S. Wheat (2002). "The Party's Over." *developments,* the international magazine, 18, p. 18+.
11. S.N. Uchegbu (2002). *Environmental Management and Protection,* 2ed. Enugu: Spotlite Publishers.
12. I.R. Ejilah, A.A. Asere, A.A.G. Olorunnishola, and S.I. Ige (2007). "Performance and emission analysis of a spark ignition engine run on commercial multigrade and monograde lubricants." Programme and Book of Abstracts of the First International Conference on Sustainable Development, held 14-15 November 2007 at the University of Abuja, Nigeria, p. 83.
13. T. Aigboje (2007). "Environmental 'air-filter' – a mechanism for engineering global clean environment." Programme and Book of Abstracts of the First International Conference on Sustainable Development, held 14-15 November 2007 at the University of Abuja, Nigeria, p. 61.
14. B.J. Bassey and L.B. Obong (2007). "The role of non-timber forest resources (NTFR) in community livelihoods: a

case study of Okiro, Obudu Local Government Area, Cross River State, Nigeria." Programme and Book of Abstracts of the First International Conference on Sustainable Development, held 14-15 November 2007 at the University of Abuja, Nigeria, p. 59.

15. E.C. Olewuezi (2007). "Sound urban solid waste management – a key factor in sustainable environmental protection and management." Programme and Book of Abstracts of the First International Conference on Sustainable Development, held 14-15 November 2007 at the University of Abuja, Nigeria, p. 54.
16. N.T. Tee and J. Amonum (2007). "Domestication of non-timber forest tree products for sustainable livelihood." Programme and Book of Abstracts of the First International Conference on Sustainable Development, held 14-15 November 2007 at the University of Abuja, Nigeria, p. 49.
17. S.A. Okueso (2007). "Improving environmental management for sustainable development in Nigeria." Programme and Book of Abstracts of the First International Conference on Sustainable Development, held 14-15 November 2007 at the University of Abuja, Nigeria, p. 46.
18. U.M. Bibi, M.A. Muhamman, S.M. Dzarma and B.M. Shehu (2007). "Examining the level of environmental awareness among rural communities in Maiha Local Government Area of Adamawa State, Nigeria." Programme and Book of Abstracts of the First International Conference on Sustainable Development, held 14-15 November 2007 at the University of Abuja, Nigeria, p.47.
19. V.E. Agbazue (2007). "Analysis of source contribution to particulate matter pollution in Benue Cement factory, Gboko." Book of Abstracts of the 30th Annual International Chemistry Conference, held 24-28 September 2007, Merit House, Maitama, Abuja, Nigeria, p.153.
20. R.I. Ngochindo (2007). "Furfural chemists, fine chemicals and feasible chemistry." Book of Abstracts of the 30th Annual International Conference, held 24-28 September 2007, Merit House, Maitama, Abuja, Nigeria, p. 55.
21. M.F. Dahiru (2007). "Determination of the effects of some petroleum products on soil's pH, minerals and maize seedlings." Book of Abstracts of the 30th Annual International Conference, held 24-28 September 2007, Merit House, Maitama, Abuja, Nigeria, p.50.
22. S.A. Akinyele and J. Ayorinde (2007). "Effect of textile mill effluent on selected chemical properties of soil." Book of Abstracts of the 30th Annual International Conference, held 24-28 September 2007, Merit House, Maitama, Abuja, Nigeria, p6.
23. T.A. Yisa and J.O. Oyero (2007). "Introduction of solar driers to fish processors around River Gbako at Bida, Niger State." Programme and Book of Abstracts of the First International Conference on Sustainable Development, held 14-15 November 2007 at the University of Abuja, Nigeria, p. 54.

INFORMATION COMMUNICATIONS TECHNOLOGIES FOR SUSTAINABLE DEVELOPMENT IN NIGERIA – A REVIEW

Isife, Chima Theresa
Institute for Development Studies, Enugu Campus
University of Nigeria, Nsukka
Tel: *+234-806-798-5288*; E-mail: *chimatheresa@yahoo.com*

ABSTRACT
Most African countries, including Nigeria, are not on course to realize the millennium development goals (MDGs) by 2015. Poverty level towers higher, as well as income inequality. This is not the case in the "information-rich" developed countries, where socio-economic sustainable development is powered by information communications technologies (ICTs). This paper argues that ICTs will provide the targeted tools for and facilitate sustainable development in Nigeria, if adopted faster than the progression shown for earlier technologies.

INTRODUCTION

The report released by the Organisation for Economic Co-operation and Development[1] up to 2000 (the end of 20th Century) show that the gap between developed and developing nations is widening due to "digital divide" or simply connectivity to the Internet. The developing countries need to achieve a "leapfrog" development to catch up with world prosperity.

Over the past 20 years, China has successfully achieved rapid economic growth by attaining the goal of quadrupling its GDP from the 1980 level. However, the first leap in China's modernization caused the problems of environmental pollution and land degradation. Such progress with focus only on economic targets is unsustainable. To reach the goal of harmonious economic, societal and environmental advancement, development must be managed by a comprehensive approach, called sustainable development[1].

Information communications technologies provide the tool needed to achieve sustainable development in Nigeria. We live in a world divided between rich and poor, healthy and sick, literate and ignorant, democratic and authoritarian, and between empowered and deprived. All traditional technologies as well as those adopted, in combination with all the policies enacted, for enhancing human development over the past centuries have not wiped these glaring disparities[1].

Development indices are depressing. More than 2 million people die of tuberculosis annually. Life expectancy in Sierra Leone is 37, a level not seen for centuries in the West. Dismal development statistics have abated the categorization of countries into developing nations, emerging economies, economies in transition, etc. "Digital divide" describes the gap between countries (and groups within countries) in terms of their or capacity to harness the power of information communications technologies (ICTs)[1].

In September 2000, the 189 member countries of the United Nations adopted eight Millennium Development Goals (MDGs), which committed them to making substantial progress toward the eradication of poverty and achieving other human development goals by 2015. The MDGs acknowledge the multidimensional nature of development and poverty alleviation. An end to poverty requires more than just increasing incomes of the poor[2]. The eight goals are ambitious: to eradicate extreme poverty and hunger; achieve universal primary education; promote gender equality and empower women; reduce child mortality; improve maternal health; combat HIV/AIDS, malaria, and other diseases; ensure environmental sustainability; and develop a global partnership for development.[3] The goals are then assigned specific targets deemed achievable by 2015 based on the pace of past international development achievements.

The Johannesburg World Summit on Sustainable Development of 2002 demonstrated a more extensive scope and included many areas of deprivation and action points. For instance, the 19th article states[4]:

> *We reaffirm our pledges to place particular focus on, and give priority attention to, the fight against worldwide conditions that pose severe threats to sustainable development of our people, which include chronic hunger, malnutrition, foreign occupation, armed conflict; trafficking in persons; terrorism; intolerance and incitement to racial, ethnic, religious and other hatreds; xenophobia; and endemic, communicable and chronic diseases, in particular HIV/AIDS, malaria and tuberculosis.*

The summit also underlined the importance of technology for development, such as cost-effective desalination of seawater, recycling and renewable energy resources, diversification of energy supplies, advanced energy technologies and even phasing out subsidies. There was an explicit reference to information communications technologies (ICTs) for development in Johannesburg. The importance of ICTs culminated in the World Summit on the Information Society (WSIS), phase 1 held in Geneva in December, 2003[2].

ICTs drive development in the "information-rich" developed countries, unlike the "information-poor" developing countries which lag behind in development. This paper argues that ICTS will provide the targeted tools for and facilitate sustainable development in Nigeria, and recommends that it be adopted faster than the progression shown for earlier technologies.

LITERATURE REVIEW

The International Telecommunications Union (ITU) estimated the worldwide ICTs market in 2002 as $21 trillion, and segmented it as Telecom Services (39%), Software and services (31%), and Hardware (30%). This comes to nearly 6.6% of Gross World Product.

Surprisingly, in developing countries, ICTs can be considered to be built on 4C's, namely, computing, communications, content, and (the often overlooked) human capacity. The recent World Summit on the Information Society (WSIS) focused extensively on 3C's, to wit, communications, content and capacity building, and less on computers. In truth, computing and other hardware continue to become less and less expensive, especially on a price performance basis. When considering the use of ICTs for development, conventional wisdom is that even if hardware is free (e.g. donated), communications, software, and training make ICTs expensive.[5]

ICTs are more than computers and telephony. Rather, ICTs are embedded in virtually all industrial, commercial, and services systems. Applications of ICTs can be divided under two broad categories. The first are those largely dependent on traditional telecommunications networks (including the internet) that enable on demand communications to provide or process information. Whether the information is used at all or/and transformed into knowledge is left to the human user who asked for it in the first place [5].

The second group of ICT applications, for want of a more appropriate name, we shall call Human independent, where information is processed and decisions are arrived at on the basis of preset criteria without human intervention at the time of decision making. These can be nearly passive systems, or part of a larger system (embedded ICTs). Examples include sensor based networks that determine automated climate control for buildings and sensor networks for malaria larvae dictation (today, or, in the near future). Many of the more discussed applications of ICTs for sustainable development are of the first category, ranging from distance education programmes, e-commerce or e-governance, while the second class of applications remains largely unrealized[6].

A few technologies can be classified as all-purpose technologies as their innovations extend over many areas, and these, in turn become indispensable elements in society's portfolio of development. Over a period, their contributions to economic and human development become impressively large, replacing older and less efficient methods. Their ubiquity makes one wonder how it was possible to manage in the past without accessing such technologies [6].

Electricity is often cited as a typical example of an all-purpose technology. In spite of electricity's obvious advantages, it took almost a century before electric power could become commonplace. Applications from new technologies are faster these days. The diffusion of radio and television was faster than electricity, and that of the internet is spectacular. Within 35 years of its existence, the internet has more than one billion users and its performance has multiplied manifold. Yet, the World Wide Web, practically speaking, is scarcely a decade old. The rapid diffusion of the internet and new communications technologies, such as mobile telephony, suggests that innovations from ICTs for sustainable development can also be faster than the progression shown by earlier technologies. This may provide society with targeted tools for sustainable development programmes [6].

The World Commission on Environment and Development (Brundtland Commission) defined sustainable development as meeting the needs of current generations without compromising the ability of future generations to meet theirs[7]. The debates of the Millennium Summit upheld this definition.[8] Hughes and Johnston[9] recognize that sustainable development is now as much about efficient resource-use and conservation of natural resources for future ones.

Sustainable development stands on three pillars in terms of its definition for the 2002 World Summit on Sustainable Development (WSSD). These are social development, economic development and environmental protection. In 1972, the first World United Nations Conference on Human Environment took place in Stockholm, Sweden, consequent upon the recognition of environmental problems as a global issue. Hence, sustained growth is the key to greater social equity. What is needed is economic growth that does not leave large segments of humanity behind. Non-inflationary growth of about 2-3% per year in OECD countries is needed to maintain high levels of employment. To enable substantial convergence with the development countries, most developing countries will need to sustain GDP growth of 6-8% per year over the next 3-4 decades. China has succeeded in this since 1990, and India is now getting on track[10].

In Nigeria, ICTs aim to develop understanding of how ICTs innovation is associated with change in society. ICTs influence the shaping of socially responsible and ethical policies and professional practices. ICTs impact changes in particular domains of human activities, including work, the home and private life and governance. Ethical, political, economic and cultural dimensions of ICTs innovations help in development. ICTs facilitate the study and reporting on how computers have affected employment levels, job content and structure, working conditions, career patterns and participation. They also facilitate addressing problems relating to computers and work and proposed measures for dealing with these problems. They encourage and support the design and development of systems which promote not only efficiency but provide job satisfaction, for example through interesting work and reduction of stress. ICTs also provide an international forum for assessing the social consequences of their ubiquitous presence and applications[11].

ICTs for sustainable development promote the safe and socially beneficial development and contribute to the development of an information society that meets the human needs of the present without compromising the ability of future generations to meet their own needs. Access to the right data at the right time, which can lead to good decision making that may translate to good governance, could be offered with ICTs in Nigeria.[11] They are involved in the development applications which involve the goals of sustainable development and equally help investigate the interaction among social, environmental and economic issues in their development and applications. They promote worldwide research and practice for their further advancement towards a safe and sustainable self-developing world. ICTs provide a platform for presenting and discussing ideas and trends in the intersection of the topics, "information society" and "sustainable development".

Notwithstanding the excellent aims and functions of ICTs, there are challenges. The simplified mode of ICTs masks the challenges that require extensive research, both in technology and in the social sciences. There are issues that determine the viability of ICTs for sustainable development, primarily focused on traditional computing and connectivity. Some of these are common to the needs of developed countries, which often have institutions and mechanisms to address some of them[12].

The digital divide is actually a manifestation of other underlying divides, spanning from economic, social, geographical, gender, and other divides.[13] Awareness, availability, accessibility and affordability are the features that determine the value of ICTs for a user. People must know what can be done with ICTs, and must also be open to using ICTs. Availability of ICTs facilities must be within reasonable proximity, with appropriate hardware/software. Accessibility relates to the ability to use the ICTs. Affordability of ICTs should ideally be only a few per cent of one's income. This covers life cycle cost, spanning hardware, software, connectivity and education[14].

Reducing the divide requires improvements across all the dimensions of ICT: computing, connectivity, content and human capacity. Personal computers (PCs) are prohibitively expensive for most people, making shared access (e.g. community centres or cybercafés) inevitable. PCs today are very difficult to use and even "experts" spend a lot of time maintaining their machines, worry about upgrades, security, compatibility of hardware, etc. [14]

While mobile telephony is improving worldwide, it remains expensive, limited in rural areas and poor at providing data connectivity. Meaningful content is lacking in many languages, and most content is not occasionally relevant. Today's systems tend to make people passive consumers of information, instead of enabling generation of information. Users need to be aware, literate and innovative to harness the power of ICTs. They also should be empowered to use ICTs, as both society and state. ICTs usage does not occur in a vacuum, rather within social and cultural norms. It is based on policy and business modes, especially regulatory in the long run. It must provide value and be sustainable from both user and provider perspectives. Affordability is a limiting factor, since we have seen that many people could avail of ICTs, but do not. Access is a severe bottleneck for increased ICTs use for many human development projects[11].

The history of the Internet sheds some light regarding the problems faced by users, both in developing as well as developed countries. Technologically, the Internet was built to be "best-effort" and security, quality of services, etc, have been continual add-ons. It was built for simpler uses and assumed literacy, affluence, and trust amongst end-users. Today, the move is to run everything over the internet, including critical applications, such as voice, video and even mission. Internet governance and protocols both need to be enhanced to expand its ubiquity and inclusiveness [14].

Availability of electricity is a critical pre-requisite for ICTs. The alternative of standby generators is very expensive. The need for low power consumption becomes critical when we consider ICTs devices that are not computers, such as mobile devices or sensors that can be minuscule. Until technology improves to reduce power consumption, the size and cost of these devices will remain high, and their penetration low. In the era of Internet, broadcasting technologies are often ignored.[15] Over the air broadcasting is an extremely cost-effective method of unidirectional imparting of information, e.g. through television (TV) or radio. Digital information can be broadcast easily, and there is already widespread usage of digital TV and, now, digital radio. These technologies can carry data signals for various end-use devices, ranging from computers to specialize but less expensive receivers that could receive data on say weather, agricultural prices etc.

ICT AND DEVELOPMENT

ICTs are viewed as both a means and an end for development. With roughly two-thirds of world economy based on services, and the rise of India, Philippines, and other nations as global ICTs players, many developing countries have accepted ICTs as a national mission. Even within manufacturing and industry, ICTs have an increasingly important role to play. During 1995-2002, when the US economy posted impressive overall growth, nearly one-third of the growth in productivity was attributable to ICTs. While the growth rates of ICTs, even in developing countries, are impressive, the base upon which these apply is very low[16].

ICTs can help achieve the MDGs by increasing efficiency, transparency, and competitiveness; opening up new opportunities and business models; and empowering citizens. The role of ICTs in the MDGs could be seen in each of the MDGs. By increasing access to market information; reducing transaction costs for poor farmers and traders; increasing efficiency, competitiveness and market access of developing countries to participate in global economy and to exploit comparative advantage in factor costs (particularly skilled labour), ICTs facilitate the realisation of MDG 1, which seeks to eradicate extreme poverty and hunger; halve, between 1990 and 2015, the proportion of people whose income is less than one dollar a day; and halve between 1990 and 2015, the proportion of people who suffer from hunger[16].

MDG 2 seeks to achieve universal primary education; ensure that by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling. ICTs could increase supply of trained teachers through ICTs-enhanced networks that link teachers to their colleagues, improve the efficiency and effectiveness of education ministries and related bodies through strategic application of technologies and ICTs-enabled skill development. Also, ICTs broaden availability of quality educational materials/resources[16].

MDG 3 seeks to promote gender equality and empower women. Using appropriate technologies, ICTs could deliver educational and literacy programmes specifically targeted to poor girls and women. ICTs influence public opinion on gender equality through information or communication programmes using a range of ICTs[16].

MDG 4 seeks to reduce child mortality. MDG 5 seeks to improve maternal health. MDG 6 seeks to combat HIV/AIDS, malaria, and other diseases; reduce infant and child mortality rates by two-thirds between 1990 and 2015; reduce maternal mortality rates by three-quarters between 1990 and 2015; and to provide access to all who need reproductive health services by 2015. These could be achieved by enhancing delivery of basic and in-service training for health workers, increased monitoring and information sharing on disease and famine, increased access of rural care-givers to specialist support and remote diagnosis, increased access to reproductive health information, including information on AIDS prevention, through locally appropriate content in local languages. All these roles are played by ICTs[16].

MDG 7 seeks to ensure environmental sustainability; implement national strategies for sustainable development by 2005 so as to reverse the loss of environmental resources by 2015; halve by 2015, the proportion of people without sustainable access to safe drinking water; and achieve by 2020 a significant improvement in the lives of at least 100 million slum dwellers. ICTs could promote these through remote sensing technologies. Communications networks permit more effective monitoring resource management mitigation of environmental risks. ICTs increase access to and awareness of sustainable development strategies, in areas such as agriculture, sanitation and water management, mining, etc. Greater transparency and monitoring of environmental abuses, enforcement of environmental regulations, and knowledge exchange and networking among policymakers, practitioners and advocacy groups could be facilitated by ICTs[17].

ICTs have not reached all the nooks and crannies in Nigeria to effect development. The country is still having energy crisis. There is no ICTs operation that will not require electricity. Since there is inadequate power supply in Nigeria, operating most of the ICTs facilities is not making progress as planned. Acquiring the Western technologies is important to the country, but managing the technologies is very difficult for the level of development that exists in Nigeria. Many children are still out of school because their parents could not afford the basic primary school fees. There are many street beggars today because they are hungry. The number of people with malnutrition is still very high. Children and mothers are still seen in unhealthy conditions in the rural areas. There are still unsafe drinking waters for most of the citizens in Nigeria. The number of unemployed graduates is enormous in Nigeria. Although ICTs have created employment for some youth who could get sponsors, many of them still find it very difficult to establish some kind of employment with ICTs. This is because ICTs business operation involves some financial backup[17].

IMPERATIVES FOR ICT TO DRIVE SUSTAINABLE DEVELOPMENT

Certain imperatives must be put in place for ICTs to drive sustainable development. ICTs must improve across the 4C's dimensions. ICTs are more than computers, and the various thematic areas of sustainable development require innovations in hardware and software for applications, such as sensors, controls systems, etc. Computers and other devices must become affordable[18], and rugged for use without extensive maintenance, security efforts or other specialized skills. They must become easier to use with interface in all local languages, and even in non-text interfaces (pictorial and spoken).

Typically, rural areas in developing countries, such as Nigeria, are without ICTs connectivity, let alone broadband (data) connectivity, at affordable prices - no thanks to the "digital divide". Universal access requires new networking and business models, perhaps combining public and private partnerships. ICTs are more than connecting to the internet. Human development programmes require integration of all forms of ICTs and media, such as mobile telephony, TV, radio, etc., as well as interconnecting systems, such as sensors, controllers, etc. [18]

ICTs in sustainable development must provide relevant content (value) to end-users in local specifics. One requirement is for tools to make it easier for people to become producers of content and information, instead of just consumers. However, we would like to achieve the Information Bill of Rights: Getting the right information to the right people in the right timeframe in the right language in the right level of detail[19].

Most people lack an awareness of the potential of ICTs. Beyond technical barriers, many limitations to incorporating ICTs are social, cultural or economic. A first goal for governments must be to increase literacy amongst its populace, especially for the historically disadvantaged, such as women. Often the success of development projects is driven by complementary (non-ICTs) institution building, such as the development of appropriate regulations, legal framework, and supply-chains[19].

To be meaningful, ICTs need to be integrated into development as well as engineering and societal systems.[7] More so, proponents or developers place too much focus on raw ICT (or even just connectivity), instead of optimally delivering value and services. Active efforts must be undertaken for global inclusiveness. Without concerted effort, ICTs, like many interventions or projects, would exacerbate existing divides, rather than facilitate sustainable development[20]. Solutions must be locally adapted, and extended into rural and other underserved areas.

A solution might appear beneficial at a pilot or small scale, but replication may pose enormous challenges. ICTs for Sustainable development (SD) must be economical, viable and provide value for end-users. They cannot thrive as charity, will become sustainable only when values are delivered. This is not to say that governmental interventions or subsidies have no role, especially during the initial stages. But, markets alone will not drive penetration into underdeveloped regions. The challenges are costly and long-term research and development required to make solutions viable. ICTs for SD research must be participatory and collaborative for the solutions to be globally relevant and sustainable[21]. Development is vast, and no single or group of developers can solve all the challenges. This requires collaboration, sharing experiences, and scaling the programs to make them relevant. Many groups or even smaller countries lack the critical mass for them to undertake the full spectrum of effort required. All stake holders, including beneficiaries and end users, must have a voice in assessing its needs, responsibilities and measures of success.

ICTs for SD must become a recognized and funded enterprise. All the stakeholders must come together and increase their interactions, recognizing that ICTs for SD is an interdisciplinary field requiring technologists, social scientists, and development professionals working together.[22] Even within traditional disciplines, ICTs for SD must become incorporated into Research and Development (R&D) and deployment projects. In the medium and long term, ICTs for SD should be categorized as a distinct field with its own defined challenges, support structures, professional societies, peer recognition, etc. Develop metrics for success and efficacy, and introduce academic rigour, cognisant of the fact that ICTs for SD is a nascent field, but attention is often focused on isolated or niche success. Very few solutions have been impartially assessed as to their claims, and fewer have been verified as to their global validity or scalability. Funding, R&D, and implementation strategies require development of metrics for relevance, effectiveness, scalability and social sustainability[23].

R&D should focus on real innovations and new challenges, instead of concerning itself with incremental changes to existing solutions, which are often touted as breakthroughs. The required innovations cannot be just technical, but also in business models and implementation strategies. It is important to identify at least a few "grand challenges" in ICTs that can lead to radical innovations in sustainable development.[24] R&D and technology development projects addressed specifically to meet the requirements of developing countries should not be left just to market forces, as these markets may not appear lucrative[22]. To help balance technology-push and market-pull, R&D needs to be supplanted by an RD&D (research, development and development) paradigm, with real world deployments and test beds. Such new models development activities should take place in a network of centres and institutions, both in the developing and developed world with contributions from the governments and global organizations.

CONCLUSION AND RECOMMENDATIONS

Nigeria is battling with sustainable development challenges, including insufficient financial resources, lack of ICTs infrastructures, poor capacity building, and many others. ICTs drive sustainable development in developed countries, and could do so in Nigeria. Learning from the experiences of some countries, ICTs need to be adopted as the "leading goat" for sustainable development, the driving force for modernization of Nigerian economy and society. Nigeria needs to work together with other developed countries in order to exchange viewpoints of state policy on ICTs for sustainable development, bridge the "digital divide", and to learn from developed countries in terms of their experience of the best practices, promoting south-south technical cooperation, such as training, case-studies and even trading of ICTs products. It is also the time for the United Nations to help Nigeria for a more equitable share for coordination, management and governance of using the Internet (for instance, the top domain names), for regulatory frameworks, improving intellectual property rights and so on.

Coupling sustainable development with ICTs is the long term answer for development challenges. Therefore, it is recommended that:

- ICTs be used in the exact amount needed to make the quality of life better in Nigeria;
- ICTs must make use of energy and resource saving technologies;
- ICTs must enhance, or at least not impair, the physical, mental and social life of the humans;
- ICTs should assure education, creativity and the development of humans, preserve cultural and biological heritage; and
- There should be allowance for real-life interactive social activities among people, since a strong and reliable sustainable balance between the use of ICTs and our human/social activities is the key issue for a better life.

REFERENCES

1. OCED (2004), "The e-Government Imperative," Retrieved on 28th May, 20010 from www.oecd.org.
2. United Nations Development Program (2003), "Millennium Development Goals: A Compact among Nations to End Human Poverty," in *Human Development report*, New York: Oxford University press.
3. M.P. Todaro and S.C. Smith (2009), *Economic Development*, London: Pearson Education Limited.
4. O.P. Obasi (2002), "Overview on Global Observing Systems in support of Sustainable Development," Keynote address presented on the World Summit on Sustainable Development (WSSD), Forum on Science and Technology innovation for sustainable development, Johannesburg, South Africa.
5. H.M. Ravnborg and O. Westermann (2002), "Understanding interdependencies: stakeholder identification and negotiation for collective natural resource management," *Agricultural System,* 73(1): 41-56.
6. P.T. Jaeger (2002), "Constitutional principles and e-government": an opinion about possible effect of the Federalism and the separation of powers on e-government policies, *Government Information Quaterly*, 19(4): 357-368.
7. United Nations (1987), *Our Common Future,* Oxford: Oxford University Press.
8. United Nations Development Programme, UNDP (2001), "Human development report", *Making New Technologies Work for Human Development*, New York: Oxford University Press.
9. B. Hughes and P. Johnston (2005), "Sustainable future," *Policies for global development future*, 3(8): 813-831.
10. J. O'Brien (2003), "Management Information Systems" *Managing Information Technology in the E-Business Enterprise*, 6th Edition, McGraw-Hill, New York.
11. J.O. Akinyede (2003), "Nigeria and its Space Mission", *GIM International*, 17(2): 13-15.
12. K. Laudon and J. Laudon (2003), *Management Information Systems*, 8ed, New Jersey: Prentice Hall.
13. R.V.S. Raj, R.T. Arunachaaram, S. Eswaran and N. Barakrishan (2004), "Mythology and Reality of Digital Divide Problem," *Sustainable ICT for Emerging Economies,* 8: 78-91.
14. A. Pouloudi and E. White (1997), "Stakeholder Identification in Interorganizational System: Gaining Insights for Drug Use Management System," *European Journal of Information Systems,* 6:1, 1-14.
15. S. Lopez-Riddaura, O.R. Masera and M. Astier (2002), "Evaluating sustainability of complex socio-environmental systems: the MESMIS Framwork," *Ecological indicators* 35: 1-14.
16. Lannin and Quiang (2003), "Poverty Eradication: Using ICT to meet MDGs - Direct and indirect Roles of e-maturity," in Dutta, Lanvin and Paua (eds.) *Global IT Report 2003-04,* London: Oxford University Press.
17. L.A. Joil (2004), "Developing Government-to-Government enterprises in Brazil": a heuristic model drawn from multiple case studies, *International Journal of Information Management*, 24(2): 147-166.
18. B. Galliers (1998), "Reflections on BPR, IT and Organisational Change" in Galliers, R.D and Bates, W.R.J (eds.) *Information Technology and Organizational Transformation,* Chichester: John Willy& Sons.

19. I. Ezz (2003), "Towards E-Government Adoption: Some Organizational Challenges for the Egyptian Government," *Proceedings of the 15th International Business Information Management Conference*, Cairo.
20. A.A. Abiodun (2002), "Space Technology and its Role in Sustainable Development," Paper presented at the Annual Meeting of the British Association for the Advancement of Science, University of Leicester, Leicester, U.K.
21. M. Themistocleou, Z. Irani, J. Kuljis and E.D. Love (2004), "Extending the Information System Lifecycle through Enterprise Application Integration": A case study Experience, Proceedings of the 37th Hawaii International Conference on System Science, Retrieved May 5th 2010 from http://csdl.computer.org/comp/proceedings/hicss/2004/2056/08/205680228b.pdf
22. R. Cyert, P.K. Kumer and J.R. Williams (1993), "Information market imperfection and Strategy," *Strategic Management Journal*, 14: 47-58.
23. J.D. Duck (1998), "The art of balancing" in Kotter, J.P. (ed.) *Harvard Business Review Change*, Harvard: The Art Publishing.
24. T. Davenport and J. Short (1990), "The New Industrial Reengineering: Information Technology and Business Process Redesign," *Sloan Management Review*, 31(4): 11-27.

BOOK REVIEW

TITLE: *The Economic and Social Impact of Privatization of State-owned Enterprises in Africa*
AUTHOR: Mike I. Obadan
PUBLISHER: Council for the Development of Social Science Research in Africa (CODESRIA)
YEAR OF PUBLICATION: 2008
CITY OF PUBLICATION: Dakar, Senegal
ISBN: 978-2-86978-229-0
PRICE: Unknown
REVIEWER: Njoku, Collins Chibuzo
Institute for Development Studies
University of Nigeria, Enugu Campus
Tel.: +234-803-740-5281
E-mail: chibuzo4dev@yahoo.com

From independence up to the early 1980s, Nigeria and the rest of the developing countries in Africa, Asia and Latin America made extensive use of state-owned enterprises (SOEs) or public enterprises (PEs) for resource mobilization, allocation and for accelerating the pace and magnitude of economic development and the determination of government finances, against the backdrop of underdeveloped and weak private sector, comprehensively disabled by fiscal constraints. There was a chemistry between PEs or SOEs approach to development planning and the Keynesian model of grandeur government or public sector involvement in economic management and development. The activities of SOEs or PEs which were mainly in the utilities and social services sector, like electricity, water, roads and telecommunications, later expanded into such unorthodox sectors, as agriculture, mining, manufacturing, commerce, banking and finance, etc. Government became an omnibus and octopus economic manager.

Regrettably, most of the SOEs or PEs did not live up to their billing. A constellation of factors necessitated a reappraisal of the role of PEs. Such factors or variables included the SOEs scandalous inefficiencies, the dismal financial failures and their heavy burden on public finances, the harsh macroeconomic environment of the 1980s arising from the global economic crisis and the resurgence of conservative thinking on economic management which formed the basis for economic liberalization.

Against the tough economic scenario, most developing countries in the African continent and beyond embraced the privatization and commercialization policy which gained popularity in both developed and developing countries after the apparently successful privatization experiments of the British conservative government of Margaret Thatcher in the late 1970s. In the 1980s, privatization became an integral element of the dominant economic policy package, later christened the "Washington Consensus" model of economic development. This model is predicated on the deregulation and liberalization of economic activities and minimal role for the state. Nigeria adopted the privatization policy within the framework of the World Bank/IMF Structural Adjustment Programme (SAP) introduced by the Babangida military presidency in 1986.

Privatization and Commercialization policies have been associated with the objectives of raising new money for the state, relieving the state of the burden of supporting non-performing and epileptic enterprises and businesses, as well as encouraging competition. Also significant are the expected benefits relating to greater efficiency, renewed investment, budgetary savings and improvement of a country's fiscal position. Since the late 1980s, privatization, as a major instrument of economic reform, has been stepped up in almost all African countries. But then, after decades of rigorous and robust implementation of the privatization programme in Africa, the need arises for a comprehensive analysis and impact assessment of privatization programme in all its hues and nuances, especially as regards the economic and social impact vis-à-vis the numerous expected beneficial claims made by its dominant international think-tanks and their local advocates. This becomes very compelling when one recalls the SAP riots of 1980s in Nigeria and the fact that privatization has been a qualified success in Africa.

This is the thematic thrust of the book, *The Economic and Social Impact of Privatization of State-owned Enterprises in Africa* by Mike I. Obadan. In the light of the clear and urgent need for a comprehensive and rigorous analysis of privatization in Africa, the book undertakes a preliminary survey and review of privatization issues to stimulate further indepth impact assessment. The book, an impressive theoretical and empirical work, from an inimitable academic, economist and development consultant, is written in ten chapters. Chapter One is an introduction and background of the study. Chapter Two is on the size, significance and performance of state-owned enterprises (SOEs). Chapter Three, deals with the case for privatization, which includes theoretical and ideological arguments and framework.

Privatization is an omnibus concept, which can hardly lend itself to a watertight definition. Hence, the book supports a narrow definition in terms of ownership transfer to the private sector, relating to sale of state assets or shares in public enterprises. This can be gleaned from Chapter Four. Objectives of Privatization and Principles and Methods of Privatization constitute the themes of Chapters Five and Six respectively. Chapter Seven is on the State of Africa's Privatization. There are theoretical macroeconomic, microeconomic and social effects and impact of privatization and the empirical evidence of the impact of privatization as contained in Chapters Eight and Nine. Methods of Impact Assessment are also subsumed in Chapter Nine. Chapter Ten, which is the concluding chapter or epilogue, is on the need for further research and summary of research issues.

The need for further research on privatization is predicated on three premises. First, the empirical findings on privatization so far is that they are not conclusive. The privatization programme in Africa is at best a mixed blessing and at worst a fiasco, when one recalls the various SAP riots across Africa and beyond and the fact that it has not turned out to be markedly superior to the performance of PEs. Private sector ownership is no guarantee for good performance, considering that private sector firms do fail and go bankrupt in various parts of the world. The current global financial and economic crisis and bank failures in Nigeria, which necessitated government stimulus and bail out plans, are cases in point.

Markets and the state do fail. What is important is not the ownership structure. But, for improved performance in terms of productivity and services, it is desirable to introduce competition and effective regulation before, rather than after, privatization occurs. Nigeria's telecommunication industry bears eloquent testimony to this. The second factor for further research is that in Africa, apart from the theoretical predictions, not much is known about the impact of privatization. The third imperative for further research is that research is an ongoing dynamic academic exercise. Indeed, research is the handmaiden of academics. And research and development (R & D) are dialectically imperative for cutting-edge global competitiveness and sustainable development.

Privatization for what? Beyond privatization and the free market approach, and the Washington Consensus on the role of the state in development and its limitations, there is the urgent and critical need for a New Consensus of people-public-private-partnership (PPPP), which must of necessity address the pervasive poverty, deprivation trap and debt peonage of African countries. Man is the fulcrum of development. Also, development is of the people, by the people and for the people. An important dimension of the New Consensus should place emphasis on government's responsibility to focus on poverty alleviation and human capital development and to help secure the foundation for private-sector driven economic growth and development. There is also the need to build state capacity and responsiveness by reacting to both government and market failures with judiciously designed reforms and encouraging the flowering and strengthening of non-governmental organizations (NGOs), community-based organizations (CBOs), faith-based organizations (FBOs) and civil society organizations (CSOs) more generally to support the development process. This is because development is a multi-track, multi-dimensional and multi-layered process of social change aimed at improvement in the quality of life of the people.

The book under review is a CODESRIA Green Book Series, which is in consonance with the current global paradigm shift in development strategy – GOING GREEN. This, by implication, means a policy of protecting the environment and ensuring environmental sustainability in our businesses, productions, services and livelihoods. In the light of its rich insight on privatization, this book is recommended to policy makers, bureaucrats, scholars, researchers and donor agencies, and should stimulate further research.

CALL FOR ARTICLES

Authors are invited to submit manuscripts for peer-review for possible publishing in the ***Technoscience Review, TR*** - an international academic research journal of science, engineering, technology and development (published biannually in May and November).

Manuscripts, which must be original, theoretical or empirical, and scholarly, are considered on the understanding that they are not submitted to any other publishers. Paper, with 1-inch all-round margin, must not exceed 8 pages 12-font-size Times New Roman single-line spacing in Microsoft Word (Windows '97-2003), should be sent electronically as attachment to the Managing Editor, WIPRO International Academic Research Journals, through E-mail: *info@wiprointernational.org* (copy *esccha@yahoo.com*).

Paper should conform to Science style of citation and referencing. Citations are numbered sequentially in block parenthesis in superscript, [x], in the text. The numbers should appear in the reference list with details, using Harvard style of referencing.

Under the title of the paper should appear the author's name (surname first), institutional affiliation, rank, e-mail address and mobile phone number, followed by italicized abstract of not more than 100 words. Table or figure should be properly numbered (e.g. *Table 1* or *Fig. 1*) and placed as close as possible to the in-text citation. Map, chart, table and figure should fit into trimmed quoto size.

Each submitted article should be accompanied by a review fee of $50 (international scholar), $20 (African scholar) or =N=2,000 (Nigerian scholar) paid into WIPRO International domiciliary US$ A/c. No. 1193010191464301 or Naira A/c. No. 1191140191464301 of ECOBANK Nigeria Plc., Enugu (Okpara Avenue Branch II). Scanned copy of payment teller should be sent electronically as attachment.

Minor and obvious corrections may be effected by the Editorial Board, but the Ms would be returned to author for major corrections. Authors will be communicated on the status of their articles within four weeks through their supplied e-mail addresses and/or phone numbers. After effecting major corrections, author will return Ms electronically as attachment for publishing in the next edition of *TR* with a pagination fee of $180 (international author), $150 (African author) or =N=12,000 (Nigerian author) plus Web metrics fee of $50 (international author), $30 (African author) or =N=3,000 (Nigerian author) paid as directed above with the scanned copy of payment teller sent as attachment. An article attracts a copy of the journal in which it appeared to the author(s), who will arrange to collect it from the Managing Editor in Enugu or pay the appropriate courier charge. An extra copy sells for =N=1,500 or $20.

For further inquiry

Contact: Managing Editor, *Technoscience Review*, Phone: +234-803-338-7472 or +234-805-315-2828; P.O. Box 9060, Enugu; E-mail: esccha@yahoo.com, onyenekenwa.eneh@unn.edu.ng OR *www.wiprointernational.org.*