UNIVERSITY OF PORT HARCOURT

Christmas Tree

Tree of Life, Tree of Knowledge

An Inaugural Lecture

by

Professor Joseph Atubokiki Ajienka
Department of Petroleum & Gas Engineering
Faculty of Engineering

Director, Institute of Petroleum Studies

INAUGURAL LECTURE SERIES

No. 47

December 15, 2005

DEDICATION

This Lecture is dedicated to

The Chain of Guidance!

and

to all my teachers,

in particular

Professor Chi. U. Ikoku
(1945-2003)

An international scholar and teacher,
a Jack of all trades, Master of some!

ACKNOWLEDGEMENT

I would like to express my gratitude to the following organisations for permission to use data and materials published by them in this lecture: Society of Petroleum Engineers (SPE), Department of Petroleum Resources, Institute of Petroleum Studies (IPS) and other members of the Petroleum family.

I would also like to express my gratitude to all my class mates at the University of Ibadan; my students and colleagues in the University of Port Harcourt and Industry who have contributed to the development of my career.

My special gratitude goes to the following:

My maternal grandmother, late Nne Ayojoin, the palmwine seller of repute, a very peaceful woman under whom I grew up with fond memories; my father, late Chief Joe Atubokiki Ajienka Opungiriko, a man of high culture and my mother Mrs Eunice Obieton Ajienka;

My other mothers: late Madam Iwari Ayisah and Madam Dorah Ayisah and late Madam Apakawari Tonka, my mother in-law Madam Catherine Atuboyedia;
Indeed, I am a child of many mothers!

My gratitude also goes to my friends, brothers, sisters and in-laws and finally

My wife, Mrs Mercy Finelady Ajienka, and our children: Orabelema Kalamba Ajienka, Nemitari Miebaka Ajienka and Soala Lolia Ajienka for their love and support.

Christmas Tree:
Tree of Life, Tree of Knowledge

The Vice Chancellor,
Members of the Governing Council,
The Deputy Vice-Chancellors,
Principal Officers of the University,
Provost College of Medical Sciences,
Dean School of Graduate Studies,
Dean Faculty of Engineering,
All other Deans of Faculties,
Distinguished Professors and Scholars,
Directors and Heads of Departments,
Captains of Industry,
My Friends from the Petroleum Industry,
My Friends from far and near,
My Students, past and present in the Faculty of Engineering,
My Students and Staff of the Institute of Petroleum Studies,
My Dear Wife and Children,
Distinguished Ladies and Gentlemen,
Great Students of Unique Uniport,

INTRODUCTION

Today is another celebration, the 47th edition of the Inaugural Lecture Series in the academic culture of this great University. Responding to the call of the royal drum of the Vice-Chancellor, I stand before you as the celebrant. As we say in this clan, the masquerade performing today is the Petroleum Production Engineering masquerade. The big masquerade of the Petroleum Engineering group, the late Professor Chi Ikoku performed in the year 2000 during the 26th edition of the Festivity. May I therefore most

respectfully, welcome you to this celebration and thank you for the great honour of your presence today.

The Inaugural Lecture is a monumental event in the career of a professor in the academic culture of a University. It is an event to inaugurate a new professor in the respected clan of professors or as it is sometimes the case, for an old professor to find time to speak of his scholarship. For the new professor, it is certainly a major milestone in his career similar to the tradition of installing a chief in a community. As one of the Acts of the Professors, the Inaugural Lecture is an occasion for self-proclamation in the Temple of the Intellect. It is an opportunity for the professor to tell the community of Town and Gown, what he has been professing to merit the title and honour. A professor is an agent of cross-pollination and fertilisation of ideas. Therefore, the wider community expects more from the professor. They want to know the relevance and benefits of his ideas, his scholarship.

Sometimes the Inaugural Lecture is described as an intellectual harvest in which the professor is the Chief Priest. And as the Chief Priest, the professor plays prophet. He prophesises what is impending, predicting gloom or bloom. In some cases the professor points to solutions to the problems he had been trying to solve and concludes by telling policy makers and policy executives the way forward. I will try and follow the footsteps of my predecessors and please bear with me as I keep faith with this high tradition of academic culture in my peculiar way.

Giving an Inaugural Lecture is one subject I believe we all learnt from our predecessors. And one of the Inaugural Lectures that touched me deeply is *Philosophy and the*

Quest for Truth delivered in 2002 by the Professor of Philosophy, Professor Nwodo. It touched me deeply because, the terminal Degree in academic pursuit, in most disciplines and in most Universities, is the Doctor of Philosophy (PhD). Therefore, a professor is not only to speak about what he professes but also what lies behind what he professes. That I believe is the *philosophy* that lies behind what he professes in his specialisation. And this philosophy must derive from his Quest for Truth because research is simply to search and search in fulfilment of the beautiful Promise: Seek and ye shall find! As researchers, we are to seek diligently on the Path of Truth. We are to seek the manifestations of the Laws of Nature in Creation in our disciplines.

I also remember the Inaugural Lecture of Professor Anosike entitled *In Praise of Enzymes* in which we heard the Anthem on Enzymes. The unique form and content of that lecture made a great impact on me. Apart from these examples, let me say that generally, I have benefited from the high academic culture of the Inaugural Lectures in this University. Let me therefore pay homage in the form of gratitude to the respected Clan of Professors.

Our people say a good market day is known in the morning. Despite, the opportunity cost of not joining the petroleum industry, I was inwardly happy when I joined the teaching career on the 2nd of April 1982. I started on the very first rung of the academic ladder as a Graduate Assistant and rose through the ranks. I joined the queue of those who asked for promotion in 1997 and by the Grace of the Almighty, I was promoted to the rank of Professor of Petroleum Engineering with effect from July 23, 2001. I can confirm that I have had a good outing in the academic

market. Indeed, it has been a good market day for me! I cannot express enough, the depth of my Gratitude to the Almighty.

My specialisation is Petroleum Production Engineering. I am proud to say that I am completely made-in-Nigeria or what today can be described hundred-percent local content. The implication of what I have said is that given the enabling environment and the support of all stakeholders, the Nigerian intellectual can hold his own anywhere in the world.

Vice-Chancellor Sir, ladies and gentlemen, what I have been permitted to prepare for you is a balanced diet that goes beyond the intellect into recognitions of Nature and the Truths of Life. For in my studies, I see the universality and wholesomeness of knowledge. Therefore, I no longer create a dichotomy between the philosophy of science and the philosophy of religion. For me, Nature is a source of inspiration that runs through the fabric of my work. It helps me to gain clarity and see the simplicity of the Truths of Life. I have also come to the recognition that every humble and open-minded investigator of Nature be he a scientist, artist or engineer draws from the inexhaustible Fountain of Knowledge that streams down from Above.

In this lecture therefore, I shall share with you some fruits I have been permitted to taste as I climbed the Tree of Knowledge. The higher we climb, the wider our horizon and the deeper our recognitions and convictions of the universality of knowledge which manifests in uniformity at both the macro and micro levels in Creation. However, the hints given here are based on my present level of recognition. As we mature, so will our recognitions deepen!

Therefore, I will encourage you to examine and investigate for yourselves.

Let me also say that this lecture by a petroleum engineer is coming at a very auspicious time. Early in 2006, we shall be celebrating 50 years of crude oil *exploitation* in the Niger Delta. Crude oil was discovered in 1956 at Oloibiri. And since then, things are no longer at ease in the Niger Delta. Once upon a time, in the days of the palm oil trade, the Niger Delta region boiled and boiled. Today, with crude oil, the region still boils and it seems things will fall apart if the centre cannot hold.

Ibiwari Ikiriko (2000) in his Anthology of Poems: **Oily Tears of the Niger Delta** lamented about this situation in the following poem:

The Palm and the Crude

In the beginning
was the palm
And the palm
Was of us
And the palm
Was by us
And the palm
Was with us

Then came the Crude
And the Crude
Was of us
But by them
And with them.

In the beginning
Was the palm,
And the palm
Oiled our palms
Balmed our joints
Sweetened our insides
And anointed our heads.

And the palm
Propelled the pacification process
And with us as proud partners
Merchants and Missions
Rode triumphant upland
To let in light
Bright as palm fruits
In the sun.

Then came the crude
And the crude
Wasted our waters
Soiled our soils
And lacerated our lot

And we, Aborigines
Of the river side, bereft, stoic,
Wash our palms
With dry spittle
As legs move up
To tie hands,

And sahelian
Dooms boom with
Maritime doom

From palm oil to crude oil, the Niger Delta region is engaged in a struggle. The struggle for justice and equity! But where there is *real knowledge*, things could be different!

Let me say immediately that the word petroleum is related to the name Peter. It is said that Peter is the rock upon which the church is built; that is the rock of conviction, Peter evinced about the Origin of Jesus. Petroleum is from the words *Petra* (rock) and *oleum* (oil). Thus petroleum is simply rock oil. Generally speaking, petroleum refers to crude oil and natural gas.

The Nigerian National Petroleum Corporation (NNPC) was called the Nigerian National Oil Corporation (NNOC). The change of name in 1977 was perhaps in recognition of the fact that the word oil was limiting and that the word petroleum encompasses both oil and natural gas. Before the year 2000, our Department was called the Department of Petroleum Engineering. In the year 2000, we changed our name to the Department of Petroleum and Gas Engineering to emphasise the need to also focus on Gas Engineering since Nigeria with an estimated gas reserve of $\pm$159 trillion standard cubic feet (tscf) is classified a gas province.

Apart from the University of Port Harcourt, perhaps the University of Pennsylvania in the United States of America, is the oldest Department of Petroleum and Gas Engineering. The University of Port Harcourt is the first in Nigeria to offer both undergraduate and graduate programmes in Gas Engineering. By all indices of academic excellence, our Department and the Institute of Petroleum Studies have contributed to making this University a Centre of Excellence in Petroleum and Gas Engineering.

The Dance of the Petroleum Masquerades

In the popular words of Professor Maduka (1994) about the culture of academic masquerades, let me say that the petroleum masquerades domiciled in the Faculty of Engineering swing in the water and air elements. The people of the Niger Delta have a rich aquatic masquerade culture. The unenlightened confuse *owu* (the name for masquerade or nature being) with *oru* (demon). But what lies behind the masquerade? What is the origin of the masquerade? Knowledge about the aquatic masquerade culture indicates clearly that most of the beautiful masquerades of the Niger Delta have their origin in Nature beings, the water sprites. In the Niger Delta, most masquerades are usually played in groups of seven.

In petroleum engineering therefore, we will have the following masquerades: drilling (well engineering) engineering, formation evaluation (petrophysics), reservoir engineering, production engineering, petroleum economics, gas engineering, and the big masquerade. The first six are the main specialisations. For a full compliment, there are other minor masquerades that have to play by the side (what our people call *Owu akpara*). These specialisations include the Health, Safety and Environmental (HSE) Engineering, computer applications etc. There is another complimentary suite of masquerades that usually play with us in teams. These are masquerades that swing in the earth element similar to the *kiriowu*. They are the petroleum geosciences masquerades. These masquerades are played from the Faculty of Science. I know at least one University abroad where Petroleum Engineering and Petroleum Geosciences have come together to form a Faculty of Geosciences and Engineering and new programmes such as Geosystems Engineering are being offered.

We play in integrated teams in harmonious dance steps. We play in teams, typical of a football team and not the relay team. In most masquerade cultures, the big masquerade plays last. But sometimes in dancing groups, the leader dances first so that the others will follow the rhythmic movements. In our petroleum and gas engineering clan, expectedly, the big masquerade, the team leader, who taught us the dance steps was the first to play the petroleum masquerade. Characteristic of his leading role, the masquerade of which the late Professor Chi. Ikoku was the chief performer was the big masquerade of our clan. The performance during the 26th Festivity of the Inaugural Lecture Series of the University of Port Harcourt was entitled *Petroleum, Mankind's Best Friend*. The late Professor Chi Ikoku, once described himself as a Jack-of-all-trades, Master of some. With degrees in mechanical engineering, chemical engineering, industrial engineering and petroleum engineering and practical oilfield experience in drilling engineering, reservoir engineering, production engineering, gas engineering and petroleum economics, the late professor was indeed a Jack of all trades and Master of some. A quintessential teacher, an international scholar under whose tutelage and guidance I learnt the dance steps of the production masquerade!

As I said before, the performance today is that of the Production Engineering masquerade. A masqeurade that plays in the central position. Exquisitely doned and attired in what we call personal protective equipment (PPE), the production engineer is responsible for producing oil and gas in a cost effective manner. I believe in quick succession, the Reservoir Engineering and

Drilling Engineering masquerades of our clan will follow in the performance.

So much for this necessary digression!

The topic of my Inaugural Lecture is *Christmas Tree: Tree of Life, Tree of Knowledge.* This topic which is appropriate for the Christmas season would evoke different reactions in different people. Many would wonder what a petroleum engineer has to say about the Christmas tree. In this lecture, I will like to celebrate the Christmas tree and through the topic draw attention to the universality of knowledge. And as I do so, you will begin to appreciate the significance and symbolism of the Christmas tree to petroleum engineering and in particular my specialisation: Petroleum Production Engineering.

Let me start with the history of the Christmas tree.

History has it that in the 7th century a monk from Crediton, Devonshire, went to Germany to teach the Scriptures. He was reported to have done many good works, and spent much time in Thuringia, an area which has become the cradle of the Christmas Decoration Industry. Legend has it that he used the triangular shape of the Fir Tree to describe the Holy Trinity of God the Father, God the Son and God the Holy Spirit. The converted people began to revere the Fir tree as God's Tree, as they had previously revered the Oak.

In the early 16th century, Martin Luther was said to have decorated a small Christmas tree with candles, to show his children how the stars twinkled through the dark night.

Figure 1: A Painting of the Christmas tree

It was reported that the early trees were biblically symbolic of the Paradise Tree in the Garden of Eden. The many food items were symbols of plenty, the flowers, originally only red and white. At the time, red was symbolic of knowledge and white for innocence or what today is symbolic of Purity. And Purity is of the Light and the Light is Life. Therefore, we can begin to see the connection between the Christmas Tree, the Tree of Knowledge and the Tree of Life.

From Europe the custom and symbolism of the Christmas tree spread all over the world. In America, Christmas Trees were introduced into several places at different times. The Christmas tree was a popular custom among the Dutch communities which settled in Pennsylvania. Tracing this history to America the cradle of the modern petroleum industry is important as we shall see later.

At Christmas, the beautiful tree is decorated. There are many carols and folklore about the Christmas tree. One of the most popular carols about the Christmas tree is **O Christmas Tree,** a traditional German Carol. The composer and the author of the lyrics are unknown. In celebrating the Christmas tree so important to Christendom and the petroleum industry, let us at this point, recall this beautiful Christmas Carol in praise of the Christmas tree as a tunic for this lecture. (O Christmas Tree: Lyrics and Music).

O Christmas Tree!

O Christmas Tree! O Christmas Tree!
Thy leaves are so unchanging;
O Christmas Tree! O Christmas Tree!
Thy leaves are so unchanging;
Not only green when summer's here,
But also when 'tis cold and drear.
O Christmas Tree! O Christmas Tree!
Thy leaves are so unchanging!

O Christmas Tree! O Christmas Tree!
Much pleasure thou can'st give me;
O Christmas Tree! O Christmas Tree!
Much pleasure thou can'st give me;
How often has the Christmas tree
Afforded me the greatest glee!
O Christmas Tree! O Christmas Tree!
Much pleasure thou can'st give me.

O Christmas Tree! O Christmas Tree!
Thy candles shine so brightly!
O Christmas Tree! O Christmas Tree!
Thy candles shine so brightly!

From base to summit, gay and bright,
There's only splendour for the sight.
O Christmas Tree! O Christmas Tree!
Thy candles shine so brightly!

O Christmas Tree! O Christmas Tree!
How richly God has decked thee!
O Christmas Tree! O Christmas Tree!
How richly God has decked thee!
Thou bidst us true and faithful be,
And trust in God unchangingly.
O Christmas Tree! O Christmas Tree!
How richly God has decked thee!"

Figure 2: A Painting of a family by their Christmas tree

That was in praise of the Christmas tree in the fields, in particular, in the temperate regions of the earth, a symbol of Love celebrated at Christmas. Let me now turn to another type of Christmas tree in the oilfields in different parts of the world, in different terrains. I wish to celebrate this

Christmas tree so important in petroleum production engineering.

The Pioneer oilfield worker played Adam

The United States of America is the cradle of Petroleum Engineering and the Petroleum Industry. The first oil well was drilled near Titusville, Pennsylvania USA by Edwin L. Drake in 1859. The pioneer oilfield workers or early petroleum engineers played Adam. They had the privilege of giving names to new tools and equipment they used to explore, drill and produce oil and gas. The typical oilfield men were not very literate and so despite the names given by engineers and technicians, they gave their own names - very often slang - to oilfield tools, equipment and workers. Thus, we have names like roughneck, tool pusher, roustabout, gooseneck, monkey board, rat hole, mouse hole, and catwalk. There are also names like wild cat, dog leg, fish in hole and fishing in oil and gas wells, drilling mud, widow maker, … and Christmas tree. Indeed the oilfield has its own character, language and units of operation called oilfield units. What is in a name it is often asked? As everything including man is what its name says, the names enable us to form pictures with which we form conceptions.

Why did they call the wellhead Christmas tree? I had traced the history of the Christmas tree from Europe to America. We saw how celebrated the Christmas tree had been and so when the wellhead was designed with wing valves, that look similar to the branches of a tree the pioneer oilfield workers named it after the Christmas tree. The core of the Christmas tree is similar to a Cross. Christmas is the Festival of the Birth of the Lord Jesus Christ. It is a Festival of Divine Love.

What could be the connection with the oilfield? We can fathom that through the Grace of the Creator of all things, petroleum a form of energy was stored in the bowel of the earth, awaiting the maturity of man to discover. Through the Love of the Creator, knowledge of this treasure, which people also call the black gold, came to man from earth fissures and seepages. Through the Grace of the Creator, this Gift of Nature had to be channelled to the surface through the wellhead rightly called Christmas tree. And so it is not an accident that the wellhead is named Christmas tree. It is the Love of God that is made manifest, in the oilfield that we may celebrate this Love every day anew in Gratitude to the Lord of All the Worlds through Whose Goodness we are afforded petroleum!

The Black Gold, Treasure of the Deep

The Christmas tree is the wellhead that caps the oil or gas well. It is the visible part of an oil or gas well that is sometimes over 10,000 feet deep. The roots of our oilfield Christmas tree reach down into the deep recesses of the earth and draw the sap, the black gold from the reservoirs. I speak of roots because one oil well can produce simultaneously from two or three reservoirs. With multilateral horizontal wells, this is more manifest as there are all kinds of interesting well architecture. The wing valves are the branches of the tree. The fruits of the Christmas tree are the crude oil and natural gas that gush out from the well. These fruits sustain the economies of the nations endowed with these resources. These fruits, oil the engine of the global economy. Wars are fought to secure the supply lines of these fruits.

Well architecture is an interesting subject. It helps us to design and build a well that is safe and functional using well

defined critical success factors or functionalities. The importance of the wellhead, the Christmas tree, lies in the fact that it enables the production engineer have effective communication with the reservoir, control flow and provide safety for the environment and workers.

Today we have dry and wet Christmas trees. The wet Christmas trees are landed on the seabed in the deep of the ocean, while dry Christmas trees are landed on the surface. Today, we speak of intelligent or smart wells; wells that are designed to enable us have real-time data of the reservoir. We can also have co-mingled production from different reservoirs with the capability to allocate production to each reservoir for purposes of flow metering and production accounting. We also speak of live and dead crude oils; of intelligent and smart wells.

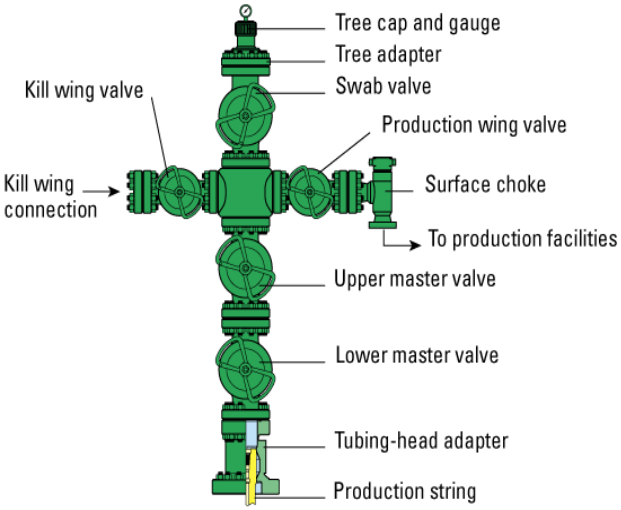


Figure 3: The oilfield Christmas tree (dry)

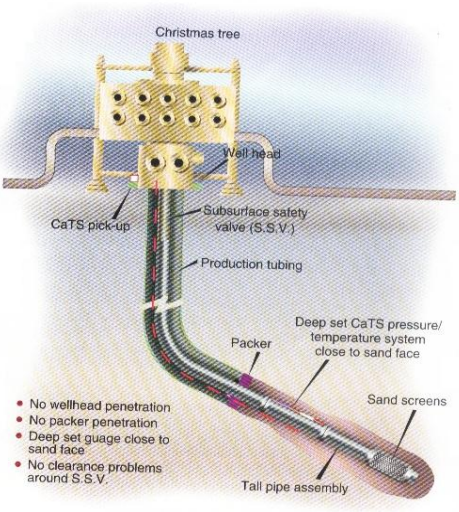


Figure 4: The oilfield Christmas tree (wet)

The Christmas trees in the oilfields are found in all seasons and in very challenging environments were exploitation of petroleum takes place. These trees are grown, cultivated, nourished and harvested by the production engineers.

Vice-Chancellor Sir, my work has been to ensure that we produce oil and gas from our wells through the Christmas tree, safely, efficiently and profitably. Like the medical doctor, my work is to ensure that our wells are healthy and produced in such a manner that they give of their potential. My work is to ensure that problems of sick wells are diagnosed promptly and the appropriate and effective innovative treatment given; and thereafter, to monitor the post-treatment performance of the well. In medical practice, prevention is better than cure but in our practice, *prevention*

is better than cure if it is cheaper. This is because the driver in all our decisions is cost efficiency of the various technically feasible and environmentally-friendly alternative solutions to a well problem.

Learning from medical diagnostics, we have made some progress in developing well diagnostics. We have developed qualitative and quantitative techniques and processes to do our work efficiently. Some of the tools such as Nuclear Magnetic Resonance (NMR) equipment we use to investigate formation damage are also used by medical doctors. Our greatest challenge is the cultivation of Christmas trees in ageing oilfields we call brown fields and in deep offshore fields.

Grow and Harvesting Reserves

At the moment, Nigeria's proven petroleum reserves stand at 33 billion barrels of oil (bbls) and 159 tscf of gas. Nigeria ranks as having the 6^{th} largest oil reserves and 9^{th} largest gas reserves in the world. Nigeria's production capacity stands at about 2.5 million barrels of oil per day (bopd). The plan is to grow our petroleum reserves to 40 billion bbls of oil and about 200 tscf of gas and produce 4 million bopd by 2010. While it is the primary responsibility of the reservoir engineer to **grow** the reserves together with the geoscientists, it is the responsibility of the production engineer to **produce** the reserves. The production process involves producing from new wells and to effectively manage the production from old wells that experience all kinds of production problems.

Green Fields, Brown Fields

The life cycle of an oil and gas field is about 30 years. From primary recovery (when the well flows unassisted) to

the transition phase i.e. artificial Lift (when we assist flow in the tubing through gas injection into the well annulus to help lift the oil in the wellbore or pumping); to secondary recovery through to tertiary recovery (when through fluid injection into the reservoir, we assist production from the reservoir), there are characteristic problems we must be proactive to handle effectively. It is important to understand developments in the well life cycle in order to develop strategies for life cycle production management.

Green fields are fields that are newly developed. The fields are fresh and have the vigour and vibrancy of youth. Brown fields are mature oil and gas fields that are more than 15 years old and begin to show signs of old age. Table 1 is an example of age distribution of wells in a company in the Niger Delta. Old age comes with its aches and pains. The Oloibiri field which is the cradle of the petroleum industry in Nigeria, discovered in 1956 is the mother field.

The vibrancy of green fields is usually exploited to the disadvantage of productivity as the field matures. Engineers push the limits of productivity as if in a hurry to exploit the oil field without due regard to best practices of maintaining regulatory agency (in our case Department of Petroleum Resources popularly called DPR) recommended production rate called Maximum Efficiency Rate (MER) or Production Allowable.

The Allowable, which is usually fixed at the beginning of a well which is newly completed or re-completed or stimulated or repaired in what we call a workover, is monitored and reviewed on a quarterly basis. The basis of fixing the allowable is the mandatory six weeks test. In Nigeria, experiences have shown time-overrun of over 36

weeks due to the inability to mature tests. The causes of this are malfunctioning test equipment, erroneous test results, poorly designed tests, logistic problems, etc.

Routine Bottom Hole Pressure (BHP) tests like routine medical check-ups are supposed to be conducted for oil wells at least once a month. But this is not the case. These tests help us monitor the health of our wells.

With the development of Information and Communication Technology (ICT), instrumentation and permanent downhole gauges, we now have wells with real-time performance monitoring capability. These wells are called intelligent or smart wells. Real-time monitoring of well condition through down hole gauges gives us critical well parameters such as production rate, bottom-hole pressure and bottom-hole temperature used in well diagnosis. However depending on the well effluent, we may determine *a-priori* the nature of the problem, and where and when it may occur. This know-how, know-why and know-when are necessary for effective production management.

Table 1: Typical Brown Field in the Niger Delta (Ikem and Russo, 1995)

Age of Wells	**No of Wells**	**Percent**
Less than 15 yrs	78	37.2
15 or more yrs	132	62.8
Total	**210**	**100**

A production problem is any surface or sub-surface condition that reduces our expectations on production outside natural decline. Sometimes, the problem originates from bottlenecks that have been introduced into the

production system due to our lack of full knowledge of uncertainties, equipment / system reliability. Production problems could be at the subsurface or at the surface.

Sub-Surface Problems can be divided into primary problems which occur as part of the drilling and well completion process and secondary problems which occur as part of the production process. Primary Problems are formation damage problems arising from drilling and well completion while Secondary Problems are flow assurance and non-flow assurance problems as shown in Table 2

Table 2: Secondary Problems in Oil and Gas Wells

Non Flow Assurance	**Flow Assurance**
High Basic Sediments and Water (HBSW)	Waxy crude (paraffin and asphaltene deposition) problems
High Gas-Oil Ratio (HGOR)	Hydrates
High Drawdown	Corrosion/ Scaling
Water Coning/Gas Cusping	Water blocking
Tubing Leaks/ Communication	High Viscosity/Drag
Formation Damage/ Low productivity	Foaming Tendency/Emulsion
Sand production	Liquid Loading

Surface Production Problems include: Under-designs/constraints, Lower availability of equipment, Loss of equipment / system integrity, Constriction in hydrocarbon flow path, Instrumentation malfunction, Bean erosion, Separator inefficiency, Conduit misalignment to separators, Ligament valve leaks, Critical Flow versus non-Critical flow, Unstable Flow, Multiphase flow metering, etc

How do these problems occur in the life cycle of the well? Like every living thing, the oilfield goes through a lifecycle. Table 3, summarises some of the features in the life cycle of wells.

Oil and Gas Wells; Causes of Well Problems

The plant pathologist, Arinze (2005) in his Inaugural Lecture informed us that plants also suffer diseases. I can confirm that Christmas trees, nay oilfield Christmas trees - oil wells and gas wells - also suffer diseases or what we may call stresses and problems. These trees are not dumb. We understand the language of oil and gas wells through a reading of production parameters. Through these, we study the causes, mechanisms and effects of problems in the life cycle of oil and gas wells as doctors study their patients. Thus, we can recognise healthy wells, sick wells and dying wells. We can diagnose the characteristic illnesses of our wells. When a well is dead, we conduct the funeral and finally bury the dead well.

The Law of Balance affects the health and well being of human beings, plants, animals, oil reservoirs, oil wells etc. Dis-ease is simply a consequence of lack of balance, of one-sidedness. In their book **pH Miracle**, Young and Young (2002) discussed the nature of sickness, disease, health and wellness and concluded that there is only one cause of disease the lack of balance in pH in the body fluids and tissues which leads to the growth and multiplication of microforms within the body; and not that disease comes from germs that come from outside of the body with specific bacteria causing specific disease conditions. Young postulates that modern medicine confused disease with the symptoms.

Table 3: Features/problems in the life cycle of oil/ gas wells.

Age	**Characteristics**	**Problems**	**Solutions**
Green field	Young <5yrs	Formation Damage	Formation Damage Diagnosis and Treatment
		Flow Assurance Problems	Flow Assurance
Trans-ition	5-10 yrs Adolescent characteristics	Formation Damage	Formation Damage Diagnosis and Treatment
		Flow Assurance Problems	Flow Assurance
		Vertical Lift Constraints	Artificial Lift
		HGOR, HBSW, Sand Cut	Production Enhancement
Brown Field	10-15 yrs plus Old age characteristics	Formation Damage	Formation Damage Diagnosis and Treatment
		Flow assurance Problems	Flow Assurance
		Vertical Lift Constraints	Artificial Lift
		HGOR, HBSW, Sand Cut, Low Productivity	Improved/Enhanced oil Recovery Production enhancement

What can we learn from this? In oil and gas wells, there is no question of foreign bodies invading the well that cause well problems (diseases of wells) except where engineers inject incompatible well treatment fluids or incompatible water or gas injection for secondary recovery. Whenever an incompatible fluid is injected either into the well or reservoir, it causes precipitation, scaling or corrosion problems. In the absence of injection of incompatible fluids, the cause of imbalance is change in conditions of chemical or hydrodynamic equilibrium in well effluent composition as a result of change in flowing or static well temperature and pressure profiles.

A study of well problems necessitates an understanding of colloidal chemistry as it affects the well effluent. Colloidal chemistry deals with both organic and inorganic substances. Colloidal systems are characterized by two fundamental conditions: 1) size of particles and 2) particle size distribution and dispersion in the medium such as liquid. Together, the particles and the medium are called colloidal system. The well effluent is in most cases a colloidal system. We have bubble flow (gas bubbles in oil); mist flow (liquid particles in gas stream); waxy crude oils with solid or semi-solid particles precipitating in oil; emulsions. Formation water has total dissolved solids, etc. Petroleum engineers need to study the nature of colloidal systems.

Colloids are most important for their electrical and vibration qualities. Particle sizes of colloids are extremely small, ranging 0.1 to 0.001 of a micron in diameter. A micron is one-millionth of a meter and a meter is about 40 inches. Colloids are characterised by tremendous surface area, the significance of such is high total energy from the electric

energy each surface is capable of carrying. This is why an emulsion with very fine entrained particles is very stable and difficult to destabilize because it is extremely difficult for the particles to coalesce.

Young and Young (2001) observed that there are some key factors that distinguish colloidal systems from regular solutions. In a colloidal system, the colloids represent 30% of the total system by volume and the continuous phase 70%. This specific ratio they say is a result of natural law. The earth is 30% colloids and 70% water so also is the human body. Apart from particle size and ratio, colloids must be heterogeneous (dissimilar components). A fascinating thing about the nature of colloids is that the system retains its colloidal properties as long as a large number, if not all, of the particles are in the colloidal particle size range; are not dissolved and not piled up or coalesced due to gravity.

Colloidal systems can collapse if particles dissolve or coalesce into non-colloidal particle size and drop out of the medium. This is of extreme importance to the health of human beings, reservoirs and wells. Colloidal integrity thus plays an important role in the health of oil wells. Unlike in human beings, the collapse of the colloidal state in well effluent is beneficial in solving well problems.

In this lecture I will share with you our modest experiences and contributions in treating and managing our Christmas Trees; I shall share with you some of our contributions in the field of petroleum production engineering. I shall also touch on the concepts of the Tree of Life and Tree of Knowledge to share with you perceptions on questions that have occupied petroleum geoscientists and engineers.

Questions about the origin and nature of petroleum! Because, we are involved and concerned, I shall also draw attention to the consequences of the use and misuse of petroleum, the Gift of Nature.

First I will discuss the health status of the oilfield and then the tripod on which production engineering stands.

The Health Status of Oil/ Gas Wells in the Niger Delta

Udegbunam et al (2000) reported that 40% of production strings in a typical Nigerian brown field are shut-in due to production problems and almost 70% of the producing intervals produce below their well potentials (see Table 4). Thus, well intervention offers opportunities for production enhancement by closing the gap between well potential and current well productivity. They reported that in the Niger Delta, about 30% of the candidate wells are likely to be impaired and would require stimulation, about 40% have high BS &W or high GOR problems and the remaining 30% are due to high sand production, restricted tubing or flowline, well repairs, low reservoir pressure requiring artificial lift, by-passed oil zones etc.

Well Diagnostics

We know that every well, every reservoir is unique and as doctors of oil and gas wells we monitor the life of oil and gas wells through the symptoms observed on the Christmas tree. We are then able to diagnose wells in distress and offer remedies. This aspect of production engineering is called Well Surveillance or Well Diagnostics or Well Forensics. Through careful and accurate well surveillance we are able to diagnose well problems; proffer remedial solutions and effect production enhancement. Figure 5 shows the process of well diagnostics.

Table 4: Well Condition in a Typical Brown Field in the Niger Delta, (after Udegbunam et al, 2000)

Wells	**Condition**
% Shut -in	40
% Flowing	60
Well Potential	**Condition**
Below Potential	70%
Potential	30%
Well Problems	**Percent**
Impaired Productivity	30
High BS&W or HGOR	40
Sand Cut	30

Comparing well diagnostics to medical diagnostics, we too take the history of the well. The similarity in the process is as follows: Age of patient/well, marital/completion status, medical history of patient/well performance history, history of previous illness/problem, family/reservoir history, present complaint/problem, history of current illness/problem, and treatment history. Table 5 compares well diagnostics and medical diagnostics.

Healthy Wells, Sick Wells, Dying Wells and Dead Wells.
In diagnosing well production problems certain critical rates and parameters are specified in the petroleum industry. Just as deviation from normal body temperature, blood level, haemoglobin level etc indicate an abnormal condition so also is deviation from these critical rates and parameters indicate well problem. These parameters are Gas-Oil Ratio (3 Rsi or 3000 scf/stb); Water Cut (+ 30%); Sand production which is disastrous (10 pounds per thousand barrels (pptb); Maximum Efficiency Rate (abandonment rate); Productivity

Index, PI (±5 b/d/psi or percentage decline in original PI depending on reservoir average and well completion type)

Table 5: Well Diagnostics vs. Medical Diagnostics

Medical Diagnostics	**Well Diagnostics**
Temperature	Well Head Temperature and Bottom Hole Temperature
Pulse Rate	Flow Rate
Blood Pressure	Well Head Pressure, Bottom Hole Pressure
X-ray	Downhole camera, Drift Run, wellbore surveys
Tests/Investigations	Well Tests (BHP Test, Production Tests, chemical compatibility tests etc); Production Logging Tool (PLT) investigation, Corrosion survey
Scan, X-ray	CT Scan
Treatment (tablets, capsules, injections)	Capsules, Chemical Injections, mechanical, thermal, electrical treatments
Treatment (minor and major Operations)	Through Tubing (TT) Operations (minor), Workover Operations (major)
Post Treatment Evaluation and follow up	Post Treatment Evaluation and follow up

Healthy Wells

Healthy wells are wells that produce at their expected potential with high oil and gas availability. A well is considered healthy, if the current Productivity Index (PI) of a well is ±10% different from the original PI, all things being equal.

Sick Wells
Wells with current PI that has changed by a margin greater than 10% of the original value are considered sick and timely remedial actions should be prescribed. The availability of such wells may still be high but the potential has declined for the same drawdown. The well has scope for repair to regain potential.

Dying Wells
These are wells with unstable and irregular production. The availability is low and the PI has changed by $\pm$ 85% of the original PI. Remedial action may or may not be worth the effort since there may not be sufficient scope for repair or sufficient scope for oil or gas gain to pay for the investment. It may well be that the well should be allowed to continue to produce until abandonment.

Dead Wells and the Funeral of Dead Wells
Through performance decline curve analysis, we can determine when well production has reached economic limit or abandonment rate. Through this, we can calculate the life of the well.

When a well is dead, there is an investigation of causes of death to document learning points. This is well forensics or autopsy. Dead wells have to be buried in a process called well abandonment. In well abandonment, the Christmas tree is removed and footprints of the well completely effaced from the environment (not from the Book of Life). The environment is then rehabilitated and made good.

Sometimes, dead wells are converted to either horizontal side track wells, enhanced oil recovery wells or drilling waste disposal wells. I was fortunate to be part of the team

that conducted the first trial in Nigeria of drilling waste disposal in Bonny 8 well. I was the production technologist in-charge of Bonny field and a representative of petroleum engineering in the Shell Petroleum Development Company (SPDC) East Divisional Drilling Waste Management Team in 1995.

Treatment Administration

Before any treatment is recommended, we normally evaluated the severity of the problem and compared the various alternatives. Administration of chemical treatment Through Tubing (TT) is usually by injection down-hole in what is called bull heading or by Coil Tubing. There are cases where if the problem is at the sand face, scale or corrosion inhibitor capsules are administered to the well by dropping the capsules in the rat hole.

Sometimes a cocktail of concoctions is administered. However, we must always ensure that there is no compatibility problem. We know that self-medication is wrong and dangerous. We need to consult the experts who have the capacity to conduct compatibility and efficiency tests to guarantee success. And to be able to do this, core samples are needed. This also underscores the need for core samples from reservoirs.

The success of a Well Treatment depends on Candidate Selection Criteria, Design of Field Application and the efficiency of Field Operation. Many failures (Table 6) are due to inadequate consideration of these key factors.

In the Niger Delta, there are some constraints for effective well intervention going from land locations through the swamp fields to offshore locations. Ikem and Russo (1995)

had observed that these constraints affect logistics and efficiency of well intervention.

Table 6: Typical Well Treatment Failures in the Niger Delta

Type of Damage	**Percent Failure**
Water Block	2
Mixed Deposits	15
Scales	6
Emulsion	10
Bacteria	3
Silt/Clay	41
Organic Deposits	20

Critical Success Factors in Petroleum Production Engineering

For effective quality control and quality assurance, environmental friendliness in production operations, as well as cost efficiency, the work of the production engineer sits on the following tripod:

1. Best Available Technologies and Software (BATS)
2. Best Operating Policies and Practices (BOP)
3. Best Available Resources (BAR) (growing and harvesting our own timbers through human capital development and capacity building)

We shall examine the impact of these critical factors on our practice.

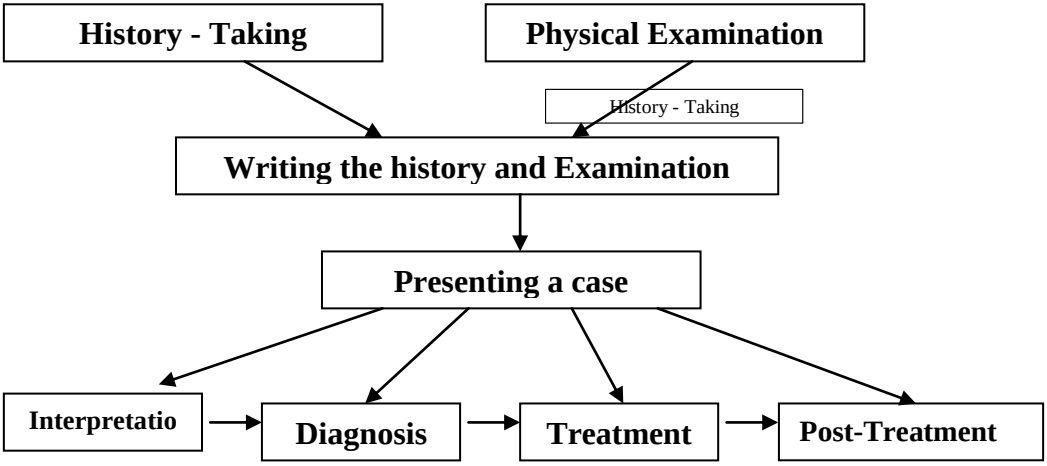


Figure: 5: Model for Well Diagnostics after Medical Diagnostics

BEST AVAILABLE TECHNOLOGIES/ SOFTWARE

Through the use of best available technologies and best practices, we are able to identify under-producing wells and proffer solutions for minimizing the production gap.

There are many ways to increase production potential. These include:

a) Improved well completion (improved completion fluid; brine quality)
b) Assessment of well impairment

c) Improved stimulation performance through new acid recipes, placement techniques, foam diversion, frac & pack, compatibility of fluids
d) Improved sand control.
e) Through Tubing (TT) sand control, relaxation of depth of sand control, long interval chemical sand consolidation (SCON)
f) Improved completion design and equipment selection – monobore, Tubing Conveyed Perforation (TCP), horizontal completions, downhole dehydration, use of wireline retrievable Subsurface Sub-critical Safety Valves (SSSVs)
g) Multiphase flow metering and pumping.
h) Debottlenecking to control vibration problems, systems optimization, flowstation optimization
i) Water and Gas shut-off treatments.
j) Flow assurance in deep offshore operations and the application of multiphase technologies

However, the field application of the benefits of such innovative processes, techniques and new technologies requires proper candidate selection and assessment of capacity constraints, improved well surveillance and improved field application.

One of the challenges faced by the production engineer in the oilfield is to model flow and heat transfer. The challenge is from the fact that we deal with multiphase flow. The concepts of single-phase flow are very limiting and inappropriate for multiphase flow. A major development that has facilitated the work of production engineers is the application of the Nodal Analysis by Brown and his team in the University of Tulsa. Nodal Analysis is simply a graphical solution of two simultaneous equations with two

unknowns, production rate and pressure (Brown and James, 1985).

Different Nodal Analysis Software make the work of the Petroleum Production Engineer easier. With such Software, production systems can be simulated through the normal processes of simulation similar to reservoir simulation. Sensitivity studies can be conducted to answer the question *what if* a particular parameter changes.

BEST POLICIES AND PRACTICES

There are Policies and Laws that govern oil and gas field planning and development as well as production operations. In Nigeria, the Department of Petroleum Resources (DPR) in the Federal Ministry of Petroleum regulates the operations of the Petroleum Industry. The DPR enforces all enabling legislations to regulate the operations of the companies. Joint venture investment decisions and management are under the purview of NAPIMS (National Petroleum Investments and Management, Services), a division of the Nigerian National Petroleum Corporation (NNPC).

The objectives of regulatory control in production operations are:

1. Enhancing well productivity and oil and gas availability. The Maximum Efficiency Rate (MER) or what is called DPR Allowable is fixed after a careful consideration of the results of the mandatory six weeks test. This test is to ascertain problem-free productivity of wells and high return on investment. It is also to secure availability of oil and gas.

2. Conservation of natural resources. This is to ensure that associated gas, which is a vital source of reservoir energy, is not wasted. This is the reason, why wells are shut-in if the producing GOR is greater than three times the solution GOR or 3000scf/stb.

3. Conservation of the environment. This is to ensure that well effluent and production wastes do not constitute environmental hazards. For instance if formation water is produced, we would need to discharge it in such a way that it does not have adverse impact on the environment.

Specifically, the DPR is empowered by some of the following legislations to:

a) Assess production potential from developable reserves.
b) Compute maximum efficient rates of wells.
c) Compute individual well allowable rates
d) Monitor the performance of wells using some set criteria, identifying problem wells and recommending remedial actions to be taken to eliminate problem.
e) Process applications to carryout well repair.

The key legislations used to regulate oil and gas production operations and processes are as follows:

1) Mineral Oils(Safety)Regulations1963;Amended 1977
2) Oil Pipelines Act 1965
3) Petroleum Regulations 1967
4) Oil in Navigable waters Decree 1968
5) Oil Terminal Dues Decree 1969
6) Petroleum Decree 1969
7) Petroleum (Drilling & Production) Regulations 1969
8) Petroleum (Amendment) Decree 1973
9) Petroleum (Drilling & Production) (Amended 1973)

10) Petroleum Production & Distribution (Anti-Sabotage) Decree 1975
11) Petroleum (Amendment) decree 1977
12) Petroleum (Drilling & Production) (Amended 1979)
13) Associated Gas Re-injection Decree 1979
14) Petroleum (Amendment) Regulations 1988
15) Petroleum (Drilling and Production) (Amended 1988)

Let us briefly review some of the critical statutory provisions of the key legislations relevant to production engineering.

Decree 51 (1969)
Part IV of the Decree deals with oil and gas field development which includes

(a) Maintenance of equipment and conduct of operations
(b) Field development programme
(c) Production of crude oil and natural gas
(d) Pressure decline study and report etc.

PART IV (37) Specifically States

"All fields, structures, reservoirs and other oil traps shall be developed and produced in strict accordance with a field development programme, which shall be submitted for the prior approval of the Chief Petroleum Engineer."

PART IV (38) States that
"The licensee or lessee shall use approved methods and practices acceptable to the Chief Petroleum Engineer for the production of crude oil or natural gas".

Other specific provisions include:

(a) to obtain the initial physical characteristics of the reservoir fluids and reservoir parameters (such as temperatures pressures, gas oil ratios, bubble point pressures, porosities, viscosities, relative permeabilities in relation to fluid saturation, fluid density and the like, the detailed data and results and analyses of which shall be submitted to the Chief Petroleum Engineer prior to, or as soon as possible after the commencement of production from any such pool or reservoir.

(b) to obtain periodical information on the data required to be obtained by paragraph (a) above, at intervals approved by the Chief Petroleum Engineer.

(c) to cause every pool in each well to produce within the limits of its maximum efficient potential or rate as may be determined from time to time by the licensee or lessee, and to submit the results of his determinations to the Chief Petroleum Engineer half yearly. Hence the need for six weeks tests to determine the maximum efficient rate and regular Bottom Hole Pressure (BHP) surveys.

Paragraph 41 also details a relevant regulation

41 (1) Prior to or upon the attainment of a ten percent decline in the initial reservoir pressure of a pool or reservoir (determined by the consideration of the average current reservoir pressure weighted as appropriate), the licensee or lessee shall commence or cause to be commenced a study to determine the economic practicability of instituting a secondary recovery or pressure maintenance project and its recommended timing.

(2) A full report of the result of the study shall be submitted to the Chief Petroleum Engineer as soon as possible (and in any case not more, than six months) after the attainment of the pressure decline mentioned in paragraph (1) above.

Thus from the provisions of Decree 51 (1969) it can be observed why oil companies are mandated to (a) carry out Field Development Plans (FDP) before field development, (b) carry out the six weeks production test before a DPR allowable is granted for a particular well and carry out effective oil and gas well surveillance to optimize productivity at minimum operating cost.

Associated Gas Re-injection Decree 99 (1979)

This decree stipulated that the flaring of associated gas should cease by 1st January 1984 from any pools or reservoir and shall in particular take all necessary steps. The compliance with this Decree has been a shifting decimal point. At present the flare-out date is fixed for 2008. Whether this date can be realised is a matter for conjecture. You need to read the lips of the operators to appreciate this.

Compliance with Regulatory Framework

The level of compliance with the various provisions of petroleum decrees/laws, regulations and recommended best practices vary from company to company. For instance many companies do not comply with taking bottom hole pressure (BHP) surveys twice a year for good reservoir management. In the past, many wells were produced with less regard to DPR Allowables which led to early and severe production problems. Many companies do not take recommended number of well tests. Many do not make provisions for data acquisition and best practices. Most

companies do not conduct reservoir and field studies when the reservoir pressure has depleted by ten percent.

Review of Available Legislations

With the development of technology and experience as well as the challenge of deep sea operations, there is the need to review existing legislations to enable DPR to be more effective. For instance, multiphase flow metering and pumping are cost effective technologies that should be deployed in the oilfield. There is the need for calibration of multiphase flow meters as we do for single phase flow meters. There is also the need to review the existing legislations to keep up with the developments in technologies. For instance, with the advent of multilateral horizontal wells, petroleum geochemistry and fingerprinting, as well as smart well technology, it is now possible to co-mingle production from different thin oil rim reservoirs and ensure effective production accounting from the different reservoirs. There is also the need to review toxicity levels in the application of production chemicals and seek alternatives (Hudgins, 1992)

Management of Brown Fields: Practices and Challenges

We have advocated a proactive approach to predicting the likely production problems that may arise in the life cycle of a well to enable us manage our oil and gas wells effectively. To do so, we need to design oil and gas wells and plan the production process based on the understanding of the following: type of well effluent (we need to characterise the produced water as much as the oil and gas), reservoir system and well completion etc (Ajienka, 2005).

We observed a lot of production practices that were detrimental to the life of oil wells and reservoirs. We

advocated that every oil well, every reservoir is unique and must be treated the way a medical doctor treats his patient. We have advocated that these practices induce early production problems and make effective production enhancement difficult. Some of these practices include:

Production Database

There is need to acquire data to populate the available database. We need to keep a large database. Without a good database and high quality data, proper well diagnostics cannot be conducted just as without patient history it is impossible to carry out good diagnosis.

On a continuous basis, there is need to carry out quality assurance and quality control (QA/QC) of all the data acquired to minimise mistakes in decision-making regarding the production system and to be confident that hydrocarbon produced can be accounted for fiscal as well as reservoir/field management purposes.

Data costs money to acquire. And without good data, we cannot carry out production surveillance and production enhancement. Many companies think it is waste of time and money to acquire data. There must be a conscious effort to create appropriate database to enhance planning and engineering practice.

Core samples are seen as national relics. They should be treated as cultural artefacts. All analysis should be done in-country; so also for reservoir fluid analysis.

For those of us in research, acquiring data for studies requires DPR permit. Even for the little data available, it is like what somebody called cemetery of information for

researchers to acquire data despite DPR permit. Sometimes, it is easier for a camel to pass through the eye of a needle than to acquire data in Nigeria! We face a graveyard of information and yet Nigerian data are easily available to schools and research Laboratories abroad perhaps through the offices of multinational companies. The studies we conduct and the modest results are for the benefit of the industry! Therefore, DPR should enforce the acquisition of data for research.

Production Enhancement

In an era of dwindling exploration potential and investment capital for drilling new wells, getting the best out of an existing asset is the challenge for production engineers. The focus of production enhancement is to minimize the gap between existing production potential and the expected maximum potential of oil and gas wells/fields. Figure 6 shows the benefits of production enhancement - namely, increased production and minimum gap in well potential. The gap in production is caused by production problems or lack of effective production management. Well Surveillance is about production gap analysis, the systematic process of identifying the factors and diagnosing the causes of the gap in production potential.

Many engineers do not conduct thorough well surveillance. They use single point analysis instead of production performance history (trend) analysis and comparison with offset wells to identify below-average producing wells. At best, Well Surveillance Flow Charts are designed to trouble shoot, but that is not enough. We need to develop diagnostic processes that are both qualitative and quantitative to enable us identify the actual causes of well problems to guarantee uniformity of decisions.

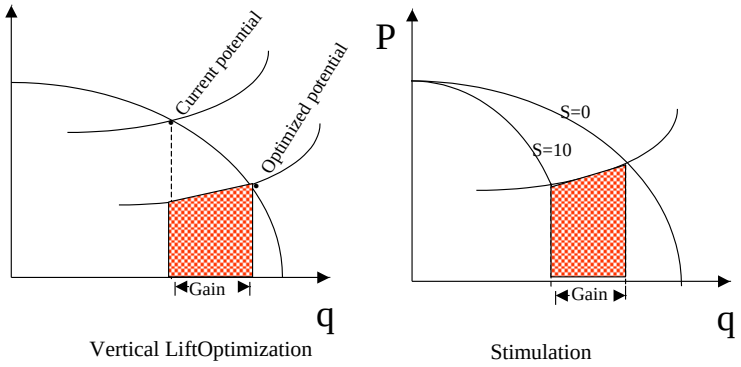


Figure 6: Benefits of Production Enhancement

We have developed diagnostic plots of pertinent parameters to predict the actual causes of well problems that have helped in cost efficient production enhancement. With these diagnostic features, the process of well diagnostics is then both qualitative and quantitative such that we can screen, differentiate and identify the causes of production problems. A three-phase differential diagnosis by elimination of all possible causes is adopted until we arrive at the actual cause of the well problem: primary or preliminary investigation, secondary or detailed investigation and tertiary or final diagnosis.

In addition to Figure 7 on general structure of Well Diagnostics, problem diagnosis can be conducted using the Flowchart in Figure 8. For every problem we have a specific Flowchart and can develop diagnostic plots.

Figure 8 is a Flowchart for diagnosing High Gas -Oil Ratio (HGOR).

Today let me share with you some of the modest advances we have brought to bear on this field of production engineering.

Before 1995, the HGOR Flowchart did not have a node to check for unstable flow. When Ajienka (1995) developed the diagnostic procedure for unstable flow, the Flowchart was modified to include a node for unstable flow.

Flow Efficiency Evaluation: We have contributed to the development of Well Inflow Quality Indicator (WIQI) or Flow Efficiency Evaluation for newly completed or stimulated wells as a benchmark to evaluate the future performance of the wells (Ajienka and Olabode, 1993; Ajienka, 1994; Ajienka and Okorie, 1995; Ajienka and Onyezuigbe, 1999).

Diagnostic Plots: Apart from flow charts for oil wells, we have developed flow charts and diagnostic plots to aid diagnosis of gas well problems, artificially lifted wells and injection wells (Ajienka, 2005). Diagnostic plots have also been developed by Chan (1995) in his paper SPE30775 and Egbe and Appah (2005) for diagnosing high water cut. Nwabueze (1996) also developed a dimensionless plot for diagnosing unstable well performance.

The importance of diagnostic plots is demonstrated by our using a step-by-step procedure for diagnosing unstable flow in oil wells which saves the industry a lot of misguided workover expenses (Ajienka, 1995). Unstable flow in oil wells is sub-optimal flow when the well is choked-in far

below its operating envelope. Under such conditions, gas slippage takes place and the well produces at apparent High Gas-Oil-Ratio (HGOR). This situation had confused many engineers to suspect gas coning or Gas Oil Contact (GOC) being in the well thus making engineers to recommend expensive gas exclusion well repair or workover. Figure 9 is a diagnostic plot for unstable flow and Figure 8 is a modification of the well surveillance flowchart to account for unstable flow.

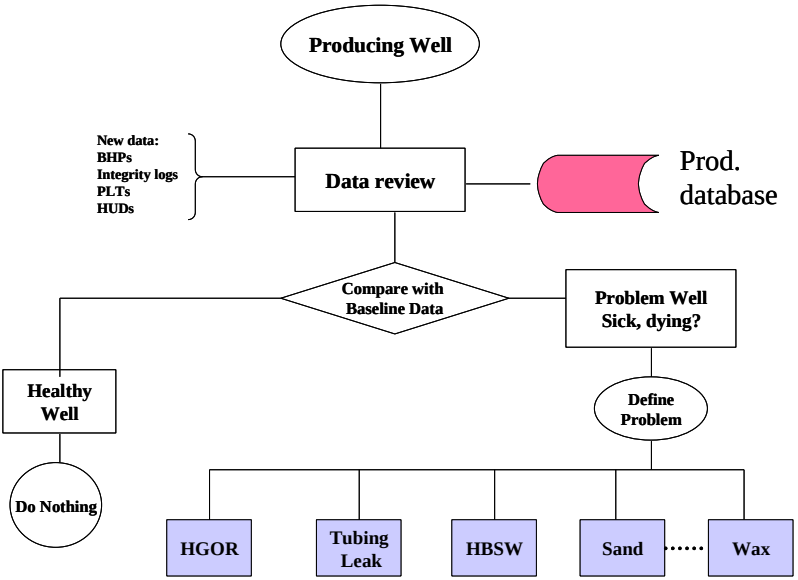


Figure 7: General Structure of Well Diagnostic Chart

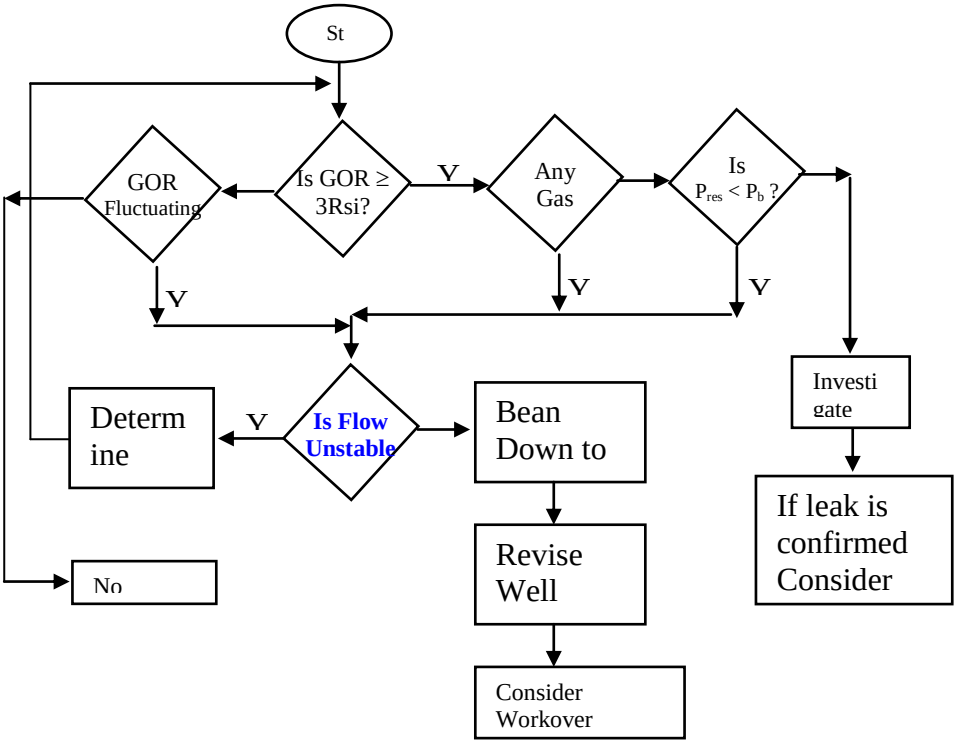


Figure 8: Typical Well Surveillance Flow Chart for HGOR

The following example illustrates this phenomenon. Table 7 and Figure 11 show the levels of GOR reduction and oil gain with bean up. At bean 18, the GOR was very high (14140scf/stb). On beaning up to 32/64th inch, the gain was over 2000stb/d.

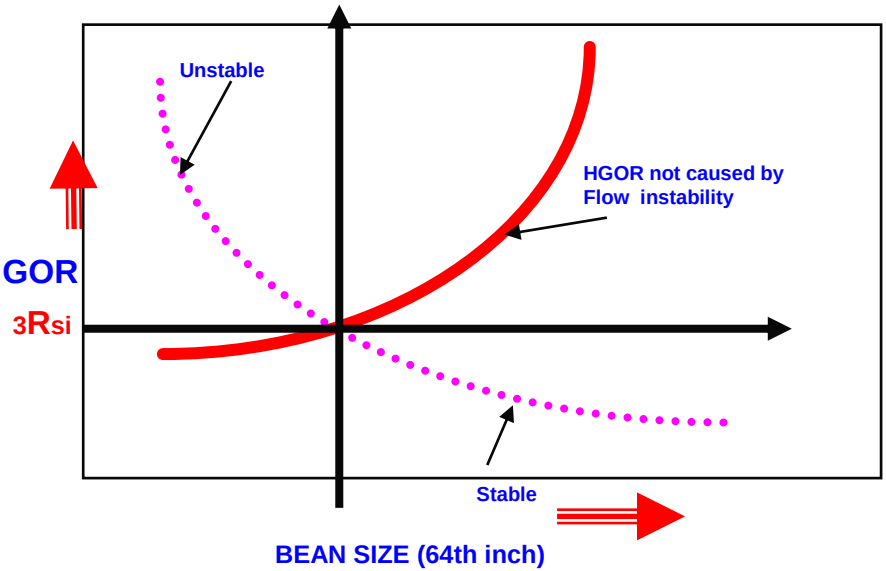


Figure 9: Unstable Flow Diagnostic Plot

Table 7: Bean Performance for Field A, Well 30L

Bean Size	**Net Rate**	**BS&W**	**GOR, R**	**R/Rsi**	**GOR Reduction (% Reduction)**	**Oil Gain (% Gain)**
(64^{th} inch)	(stb/d)	(%)	(scf/ stb)	(scf/ stb)	(scf/stb) (%)	(stb/d) (%)
18	229	-	14140	17.04	-	-
20	477	-	6461	7.78	7679 (54.3)	248 (108.3)
24	816	-	4591	5.97	9189 (65.0)	587 (256.3)
28	1155	-	4139	4.99	10001 (70.7)	926 (404.4)
32	2311	-	1497	1.80	12643 (89.4)	2082 (909.2)

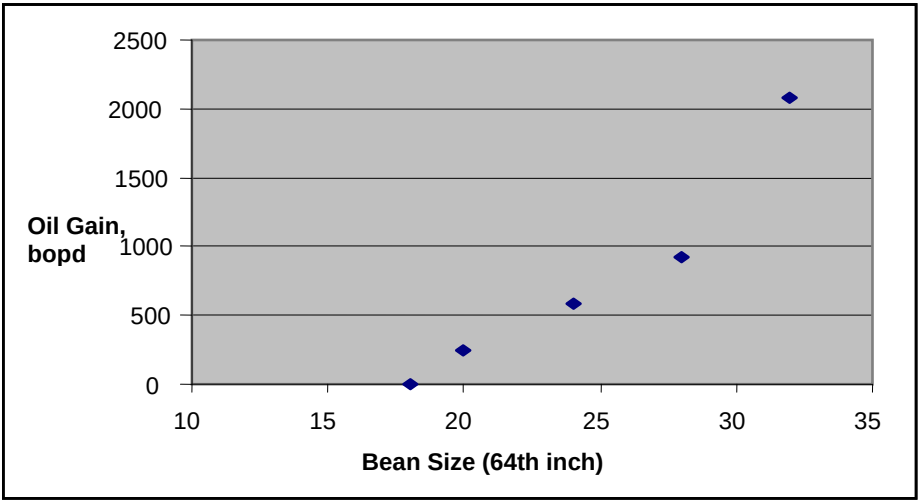


Figure 10: The Effect of Beaning up on Oil Gain

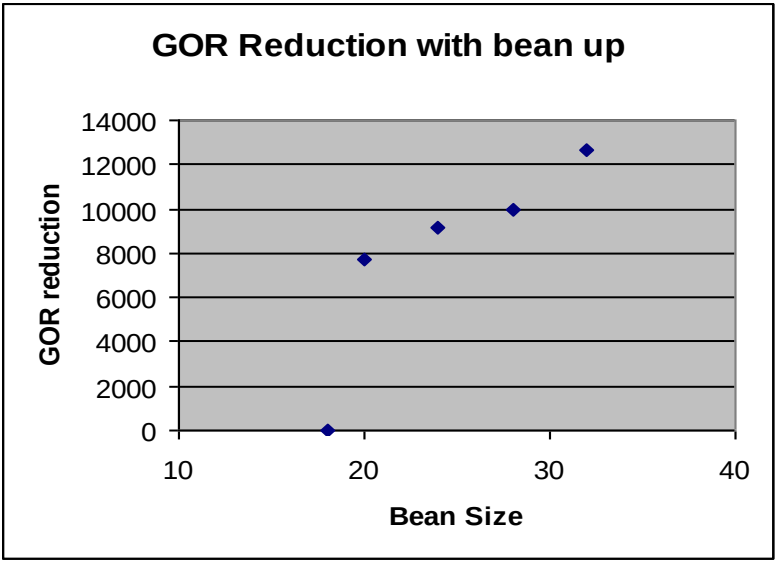


Figure 11: The Effect of Beaning up on GOR Reduction

Another phenomenon that is sometimes confusing to production engineers is the increase of productivity index instead of the normal decline with time, which is indicative of formation damage. Ajienka (1994) showed that the phenomenon is attributable to high oil water viscosity contrast. A procedure for predicting the phenomenon was suggested. This problem underscores the need to have full analysis of formation water as we do for oil and gas. Neglecting the analysis of formation water is not a good practice. As petroleum engineers, we are running a race against formation water. Water influx into oil and gas reservoirs causes bypassed oil and gas and creates production problems.

Nind (1964) had also suggested some fundamental diagnostic plots for identifying some production phenomena.

Multiphase Flow Metering: In the oil industry we deal with simultaneous flow of oil, gas and water. The analysis and metering of such flow was a major challenge (Owolabi et al, 1991). Initially, many engineers handled multiphase flow as if dealing with single-phase flow; thereafter they corrected for the presence of entrained phases. Ajienka and Ikoku (1984) derived a generalised multiphase flow model applicable to continuous gas phase flow and continuous oil phase flow through chokes. With this, we developed a simple graphical procedure for predicting critical and sub-critical multiphase flow.

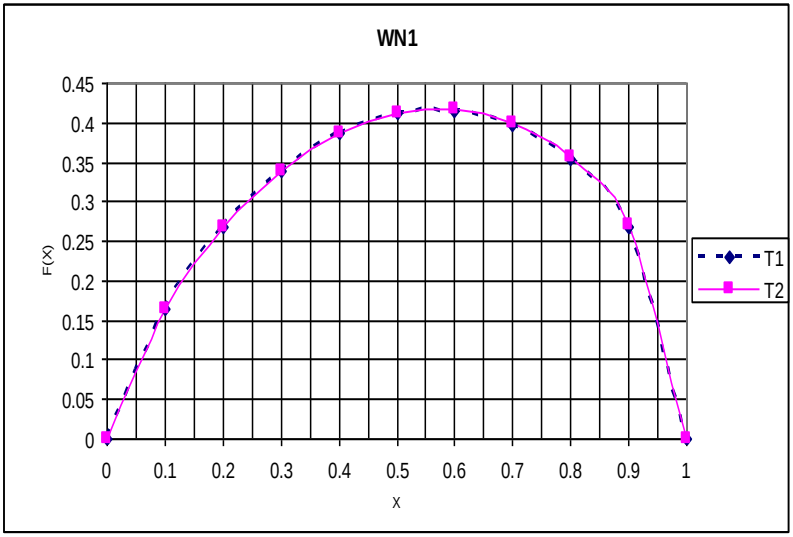


Figure 12: Prediction of Multiphase Critical Flow

Hitherto, it was assumed that multiphase critical flow occurs at a fixed critical pressure ratio similar to single phase flow. However, our work demonstrated that multiphase critical pressure ratio depends on the composition of the mixture. And this can be predicted using our graphical approach. The usefulness of this work is that critical flow at the Christmas tree which ensures that surface interruptions do not affect reservoir performance is guaranteed and accurate flow metering using the wellhead choke can be done. In addition, through careful design of sub-critical subsurface safety valves, well safety can be guaranteed and the environment protected in the case of damage to the Christmas tree.

At this point it is important to comment on the need for better metering facilities and regular meter proving. With multiphase flow metering, there is also the need to regularly calibrate multiphase meters as we had done with single

phase flow meters. The new generation of multiphase flow meters can without separation meter the different phases of multiphase flow. These meters also need calibration. Ajienka et al (2004) have proposed techniques for calibrating multiphase flow meters.

Going Deeper and Deeper and the Challenge of Flow Assurance

Offshore exploration and production operations in deeper frontiers (Table 8) are becoming more challenging. With increasing water depths, and over 36% of discovered reserves, the Gulf of Guinea is one of the active zones in E&P activities (Table 9). The region is very strategic to global petroleum supplies.

Table 8: Challenge of Water Depth (after Andrier, 2005)

Water Depth (ft)	**Classification**	**Region**
1000 - 3000	Conventional Deepwater	Gulf of Guinea, US Gulf of Mexico, Brazil, North Sea, Asia -Pacific
3000 – 5000	Deepwater	Gulf of Guinea, US Gulf of Mexico, Brazil, North Sea, Asia -Pacific
> 5000	Ultra Deepwater	Gulf of Mexico, Brazil

Table 9: Conventional Deepwater and Discovered Reserves (MMbbls) (after Andrier, 2005)

Region	Producing Fields	Fields online by 2004	Fields online after 2004	Total Reserves	Percent of Reserves
Gulf of Guinea	730	5550	5350	11630	36.8
Brazil	4710	3150	1040	8900	28.2
US Gulf of Mexico	2140	2940	720	5800	18.4
North Sea	2720	630	240	3590	11.4
Asia Pacific	690	590	360	1640	5.2
Total	10990	12860	7710	31560	100.0

The major production challenges deep offshore are summarised in the Table 10 below. At the moment, there is a big scope for research to bridge the technology gaps that exist.

Waxy Crude Oils

Nigeria has a considerable reserve of waxy crude oils. Waxy crude oils precipitate organic deposits (see Figure 13) at a temperature called cloud point. As the temperature decreases to a point called the pour point, the crude oil solidifies. Therefore, the management of waxy crude oil wells requires good production engineering. If we know the cloud point and pour point of a crude oil as well as the wax content, we can proactively design our well completions and

conduct production operations in such a way that well problems and the severity of problems can be anticipated and handled in a cost effective manner. Methods of handling waxy crude oils are summarised in Figure 14.

Table 10: Major Production Challenges in Deep Water Field Development

Aspect	**Challenges**
Wellhead Production Platform (PF)	Mooring, Riser/PF interface
Floating Production Storage Offloading (FPSO)	Station Keeping/Mooring Tandem Offloading
Risers/ Umbilicals / Flowlines	Mechanical Behaviour/Installation Thermal Insulation/Heating
Flow Assurance	Hydrates, Wax, Asphaltenes, Scaling, Viscosity effects, Thermal Insulation, Cool down, Flow Calculations, Artificial Lift
Subsea Systems	Component Qualification Installation

When waxy crude oil wells are completed and handled like the conventional crude oil wells we incur more costs. Ajienka and Ikoku (1980), Ajienka and Eno (1995) have developed diagnostic plots for waxy crude oil surveillance. Ajienka et al (1994) had also conducted a similarity study on how to develop waxy crude oil fields in SPDC East.

Figure 13: Paraffin Wax Deposits in Pipes

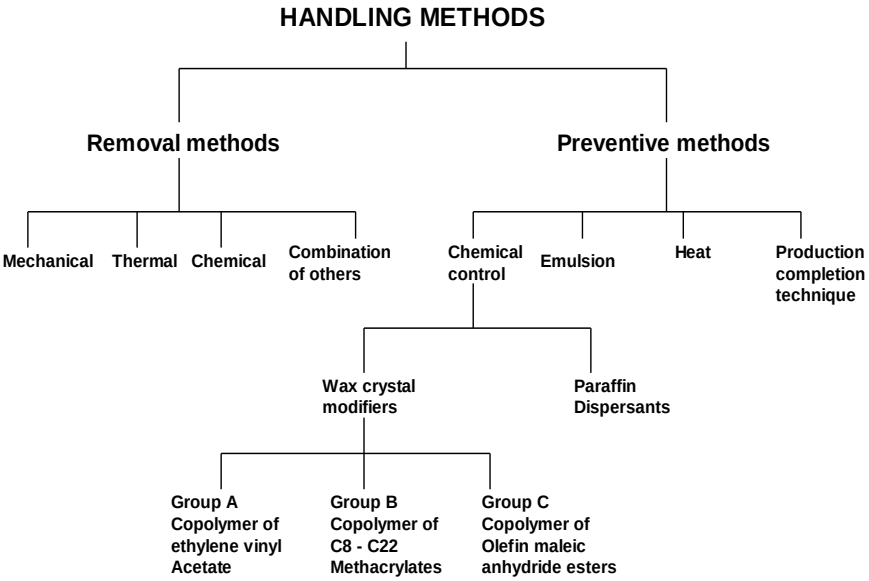


Figure 14: Methods of Handling Waxy Crude Oils

Scaling: Scaling in oil wells is another major flow assurance challenge in the Niger Delta. The most common scales are calcium carbonates. Figure 15 shows scale deposits. Predicting the temperature and pressure profiles in the well, Nwonodi and Ajienka (2005) have published diagnostic plots to predict the severity and point of deposition in oil wells.

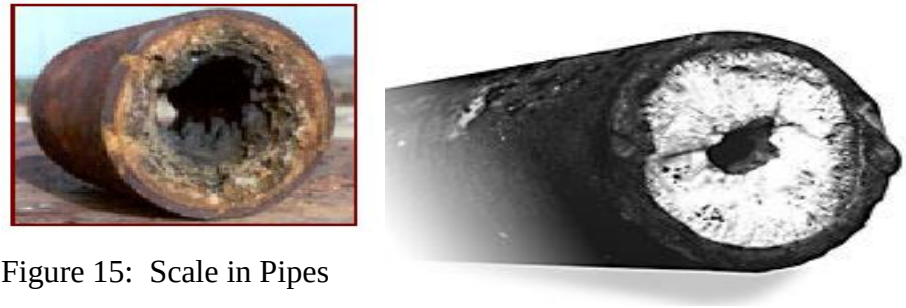


Figure 15: Scale in Pipes

Chemical Demulsification of Oilfield Emulsions

The process of selecting the optimum demulsifier out of a wide range of demulsifiers for resolving oilfield water-in-oil emulsion was very tedious and time consuming. Consequently, Ajienka et al (1993), Opara and Ajienka (2004) developed a new stage-by-stage procedure for screening, ranking and selection of demulsifiers for oilfield emulsion resolution using the dielectric properties of oilfield emulsions and demulsifiers. An interesting feature of this work is that hitherto, engineers and chemists had postulated that the stability of an emulsion depended on the Hydrophile Lipohile Balance (HLB). Our work has shown that more than the HLB, the critical factor is the dielectric property of the stabilising agent which is a function of the colloidal

integrity of the emulsion. With this work, it possible to use information from multiphase meters to predict the dielectric permittivity of emulsions real time and narrow the range of selection of demulsifiers or customise the formulation of demulsifiers. Using the new technique, we compared the efficiency of emulsion resolution through bottle test, E_m and Efficiency predicted using dielectric permittivity, E_k as shown in Figure 16. The result clearly showed a good correlation. Thus, giving us the confidence that we can use this predictive technique to screen and rank a wide range of demulsifiers and only perform confirmatory bottle tests on the best demulsifiers. This technique is robust and saves time.

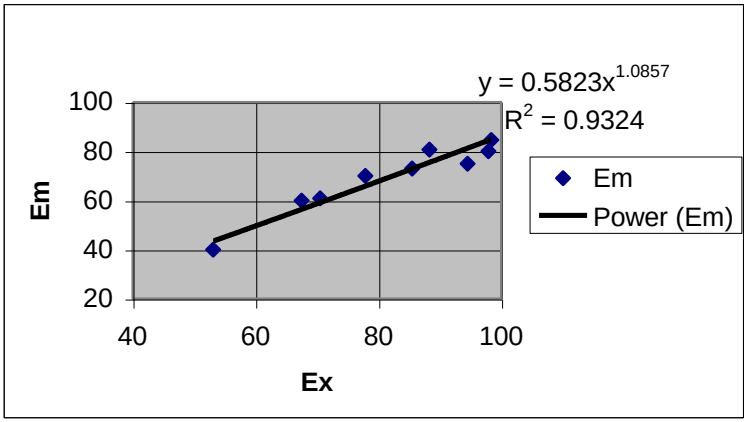


Figure 16: Correlation of Efficiencies between Bottle Test and Dielectric Permittivity

Health Safety and Environmental (HSE) Performance

On environmental compliance to DPR/FEPA Guidelines in the discharge of effluent waste water from flow stations, Inyiama and Ajienka (2005) have shown that despite the considerable effort made by many operators, there is still scope for improvement particularly the content of heavy metal pollutants such as lead and zinc.

From the study of Hudgins (1992), it is necessary to control the dosage and type of production chemicals as the final discharged concentrations constitute environmental hazard. There is therefore the need to develop stringent statutory limits and substitute alternatives to ensure environmentally friendly operations.

Ugbebor and Ajienka (2004) evaluated HSE performance of three companies for a 12-year period (1991–2002) using key performance indicators such as Fatalities, Lost Time Injuries (LTI) and Oil spill incidents. The results showed a total of 45 fatalities and 619 LTIs. It was observed that production factors contributed to greater number of spill incidents with 1475 occurrences (41.6%). Next is sabotage/theft with 1239 (35%); followed by corrosion with 705 times (19.9%), then other factors with (1.7%), engineering with 51 times (0.4%) and Drilling being the least with 13 times (0.4%).

There is need to pay serious attention to unsafe wells. Some companies specify threshold Casing Head Pressure (CHP) equal to 650psig. The study of the cause of Obelle Fire Disaster shows that this is not realistic (Ajienka and Kuye, 1999)

BEST AVAILABLE RESOURCES

For effective quality control, productivity and cost efficiency, oil and gas companies need best available human resources. The petroleum industry is international so is the need for internationally trained engineers who are capable of working in multi-cultural environments and in multidisciplinary teams.

The Nigerian educational system has been plagued by several chronic problems such as under-funding; poor infrastructure; poor remuneration of staff and consequently brain drain; frequent industrial strikes, as well as students' unrests and the consequent incessant closure of universities, leading to prolonged academic calendar. Not the least is the problem caused by explosion in students' population in professional disciplines. This leads to high students-lecturer ratios which further compromise quality training. All these have led to systematic decline in educational standards and the production of half-baked or quarter-baked graduates. Consequently, industry found most graduates un-employable. One Human Resources Manager of a multinational oil company described the situation in Nigeria as very poor harvest of graduates. Agbon and Ajienka (1990) at the Annual Society of Petroleum Engineers (SPE) Conference in Warri canvassed the position that industry should intervene in petroleum engineering education in Nigeria before things get out of hand. This position was instrumental to SPE initiating the Meeting of Heads of Departments (HOD's) of Petroleum Engineering Departments with the Permanent Secretary Federal Ministry of Petroleum Resources, Senior SPE and industry officials.

The Council for Regulation of Engineering in Nigeria (COREN), which oversees accreditation of engineering programmes, regulation of professional practice and registration of engineers, has repeatedly emphasized the need for excellence in professional practice and has drawn attention to falling standards in accreditation reports.

From Table 11, it can be observed that the Faculty of Engineering, University of Port Harcourt grossly violated the students/staff ratio of 9:1 as recommended by the

National Universities Commission (NUC) or 8: 1 as recommended by COREN. The violation has also been highlighted in NUC Visitation Panel Reports on Departments; COREN Accreditation Reports on Departments; External Examiners' Reports on Departments; Communiqué issued by the Meeting of the Committee of HOD's of Petroleum Engineering Departments with the Permanent Secretary Federal Ministry of Petroleum Resources, Senior SPE and industry officials to deliberate on Students Industrial Training placements on August 2, 2002. One of the overriding issues is a call on all Petroleum Engineering Departments to cut down on students' enrolment.

Table 11: Students: Staff Ratio, Faculty of Engineering Uniport, 2001/2002 Session

Department	**Total No. of Students**	**Total Number of Academic Staff**	**Students: Staff Ratio**	**Percent Increase (%) in Students**
Chemical	606	11	59	512.1
Civil & Environmental	251	11	22	153.5
Electrical & Electronics	606	7	86	861.9
Mechanical	662	14	47	425.4
Petroleum & Gas	661	10	66	634.4
Total	**2786**	**53**	**52**	472.1

To be able to achieve corporate goals, technical skills were no longer adequate. Oil and gas companies need

multidisciplinary skills and soft skills such as Health, Safety and Environment (HSE) principles in practice, as well as principles of clear communication and team skills for optimum productivity. Industry is also interested in cost conscious staff to maximise profitability. And these skills have been lacking in our curricula.

As a first step industry insisted on recruiting, first class honours and second class (upper) honours graduates. The second step was to recruit Nigerians trained abroad. The situation also justified the use of globalisation to recruit foreigners.

On the other hand, there is the patriotic clamour for local content and capacity building, which gained ground from the late nineties. All these, set the stage for a justified direct industry intervention in university education through the Shell Petroleum Development Company (SPDC) training programme called Shell Intensive Training Programme (SITP) in 1998. The programme was designed to develop the skills of young Nigerian graduates (SITP/1) and Technicians (SITP/2) and to prepare them for employment.

Also, the Petroleum Technology Development Fund (PTDF), a parastatal of the Federal Ministry of Petroleum Resources established by Decree 25 of 1973 with a mandate to train Nigerians towards active participation in the Oil and Gas Industry has over the years awarded post graduate scholarships abroad for oil and gas courses.

However, unlike the Shell SITP programme, the Nigerian National Petroleum Corporation (NNPC) and Elf Petroleum Nigeria Limited (EPNL) Joint Venture opted for strategic partnership between industry and academia giving birth to the establishment of the Institute of Petroleum Studies (IPS)

at the University of Port Harcourt. The Institute of Petroleum Studies (IPS) is an international post- graduate institution established through collaboration between IFP School France and the University of Port Harcourt Nigeria in the year 2002. The EPNL/NNPC Joint Venture as part of its sustainable development programme pioneered the sponsorship of the Institute (Ajienka et al, 2005)

The mission of the Institute is *to meet the needs of the petroleum industry through a commitment to excellence in training, applied research, continuing education and capacity building.*

So far the experience at IPS has been rewarding and challenging.

Let me say here that quality control starts with the inputs to a process, the raw materials. Quality control should not start with the finished products, the graduates. The experience of the Universities in revalidating the JAMB scores of candidates is a very useful exercise. The exercise will give credibility to the admission process and with time, we will see some improvement.

From the experience of IPS, I will also like to advise that globalisation of higher education, should not be imitation of institutions abroad. True progress lies in the upward development of the culture of a people. It is true that universities are universal but internationalisation should be adapted to the culture of the people. In collaborating with IFP School France, we have been conscious of our culture and values.

Let me also say that real knowledge comes through experiencing. And that is why it is generally recognised that experience is the best teacher. To know of the existence of something without experiencing it is not real knowledge. A teacher can only help his pupil to experience so that he can acquire knowledge. If we compare the traditional form of teaching which is training and apprenticeship and the way we now teach or rather lecture, you will see how lifeless is the process called lecturing particularly in the professional disciplines. Robust teaching and presentation techniques as well as effective use of telematics to train students are evolving rapidly.

In Nigeria we have destroyed the foundation for formal education, for the acquisition of knowledge. Not valuing teachers in society is a great disservice. It is equivalent to parents leaving their children to poorly treated and disgruntled house helps to look after. In Nigeria, the beautiful words: the teacher's reward is in heaven, which hold a great promise to a noble profession, is quoted mockingly. But we need not ridicule the saying or the teacher!

To compound matters, we could not run practicals in schools and introduced the so-called Alternative to Practicals or Theory of Practicals. This is the greatest blow to science and professional education. We completely destroyed the basis of acquiring knowledge through experiencing. Even the industrial training scheme and National Youth Corps through which students and graduates can acquire knowledge by experiencing have been destroyed. Today we now produce graduates without knowledge. Beyond this stage, it would be difficult to

conjecture how things would develop unless some robust and sustainable intervention takes place.

The world is going back to mentorship and apprenticeship. Training is from the word train. A train has a locomotive head that pulls the coaches behind it along the track of its movement. The expert is the engine, the mentor who should coach the apprentices, imparting to them his experience and making them to acquire knowledge through experiencing. This is how it is with the fisherman. This is how it is with the Igbo trader who has a beautiful natural school in the market place where the graduates acquire the real MBA, the knowledge, and not necessarily the certificate in a country crazy with certificates. But this can only be possible where we maintain the right students: teacher ratios and where we have the appropriate facilities.

What can we learn from all these? True progress lies only in the development of our own culture be it in academics or R& D. There is no progress in the imitation and copying of other cultures which include policies and practices. We must reflect and grow our own capabilities according to the measure of our abilities.

Petroleum and the Quality of Life

Petroleum accounts for 95% of the foreign exchange earnings; 97% of total exports and 65% of government budgetary revenue. From the time crude oil was discovered and exploited in Oloibiri in 1956 to the year 2005, about $300 billion have been realised(Okowa, 2005). This is enormous wealth than can transform a nation.

Despite this wealth, the indicators of poverty published by the National Economic Empowerment and Development

Strategy (NEEDS) are staggering. Table 12 below summarises these indicators.

Table 12: Dimensions of Poverty in Nigeria in 1995, 1999 and 2001 (NEEDS Document, 2004)

POVERTY DIMENSIONS AND INDICATORS	**1995**	**1999**	**2001**
INCOME			
Population below US$1 per day (%)	70.2		
Population below minimum level of dietary energy consumption (%)	13		7
SERVICES			
Schooling			
Primary School enrolment (female %)	27.8	45.9	
Primary School enrolment (male %)	52.2	54.1	
Youth literacy (% ages 15 - 24)	81.1		87.8
Health			
Access to essential drugs (% of total population)		10	
Access to physicians (per 100,000 people)		<30*	
Nigerians living with HIV/AIDS (million)		>5	
Prevalence of HIV, female (% of ages 15-24)			5.8
Incidence of tuberculosis (per 100,000 people)			305
Under 5 mortality rate (per 1,000)	187		183
Infant mortality rate (per 1, 000 live births)	112		110
Immunization, measles (% of children under 12 months)	44		40
Immunization, full (% of total		17	

children)			
Maternal mortality (modelled estimate, per 100,000 live births)	1100	704*	
Clean Water			
Access to safe drinking water (% of population)		50	
Access to safe drinking water (% of urban population)		80	
Access to safe drinking water (% of rural population)			40
Access to improved water source (% of population)			62
Access to improved sanitation (% of population)			54
GENERAL			
Population (millions)	111.3		125
Average annual growth in GDP		2.9	2.9

*Source: World Bank; * Baseline data upon which reform projections were based.*

In addition, the impact of petroleum on the quality of life in Nigeria was compared to that of some selected OPEC countries and in some cases with non-OPEC countries (Appendix A). The result of the comparison of statistics is disheartening (IPS, 2005).

Generally, it is obvious that despite the contribution of petroleum wealth to the national economy, Nigeria performs below most OPEC countries in several indicators of quality of life. Nigeria is a classic example of the paradox of a wealthy but poor nation. A rich poor nation or a poor rich nation! A country plagued by what is called the Dutch Disease. Nigeria is a graphic illustration of sudden mineral wealth that has negative impact on the development of the

people of underdeveloped countries. In many developing nations, sudden mineral wealth did not translate to development. The sudden wealth created a class of people turned super rich. And through the aiding and abetting of foreigners, these nations became burdened with very heavy debts. They sank into the dark valley of debt. The people abandoned agriculture and other resources to their detriment. When we understand that every Gift of God must be loyally administered as explained in the Parable of the Talents. You will then not need any prophet to predict to you the possible consequences.

Petroleum, Poets and Prophets

Petroleum as the main stay of the Nigerian economy has affected every aspect of our lives. As art is a product of the people's spirit, an expression of the people's spirit; even our art has been influenced by the exploitation of petroleum. Petroleum is also the subject of many literary works. I will draw attention to a few lamentations associated with the exploitation of petroleum. The artists, in particular the poet is a modern day prophet who through a refined perception, speaks truth to those who care to listen. Today men are too intoxicated to listen and their conscience has become leprous.

In their works, two sons of the Niger Delta have bemoaned the impact of petroleum on the famished lives and land of the people of the Niger Delta. Professor Adiyi Martin Bestman in his collection of poems: **Textures of Dawn** lamented the environmental degradation in the poems *Jenbarimiema* (p17-19), *The Fisherman's Wry Cry,* and *Kiabara, dive no more* (p39-43)

The late Dr. Ibiwari Ikiriko's collection of poems is a lamentation graphically entitled **Oily Tears of the Niger Delta**. Ibiwari Ikiriko wept and wept volumes of oily tears. A typical example is the poem entitled *The Fisherman's Net* (p27). But when lamentations fall on hardened soil, gain turns to pain and pain begets pain.

Ola Rotimi in his Inaugural Lecture, quoted his play **IF** in which he also spoke through the mouth of the Kalabari fisherman, interpreted by Mama Rosa, the lamentations of the fishermen whose means of livelihood had been destroyed by years of oil exploration and exploitation.

Professor J. P. Clark-Bekederemo also lamented the devastation of the Niger Delta in his play **All for Oil**.

Many have lamented the boom there and the doom here. And yet, Nigeria is described as the most religious country on planet earth. How I wish we understand the 10th Commandment of God which states: *Thou shalt not covet thy neighbour's property, nor his cattle, nor any thing that is his* …. **Nor anything that is his!** There lies a hint which I thought is quite explicit.

In his inaugural lecture: Oil, "Babylonian", "Mathewnomics" and Nigerian Development, Okowa (2005) concluded with a lamentation on the misuse of petroleum wealth, and predicted a Divine Intervention in the form of visitation of the Wrath of the Creator, the Author of the Gifts of Nature. We do not need to look far to come to the simple but inevitable conclusion that what a man sows that shall he reap and what a nation sows that shall it reap. This is a very simple but adamantine Law of Nature that

affects individuals as well as nations. And the process of reaping the consequences has already started!

TREE OF LIFE AND TREE OF KNOWLEDGE

Vice- Chancellor Sir, as I said before, I used to wonder, why Universities *generally* chose to award the terminal Degree Doctor of Philosophy (PhD) irrespective of the Discipline. Why not Doctor of Engineering or Science or Management or Education or Medicine as the case may be. Again why Doctor? In Professor Nwodo's Inaugural Lecture: Philosophy and the Quest for Truth, I recognised the centrality of philosophy in all Disciplines and perhaps the reason why most Universities award the Doctor of Philosophy (PhD). But I was amazed at the limitation of the intellect when the greatest philosophers defined Truth as they saw it.

And so we may ask as once Pontius Pilate asked the Lord Jesus: What is Truth? Pilate asked the question, when Jesus spoke of Himself as bearing witness to the Truth. A deeper insight into the Teachings of Jesus would clearly indicate that God is The Truth! Therefore, what we should seek in all our studies, the pursuit of philosophy, should be the Quest for understanding the Manifestations of the Truth, the Quest for the recognition of the Will of God in Creation in our various disciplines.

In the Scriptures precisely in the Book of Genesis of the Bible, Chapter 2 verse 9 is the **allegory** of the two trees; The Tree of Knowledge and the Tree of Life. We all know what a tree is. Put simply, the Tree of Life is about Life. And God alone is Life! He is the Living Light out of Whose Radiations we came into being. A crude analogy is the sun without which nothing can live on earth. God is Light; The

Living Light! Therefore, the Tree of Life has its roots in God and the branches and fruits manifest as His Creations and Creatures.

The Tree of Knowledge is about Knowledge. What then is knowledge? Knowledge is what the brain or rather the intellect of man can absorb and conceive. Knowledge comes through experiencing and learning. Again and again I must emphasise that knowledge acquired through experiencing is superior and that is why it said: *Experience is the best teacher!*

What men call knowledge is a groping from the ground up! In this, the allegory of the seven blind men feeling different parts of an elephant, and lacking an overview of the whole, each one described what he experienced as different from the elephant epitomises the perspectives of various philosophers about what Truth is. This is justifiably so, because mankind truly do not know what The Truth is.

Even in the manifestations of Truth, once it was generally agreed that the earth was flat. Years later, it was recognised that the earth is spherical. Once it was generally agreed that the earth was the centre of the solar system but today we know better that the sun and not the earth is the centre of the solar system. But the process of spreading new recognitions is fraught with persecutions and hostility. It meets with dogmatic clinging to the old. People have pathological fear of new knowledge and discoveries. Why this is so can be attributed to professional envy, ignorance and egocentricity. Those through whom new recognitions came ended up as martyrs. Galileo suffered this fate as with many great discoverers. Even the church had its hand in these persecutions!

From what has been said so far, the Tree of Knowledge has its seat in the intellect; in the frontal brain while in every creature is an aspect of the Tree of Life since the creature is a fruit of the Tree of Life. Herbert Vollmann (1985) has drawn our attention to the fact that longitudinal sections of the frontal brain and the back brain give evidence of these trees. Now the real calamity that has befallen humanity! Over hundreds of years, we brought about an imbalance in the development of the brains. Through emphasis or one-sided cultivation or development of the intellect, a product of the frontal brain; i.e. the indulgence in the fruit of the tree of knowledge, the frontal brain became overdeveloped while the hind brain gradually became underdeveloped. This makes it difficult for us to have balance, clarity of insight and understanding.

What is the implication of this for our subject, petroleum and the relationship with the Christmas tree? The question has often been asked: what is the origin of petroleum, the black gold that flows up the Christmas tree. The question disturbed me right from my undergraduate days in the petroleum geology class at the University of Ibadan.

On the Origin of Petroleum

What is the origin of Petroleum? Scholarly Theses were written for and against. The arguments have raged on even today (Kenny et al, internet sources).

And yet it is said: *"In the beginning was the Word, and the Word…." There is nothing that is created that is not created by Him. (***John 1:1.)**

It is also said in the Book of Genesis in the Bible: Creation came into being when the Creator said: "Let there be Light". The Creator is the Source of all things. He is the Light, and everything has its origin in His Radiations. The Light is not the light of the sun but the Creator Himself. At best He can be described as the Light, the Truth and the Life. This is important for this lecture.

There is an analogy between the origin of man and the origin of petroleum. In the case of the origin of man, the arguments were between religionists who insist on creation and scientists who insist on evolution.

But the Bible is quite clear in the allegory of the creation of man when it said, *"God moulded man from the dust and breathed into him the breath of life and he became a living soul". (Genesis 2: 7)*

Thus, it is very clear that two processes are involved – the moulding of the body, (which science has observed) and the incarnation of the breath of life, the soul, (which science cannot investigate) the real essence that animates the body.

How does this relate to the origin of petroleum? Some scientists argue that petroleum originated from organic matter (biogenic), others argue it is inorganic matter (abiogenic). Both are unanimous that it originated from matter but what kind of matter. The arguments have been fierce even in recent times particularly from the Russian scientists (internet references). But do we need to debate or argue?

The hint lies in one sentence: ***Petroleum is a form of energy!*** (Ajienka, 1993). What therefore is the form? What

is the process of forming and what is energy, the content or essence. What scientists have studied so far is the form and the evidence tilts towards organic form while the essence, energy, is neither organic nor inorganic. Organic chemistry deals with carbon and its study of all compounds related by carbon (usually in combination with hydrogen and oxygen). In petroleum we deal with hydrocarbons. Carbon is considered the foundation of living matter. Atoms in the molecule of life are organized around carbon somewhat like a hub; proteins, fats, carbohydrates, the blood, chlorophyll are all examples of compounds that contain carbon. Inorganic chemistry means no carbon, and is primarily the study of substances in the mineral kingdom. In the combustion processes of petroleum, energy is released and what is left, the combustion bye-products are of organic origin. This underscores the organic nature of petroleum.

What is energy? Energy emanates as radiations of the Light that brought Creation into being. Scientists will continue to study the nature of energy, for the knowledge of what energy is, is of revolutionary importance. Energy came from the Radiations of the Light. The recognition in science is right: *Energy can neither be created nor destroyed!* Who does this assertion refer to? Man of course and not the Creator of all things.

Now what is the further relationship between the organic form and the form of man? In the evolutionary process on earth, man was the last to arrive. With the arrival of man, it was a major cosmic turning point. The cosmic turning point and the coming of the human spirits came with a peculiar stream of energy. This was followed by geologic upheavals in which the plant and animal forms existing up till then went through a process of disintegration and transformation

to provide the source materials which in absorbing energy or union with the stream of energy led to the formation of petroleum. That is why petroleum (oil and gas), coal and all hydrocarbons are called *fossil* fuels. With this an important question can be asked. Is Africa truly the cradle of humanity on earth?

When life forms developed on earth, this took place in all continents so also is the coming of human beings. Therefore, the process of disintegration of organic matter that led to the formation of petroleum took place in all continents. And petroleum is found in all continents in sedimentary rocks of different ages. Sedimentary rocks! There lies another hint. The process of sedimentation is an ongoing process not a one-time event. Let me repeat: Petroleum is found in all continents in sedimentary rocks of different ages. This is because the incarnation of man took place over different ages in different parts of the earth.

The deep sea petroleum finds are also indications of life in the lost continent of Atlantis (See Figure 17).

As to why the Middle East is where most of the giant oil fields are found, it can be said that the region was the epicentre of profound activities on earth, a region under direct focus of Light Activities. So much for scientists to reflect upon!

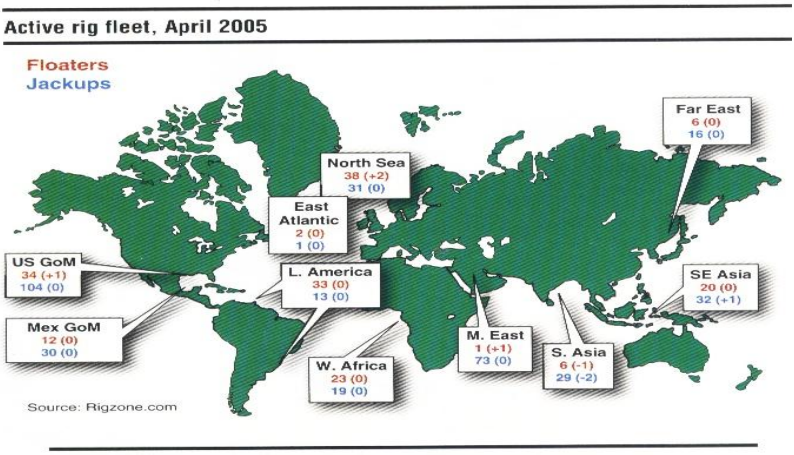
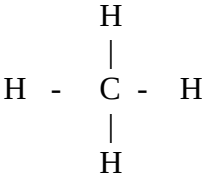


Figure 17 showing high concentration of rig activity in the area from the North Sea to Gulf of Mexico and the Gulf of Guinea in the Atlantic Ocean

On the Nature of Petroleum

The state of petroleum whether solid, liquid or gas is essentially subject to temperature and pressure. However, it is important to note the structure of the primordial hydrocarbon – Methane



For me, the interesting thing is that the fundamental structure of methane is the form of an equal armed cross, like a plus sign. The Cross is the symbol of Truth, which sustains Creation. This immediately helps us to see a link between petroleum and the Nature of Light vis-à-vis the forming of Creation.

Crude oil has a very interesting nature. Like the Light that gives the rainbow colours when diffracted through a prism, crude oil when passed through a refining process gives different products. First the lightest products and last the heaviest products. Each product condenses at a certain temperature of condensation.

What can we learn from these processes? When the Lord said: Let there be Light, there was Light. Condensations from the Light at different levels of cooling off, away from the Source, gave rise to planes and planes of Creation. Each plane inhabited by creatures of the same homogeneity and consistency. Can we now understand why Jesus described Creation in one simple sentence: *In My Father's House are many mansions!* Mansion and house which is bigger in human reckoning? This is a point for reflection.

Also, like the products of the refinery, the lightest and strongest products condensed out first followed by the heavier condensates. When a stream flows, the strongest particles to withstand the force of the source of the stream, will be deposited close to the source while the weakest will be deposited furthest away! As above, so below!

Another interesting feature of the homogeneity of species or products is that kerosene, a bye product of petroleum, has its uses different from petrol and diesel. One cannot be substituted for the other in their usage. So also is it in Creation and its creatures. Man is different from animals in nature, consistency and homogeneity. And yet all are bye products of condensations from the "Let there be Light" that took on form at different planes of Creation and are fundamentally different.

The refinery is a great discovery. The refinery process is like a mirror image of the creating process. A great reflection of the creative process of the Creator!

Formation Water, a Great Secret of Creation!

I have often felt that the life of a petroleum engineer is a race against formation (reservoir) water. The Petroleum Geosciences teach us that the petroleum reservoir was originally an aquifer filled with 100% water. The formation of petroleum pushed the water away leaving what we call interstitial water. The Petroleum Engineer has to manage formation water to ensure that he uses it to maximise well productivity.

Now comes a bang! The profound revolutionary discovery by Dr Masaru Emoto, the internationally renowned Japanese Researcher, and Nature Study exponent. Emoto (2004) has shown that water is a great transmitter of energy; water bears memory of information. Therefore, formation water in which petroleum is born will also bear records of life and history of the cosmos. And the different levels of aquifer as we drill for oil will also tell a story of the sedimentary process.

I have advocated that we study formation water characteristics the way we study oil and gas characteristics for good engineering. But now a vista of opportunities opens before our gaze and we can get more from formation water! We can see some amazing pictures of water crystals from polluted water, natural spring, water affected by our thoughts, words and music at Dr Emoto's website.

Nature Study

Vice-Chancellor, Sir, Petroleum is a Gift of Nature. And so in this lecture I am oblidged to pay tribute to Nature. Particularly, knowledge about Nature our schools do not teach. In those days, we used to have in our primary school curriculum, the subject **Nature Study** until the intellect completely derailed the educational system. Replacing Nature Study with integrated science and such other splittings at the primary school level was a collosal mistake. With this, the foundation was laid for wrong education. Children are close to Nature and the subject Nature Study should have been a platform to teach about Nature and anchor the education of our children on the right foundation.

But it is not surprising that the derailment took place. For man does not know what lies behind Nature and why Nature is evergreen. It is often said that Nature is evergreen. Why is this so? What makes Nature evergreen; what lies behind Nature? Why are we enchanted about the beauty of the flowers, the meadows, and the colour spectrum of the rainbow? Are we not puzzled at the proverbial far-seeing eye of the eagle, at the wonder of the butterfly breaking out of the cocoon and the firefly that twinkles in the night? Has it not become common knowledge that the study of migratory birds and wild animals is a source of guidance to know when major disasters such as volcanic eruptions, earthquakes, storms and hurricanes, are about to occur in a place. What guides these wild animals and migratory birds to move away before such disasters. This should be cause for reflection.

Nature is the Work of the Creator. Nature is agog with life. Behind Nature lies the Nature Beings who animate

and activate all that we call Nature. The people of the Niger Delta are familiar with the knowledge of Nature Beings. Our cultures are influenced by this knowledge. Films have been produced using the knowledge of Nature Beings. Art works abound about Nature Beings. Several books have been written about Nature Beings in various cultures. For instance, in his book, Daniel Swaroski (1982), the Austrian bussinessman and author documented encounters and pictures of Nature Beings in Europe.

Let me share with you technology from Nature in the oilfield I found in a product manual on Flow Assurance by Shell Global Solutions (2005) on the development of Low Dosage Hydrate Inhibitor (LDHI).

" We sometimes find solutions to complex technological problems concealed within some of nature's basic life forms.

Operators are faced with inherent complications of hydrocarbon flow in high pressure, low temperature waters of the Gulf of Mexico. Shell researchers looked for possible answers from the inhabitants that thrive in those types of environments.

The investigation began when our scientists happened upon an article about certain arctic fishes that possess a natural protein that inhibits agglomeration of ice crystals in their blood stream. Years later, Shell researchers began synthesising these proteins in the laboratory. Eventually, this research led to the development of Low Dosage Hydrate Inhibitors as we know them today."

In the amazing contours of wood veneer, I see a great reflection of sedimentation which indicates how the pattern of contours is to be made by geologists.

Another Nature Study exponent, Dr George Washington Carver was described as one of the most remarkable and extra-ordinary minds; a multi-talented man who came to amazing discoveries through flashes of intuition, Nature study and inspiration. Dr Emoto and Dr Carver are examples of people - pure and applied scientists, social scientists, artistes etc - of whom it is said: *"The Lord gives to His own in their sleep"*.

Dr Carver has this to say: *". . . the most beautiful things in life are God's wonderful handiwork expressed through Nature…"*

Of his discoveries, he said: *"It is not we little men that do the work, but our blessed Creator working through us…"*

Why am I paying this tribute to Nature? The fact is that Nature is evergreen because Nature stands faithfully on the Path of Truth. For scientists and researchers in particular, the easiest route to the recognition of the Truth and discovering lasting solutions to mankind's multiplicity of problems is the study of Nature. The Laws of Nature are simple, clear, adamantine, uniform and consistent. Lasting solutions are possible when we realign our studies to the currents of these Laws. These attributes of the Laws of Nature clearly teach us that they emanate from the unchangeable Perfection of the Primordial Source that sustains and maintains Creation. Therefore, gaps, contradictions and illogicalities are absolutely impossible in the working of these Laws which science should rightly

study. Any inconsistency observed can only be an evidence of a lack of understanding.

CONCLUSION

The opportunities for effective reservoir and production management in Nigeria are offered by the use of best available technology, best practices and best regulatory policies. Therefore, there is the need to review our policies to accommodate the evolution of new technologies and practices. In addition, sound production management principles will result in the ultimate benefits of reservoir and production management: increased reserves, enhanced reservoir/well productivity and higher return on investment.

The late Prof Chi Ikoku, the big masquerade of our clan used to ask me *what is new?* This question lies at the core of research. The newness may be in process optimisation, in cost efficiency, in safety and environmentally-friendly operation, a new clarity, explanation or perspective. I have benefited from this great scholar. What is new? Is the question we must constantly ask ourselves in our research. A researcher who does not make a difference has not exerted himself to be creative and innovative. We need not re-invent the wheel but we should improve on its efficiency.

Vice- Chancellor Sir, the wellhead called Christmas tree is the crown of the oil or gas well. As a petroleum production engineer, I was concerned about the health of our oil and gas wells. Most of my work is centred on the Christmas tree. That is what I have tried to profess with my students that this country should be blessed with the black gold to become a truly egalitarian society, a country where the quality of life should be better than we are experiencing

today. Therefore, it is a source of pain for me to see doom in the midst of boom.

The Christmas tree in the fields is a symbol of the Love of God celebrated at Christmas Festivals. So also do we need to celebrate the Christmas tree in the oilfields everyday anew as a reminder of the Love of God that permits us Gifts of Nature out of His Abundance! It should also be our duty to make the oilfields, as green as possible in terms of environmental friendliness of our operations.

I have advocated Nature Study, in particular for the children, to build the right foundation for all education. I was fortunate to have had a little of Nature Study as a child. The beautiful words Nature Study constantly ring in my mind and so in all my studies I tried to observe Nature keenly as part of my general Quest for Truth. And in doing so with an open mind, I have been guided to some discoveries of the Working of Nature that have given me clarifications useful in my discipline. This is the precious secret you may call the philosophy that lies behind my working. Today I feel pained that the best students are not attracted to the ***pure*** sciences where Nature is studied and great discoveries can be made. Unwilling students are attracted to the important disciplines concerned with Nature.

I have also pointed to the fact that every Gift of Nature such as petroleum must be loyally administered else the misuse carries grave consequences. The boiling up in the Niger Delta, the plague of the so-called Dutch Disease are evidences of the lack of equity in the use of petroleum. We should not forget the Admonition: To him who has and who does not use aright, the little he has will be taken away and

given to him who uses aright. This Admonition applies to all Gifts and Talents.

The arguments about the origin of Petroleum which have raged are unnecessary for Petroleum is a form of energy; and energy can neither be created nor destroyed by man. Energy came from out of the Radiations of the *Let there be Light*. Petroleum is a peculiar Gift of Nature which bears in its nature a part of the secrets of Creation. Knowledge which we can draw from, if we diligently climb the ladder of ascent on the Tree of Life! Humanity is afforded Extension of Knowledge whenever we are mature for it.

We are in the Age of Knowledge. Knowledge makes a world of difference between the ignorant and the wise particularly in today's knowledge-based economy. Knowledge makes the difference between the developed, the developing and the underdeveloped. In the age of the global village, it is knowledge that has made some to invest in and sell bandwidth in space while the ignorant kills himself over land on earth. It is lack of knowledge that makes some to be unable to suppress the primordial instinct of acquisitiveness while others truly lay up their treasures high above where thieves will not reach. Knowledge makes the difference between the wise and the ignorant.

Finally, I will like to bow my spirit in Gratitude to the Almighty for His Immeasurable Goodness and Guidance that I have been afforded in my career and experiencing. When I dedicated my PhD Thesis to the Chain of Guidance, I did so consciously. For immeasurable is the Guidance on my path of experiencing. This Inaugural Lecture is also dedicated to the Chain of Guidance, my teachers and parents and all those whose paths I have crossed, who were used as

tools to help in my growth and maturity. Indeed I am grateful.

Once again, I thank all of you for attending my Inaugural Lecture. Your attendance is a great honour and support for me. What remains is to wish you the Grace of the Lord. In the air is already the feeling of Christmas. As we prepare to celebrate Christmas this year, the Festival of Love, do not forget yourself. Remember the Christmas tree and remember to give yourself a Christmas Gift. Let every one give himself or herself a Christmas Gift, a simple gift even the poorest of the poor can afford. And the gift is simply to dedicate ourselves to Goodness and to use the Gifts of Nature aright. We all can do this, it is within our means! And when we succeed in doing so, great will be His Grace over us. For in giving selflessly and doing everything in goodness, we receive abundantly.

Let us now end this lecture with the beautiful Carol (O Christmas Tree!) in praise of the Christmas Tree in Gratitude to the Almighty through Whose Goodness and Guidance, petroleum, a source of energy connected with the advent of man on earth was discovered; Who through an Extension of Knowledge permits us insight into His Will in Creation. And like every Gift of Nature, may we use this Gift aright, to the blessing of all.

(CAROL)

Merry Christmas and Thanks – a – Million!

Joseph Atubokiki AJIENKA
joseph.ajienka@ipsng.org
jajienka@yahoo.com
+234-803-3166-856

NOMENCLATURE

BHP: Bottom Hole Pressure
DPR: Department of Petroleum Resources
EGP: External Gravel Pack
HSE: Health Safety and Environment
HLB: Hydrophile Lipohile Balance
IGP: Internal Gravel Pack
LTI: Lost Time Injury
MER: Maximum Efficiency Rate , DPR Allowable
PERF: Perforated without sand control
PPE: Personal Protective Equipment
SCON: Chemical Sand Consolidation
E_m: Efficiency of emulsion resolution through bottle test
E_k: Efficiency predicted using dielectric permittivity

BIBLIOGRAPHY

Agbon, I. S. and Ajienka, J. A. (1996):"The Future of Petroleum Engineering Education in Nigeria", ***Refereed Proceedings***, p141-147, Paper SPENC 9614, 20th Annual International Conference of the SPE Nigeria Council, 17th - 21st Sept., Warri, Nigeria.

Ajienka, J. A, Ebong, M., Abolarin, A. and Beun, P.(2005): "Human Capital Development and Capacity Enhancement through International Collaborative Graduate Programmes for the Petroleum Industry", **Petroleum Training Journal,** Vol. 2, No2, July.p45-58

Ajienka, J. A. and Kuye, A. (1999): " Impact of Unsafe Wells on the Environment: Lessons from Obelle Fire Incident, " ***Refereed Proceedings***, Nigerian Society of Chemical Engineers Proceedings 29, 95-103

Ajienka, J. A., Mofunlei, S. and Ihegwara, P. A. (2004): **Multiphase Meters: Testing, Economics and Quality Control**, IPS Monograph Series, 57pp.

Ajienka, J. A. (1993): *Suggestions on improving well surveillance*, Inter Office Memorandum, April 19, PEBE, SPDC-E

Ajienka, J. A. (1993): On the Origin of Petroleum, SPE Section 103 PH Newsletter, Vol. 20 June p3

Ajienka, J. A. (1994) " Well Inflow Quality Indicator, Dimensionless PI: Procedure using the QIP Approach", SPDC-E Nigeria, December 1994, pp12.

Ajienka, J. A. (1995): "Effect of High Oil/Water Viscosity ratios on Oil Well Productivity index and WIQI," (unpublished), SPDC (March) 5pp.

Ajienka, et al (1993): Otakikpo Development Feasibility Study Report, SPDC -E, Nigeria, August

Ajienka, J. A. (1995): "Prediction of Low bean size induced Unstable flow in oil wells", PEME 95.39 (March), SPDC-E, Nigeria Production Tech Forum, SPDC -E, August 30,

Ajienka, J. A.(2005): **Production Enhancement**, SPE Short Course Text.

Ajienka, J. A. and Olabode L. (1993) "Calculation of Well Inflow Quality Indicator (Dimensionless PI)" SPDC-E, Nigeria, August 1993, pp 48.

Ajienka, J. A. and Okorie, S. E. N. (1995) "Determination of average dimensionless PI and its Application to Well Surveillance" SPDC-East Nigeria, pp 12.

Ajienka J. A. and Onyeizugbe, S. O. (1999): “Prediction of Well Completion/Performance Efficiency”, Field Operations Manual Series No-1, 1999)

Ajienka, J. A. and Essien, Eno Eyibio. (1999): Waxy Crude Oil Well Surveillance: Field Operations Manual; Studies in Petroleum Production Optimization, Field Operations Manual Series, No. 4, 16pp: Series Editors: Opara, P. A. I. and Ajienka, J. A.

Ajienka, J. A. and Ikoku, C. U. (1986): “A Generalized Model for Multiphase Flow Metering," ***Refereed Proceedings***, p67-84, Paper SPEN 8606, 10th Annual International Conference of the SPE, Nigerian Section, 6th - 8th August, Lagos. Also **Paper SPE 17174**, SPE International USA

Ajienka, J. A. and Ikoku, C. U. (1988): “Prediction of Critical Multiphase Flow through Restrictions," ***Refereed Proceedings***, p107-120, Paper SPEN 8807, 12th Annual International Conference of the SPE, Nigerian Council, 4th - 6th August, Port Harcourt

Ajienka, J. A. and Ikoku, C. U. (1990): "Waxy Crude Oil Handling in Nigeria: Practices, Problems and Prospects," Energy Resources, Vol. 12, 463-478.

Ajienka, J. A. and Ikoku, C.U. (1991) "An Economic Evaluation of Methods of Handling Waxy Crude Oils” paper presented in the 1991 SPE Annual International Conference, Port Harcourt.

Ajienka, J. A. and Ikoku, C. U. (1990): "Waxy Crude Oil Handling in Nigeria: Practices, Problems and Prospects," ***Energy Sources, Vol. 12***, 463 - 478.

Ajienka, J. A. and Ikoku, C. U. (1991): "An Evaluation of Critical Multiphase Orifice Flow Correlations," ***Nigerian Journal of Petroleum and Energy, Vol. 1, No.1***, 75 - 83

Ajienka, J. A. and Ikoku, C. U. (1991): "Economic Evaluation of Methods of Handling Waxy Crude Oils," ***Refereed Proceedings***, Paper SPENC 9109, 15th Annual International Conference of the SPE, Nigerian Council, August, Port Harcourt, Nigeria

Ajienka, J. A. and Ikoku, C. U. (1991): "The Effect of Temperature on the Rheology of Waxy Crude Oils," ***Paper SPE 23605****, SPE-AIME, USA*

Ajienka, J. A., Ogbe, N. O., Mbakwe, A. , Mmaji, J. O. Airuehia, G. A. and Ezeaniekwe, B. C. (1992): " A New Approach to Demulsifier Selection for Optimum Oilfield Emulsion Resolution," ***Refereed Proceedings***, Paper SPENC 9210, 16th Annual International Conference of the SPE Nigeria Council, August, Lagos, Nigeria

Ajienka, J. A., Ogbe, N. O. and Ezeaniekwe, B. C. (1993): "Measurement of Dielectric Constant of Oilfield Emulsions and Its Application to Emulsion Resolution," ***Journal of Petroleum Science and Engineering, 9,*** 331 - 339

Allen, T. O. and Roberts, P. A. (1982): **Production Operations Vol 2,** Chapter 1, OCGI, Tulsa

Andrier B. (2005): Offshore Engineering, IPS Lecture Notes, pp71

Anosike, E. O. (1987): **In Praise of Enzymes**, University of Port Harcourt Inaugural Lecture Series No.6 June 9, 22pp

Arinze, A. E. (2005): **Plant Pathology and Post Harvest Food Loss**, University of Port Harcourt Inaugural Lecture Series No. 43, July 28, pp98.

Bestman, Adayi Martins (1998): **Textures of Dawn**, Obafemi Awolowo, University Press Limited, 56pp

Brown, E. Kermit and James, F. Lea (1985): "Nodal System Analysis of Oil and Gas Wells". **JPT**. (Oct.): pp. 1751-1763.

Chan, K. S. (1995): "Water Control Diagnostic Plots", SPE paper 30775 presented at the SPE Annual Technical Conference and Exhibition, Dallas, U.S.A., Oct. 22-25.

Clark-Bekederemo, J. P. (2000): **All for Oil**, Malthouse Press

Clark, Glenn (1939): **The Man who talks with Flowers – The Life Story of Dr George Washington Carver**, Macalester Park Publishing Co. Minnesota, USA, 62pp.

DPR (1991): "Environmental Guidelines and Standards for the Petroleum Industry in Nigeria", Lagos

Egbe, T. and Appah, D (2005) "Water Coning Diagnosis using Spectral Analysis", Paper presented at the 2005 NAICE of SPE, Abuja, August 1-3

Emoto, M. (2004): **The Hidden Messages in Water**, (English translation of the 2001 book), Beyond Words Publishing Company, Oregon, USA, 159pp.

FEPA (1991a):"Guidelines and Standards for Environmental Pollution Control in Nigeria, Decree No 58 of 1988, 1991, Lagos.

FEPA (1991b). National Guidelines and Standards For Industrial Effluents, Gaseous Emissions and Hazardous Wastes Management in Nigeria.

FEPA (1992). Environmental Impact Assessment Decree. Federal Government Printer, Lagos.

Hudgins, C. M. Jr, (1992): "Chemical Treatments and Usages in Offshore Oil and Gas Production Systems", **JPT**.

IPS University of Port Harcourt (2005): Petroleum and the Quality of Life in Nigeria, IPS Monograph, under review.

Ikem, J. and Russo, M (1995: Preventing Hazards through Well Monitoring, Proceedings of 1st ARPO Convention, AGIP)

Ikiriko, Ibiwari (2000): **Oily Tears of the Niger Delta**, Kraftgriots, 64pp

Ikoku, Chi U. (2000): **Petroleum: Mankind's Best Friend**, University of Port Harcourt Inaugural Lecture Series No.26 July 19, 91pp

Inyiama, Q. E and Ajienka, J. A (2005): "Evaluation of Environmental Compliance of Effluent Wastewater from Flow Stations in the Niger Delta (A Case Study of 3 Operating Companies)", paper under review

Kenny, J. F, Shnyukov, Ac. Ye., Krayushin, V. A., Karpov, I. K., Kutcherov, V. G. and Plotnikova, I. N. : Dismissal of the Claims of a Biologica Connection for Natural

Petroleum,http://www.gasresources.net/DisposalBioClaims.htm p13

Maduka, Chidi Tom (1994): **Across Frontiers: Comparative Literature and National Integration**, University of Port Harcourt Inaugural Lecture Series No.14 April 21, 41pp

National Economic Empowerment and Development Strategy (NEEDS) (2004), Federal Republic of Nigeria.

Nind, T. E. W. (1964): **Principles of Oil Well Production**, McGraw Hill Book Co., NY, p136 - 140.

Nwabueze, Vincent (1996): Field Review Report, SIPM, The Hague

Nwodo, C. S. (2002): **Philosophy and the Quest for Truth**, University of Port Harcourt Inaugural Lecture Series No.26 July 19, 38pp

Nwonodi, C. U. and Ajienka, J. A. (2005): "The Effect of Temperature and Pressure on Scale Deposition Profiles in Producing Wells", Proceedings Offshore West Africa (OWA) International Conference & Exhibition, Abuja March 21-23

NUC Report (1989): "Approved minimum academic standards in engineering and technology for all Nigerian Universities"

Okowa, W. J. (2005): **Oil, "Babylonian" Mathewnomics" and Nigerian Development**, University of Port Harcourt Inaugural Lecture Series, No. 40, February 10

Opara, C. R. and Ajienka, J. A. (2004): "The Application of HLB – Dielectric Permittivity Correlations for Oilfield Emulsion Resolution", paper under Review

Origin and Natural Occurrence, http://www.factmonster.com/ce6/sci/A0860336.html http://www.1911 encyclopedia.org/P/PE/PETROLEUM.htm p36

Owolabi, O. O., Dune, K. K. and Ajienka, J. A. (1991): " Predicting Critical Multiphase Flow Performance Through Well head Chokes for Niger Delta Oil Wells**,"** ***Refereed Proceedings,*** Paper SPEN 9110, 15th Annual International Conference of the SPE, Nigerian Council, August, Port Harcourt, Nigeria.

PTDF Overseas Scholarship Advert in Guardian Newspaper, Sat. January 31, 2004 page B10

Rotimi, Ola (1991): **African Dramatic Literature: To be or To Become**, 11th Inaugural Lecture, University of Port Harcourt, 30pp

Shell Global Solutions (2004) Flyer on Flow Assurance: Development of Low Dosage Hydrate Inhibitor (LDHI).

Swarovski, Daniel (1982): **Life - A Miracle**, Sieben Quellen Verlag Innsbruck Austria, 96pp

The Origin of "Fossil" Fuels: The Change of Scientific Paradigms, http://www.evomind.com/the_origin.htm p28

Udegbunam, E. Ugwuzor, D. Poupeau, J.F. (2000): "Squeezing Remaining Reserves out older Producing Fields". Paper SPENC 66078 Referred Proceeding 24th SPE

Nigeria Council Annual International Conference & Exhibition 7-9 August, p 233 - 239.

Ugbebor, N J and Ajienka, J. A. (2004): "Comparative Evaluation of HSE Performance of Some Oil Producing Companies in the Niger Delta Region of Nigeria", Paper under review

U. N. D. P. (2004): Human Development Report, (internet)

University of Port Harcourt, Faculty of Engineering Report (2002) on Status of Engineering Students/Entry Requirements

Vollmann, Herbert (1985): **A Gate Opens**, Composite Volume, Stiftung Gralsbotschaft Publishing Co., Stuttgart, 394pp.

Young, R. O. and Young, S. R. (2001): **Sick and Tired?** Reclaim Your Inner Terrain, Woodland Publishing UT, USA, 295pp

Young, R. O. and Young, S. R. (2002): **The pH Miracle, Balance Your Diet, Reclaim your Health**, Time Warner Paperbacks, NY, USA, 402pp;

Appendix A

Table. A1: Quality of Life Indicators of different countries.

Economic Indicators	Countries			
	Nigeria	**United Arab Emirate (OPEC)**	**Malaysia (NON OPEC)**	**South Africa (NON PROD.)**
Population	133,881,703	2,484,818	23,092,940	42,768,678
Population growth rate	2.53%	1.57%	1.86%	0.01%
Death rate Deaths/1,000	13.76	4.02	5.12	18.42
Net migration rate	0.26 migrant	1.22% migrant	0 migrant	-0.35 migrant
GDP - real growth rate	3%	2.4%	4.2%	3%
GDP – per capita	$875	$22,000	$9,300	$10,000
Population below poverty line	60%	NA	8%	50%
Inflation rate (consumer prices)	14.2%	2.8%	1.9%	9.9%
Unemployment rate	28%	NA	3.8%	37%
Industrial production growth rate	0.4%	4%	5%	3%
Electricity – consumption, KWh	14.55 billion	35.1 billion	63.48 billion	181.2 billion
Oil - production million bbl/day (2001 est.)	2.256	4.8	0.73	0.19
Oil - proved reserves billion bbl (January 2002 est.)	27	52	3.729	0.007

Source: CIA World facts www.ciaworldfacts/gov/; 2002

Table A2: Summary of Comparison

Quality indicators	Effect on quality of life	Ghana	Nigeria
Crime rate	Negative	10th in Africa	5th in Africa
GDP	Positive	3%	3.5%
Death rate	Negative	10 deaths per 1000	14.1 deaths per 1000
Literacy rate	Positive	64.5%	57.1%
Corruption	Negative	6.1%	8.4%
Inflation	Negative	25%	14.9%
Population under $1/ day	Negative	44.8%	70.2%
Gross income per head	Positive	$308	$312
Unemployment rate	Negative	20%	28%
Average communication cost	Negative	$0.03	$0.2

Table A3: Nigeria & Other OPEC Members

	Population(millions)	Per Capita Income($)	Gross National Income($millions)
NIGERIA	120	240	27594
LIBYA	6	6510	32900
INDONESIA	210	1080	213384
KUWAIT	2	20470	35901
VENEZUELA	25	3020	67333

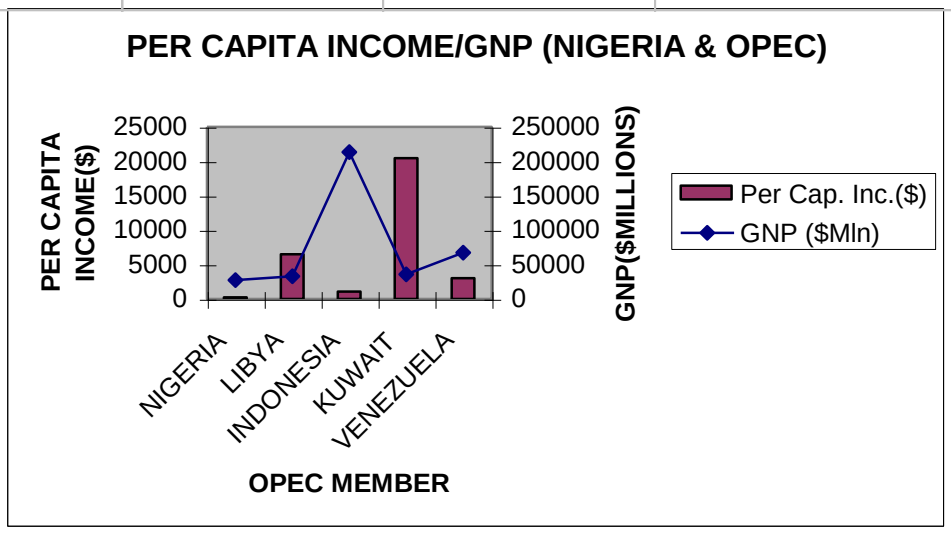


Figure A1: Per Capita Income/GNP (Nigeria and OPEC countries)

Table A 4: Nigeria & Non-OPEC Members

	Per Capita Inc ($)	GNP ($Mln)
NIGERIA	240	27594
GHANA	360	8223
SINGAPORE	30510	92987
SYRIA	1160	16808
BRAZIL	4400	709591

Table A5: HDI Comparison*

Measuring Index	Countries		
	Nigeria	**Libya**	**Ghana**
Population(million)	133	5.5	20.1
GDP (billion)	$42.7	$19.7	$6.01
Per capita GDP	$321	$3,567	$300
Life expectancy (yrs)	51.7	70.5	56.8
Literacy rate , %	63.9	80	68
HDI ranking	148th	64th	127th

* Values as at December 2002 (www.undp.org)

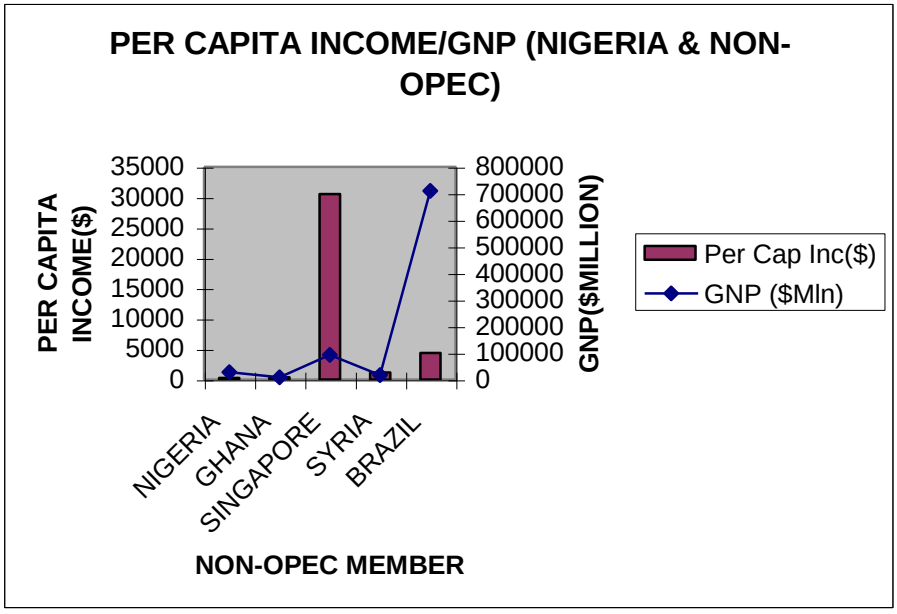


Figure A2 : Nigeria and non-OPEC Countries

TABLE A6: COMPARISON IN TERMS OF SOCIO-ECONOMIC DEVELOPMENT

COUNTRY / INDICATOR	NIGERIA	LIBYA	ANGOLA	GHANA
Population	117.9 million	(2002E): 5.5 million	12.3 million	N/A
GDP purchasing power parity	$113.5 billion	$7.0 billion	$45 billion	$33.6 billion (1998 est.)
GDP-per capita purchasing power parity	$875	$1,400	$1000	$1,900 (2000 est.)
Inflation rate	14.2%	(consumer prices, 2003F): 2.5%	N/A	(consumer prices) 27.7% (1997 est.
Population below poverty line	60%	N/A	61% (1998E)	31.4% (1992 est.)
Unemployment rate	28%		N/A	20% (1997 est.)
Electricity production	(1/1/99E): 5.9 gigawatts	4.6 gigawatts (100% thermal)	NA	5.466 billion kWh (1999)
Electricity consumption.	14.55 billion kWh (2001)	N/A	NA	5.573 billion kWh (1999)

Table A7: Comparing the GDP of Nigeria with those of Selected Countries[1]

	Population Million	Population %world	Income capita	GDP 95 Million $	GDP %world
Nigeria	*126.72*	*2.28*	*311*	*39,349*	*0.2*
Japan	125.2	2.25	24,019	3,007,183	15.32
Egypt	59.23	1.07	738	43,732	0.22
Benin	5.56	0.1	309	1,717	0.01
Venezuela	21.64	0.39	2,651	57,371	0.29
Iran	61.28	1.1	3,106	190,341	0.97
Switzerland	7.04	0.13	26,716	188,082	0.96
South Africa	41.24	0.74	2,186	90,156	0.46
Brazil	155.82	2.81	2,135	332,616	1.69
USA	263.43	4.74	20,698	5,452,500	27.77

[1] Source: World Bank (1995a)

Table A8

QUALITY INDICATOR	NIGERIA	SAUDI ARABIA	COTE D' IVOIRE	EQUADOR
General				
Population growth rate	2.53%	3.27%	Average	_
Net Migration rate (per1000 population)	0.26	1.23	-	-0.52
Health				
Birth rate (per1000 population)	8.75 births	37.2 births	high	24.94 births
Death rate (per1000 population)	17.76 deaths	5.79 deaths	8.55 deaths	0.29 deaths
Economy				
GDP growth rate	3%	0.6%	-1.7%	3.3%
GDP (purchasing power parity)	$875	$10,500	$587	$3,100
Population below poverty line	60%	NA	High	70%
Inflation rate	14.2%	1%	3.2%	12.5%
Unemployment rate	28%	25%	Moderate	7.7%
External debt	$29.7 billion	$25.9 billion	-	$14.4 billion

REFERENCES

1. Department of Energy; Sapa-Agence France Presse July 22, 2002; "US Not Pressuring Nigeria To Quit OPEC Says Envoy," Sapa-Agence France Presse, July 25, 2002;
2. Arab Maghreb Union http://www.eia.doe.gov/cabs/maghreb.html
3. *Kristin Reed </news/students/2003/angola/bio.shtml>*
4. http://www.eia.doe.gov/emeu/international/libya.html
5. OPEC Revenues Fact Sheet http://www.eia.doe.gov/cabs/opecrev.html
6. **http://travel.state.gov/libya.html**
   Microsoft Internet Explorer 2000, www.geography/about.com
7. Nigeria's Business Day, Volume 3, No 78, Monday, October 20, 2003, pp 56

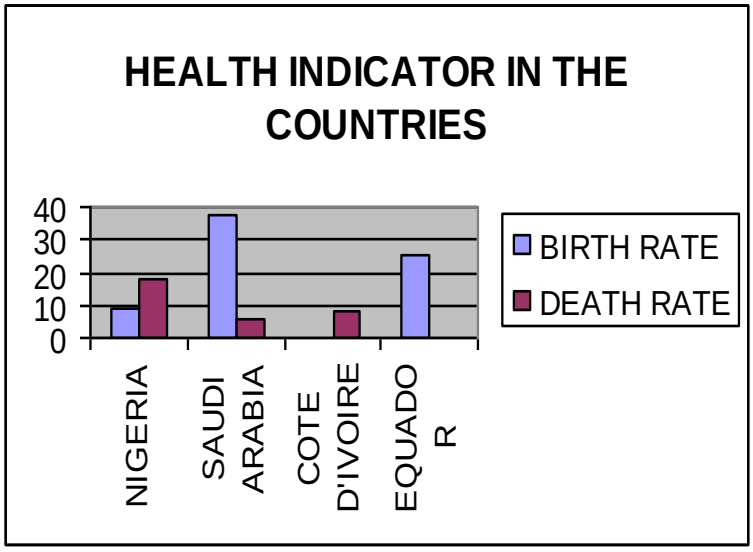


Figure A3: Health Indicators

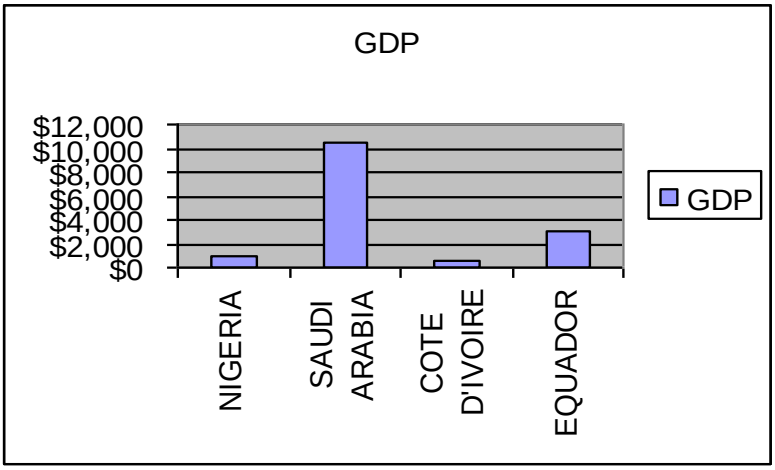


Figure A4: GDP

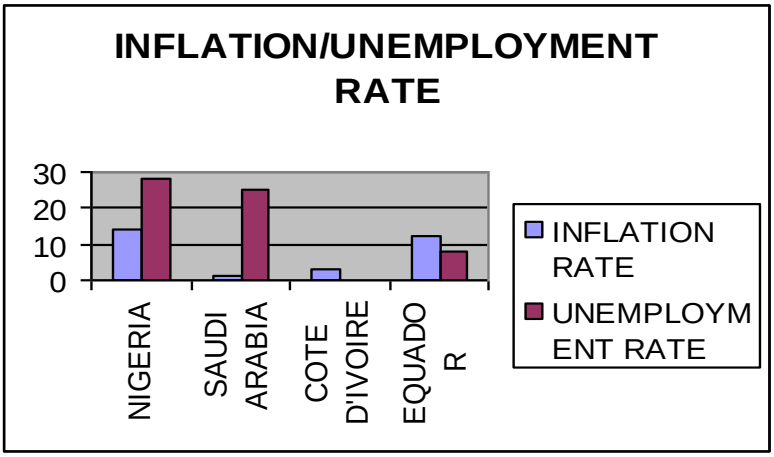


Figure A5: Inflation and Unemployment Rates

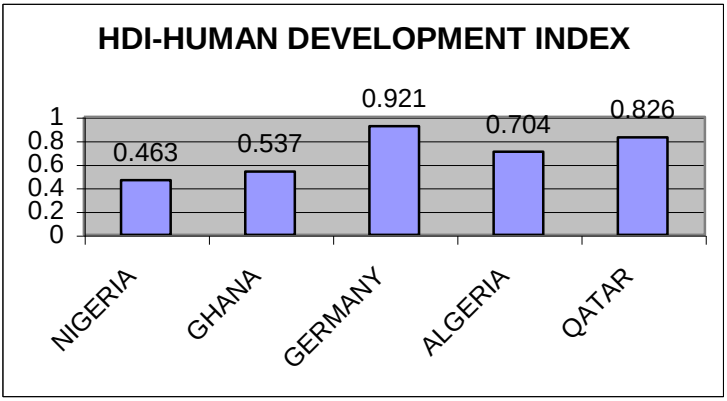


Figure A6: HDI

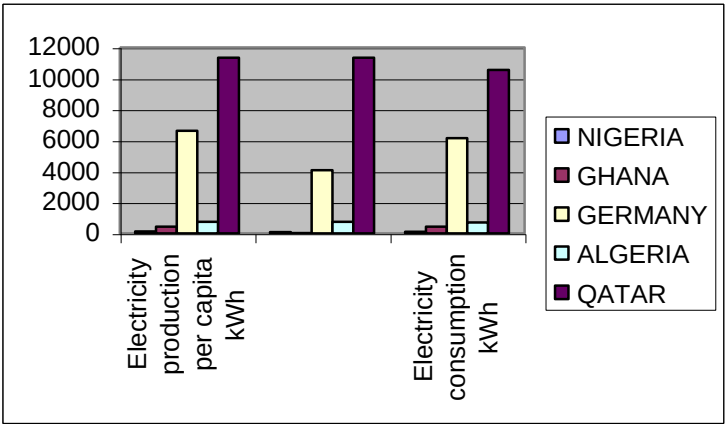


Figure A6: Electricity Statistics

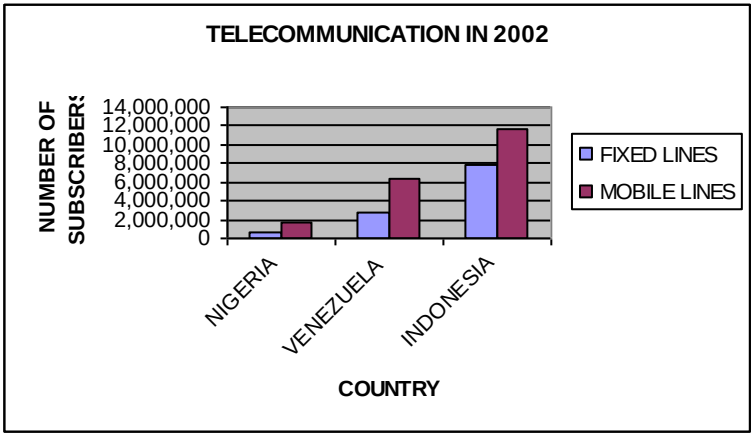


Figure A7: Telecommunication

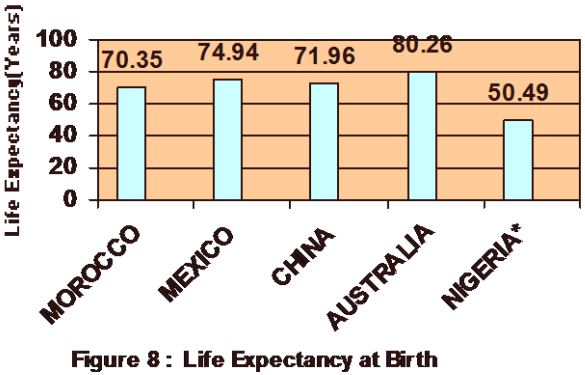


Figure 8 : Life Expectancy at Birth

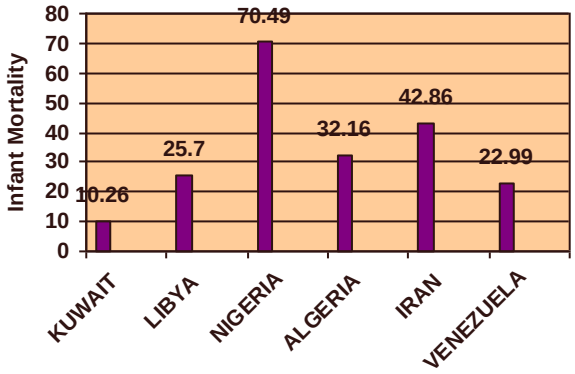


Figure 9 :Infant Mortality(deaths per 1000 live births)

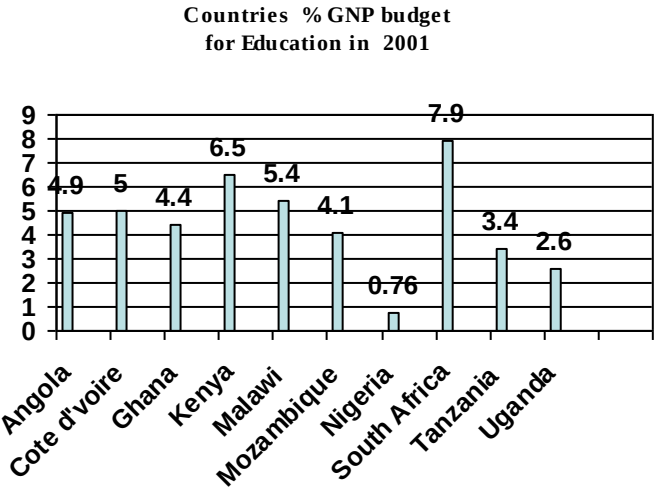


Figure A 10: GNP