The Soil We Do Not Know

PREAMBLE

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Deputy Vice-Chancellors and other Principal Officers of the University,
President of Soil Science Society of Nigeria and members of the executive,
President of the University of Nigeria Alumni Association and other officers present,
Deans of Faculty
Directors of Institute and Centre
Heads of Department
Distinguished Professors
Past Inaugural Lecturers
Heads of Administrative Units
Distinguished Academics and Administrators
My Lords Spiritual and Temporal
Igwes, Chiefs and Elders
Gentlemen of the Press
Lions and Lionesses
Ladies and Gentlemen

My Academic Career

I had a peculiar case. I started my primary school three years later than most of my age mates because I had to look after my junior ones and carry out other household chores. The two sisters I have were much junior to me and my senior brother was in school then. However, when I started primary one in 1965 (except for the civil war 1967-1970) and NYSC in 1982, I did not stop till I bagged my PhD in 1989.

During my primary school days, both my teachers and my mates liked me a lot. I was doing well too. I also helped my mates in virtually all subjects. In fact, there was a time I could pick a piece of chalk and teach them when our teacher was not present. This spirit was in me not necessarily to demonstrate superiority over my mates but due to the fact that most of them felt that they understood any topic (especially maths) better when I explained it than our teacher did. Some of my mates here now are Barr. T.O.C Attamah and Mr. Emma Attah. In the long run it was only TOC that got a distinction grade in the first school leaving certificate examination, all others at the top of the class got credit passes.

My secondary education was not very smooth. I did my class one at Adada Secondary School, Nkpologu. It was where I met Prof. Fab Onah, my bosom friend. It was football that first brought us together. I played well and he was the school goal keeper. Our house (St. Jude House) won the school cup that same year. It was Mr. C.C Ottih, a tutor from my village that helped me gain admission into the school after our names were published in the Renaissance news paper without school allocation. That year, I scored 36/36 in the year's entrance examination. We did class one for six months because that was the year the school calendar changed from January to December to January to September. At the end of my class one in September I could not go back to Adada because the business fortune of my uncle had a hitch as a result of the change from pounds to naira. I had to change to Community Secondary School Isi-Enu and finished in June 1977 in Division 1 distinction. It was then that I found out that I was actually posted to the School *abinisio*.

I gained admission to read soil science in September, 1977. My first choice course was Agricultural Economics but I learnt that the Department of Agricultural Economics refused to give admission to those awaiting WAEC results that year because of the much orchestrated "Expo 77". That happened against my score in the UNN entrance examination which was about the best in the Faculty. As was and still the case, the Department of Soil Science lacked candidates and I was offered provisional admission by the department. When I came in, I got the information about why I was not admitted to read agricultural economics and when there was advice for me to change course, I refused because I did not know why I was admitted to read soil science. I felt that it was

God that placed me to read soil science and to date, NO REGRETS.

My first degree career was smooth. I got the Federal Government merit award after my first year. My first year result was very interesting to me. After the examinations, I did promise God that if I was able to make a GPA of 3.0/4.0, I would make a first class. Surprising to me, I made 3.41/4. I then faced a challenge based on my promise to God. One of the most interesting results during that year was Bio 151 (12 Volts). More than one half failed, the other got C grade, and only 3 of us got BC in the Faculty of Agriculture. You know what a C or BC grade could do to one's GPA. In any case God granted me my prayers and I also responded to his **treatment** as I eventually bagged first class honours

My NYSC was hitch free. It was during the period that UNN advertised for the position of Graduate Assistants in various departments and I applied. My appointment as a graduate assistant was one of happenings in my life that convinced me that God exists and he loves me. The application was submitted when we were in the Camp and I informed the University about my new address when we were posted out. My invitation to attend the interview was sent to NYSC secretariat (my old address). It was when we went to receive our allowance and while waiting for a colleague that had a problem, that I went through a heap of letters at the NYSC secretariat and behold my letter of invitation for the interview was there. The interview was scheduled for the next day. I quickly went back to my station got my things ready got back to Sabon Gari, Kano and joined a night bus. Behold I was able to attend the interview and luckily I was successful.

We passed out on 06/07/83 at Kano and I found a night bus to assume duty as a Graduate Assistant on 07/07/83 in the Department because the letter of appointment read that the effective date of your appointment was the date you assumed duty. Apart from not taking any chance, I didn't want to waste a day. Prof W.O. Enwezor was the head of department then and he welcomed me allocating a laboratory on the ground floor of Cardoso building as my temporary office. Things were far better then for all categories of workers than now with regards to research opportunities, even though austerity measure effects had started creeping into the system. I quickly registered for my Master's programme and finished up in good time but Prof F. Ndili's policy cut up with many of us (here Professors Okorji , Ezekwe, Igbo, Oforma etc will never forget the storey). His policy was that unless one obtained one's PhD, dreaming about becoming a lecturer in UNN was a mirage. All graduate assistants had to form an association. Some left the University e.g. Professor Obioma of Education. Luckily, by 1987, we succeeded and we were all regularized and many got double or triple jumps. I jumped to lecturer II. Three years later, I was promoted to lecturer 1 and in 1993; I was promoted to a senior lecturer. In 1999, I was promoted full professor.

You can see that initially the greater part of my academic career was at UNN. The period was, however, traversed with many academic activities and training at IITA (Ibadan), ICTP (Trieste) and Dresden University, Germany.

Late Professor JSC Mbagwu was the first to present an inaugural lecture from my Department. The topic was *From Paradox to Reality; Unfolding the Discipline of Soil Physics in Soil Science*. It was the 32nd held in May, 2008 about sixteen years ago. In his preamble, he gave details on the roles of Soil Physics in soil management and conservation. He was a well known researcher and prolific publisher in that area. He also explained some of the problems Soil Science had, as a profession, and that of the low enrolment experienced by various departments of Soil Science in Nigerian universities. He also highlighted his major research findings.

I wish to observe Mr. Vice Chancellor that going through most of our previous inaugural lectures; it would appear that there is no standard format or pattern of presentation, allocation of to various aspects e.g. preamble/introductory notes/prologue/ introduction or the main body of the presentation. Well, when I discovered this, I was happy because that meant I would be at liberty with regards to what I would present. It is perhaps the reason why some earlier presenters have referred to inaugural lecture as an academic sermon. However, I would suggest some elements of consistent format since it is one of the most important publications the university can boast of. In my presentation, I have given a little chunk to preamble and what the soil is to humanity so that all of us will take something home. This is not to say that soil scientists and experts in agronomy here present will consider this lecture *a waste of their time*. I have the impression that in a lecture like this, all participants must have something to say about the lecture at the end of it. At this point I beg to proceed to the lecture.

EMMERGENCE OF DEPARTMENT OF SOIL SCIENCE AT UNN

In this university soil science was part of Plant/ Soil Science degree programme from 1960 to the end of 1972/73 academic session. In 1974 the University split this programme into B. Sc (Soil Science) and B. Sc (Crop Science) programmes as full-fledged departments. In 1978 a joint B. Agric programme for undergraduates in the departments of Animal Science, Agricultural Economies, Agricultural Extension; Crop Science and Soil Science was introduced but students specialize in each programme in the fifth year. Soil science students obtain B. Agric (Soil Science) degree.

According to our fore bearers (some of whom are here today), the **Philosophy** of the programme rests on providing broad theoretical and practical training in the basic agricultural sciences for the first three years and a full year's practical training in approved farms and other agro-based establishments during the fourth year. In the final year soil science students would receive intensive training in the areas of soil survey, genesis, classification, land evaluation and management; soil physics and hydrology including irrigation and drainage practices; soil and water conservation, soil chemistry and fertility as well as soil biology and biochemistry. In addition, each student undertakes a research project on a specified agricultural problem under the supervision of a member of staff.

Thus, at the end of the programme, the B. Agric graduates in general would have acquired adequate knowledge and skill to effectively engage in production and research in every aspect of agriculture and related areas that would provide solutions to Nigeria's agricultural and rural development problems and improve agricultural productivity in general and also general land management for environmental sustainability and quality control. Again skills acquired would enable B. Agric graduates establish and manage their own farms profitably; or become gainfully employed in private and public sectors.

This brief history is for you to know in the course of my presentation whether I attempted to pass through the Faculty and the Department and whether both passed through me also.

I must hint this august audience that following the directive from Soil Science Society of Nigeria, all the documents concerning the change of the name to **Department of Soil Science and Land Management** are now awaiting the approval by the senate of UNN. This is to conform to the current names in other universities in the country and facilitate the registration

of soil science as a profession. The department has been working on the document since 2012. This will enable the general public know more about what soil studies embrace.

LAND AND SOIL

As I eventually specialized in soil science and the topic relates more to soil I will not go into general agriculture but my research in specific areas will highlight it in this presentation. So basically I want to start by distinguishing between land and soil.

The concept of land has been defined as the area of the earth's surface the characteristics of which embrace all reasonably stable, or predictable cyclic attributes of the atmosphere vertically above and below this area including those of the atmosphere, the soil and underlying geology, the hydrology, the plant and animal populations, and the results of past and present human activity, to the extent that these attributes exert a significant influence on the present and future uses of the land by man (FAO, 1976).This definition simply says that a piece of land has its perimeter as the only definitive boundary. This is because vertically above and below its surface you cannot encroach from another piece of land. You cannot take anything within it including firewood, grasses, rain water, underground water, minerals etc without the owner's permission.

Land has also been referred to as the totality of fundamentals to our existence (Akamigbo, 1999). In Nigeria, just like in all nations, land is used for various purposes. However, land use types differ from one location to another depending on the immediate needs of the government, community or individual concerned. According to (FDALR, 1996), in Nigeria, land is used for agriculture, urban development, industrial and commercial purposes in that order of decreasing importance.

Table 1: Land mass distribution by use types in Nigeria

Total area	923,768 sq km			
Land surface (sq km)	Water surface (sq km)	Arable/land (%)	Permanent crop/land (%)	Others/land (%)
910,768	13,000 sq km	31.29	2.96	65.75
		42 under cultivation		

(Sources: Metz, 1991; Asadu et al. 2004)

The 1990, estimates in table 1 indicate that 82 million hectares out of Nigeria's total land area of about 91 million hectares were arable. However, only about 34 million hectares (or 42 percent of the cultivable area) were being cultivated at the time. Much of this land was farmed under bush fallow, a technique whereby an area much larger than that under cultivation is left idle for varying periods to allow natural regeneration of soil fertility. Another 18 million hectares were classified as permanent pasture, but much of this land had the potential to support crops. About 20 million hectares were covered by forests and woodlands. A large proportion of this land also has agricultural potentials. The country's remaining 19 million hectares were covered by buildings or roads, or were considered wasteland.

Soils are dynamic natural bodies comprising the uppermost layer of the earth, exhibiting distinct organization of their mineral and organic components; including water and air, which formed in response to atmospheric and biospheric forces acting on various parent materials under diverse geomorphic conditions over a period of time (Yaalon, and Arnold, 2000). The most popular definition of soil is often associated with its role in agriculture. Simply put, it is that natural part of the earth’s surface that supports agriculture, be it crop or animal production. Unlike land, soil is three dimensional, having its lateral boundaries as another soil types or “not-soils”, upper boundary as the atmosphere and lower boundary as undisintegrated rock or water. With all its biological content and its roles, soil is alive and it is life. Soil is part of the natural environment (land), which sustains agriculture and food production. It is the interface between earth, air and water and hosts most of the biosphere, and

a. provides ecosystem services critical for life:
b. acts as a water filter and a growing medium;
c. provides habitat for billions of organisms, contributing to biodiversity; and
d. supplies most of the antibiotics used to fight diseases.

Humans use soil as a holding facility for solid waste, filter for wastewater, and foundation for our cities and towns.Allton (2013) indicated that “Soil is fundamental to our life on Earth and yet we don’t really consider it either in educational or political arenas. Why is soil not protected in the same way as air and water? And how can we improve the awareness of this precious resource? Towers (2013), Chair of the British Society of Soil Science

Education Committee said: "Soil scientists have tried for many years to convince society at large, including our politicians, that soil is one of our vital national resources" during a conference oninitiatives from around the world meant to help raise awareness on soils using novel and imaginative techniques.

The Soil Science Society of Nigerian in all its annual conferences had always reflected in its communiqués since its formation over 38 years the importance of soil resources in the development of any nation but all these had been falling on the deaf eyes of our politicians and governments.Our soils have been very patient with us!

USE AND MISUSE OF THE TERM "SOIL"

In Igbo Culture *soil* and *land* are often used interchangeably.

Examples:

i. We are often warned by our elders that if a person tells a lie or commits any crime, the land will catch (deal with) the person. Here land or soil is regarded as a powerful spirit or god that does not tolerate lies and deceits.

ii. One who cultivates the soil (land) stands to enjoy the fruit of his labour (*Eka ajaja na ebute onu manumanu*).

iii. There are lands designated in many villages as holy land (*Ana d'nso*) especially around shrines and nobody dares defecate on the land (soil).

iv. There are many Igbo names reflecting the importance of land including mine: (Al ja (Anija = Ani-Jr) because it was taken after my uncle's name who is also my guardian i.e. Al kan (Ani-Snr); Aniagbaoso (land Is immovable/fixed), Anibueze (land is king); Anikwe (if land agrees because land determines a lot world- wide); Aniako (land cannot varnish) etc

Some negative uses

i. Ife dalu n'ala e telugo aja (Anything that has fallen on the ground has been contaminated or has contracted dirt).

There is a saying that why most people threat soil with neglect is that they often regard soil as “dirt”. Allton (2013) during an international conference by EU and FAO was furious about how we treat soils and said with regrets that “The trouble with Soils is that we all just treat them like dirt”.

Allton clearly stated further that “Soil is fundamental to our life on Earth and yet we don’t really consider it either in educational or political arenas

ii. Soil and Soiling: Soiling one’s hand, name, or image is a common expression. This expression is one of the most negative uses of the term “soil”. Soil is so used just because many of us think that contacting the soil pollutes. But the soil is a purifier. Think of what the world would have been since creation (Adam’s age) if all the dead people had not been converted to soil organic matter by soil microbes and subsequently to mineral elements by mineralization. What is the origin of the common statement that “you need only six feet when you die” in cultures that bury their dead bodies in the soil?

Our forefathers were great soil scientists. They knew that if a dead body was buried below six feet (1.8 m), it would take donkey years for the body to revert to soil. This is simply because this depth is about the limit for active microbial activities responsible for converting such bodies to soil materials in a normal soil. In fact, soil scientists limit most of their studies to 1.8 m depth except in few cases where details of the origin of the soil are required. This means that some of us who dig graves beyond six feet and use concrete materials, marbles and plastics are creating more jobs for microbes because they are not biodegradable. Therefore, they are denying future generation access to such land. Our forefathers did not do that, they only planted a simple shrub to mark the grave and in less than five years the grave was under a crop.

Where they had grave yards, it took a little longer before another body was buried there. The Muslims adhere strictly to this, thereby making soil more or less a renewable/ reusable natural resource.

THE SOILS WE KNOW

I want to start my main presentation from the known soils to the unknown soil. This will involve how soils are formed, factors and processes that lead to soil formation. What are soil characteristics and how relevant are they in understanding and classifying soils? Some research works in relevant areas will be used to illustrate my own contributions.

How Soils We Know Are Formed

Soil is formed by natural processes which act on factors of soil formation viz: parent material, climate, living organisms, topography over time. African surfaces are among the oldest in the world; thus, the relationships between the soils and these five soil forming factors are much more complex because the land surface has undergone a series of vegetative and climatic shifts (Foth and Schafer, 1980). Generally, soil is part of the land and land degradation very often includes soil degradation.

Any soil is formed by the interaction of factors and processes of soil formation. Soil is a mass of materials formed and influenced by some known factors or factors that can be predicted from its characteristics. The soil exhibits the signatures of the factors and certain processes which combined to produce that specific characteristic. Soil is also considered to be a synthograph; a graph recording any thing that happens to it. Ability to read this graph and interpret it is a prerequisite for understanding soil characteristics and the use the soil can be put. The known factors whose signatures are usually manifested are five and they are parent material, organisms (plants and animals), climate, age of the land and topography. Soils are products of the combined activity and reciprocal influence of these factors. Jenny presented the factors of soil formation using a hypothesis that drew together many of the current ideas on soil formation, the inspiration for which was owned much to the earlier studies by Dokuchaev of Russian in 1883. The hypothesis was that soil is formed as a result of the interaction of many factors, the most important of which are represented in the well known state factor equation as follows (Asadu et al 2012):

s = f (pm, c, o, a, r, ……..)

Where s = soil or soil property
f = function
pm = parent material
c = climate
o = organism (biosphere)
a = age (time factor)
r = relief (topography)

The dots represent some intrinsic factors that might have minor contributions or influence on the soil such as mineral accession from the atmosphere, or fire. Jenny later redefined the soil forming factors as 'state' variables and included ecosystem properties, vegetation and animal properties, as well as soil properties. In order to understand the effect of one factor on a particular soil property s, only one of the control variable (e.g. climate) varies, the others being constant or nearly so. In this case the equation is referred to as a climofuntion because climate is the controlling variable. This can be represented as

$$\mathbf{S= f\ (\underline{c},\ {\scriptstyle pm,\ r,\ o,\ t...})}$$

and the range of soils formed is called a climosequence. Similarly, if the controlling variable is relief or topography then a series of soils formed is called a *toposequences; Biosequences* for organism as controlling variable; *lithosequences* for parent material as the controlling variable and *chronosequences* for time or age as the controlling variable.

Parent material and relief define the initial state of soil development, climate and organisms determine the rate at which

chemical and biological reactions occur in the soil (the pedogenic processes), and time measures the extent to which a reaction would have proceeded. The characteristics of the soil body are also influenced by the processes that led to its formation.
The factors of soil formation may be grouped into active and passive ones (Asadu et al 2012).

Passive factors

The passive soil forming factors represent the constituent which serve as the source of the mass (mineral matter) and some environmental conditions which affect it. The passive factors include parent material, topography and time i.e. age of the land.

Parent Material

The parent material is classified as a passive factor of soil formation essentially because on a continental or world basis different climatic and biological conditions tend to make different soils from the same parent material, while similar soils may form from different rock materials when climatic and biological factors are similar. The effects of parent materials on soil properties are best studied on immature or young soils (Entisols/Inceptitisols) or where slope factor is important i.e. erosion is rapid.
Parent material is defined as an unconsolidated material found in place where pedogenesis has not set in. They are made up of the products of breakdown of different rock materials – igneous, metamorphic or sedimentary. It is related to the c – horizon in soil profiles. It is the initial material from which the soil is formed e.g. newly weathered rock materials or emerged beach sand or river sand, sand dune or earth materials recently deposited by water, ice or other earth movement.

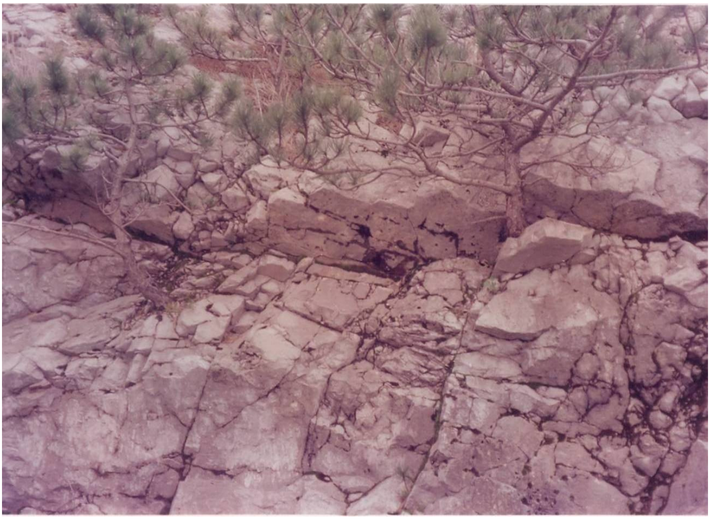


Plate 1: Effects of plant roots on physical rock weathering to form parent material

The parent material may be formed *in situ* (plate 1). In this situation it is even performing the function of a soil by supplying the growing plant nutrients and support. *A* parent material may also be a *transported* material for example beach sand or lacustrine (lake) or marine deposits.

Parent materials affect different soil properties like texture, reaction, cation exchange capacity. Soils formed from coarse grained parent materials like quartz give rise to sandy textures while fine grained parent materials like limestone residuum result to fine (clayed) textures. Again basic igneous rock materials weather into parent materials which form soils that are high in exchangeable cations and are basic in reaction as opposed to acidic rocks e.g. granite that give rise to acidic soils. The parent material provides the soil mineral matter which constitutes almost 45% of the soil body by volume and a lot more by weight. *Lithosequence* is described as a set of soil with differences due solely to the differences in parent material.

Topography/Relief
Slope angle and length determine the degree of influence of topography. Other factors of topography of equal importance are site, location along slope, altitude and aspect. Slope affects the depth of A-horizon because it determines the rate of erosion of the topsoil.
Slope position refers to what part of the slope as shown in fig. 1. This affects leaching processes.

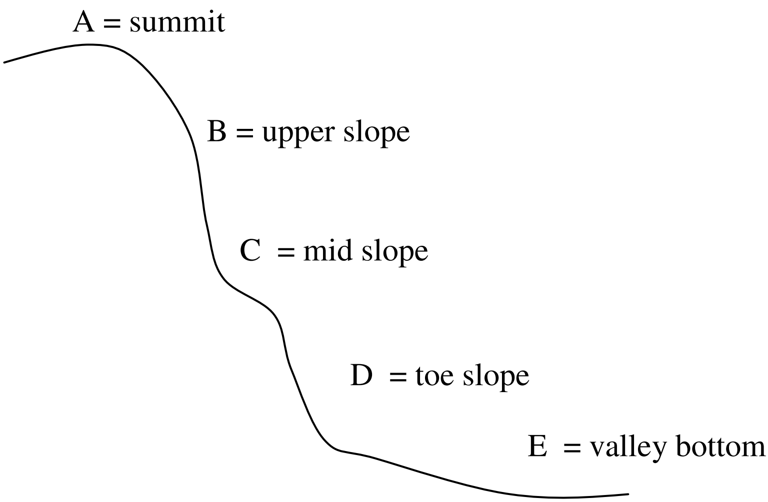


Fig. 1. Schematic diagram showing different parts of slope

The upper slopes are often better drained and are reddish in colour as opposed to yellow or brown colours resulting from poor drainage at the lower/toe slope. *Some selected primary topographic attributes important in table 2.*

Table 2: Selected primary topographic attributes important in pedology.

Topographic attribute	Definition	Hydrologic significance
altitude	elevation	climate, vegetation type, potential energy
slope	gradient	overland and subsurface flow, velocity and runoff rate
aspect	slope azimuth	solar radiation
catchment area	area draining to catchment outlet	runoff volume
specific catchment area	upslope area per unit width of contour	runoff volume
flow path length	maximum distance of water flow to a point in the catchment	erosion rates, sediment yield
profile curvature	describes the shape of a slope in a downward direction and indicates the rate of change in gradient	water flow, flow velocity, sediment transport processes (erosion, deposition)
plan curvature	describes the shape of the slope in a direction perpendicular to the slope and indicates the rate of change in gradient	converging/diverging flow, soil water content

Source: Asadu et al 21012

Time (Age)

This is another passive factor of soil formation and is the duration of the pedogenic processes from the time of the inception of the parent material to the time the mature soil is formed. This varies according to the intensity of other soil forming factors. The former are the agents that supply the energy that act upon the passive factors which in turn supply the reagents or materials for the processes of soil formation. The active factors are made up of the elements of biosphere, atmosphere and hydrosphere.

Active Factors

1. and rain.

Climate

The major climatic elements involved in soil formation are precipitation (moisture) and temperature. Climate may be micro-climate (local climate covering few m^2), meso-climate (covering some km^2) or macro- climate (global or regional)

Effects of precipitation

The balance between the amount of precipitation (water, snow, sleet) and evepotranspiration (evaporation and transpiration totals) affects the amount of moisture available for physical and chemical weathering of rocks. Without moisture, several chemical weathering processes such solution or hydrolysis, hydration and carbonation would not take place. Precipitation is also important in soil erosion, leaching and vegetation establishment and growth. Thus, climate as an active soil forming factor controls the contributions of many other factors.

Effects of temperature

Solar radiation is the main source of heat energy on earth's surface. Temperature measures heat energy and is influence by such additional factors as latitude and altitude, and the extent of absorption and reflection of solar radiation by the atmosphere, soil and water surfaces. Both the direct radiation and diffuse radiation increase with elevation, change with season, and is influenced by cloud cover or other atmospheric constituents including air pollutants.

Temperature affects the rate of mineral weathering and synthesis, and the biological processes of growth and decomposition. Weathering is intensified by high temperatures; hence weathering is stronger in the tropics than in humid regions. Temperature also influences the degree of thawing and freezing (physical weathering) in cold regions. Biological processes are intensified by rising temperatures. Reaction rates are roughly doubled for each 10°C rise in temperature, although enzyme-catalyzed reactions are sensitive to high temperatures and usually attain a maximum between 30 and 35 °C.

The zonal concept of soils associated with the Russian classification was based on climatic effects on soils. The climatic zones were associated with broad belts of similar soils in Russia with the following definitions.

Zonal soils are those in which the climatic factor, acting on the soil for a sufficient length of time, is so strong as to override the influence of any other factor.

Intrazonal soils are those in which some local anomaly of relief, parent material or vegetation is sufficiently strong to modify the influence of the regional climate.

Azonal or immature soils have poorly differentiated profiles, either because of their youth or because some factor of the parent material or environment has arrested their development. It should be noted that concept of soil zonality is not very helpful when applied to soils of the subtropics and tropics because of old land surfaces and many cycles of erosion and deposition associated with climatic change.

Organism or Biosphere

Biosphere as a factor of soil formation includes both fauna and flora.There are interrelationships between organisms and climate. For instance, vegetation is dependent on climate and also soil type. This interrelationship makes it difficult to isolate the effects of organisms. Man through his activities also influences soil formation both positively and negative as illustrated below. His activities may influence the soil directly or through the other factors of soil formation.When he adds mineral fertilizers, accumulates shells and bones or removes excess amount of salt from the soil, there is a positive effect on the soil properties and use. On the other hand if he mines the soil by removing through harvest more plant and animal nutrients than are replaced or adds materials in amounts toxic to plants or animals he diminishes the value of the soil. The impact of man can also be through his agricultural practices including the cutting down of the natural vegetation, urban and industrial development. The use of heavy machinery compacts soils and decreases the rate of water infiltration into the soil, thereby increasing surface runoff and erosion. The general impacts on specific factors are summarized below.

Impact on topography

Man can positively influence the effect of topography on soil by checking erosion through surface roughening, land forming, improved drainage, bunding and terracing. On the other hand, through mining of earth materials and minerals, and excavation raising of land levels, man causes accelerated erosion which is a negative contribution to soil formation

Impact on climate

The soil climate can be changed by man's activities and the change may be beneficial for example by adding irrigation water and rain making to improve soil water, warming and cooling of soil by surface mulching, diverting or breaking wind to prevent wind radiation, draining excess water, change of soil colour can affect absorption of solar radiation and soil temperature. Subjecting soil to excessive insolation, to extended first action to exposure to winds to compaction. Man can also create smog through burning and stirring of dust

Impact on other organisms

Introduction and control of populations of plant and animal that are beneficial e.g. legumes and mycchoriza, addition of organic matter including excreta, removal of pathogens will impact positively on the soils. On the other hand through burning, over use of chemicals including radioactive ones, overgrazing, excessive cultivation can impact negatively on the soil.

The soil properties mostly affected by plant include

- (a) Organic carbon profiles
- (b) Nitrogen profiles
- (c) Soil pH may also be influenced by nature of plant residue
- (d) Bulk density is also affected

Among the most important other visible animals that affect soil profile development are very small insects such as springtails, mites, and celaphids that are abundant in the raw humus of the podsol soils; ants and termites very active in many soils of the world; many small crustaceans, such as wood lice or millipedes and centipede.

The functions of two important organisms in our environment include:

Earthworms

- (a) Convert raw vegetable matter to humus.
- (b) Mixing the humus with mineral portion of the soil
- (c) Formation of earthworm exists giving the soil characteristics granular or crumb structure
- (d) Carry organic matter to the subsoil as they burrow.
- (e) Loosen soils through their burrowing activities enhanced percolation and aeration
- (f) Heaping of leaves/petioles to form earthworm midens.

Ants

2. Contribute to the organic matter of soils as they cut leaves and plants to keep them where fungi grow and the faeces for organic matter.
3. They tunnel and move materials from one horizon to another and aerate increase percolation of water.
4. Build anthills or mounds from excavated materials.
5. They clear vegetation thereby exposing the soil surface to erosive agents such as wind

PROCESSES OF SOIL FORMATION

There are two overlapping processes that responsible for producing any soil viz: accumulation of parent material and the differentiation of horizons in the profile. The dominant soil formations processes are determined by regional climate interacting with vegetation and other factors of soil formation. The results of these interactions are different soils in different regions.

Soil Genesis

Soil genesis or soil formation consists of two overlapping steps namely: the accumulation of parent material and the differentiation of horizons in the profile. Essentially, processes of soil formation act both singly and collectively to modify the saprolite, that is, the inorganic (dead) rock debris, to produce the living soil. The first step is the accumulation of solid and colloidal material essentially rock materials. The second involves the differentiation of horizons by addition, removal, and transfer of materials and energizing solutions.

The under- listed are specific processes which add to the formation of some fundamental horizons.

1. Formation of A_0 (humus) layer
   Litter accumulation and decay
   Specific processes – Humus formation, peat formation, vegetation growth. This involves such physical processes as infiltration through mechanical translocation and chemical processes of solution,

precipitation and hydration as well as biological reactions involving humification and mineralization.

2. Eluviation – formation of A horizon.

   This involves leaching of bases, podzolization, lateritization, humus formation. The physical features include texture and structure formation but chemical reactions that may occur include oxidation, reduction, carbonation, silication, desilication, sorption, iron exchange as well as such biological reactions as Ammonification, nitrification, and denitrification nitrogen fixation.

3. Illuviation – formation of the B-horizon

   Accumulation of lime, clay, iron and aluminum.

4. Differentiation in the mass of the various horizons

The Processes

1. Humification – This is the process of decomposition of organic matter and the synthesis of new organic complexes. The materials usually humified include dead leaves, twigs, branches, tree trunks, herbaceous vegetation, and remnants of animal life. The usual residual product of humification is humus. The rate of accumulation of organic residues, the reactions that take place in the A0 layer, and the general characteristics of this layer vary with the climate. In the humid tropics and subtropics, conditions are ideal for microbial activities and the consequent breakdown of the natural organic matter and the synthesis of humus complexes. We have in these regions a rapid "burning up" of organic matter. This is not the case in the temperate region where organic residue accumulates because of the unfavourable decomposition factors of low temperature and low microbial activities.
2. Mineralization – This involves the decomposition of organic matter to its fundamental composition, i.e. to CO_2, and other gases, water and minerals. This process

proceeds simultaneously with humification in the A0 layer and at any point in the profile where organic matter appears. Whereas humification increases the organic acids and acidoid content of the humus complex, mineralization tends to decrease these acids and to increase the basoid content.

Other biological process: The other processes – ammonification, nitrification, denitrification etc are all connected with the process of nitrogen fixation and nitrogen cycling in the biosphere.

Physical and Chemical Reaction

Leaching: This is about the most important process involved in horizon differentiation. It operates to some extent in all soils and is fundamental to all the more complex soil forming processes such as laterization, podzolization, and calcification. Simply put, leaching is the removal in solution of constituents from the soils. The process of leaching is most prevalent in wet regions and the most affected salts are those of most readily soluble minerals. Clay is also translocated during leaching. Leaching has both advantages (like in leaching out of some sodium salts that have deleterious effects) and disadvantages especially when it becomes excessive because most nutrients needed by plants are lost to the ground water.

Eluviation/illuviation: The two words are analogous to the words emigration and immigration. Eluviations is the movement of material out of a portion of the soil profile as in an albic horizon, while illuviation is the movement of material into a portion of soil profile as in an argillic or spodic horizon. Essentially the process as involve the movement of material, usually clay, organic material or Fe and Al hydroxides in suspension from one part of a soil horizon (usually an upper E horizon) within a given soil profile.

Two aspects of eluviation are mobilization and translocation, while illuviation also involves translocation process and their interruption by immobilization of the moving materials. The

process is impeded in an environment where Al^{3+} and Ca^{2+} saturate the soil, as they cause flocculation. Under the tropics, eluviations-illuviation process are enhanced in moderately acid environments dominated by the cations K^+, H^+ and Na^+. the process requires a network of pores and fissures so that the materials can move in suspension, thus implying that wetting and drying cycles must exist within environment of the process; the pores remaining open during the dry cycle and the dry cycles and particles in suspension moving down the pores during the wet cycle. Eluviations-Illuviation process when it involves clay often lead to the development of argillic (Bt) horizons and the processes are variously called Lessivation, Deargillation-Argillation or Argeluviation-Argilluviation processes.
These processes are related to leaching as they involve the movement of soil materials, in solution or in suspension, from one place to another within the soil. However, leaching may lead to total loss of materials from the soil body while eluviation/illuviation only refers to translocation of materials within the soil. The direction of movement of soil water determines the direction of eluviation. Hence, eluviations may be vertical (upward or downward) or lateral material moved are often but not always in colloidal nature.
Furthermore, illuviation refers to the deposition of the removed (eluvial) materials. The processes lead to the formation of eluvial (usually A) horizon and illuvial (usually B) horizon especially in regions where precipitation is in excess of evepotranspiration The reverse is the case in dry areas where evapotranspiration exceeds precipitation. This often leads to calcification just like leaching leads to podzolization.

In summary, after the weathering of bedrock and debris accumulation to produce the parent material or the saprolite, gradual accumulation of organic matter at the soil surface results in the development of an A horizon, due to processes such as decomposition and mineralization. After an A horizon is formed, then a B Horizon is slowly developed. Leaching especially in the humid environment, from the upper part of the soil profile (e.g. clays, organic material or Fe and Al hydroxides) gives rise to the formation of an eluvial horizon (E horizon). These materials accumulate in a horizon below the E, to form illuvial horizon, the textural Bt horizon often referred to as a horizon of accumulation. Eluviation/illuviation process as involving clay, often lead to the development of argillic (Bt) horizons and the processes are variously called lessivation, Deargillation-Argillation or Argeluviation-Argiluviation process. This is illustrated in figures 2 and 3

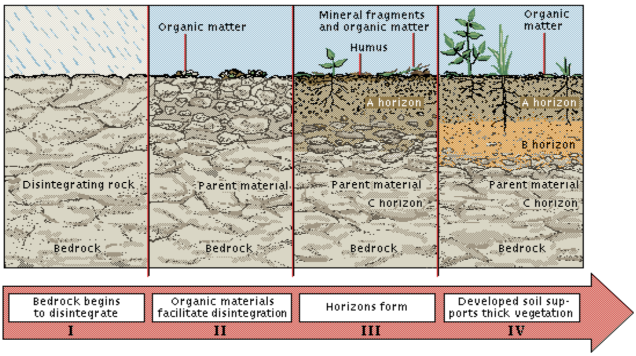


Fig. 2: Stages in soil development A and B horizons
(Source: Asadu et al 2012)

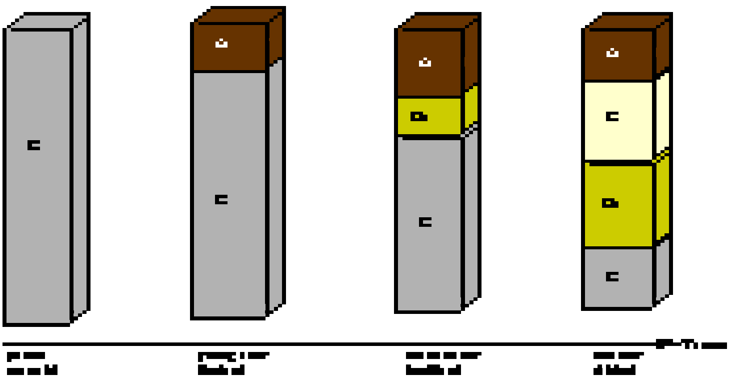


Fig.3: Stages in soil development A, E and Bt horizons

Other more Complex Processes

Most of the processes of soil formation do not operate in isolation but the prominence of each process depends on the climatic environment. These other processes are just amalgams of already discussed processes. The most important processes include; podzolization, laterization, calcification, salinization, gleization, and solodization distinguished mainly on the climatic basis.

Laterization/Lateritization/Ferrallization

This is the process that leads to the formation of laterites and lateritic soils often variously called latosols, oxisols and ferruginuous tropical soils. These processes prevalent in warm to hot humid regions especially in the areas classified by Koppen as having A climates namely the equatorial (Af) climate, the tropical (Aw) climate and the monsoon (Am) climate. Topography is also an important factor in relation to groundwater situation as well as depth of effective soil. Laterization takes various stages and is usually under heavy rainfall conditions and where organic decay and mineralization of leaf fall leads to the formation of organic acids. Because of the released bases from chemical weathering the environment is mildly acidic to mildly alkaline (pH 5 - 8) soil solution.

This condition favours desilication in preference to Fe and Al. It may also involve the alteration of high silicate clays e.g. montmorillonite group to low-silicate clays e.g. kaolinite. Depending on the groundwater condition laterizaiton may lead to stratified or unstratified profiles. (Table 3).

Podzolization

This leads to the formation of podzols and podzolic soils usually in cool humid regions (Koppen’s C and D climate). Podzolization is derived from the Russian term podzol which means ‘ash underneath’ and like laterization the basic operating process is leaching of bases and colloids but here it is more intensive (Table 3) with soil pH values ranging from 3-4.

The process involves removal of soluble bases as well as Al and Fe but Si remains in place unlike in laterization. This makes the A2 horizon somewhat lighter in colour. Inorganic clays tend to be peptized and susceptible to dispersion and downward movement. Illuvial B forms where sesquioxides, clays, bases and humus are deposited. Podzols are more commonly found under coniferous forests while podzolic soils may be found under a wide range of vegetation and climates.

Calcification

This is prevalent in low-rainfall areas especially the continental interiors of the temperate grassland. It results to the formation of calcic horizon in B or C horizon and a mollic epipedon well saturated with Ca and the soils are called mollisols or chernozem. Here evepotranspiration exceeds precipitation and leaching of bases does not occur but because of high evaporation, there is concentration of salts and subsequent precipitation of Ca and Mg bicarbonates and this may lead to crust formation or formation of indurated zone called calcrete or caliche. Calcification is the prevailing process in prairie grasslands.

De-calcifications, on the other hand, are reactions that remove $CaCO_3$ from one or more soil horizons. Under less arid conditions, more mobile soluble constituents (K^+, Na^+) move down the profile rather than to the surface. On the other hand, the less soluble Ca^{2+} compounds are mobilized but reprecipitate lower in the soil possibly as Bk or Ck horizon. Because of the strong biological activity in these soils, considerable CO_2 is liberated by respiration. This enables $CaCO_3$ to be converted into the soluble bicarbonate which can move down through the profile in decalcification process (table 3).

Salinization

This results from increasing dryness and involves the accumulation of sodium salts to form saline soils e.g. solonchaks. De-salinization is the removal of soluble salts from salic soil horizons.

Gleization: This is an important process of soil formation under impeded drainage leading to the formation of hydro-morphic soils. This can occur due to topographic effect, swampy low-relief area, valley bottoms etc or to geological influence e.g. poorly drained, clayey soils. Mottling is a characteristic of the soil where there is periodic drying. Glyeying may be due to surface-water or underground water. Where there is complete saturation without occasional drying the soil colour is grey or grayish white but rust-coloured ferric oxide gives the mottle colour in the soils that are occasionally dry. Peat is formed in areas of extreme poor soil drainage. The peat formed may be acid or neutral to mildly alkaline depending on amount of leaching taking place and this leads to either acid moor peat or basic fen peats.

Table 3: Schematic representation of the processes of formation of three major soils in three different regions of the world

Laterization	Podzolization	Calcification
Heavy Rainfall ↓	Rain water ↓	Rain water ↓
Production of Organic acids, H+	Production of Organic acids, colloidal org. matter	Production of Organic acids, H+
Breakdown of clay minerals, accumulation of Fe, Al	Leaching and breakdown of clay minerals	Very slight Leaching, accumulation of organic matter
Losses of Si ↓	Losses of colloidal organic matter. Fe, Al, Si, Ca, Mg, Na, K. ↓	Slight gain in exch. Ca, Mg, Na ↕
Some formation of kaolinite	Accumulation of colloidal organic matter. Fe, Al,	
Losses of Si, exch. Ca, Mg , Na, K ↓	serious Losses of exch. Ca, Mg, Na, K. ↓	Virtually no loss to Drainage waters
Dranaige waters	Dranaige waters	

Source: Modified from Asadu et al. 2012.

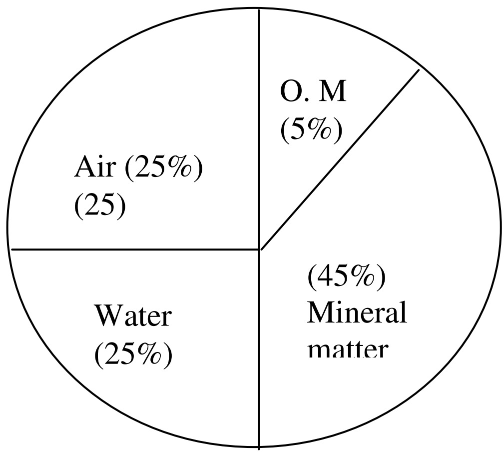
Soil Morphology

The soil profile

A vertical cut through any soil shows some characteristic layers. The degree of development of these layers better knows as soil horizons may differ from one soil to another depending on the age of the soil and other factors of soil formation. This vertical section of the soil from the layer to the parent material or the C horizon is designated the soil profile.

Soil Horizon

The different horizontal layers of the soils seen in a vertical section of the soil and usually developed in the course of soil formation is referred to as the soil horizon. The number of horizons a soil has depends on the age of soil. A fully developed soil would have three major horizons namely A, B and C seated on the parent rock R, sometimes there is an organic litter horizon designated O on top of A-horizon. By volume in an ideal situation, the constituents of the soil is made of 45% mineral matter, 5% organic matter, 25% soil air, and 25% soil water (fig. 3). I must point out that this ideal situation is hardly met in any soil. In ideal condition the volume composition is as shown below.



Fig, 3: Schematic representation of constituents of the soil

The Mineral Matter
This is made up of the particle fragments from the decomposition of the rock from which the soil was formed as well as the resulting minerals. The soil particles often designated as the fine-earth include sand, silt and clay. These particles determine what is called the soil texture. Soil texture reflects the relative proportions of these particles in a particular soil.

Usually the texture of a soil is determined by particle size analysis in the laboratory or estimated by feel with an experienced hand. The percentages of the fractions obtained are used to obtain the textural class name from a textural triangle (fig. 4).

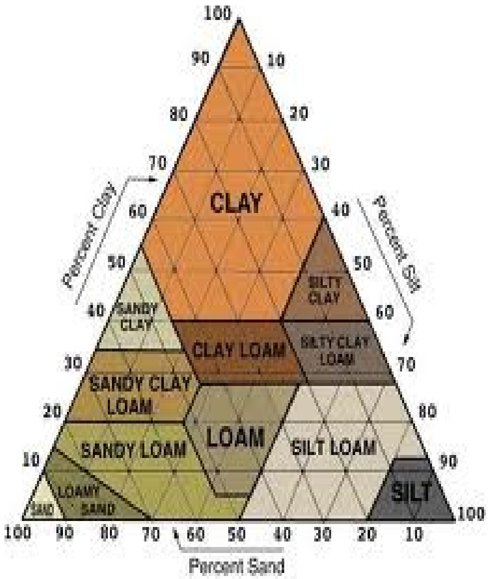


Fig. 4: The textural triangle

There are 12 possible textural names obtainable from the textural triangle into which any soil can fall. These include sand, loamy sand, sandy loam, sandy clay loam, sandy clay, loam, silt loam clay loam, silty clay loam, silty clay, silt and clay. The grading of the particles is based on their respective diameters and the internationally accepted ranges in equivalent diameters for each are:

Sand fraction: 2.0 – 0.02mm, Silt fraction: 0.02 – 0.002mm, Clay fraction: < 0.002mm

In some soils particle of sizes greater than 2.00mm in diameter may be found and they graded differently from gravel to stone. Thus when you come across gravelly or stony soils, they are scientific soil names with being qualified by the dominance of particles greater in size than sand particles.

Organic Matter

This includes all dead, freshly fallen, decomposed, or only partly decomposed plant and animal material in and on the soil. In a wider perspective it includes micro-and macro-organisms living in the soil. The composition of decomposed organic matter may include lignin, cellulose, proteins, fats and waxes, but lignin is the most resistant to decomposition. Humus, a dark, structureless, and gelatinous substance found in the soil is a product of the decomposition of organic matter. The chemical composition of humus is not well known. Humus plays a very important role in the adsorptive capacity of the soil.

The living organisms in the soil include micro-flora such as bacteria, actinomycetes, fungi, algae, and lichens; micro-fauna such as protozoa (e.g. amoebas, ants, termites, eelworms, earthworms, mollusks, and arthropods.

Soil Air

The soil air makes up the soil atmosphere from which the living part of the soil obtain their oxygen for their metabolism and other reaction like oxidation. Air is contained in macro-pores and often times the amount of air in the soil is determined by the water content. Hence its composition by volume is not constant but dependent on the rates of use of oxygen and CO_2 as well as that of replenishment from the external atmosphere. Below is an indication of the differences between soil air and atmosphere in percentage (Table 4).

Table 4: Composition of atmosphere

	CO_2	O_2	N_2
Soil air	2 – 20	15 – 20	0.02 – 0.4
Atmosphere	0.03	21	79

All the components of soil air are variable. Aeration i.e. the circulation of air in soil is affected by water content and soil structure. Waterlogged soils are poorly aerated; hence the prevalent reaction is reduction instead of oxidation. This sometimes gives rise to the formation of toxic substances injurious to plants and micro-organisms in the soil.

Soil Water

Water is found in the soil as a solution of dissolved salts or in suspension or in colloidal form depending on the type of substances present in the soil. Rain water is the main source of soil water and the amount of water entering the soil depends on the infiltration rate of the soil as well as permeability. These two processes are determined by soil texture, structure, initial moisture content and extent of vegetative cover.

There are three types of soil water namely;

1. Capillary water – which occupies the capillary or micro-pores.
2. Gravitational water – found in the macro-pores especially when the soil is saturated or immediately after rainfall. This is free-draining water.
3. Hygroscopic or adsorbed water on clay and organic matter particles. A soil is said to be at its field capacity when the macro-pores are drained off their water and micro-pores are filled with water.

Adsorbed water is held by electric charges on the clay and organic matter particles while capillary water is held by capillary attraction. When the amount of water in the soil becomes so small that the crop growing in the soil can no longer maintain the turgidity of their cells due to lack of water i.e. the plant wilts, the moisture content of the soil is termed the wilting coefficient and this point is defined as the wilting point. The amount of water when the plant becomes permanently wilted is called permanent wilting percentage. The hygroscopic coefficient refers to the water content when there is total lack of water in the micro-pores and the remaining water in the soil is only held by electric charges on the clay and organic matter surfaces. Water is lost from the soil by evepotranspiration and percolation.

Soil Classification

In order to have an organized system of soil knowledge, systematic soil classification became very crucial in soil studies; hence the existence of many systems; the most popular being the American Soil Taxonomy (USDA Soil Taxonomy).

Other different soil classification systems in the world such as USSR Soil Classification System, European Soil Classification system, French Soil Classification System, Canadian System of Soil Classification and American Soil Classification System (Soil Taxonomy). Among these, only the Soil Taxonomy is discussed briefly due to its fairly universality.

Definition Classification per se is the ordering or arrangement of objects in the mind and their distribution into comportments. Classification is necessary if we want to understand any heterogeneous group. The objectives of classification include:

i) Have an organized knowledge
ii) Bring out and understand relationship among individuals and classes of the population being classified
iii) Remember the properties of objects classified.
iv) Learn new relationships and principles of the population being classified
v) Establish groups or sub-divisions of classes of objects under study in a manner useful to practical purposes.

Taxonomic Terms used in Classification

1. Class: A group of individuals or units similar in selected properties and distinguished from all the other classes of the same population by differences in these properties.
2. Taxon: This is a class at any taxonomic level of generalization
3. Category: This is a series or an array of taxa produced by different criteria within the population at a given level of abstraction.

The various categories of three prominent soil classification systems are shown in table 5.

Table 5: The categories of three important classification systems

US Soil Taxonomy	Russian System	Canadian Systems
Order	Class	Order
Suborder	Subclass	Great group
Great group	Type	Sub-group
Sub-group	Subtype	Family
Family	Genera	Series
Series	Species variety	Types

The US Soil Taxonomy

This is an American system of soil classification and is based on measurable morphological properties. The system makes use of 'diagnostic' horizons i.e. those horizons with specific characteristics which are peculiar to certain soil forming processes.

The differentiating characteristics selected are properties of the soils themselves, including soil temperature and moisture; genesis is not employed except as a guide to relevance and weighting of soil properties. Definitions are precise and quantitative rather than comparative.

The names used are connotative as far as feasible and they are relatively short. A formative element from each of the higher categories is successively carried down including the family category such that with little experience, one can make several statements about soil properties simply from analyzing the name of the soil. Though the names may seem awkward and strange at first with a little study, and experience one can appreciate the advantages of this nomenclature.

Soil moisture content is one the major criteria used in soil taxonomy that needs to highlight. The term soil moisture refers to the presence or absence either of ground water or of water held at a tension of less than 1500 kPa in the soil or in a specific horizon at certain periods of the year. Water held at a tension of 1500 kPa or more is not available to keep most plants alive. In Table 6. The soil moisture classes as defined in Soil Taxonomy are listed..

Table 6: A classification of soil moisture regimes.

Soil moisture regime	**Characteristics**
Dry	Soil moisture content less than the amount retained at 15 atmospheres of tension (1500 kPa - permanent wilting point). 'In most years' - 6 out of 10 years
Xeric	Soils of temperate areas that experience moist winters and dry summers (i.e. Mediterranean climates)
Aridic/Torric	Soils are dry more than half the time (in arid climatic zone)
Perudic	In most years precipitation exceeds evepotranspiration every month of the year
Udic	In most years soils are not dry more than 90 consecutive days
Ustic	In most years soils are dry for 90 consecutive days and moist in some part for half the days the soil temperature is above 5°C (i.e., during potential growing season)
Aquic	Soils that are sufficiently saturated, reducing conditions occur. They usually have low chroma mottles or have gleyed subsoils

When soil moisture is high, as in wet or humid climates, there is a net downward movement of water in the soil for most of the year, which usually results in greater leaching of soluble materials, sometimes out of the soil entirely and the translocation of clay particles from upper to lower horizons. In arid climates there is net upward movement of water in the soil, due to high evapotranspiration rates, which results in upward movement of soluble materials (e.g. salts). These accumulated materials can become cemented (hard pans), which are impenetrable to roots and lower infiltration tremendously.

Soil temperature regimes (Table 7) are also important is Soil Taxonomy. If the name of a soil temperature regime has the prefix iso, the mean summer and mean winter soil temperatures for June, July, and August and for December, January, and February differ by less than 5^{o}C at a depth of 50 cm.

Table 7: Definitions and features of soil temperature regimes.

Temperature regime	**Mean annual temperature in root zone (^{o}C)**	**Characteristics and some locations**
Pergelic	< 0	Permafrost (i.e. the depth of freezing in winter exceed the depth of thawing in summer, as a consequence, a layer of permanently frozen soil of grounds develop) and ice edges common. Tundra of northern Alaska and Canada and high elevations of the Rocky Mountains.
Cryic	0 -8	Cool to cold soils of the Northern Great Plains of the U.S., forested regions of eastern Canada.
Frigid	< 8	A soil with a frigid regime is warmer in summer than a soil with cryic regime. The difference between mean summer and mean winter soil temperatures is more that 5^{o}C.
Mesic	8 – 15	Midwestern and Great Plains regions where corn and winter wheat are common crops.
Thermic	15 – 22	Coastal Plain of southeastern U.S. where temperatures are warm enough for cotton.
Hyperthermic	> 22	Citrus areas of Florida peninsula, southern California. Tropical climates and crops.

The differentiating criteria at the Category Level of Soil Taxonomy are presented below.

Category:	**Nature of differentiating Characteristic**
Order:	Soil forming processes as indicated by the presence or absence of major diagnostic horizons.
Suborder:	Genetic homogeneity, properties associated with wetness, soil moisture regimes, major parent material and vegetational effects as indicated by key properties e.g. organic fibre decomposition in Wistosols.
Great-group:	Similar kind, arrangement and degree of expression of horizons with emphasis on upper sequum, base status, soil temperature and moisture regime, presence or absence of diagnostic layer (plinthite, fragipan, duripan)
Sub-group:	Central concept for great group and properties indicating integradation to other Great-groups, Suborders and Orders and extragration to "not soil".
Family:	Broad soil textural classes averaged over control section or solum, mineralogical classes for dominant mineralogy in solumn, soil temperature classes at 50cm depth based on mean annual soil temperature.
Series:	Kind and arrangement of horizons, colour, texture, structure, consistence and reactions of horizons, Chemical and mineralogical properties of the horizons.
Variants:	Differences in properties important for land use, extent less than 800 ha.

Soil Taxonomy adopts some formative elements used to coin the soil names. Their definitions are presented in table 8.

Table 8: Summary of the formative elements of soil orders in American soil taxonomy

Soil Order	Formative element	Derivation	Mnemonicon
1. Vertisol	ert	L. Verto (turn)	Invert
2. Entisol	ent	Nosense,	Syll. Recent
3. Inceptisol	ept	L.inceptum (beginning)	Inception
4. Aridisol	id	L. aridus (dry)	Arid
5. Spodosol	od	Gr. Spodos (woodash)	Podzol
6. Andisol	and	-Andic prop	
7. Ultisol	ult	L.ultimus (last) (high fe+Al)	Ultimate
8. Mollisol	oll	L. Mollis (soft)	Mollify
9. Alfisol	alf	nonsense syllable	Pedalfer
10. Oxisol	ox	Fr. Oxide (oxide)	Oxide
11. Histosol	ist	Gr histo (Tissue)	Histology
12. Gelisols			Under ice

Simplified Keys to Soil Orders of Soil Taxonomy

These are simple definitions of the twelve orders of the USDA Soil Taxonomy. The are minimal descriptions that can enable have an idea of the characteristics of each soil order.

1. Histosols
   - No andic properties e.g. high Al in 60% of thickness
   - Thickness of organic + fragmental materials is 40cm or more but less than 50cm
   - Organic material saturated for at least 6 months or more per year - bulk density. moist of less than 0.1g cm-3
2. Spodosols
   - Spodic horizon in 50% of each pedon.
   - Ap horizon with 85% or more of spodic material. Spodic horizon is 10cm or more thick, coarse – loamy texture, a cryic (0^0 – 8^0C) or pergelic (0^0C) annual T^0.
3. Andisols
   - Andic soil properties in 60% more of the

		thickness – Al + Fe3 greater than 2%, bulk density of 0.9 g/cm or more.
4.	Oxisols	- Oxic horizon – (conc of sesquioxides) with 150m of mineral soil. - 40% or more clay (weight) in fine-earth fraction between mineral soil surface and a depth of 18cm.
5.	Vertisols	- Slickensides close enough to intersect or wedge-shaped aggregates which have their long axes tilted 10 to 60^0 from the horizontal. 30% or more clay in fine-earth fraction cracks that open and close periodically.
6.	Aridisols	- Aridic moisture regime, hard and massive epipedon, salic horizon.
7.	Ultisols	- Argillic or ka dic horizon – no fragipan. - 35% base saturation by sum of cations.
8.	Mollisols	- Mollic epipedon soft, high base saturated surface horizon. - base saturation 50% or more by NH4OAC in all horizons.
9.	Alfisols	- An argillic, a kandic or nitric horizon. - Fragipan with clay film 1 mm or more in some parts, base saturation 35%
10.	Inceptisol	- incipient horizon formation. - cambric horizon - Aquic conditions within 50 cm of mineral soil surface for sometimes in most years.
11.	Entisols	- Young soils with no horizon development.
12.	Gelisols	- Soil continuously under ice in the temperate region

THE SOIL UNITS OF FAO/UNESCO SOIL MAP OF THE WORLD

This represents an international effort made by FAO/UNESCO to harmonize the various systems of soil classification. The system tends to combine the terms used in other systems so that more world communities can comprehend the terms.

The effort was aimed at preparing a universal worldwide correlation of soil units, obtaining an inventory of the world soil resources through a set of soil maps with a common legend, and providing for ready transfer of land use and management knowledge. The nomenclature for chosen diagnostic horizons and for the classes themselves has been drawn in part from 'classic' soil names, stemming from the original Russian soil type terminology as well as some of the recently coined soil names used in Western Europe and Canada plus a few names developed especially for this purpose for e.g. Luvisols and Acrisols.

The FAO/UNESCO map Units are as follows:

1.	Fluvisols	-	Water deposited soils with little alteration
2.	Regosols	-	Thin soil over unconsolidated material
3.	Arenosols	-	Soils formed from sand
4.	Gleysols	-	Mottled or reduced horizons, due to witness.
5.	Rendzinas	-	Shallow soil over limestone.
6.	Rankers	-	Thin soil over silicious material
7.	Andosols	-	Volcanic ash with dark surfaces.
8.	Vertisols	-	Self-mulching, inverting Soils, rich in montmorillonite clays.
9.	Yermosols	-	Desert Soils.
10.	Xerosols	-	Dry soils of semi-arid regions
11.	Solonchaks	-	Soluble salt accumulation
12.	Podzoluvisols	-	Leached horizons tonguing into argillic-B-horizons
13.	Podzols	-	Light-coloured alluvial horizon and subsoil accumulation of iron aluminium and humus.
14.	Luvisols	-	Highly weathered soils with argillic horizons.

THE CONCEPT OF DEAD SOIL AND SOIL RESURRECTION

Dead Soil

From agricultural perspective, soil is a dynamic natural body on the surface of the earth in which plants grow and it is composed of minerals (trace elements such as boron, cobalt, copper, iron, manganese, sulfur, zinc and other nutrients such as nitrogen, phosphorus and potassium), organic material (that improves soil structure and soil moisture retention) and living forms (Are et al , 2010).

The concept of dead soil encapsulates the "balance-sheet" theory of plant nutrition, an axiom that in a normal environment the soil has capacity to support plant growth. Any soil lacking one of the 16 essential elements and other essential crop growth factors to the extent that it becomes unproductive can be regarded as "dead". Such soils usually lack balance of the appropriate combination of the 3 major soil components: physical, chemical and biological properties that support plant and animal growth.

HOW TO KILL THE SOIL

Soil nutrient depletion

Soil nutrient depletion occurs when such a nutrient is removed and not replaced, and the conditions which support soil fertility build up are not maintained owing to the combined effects of climate extremes (rainfall and temperatures) as well as socio-economic activities of man either directly or indirectly. This is one form of soil mining similar to milking a cow without feeding it. What do you expect? The cow will die!

Inappropriate land use practices

Inappropriate land use practices such as saline irrigated water application, over cultivation of land that leads to mineral and organic matter depletion (nutrient mining), compaction due to intensive tillage, quarrying activities, soil erosion by water, wind and ice as well as downward or down slope movement of soil materials by colluviation or by living organisms (bioerosion);

overgrazing, over use of inputs e.g. synthetic fertilizers and herbicides, which leave harmful residues and build-up of toxic elements (chemical contamination) that inhibit microbial activities.

Climate fluctuations

Climate fluctuations create uncertainties e.g. weather fluctuation associated with increasing rainfall intensity and amount leading to flooding, erosion and reduced vegetation cover. Increasing temperature affects adversely plant growth and accelerates soil degradation processes, for example weathering, mineralization, leaching, etc. In the warmer world of northern latitudes intensification of floods, drought and heat spells exacerbate production instability and intensify soil degradation.

Anthropogenic Activities

Loss of inherent soil fertility (physical and chemical) can be through indiscriminate bush burning, over grazing, misuse of agrochemicals, bad cultural practices etc. A soil that has lost its intrinsic qualities is dead and manifests in reduced crop yield.

Forest degradation

Forest degradation (reduction of biotic resources and lowering of the productive capacity of forests and range lands); acid sulphate formation, urban and industrial encroachment on to agricultural lands. Deforestation leads to desertification that declines the biological or economic productivity of soils especially in arid and semi-arid areas (Amide, 2003).

Some of the above activities are indications that a soil can be degraded in many ways, the consequences may lead to the following.

i. Physical, chemical or biological run-down causing a reduction in vigor. This can result from excessive product removal (depleting soil nutrients), reduction in plant growth, lowered organic cycling, increased soil temperature, compaction and surface crusting.

ii. Reduction in mass and volume through erosion. Degradation reduces the physical size of the soil ecosystem.
iii. Accumulation of specific soil chemicals to levels that detrimentally affect plant growth. Such materials include: soluble salts (causing salinity); hydrogen ions (causing acidification); and, chemicals from industrial, mining or agricultural activities (chemical contamination).

Some local farmers describe such soils; for instance, by saying that the soil is 'thirsty' if well drained and 'weak' if not fertile. The soil can also get 'tired' or 'go mad' if it is cultivated without fallowing or addition of external nutrients. The soil may 'cry' because it is so coarse that it makes a squeaking sound when walked on (Ezeaku *et al.,* 2005).

SOIL RESURRECTION

Good management of the soil resources leads to amelioration of the degradation problems and result to soil restoration. Soil amelioration techniques have been adapted and the common ones are: use of organic residues, cover crops/mulch, agroforestry and alley cropping, good tillage and fallow systems, etc (Ezeaku, 2011). Note that soil formation (production) takes a long time, an average of about 100 years to generate a millimeter of soil (Hillel, 1991). According to Johnson and Lewis (2007), the following weathering rates are in units of micro-meters per thousand years (Table 9).

Table 9: Soil material weathering rates under different climate regimes in units of micrometers per thousand years.

Material	**Climate**	**Rates**
Basalt	Cold	10
Basalt	Warm, humid	100
Granite	Cold	1
Granite	Warm, humid	10
Marble	Cold	20
Marble	Warm, humid	200

Source: Johnson and Lewis (2007)

Although the soil can be renewable (reusable) following appropriate management, the time span needed for its regeneration is long and therefore should be treated and utilized in a sustainable manner. Thus resurrection approaches include;

- Slightly degraded soils can be improved by crop rotation, minimum tillage techniques, etc;
- Moderately damaged land takes more resources than an average farmer can afford. Changes in soil conservation practices can slow land degradation, but not restore fertility often. National programs will be needed for such lands, requiring major structural change (e.g., draining, contour banks, etc);
- Severely eroded land is generally abandoned. Restoration efforts require heavy engineering construction such as deep ditches for drainage, terraces, mechanized deep plowing to remove compaction, aforestation programs to combat desertification.
- Treatment of soil-root zone with organic amendment. This is localized placement techniques such as side dressing. Organic material and animal manures and crop residues improve tilt, fertility, protect soil from water and wind erosion, prevent nutrient run-off and leaching. Physical benefits include increased soil/water holding capacity, soil aggregation, soil aeration, permeability and decreases soil crusting and bulk density (Mbagwu, 1989).
- Use of a wide variety of organic wastes and residues as soil conditioners and sources of plant nutrients (Asadu and, 2014).
- Reduced tillage, stubble cultivation, minimized stock damage, crop rotation, grazing management.

USES AND IMPORTANCE OF SOI

The three quotations below tend to summarize the significance of soil in any nation. The citizens of any nation must feed well before they can think well. A hungry man is an angry man. Can a hungry and angry man move a nation forward? Our recent book on

"The reality of man-made food insecurity in Nigeria: A comprehensive analysis" dealt with why we are the architects of the problems of food insecurity in this country and how this country can feed itself with a lot of excess for export.

QUOTES

"A nation that destroys its soils destroys itself" (Franklin Roosevelt, 32nd US President)

"A nation which cannot feed itself is at the mercy of others and can hardly boast of self-reliant" (Obasanjo as Head of State during the Launching of Operation Feed the Nation, OFN in 1996)

The Eleventh Commandment

"Thou shalt inherit the holy earth as faithful steward, conserving its resources and productivity from generation to generation. Thou shalt safeguard your fields from soil erosion; thy living matters from drying up, thy forests from desolation, and protect your hills from overgrazing by thy herds, that thy descendants may have abundance forever. If any shall fail in this stewardship of the land, thy fruitful fields shall become sterile stone ground and wasting gullies, and thy descendants shall decrease and live in poverty or perish from off the face of the earth". (Lowdermilk, 1975 , Courtesy, Dr Israela Ravina, Technion, Haifa, Isreal)

Soil is used for several purposes which are summarized below

1. To make Man

Man was made by God. This is how man was made. "Then the Lord God took some soil from the ground and formed a man out of it; he breathed life-giving breath into his nostrils and the man began to live" (Genesis 2: verse 7). This is very clear. So the story of soil is essentially the story of humanity. For instance, Hillel (1991) wrote that the Latin word for 'man', *homo*, is derived from the same root as 'humus' linking the association between human beings and soil. Similarly, humus is a Latin word meaning, ground, derived from the Latin *humi* 'on the ground', the same etymological root that gives us the word humble. When soil scientists say that soil is life and it is alive, we mean that soil (man) is the most sacred thing (being) we should not denigrate or toy with. This means that we must accord soil its respect if we must have some respite in the world.

2. Agricultural Application

Soil is regarded as a resource on which farming industry as well as the increasing population of the world, particularly the third world depends. This earth material is the "mother" of all forms of agricultural and agro-allied industries. The phrase *Soil Nnem* is common to all who know one of the foremost pioneer professors of soil science in Nigeria who retired from this University – Professor I. Unamba-Oparah. He cried out during the days of Operation Feed the Nation; OFN, and lamented thus; Go to those sites and see how they are bulldozing *Soil Nnem,* exposing them to erosion. Many of the OFN sites have been impoverished and many abandoned.

Soil is used for farming, ranching and forestry. All forms of cultivation of crops/plants are carried out on the soil. The yield of these plants are used as food and feed for man and livestock. Late Professor F.O.C. Ezedima when he was alive defined agriculture simply as the use of three Fs to produce five Fs. The three Fs are farming; forestry and fishing on land (soil) and the five Fs are food, feed, fuel, fun and fibre. The use of hydroponics to produce crops has been demonstrated but what amount of food do you expect from that and how economical is the system? However, the system must be placed on land (soil).

Also, agro-related and non-agricultural industries are provided with raw materials from the yield of crops/plants and livestock grown in the soil. In all agricultural land use programmes the availability of water for crops, livestock and many other purposes is of primary importance. Farm ponds and reservoirs provide a logical source of such water, for they are designed and adjusted to fit the individual farm. Conservation and protection of land also depends on the control of excess waters. In many establishments soils are used to make such embankments in farm, e.g. pond and dam construction. Soil embankments in the forms of dikes, levees, detention dams are important good protective structures on farm lands.

3. **Industrial Uses of Soil**

Soils differ in physical, chemical and biological properties. These differences may range from very striking textural variations to more subtle colour variation. These differences detect that the soils can be put to different uses and any given soil might be relatively more suitable for specific use. Therefore soils must be managed differently and will behave differently when used for varying purposes. The main basis for classification and understanding soils is the soil profile description made in the field coupled with results of laboratory determinations of soil properties. Some characteristics of the soil which may determine its use industrially include colour, texture, structure, consistence, slope/relief, mineralogical and chemical compositions as well as soil reaction. Usually, the soil map depicts soil properties and functions in the context of specific use.

Industrial uses of soils can be discussed under the following – agricultural application, environmental application, engineering and architectural application and source of raw materials. Having discussed agricultural application, let us look at others.

4. Environmental Application

The soil is responsible for our safe environment as follows

a. rubbish absorber , storer, converter, think of the rubbish generated within your community including dead bodies in a year and ask yourself if soil is not doing us this favour where shall our safety lie.

b. Your portable water has been purified before and filtered by the soil system before you make your boreholes to harvest the underground water

c. Carbon sequestration; Soil absorbs and store virtually all the greenhouse gasses being produced due climate change etc

5. **Engineering and Architectural Application**

Engineering application of soil has contributed a great deal in making soil more useful. Engineering analysis and data make soil information more quantitatively described so that it can be more fully utilized. Soil is used as a platform for erection of man-made structures. Examples of engineering and architectural project types that use soil/soil information to achieve their purposes include

(a) office buildings, residential estates and schools.
(b) water supply schemes (construction of concrete pipes embankments and channels for water movement).
(c) civil design and public infrastructure.
(d) campus and site design for institutions.
(e) parks, botanical gardens, arboretums, green ways and nature preserves.
(f) recreation facilities like golf course, theme parks, and sports facilities.
(g) housing areas, industrial parks and commercial developments.
(h) highways, transportation structures, bridges and transit corridors.
(i) large or small urban regenerations schemes.
(j) forests, tourist or historic landscapes, and historic garden appraisal and conservation studies.
(k) reservoirs, dams, power stations, reclamation of extractive industry applications or major industrial projects.
(l) coastal and offshore development.

5. Raw Material

Soil in its natural state or when slightly changed are used or made into something else. Many industries use the soil as raw material in the manufacture of wide range of products; for examples

- making of Portland cements.
- manufacturing of specially concrete products.
- making of plaster moulds.
- fillers in paints.
- for glass manufacture.
- for making of ceramics.

- used in mineral fibre.
- used as chemical, feed and polymer additions.
- high-strength floor underlayment.
- industrial palates and gypsum cements for cart and casting.
- road and surface repair patching materials.
- for making of thermoplastic, thermoses and coatings.
- as erosion and dust control products.
- and as hydro seeding.

6. Soil Eating(Esophagi)

Tasting of soils whether sweet or sour is an old practice; hence many cultures practice esophagi (soil eating). For instance, West African women eat clays and earth processed by termites to obtain calcium (Chukwu *et al.,* 2005). Kaolin-based mixture is taken to settle stomach upsets (Whole Earth, 1999). Children are recommended to eat more soil to build up their immunity (Rook and Standford, 1998). A Siberian tribe carried small balls of local earth to nibble on their travels to remind them of their home. Roman farmers distil soil through a wine strainer with water and drink the liquor. Central American native communities ate clay tablets (Berry, 1996); Swedish and Finlanders use clay to extend bread in famine times, while the Japanese Ainu people have a clay lump soup.

Many minerals produced in the country come from the soil.

7 Archeological Importance of Soil

Archaeology or the science of "rubbish" and soil are two separate disciplines and endeavors but has interrelationship with one another. Soil science serves as a base for the study of artifacts and various other archaeological features, thus the course Archaeology cannot be studied in isolation. Archaeology is the scientific study of material remains of ancient things as a way of understanding past life activities that took place in a certain place. The discipline has three branches: Experimental archaeology (uses scientific approach in studying, describing, and analyzing of artifacts and archaeological features), Ethno-archaeology (uses mainly observations than relying purely on scientific experimental approach though it has relationship with experimental archaeology in their mode of operation), while marine archaeology uses scientific approach to study material remains and artifacts found in oceans and seas in order to show the past life activities in the oceans and seas and how past life activities have influenced the marine body (Hoopes, 1996). The concepts of 'artifacts' and 'feature' in archaeology are related to soil. For instance, artifacts refer to any object that was manufactured or altered by human activity, while feature refers to any type of archaeological remain that is not easily removed for transport back to the laboratory. Examples of features include house foundations, walls, tombs, stone, fibre, pottery, and ceramics.

Store house of Information: Soil is important for archaeologists, because it provides a source of information about the past climate, vegetation and animals (ecofacts), as well as anthropogenic artifacts and features. Any life activity carried out in a place does not completely disappear as the soil makes a copy of such activity and stores the information for subsequent generation. For instance, with careful observation and study of soil properties such as morphology, physical, chemical and mineralogy, archaeologists can identify precious human impacts on sites and use the knowledge to determine the activities that led to the present soil characteristics. Bone artifacts, if analyzed can reveal the kind of mineral the bone is made of and in essence can suggest the kind of diet eaten by the ancient people. For soil scientists, the morpho-physico-chemical properties of the soil are used in classification schemes and for land use planning purposes.

Tools and Social Identity: Lithics are artifacts of stones found during soil survey studies. Lithic raw material called obsidian, a natural glass that is as a result of volcanic activity can be used to make blades of extreme sharpness, which serve as a cutting tool for soil sampling activities such as for bush clearing and soil sampling. Ancient pottery as a fired clay material is extremely durable and can last for decades and can reveal a wealth of information about past societies including details of their level of technology, social organization, subsistence pattern, ritual activities, etc. Similarly, ceramic as a fragment of fired clay daub has been used in ancient villages in southeastern Nigeria to paint walls of mud farm houses. In ancient Costa Rica, clay daub is used to plaster the walls of houses made of bound reeds or poles-a technique called "wattle-and-daub". Clay paintings and drawings are also used extensively in traditional mud house in Nigeria. These show the aesthetic beauty of clay materials.

Wealth and Prestige: Soil excavations reveal precious artifacts such as gold, stones, diamonds, etc. It provides valuable information about the affluence of past people who owned them.

Cultural Identity: Remains such as artifacts and ecofacts found within the soil of certain places help to trace the culture of the people that occupied a certain archaeological site. Example, the discovery of hoe-like and digger-like tool would show that the ancient people who lived in an archaeological site engaged in farming.

Settlement of Disputes: Archaeological information about the ancient people helps determine the original settlers in the place of dispute. For instance, the discovery of a slate with inscription during survey activities in soils can reveal the language of a certain people who lived at a place in a remote past. If such a site is under dispute the people that speak the language found inscribed on the plate is assumed the owner of the site or land.

Soil and crop marks (best visible from the air during dry weather) are good indicators of past use of the land. These markings generally appear due to different levels of crop growth caused by buried structures such as stone walls and refilled ditches

8. Cultural (Secrete) Importance of Soil

Soil is the result of physical, geological and biogeochemical processes, which needs understanding and identification as the source of our survival, the means and meaning of our existence.
The soil is complex and full of secrets hidden underneath its often-uncompromising surface. The key to under locking its secrets is to connect it with human lives. Soil is the backbone for life, for without it, humanity cannot survive as a species. Taken together, science and humanities can help us understand soil and human interactions with it, and improve both our soils and our human conditions.
As a species, we have had an enormous impact on the soils of the planet. Our need for food has led to environmental destruction and the downfall of countless civilizations. At the same time, our dependence on soil for our existence, soil's contribution to our cultures, means soil has an important place in our physical, spiritual and emotional life.

a. Soil Worship: Soil's fundamental importance to human life is reflected in ancient religions, many of which have soil gods. In ancient Egypt, for example, Khnum the rain headed god was a potter-god who had a strong association with the Nile inundation and soil fertility, and some times shown modeling clay on his potter's wheel to form the bodies' of humanity (Egyptology online 2004).
Ancient cultures personified the earth and nature, gave them human feelings, and interpreted their actions as human because they saw in nature the same cycle that they themselves were not part of: birth, maturity, death and decay. The earth was referred as the mother, "the source of fertility, the site of germination and regeneration, indeed the womb of life (Hillel, 1991).

b. Fundamental virtue to hospitality

The fundamental virtue of the soil is hospitality; hence, Logan (1995) noted that while civilizations and soil have been mutually destructive, individuals and communities have enjoyed a mutually beneficial relationship such as 'good soils make good people' and 'healthy soils make healthy people'. Ethnopedology, the cross-cultural study of soil knowledge, is showing that indigenous people have substantial knowledge about their soils, based on soil properties they see and experience when they try to grow food in local soils (Ezeaku *et al.,* 2005).

c. Determinant of quality of human food culture

Soil is a determinant for quality of human food culture. For instance, 2.2 billion people in 130 countries are at risk from iodine-deficient soils, which can lead to goiter, cretinism and low IQ (Hetzel, 2001). The deficiency is due to leaching of iodine by glaciations, high rainfall or flooding of river valleys or vast estuaries, and the physical, mental and social health of countries can be improved by adding iodine to their diet.

d. Base for human civilization

Soil had been the base for human civilization. All civilizations have relied on soil materials to make their buildings, cookery and art. The Sumerians used clay tablets to record their activities (Pawluk, 1999). Using clay to make pots and bowls for human use is one of mankind's oldest arts, and because they are so enduring they have provided useful clues to our early history.

Soil contributes to human literature. In every culture's poetry and literature, the word soil is used as a metaphor for life, fertility, belonging, groundedness, richness and productivity. The extensive use of the soils' as metaphor indicates earlier cultures' familiarity with soil activities.

e. Sensual appeal

Soil has sensual appeal. Soils appeal to our senses, touch or feeling, smell, and even taste. Pedologists admire soils for their intrinsic beauty, while morphologists admire the aesthetic beauty of the extrinsic features of the soil landscape. Many farmers and gardeners are enthralled by soil, not only because it feels good but because it brings us into relationship with the primal forces of life and death, both physically and symbolically. We nourish life from seed, watch it grow, thrive, spring full of color and vitality, and then wither and die. This is the natural order of things in all life (Johnson, 2002). When we appreciate the flush green vegetation we are indirectly appreciate the soil. Note that the flush green grass often experienced at the beginning of each rainy season is due to adequate supply of nitrogen from soil nitrogen at that time.

f. Soil as a spiritual core

Touching the soil literally earths us; connect our human spirit to our core. Our connection to a ground in the earth is crucial if we are to remain healthy in body, mind and spirit. When we stick our hands in the soil, we affirm our connection to that which sustains us. This connection with the earth is the same connection that our ancestors had with their soil gods. Subconsciously we have a link with the soil that goes deep to the core of our existence on earth and connects us to the spirit of what it means to be alive.

In some intuitively perceivable sense, the quest for a deeper understanding of the soil's role in the natural environment and in the life of humanity is more than intellectual exercise; rather it is something of a spiritual pilgrimage, impelled by an ancient call, a quest to return to a life of greater authenticity (Hillel, 1991). When we want to be closes to God why praying, get closes to the soil (ground), for instance, by kneeling down, prostrating, placing the head on the ground or kissing the ground. This also true when, we ask for favour from higher authorities.

Knowing and understanding soil connects us to a wider perspective than our current existence, hence impossible to contemplate the life of the soil for a very long time without seeing it as analogous to the life of spirit. We depend on soil for food to survive, and when we die we return to the earth to make soil. In accordance, Berry (1996) wrote that the soil is the great connector of our lives, the source and destination of all. Xenophobes (580 BC) aptly wrote "For all things came from earth and all things end by becoming earth". This is demonstrated in many cultures when dead bodies are buried by throwing some soils into the grave when the coffin containing the dead body is inside the grave.

EXAMPLES OF SPECIFIC SOIL STUDIES

When I registered to read soil science, it was from my fourth year that I started planning how I would master the subject because as I said earlier I had taken a firm decision to pursue my career in soil science. What occurred in my mind was that I must understand the "soil" first. That meant I must acquaint myself with soil formation (genesis), understand its characteristics (soil characterization, survey and classification) before its uses especially in agricultures (soil agronomy) and its role in environment as well as its management. In this section I present some selected studies to illustrate my efforts in the above areas from my journals publications only. In the early days of mentoring, we were meant to publish our work in **reputable** journals across the continents. The belief was that for your professorial appointment or promotion, you must be seen as having published widely in *international* journals and that meant for us, those journals in your research areas familiar with those external assessors likely to be appointed to assess you from Africa, Europe and America. That time if you were in Africa working in any field of agriculture and you had not published in *East African* agricultural. *and Forestry, Journal Kenya;* it would appear as you had been left behind.

The case of impact factor was not in vogue even though most of those journals especially those in Europe and America already had impact factors. These days' even journals with less than five volumes, without specific country addresses, claim outrageous impact factors just because of the emphasis placed on impact factor. For any journal to any impact factor, it should have been publishing for at least 10 years from my own point of view or had 10 volumes interrupted.

a. **Understanding the Origin and factors of Soil Formation**

My first degree thesis centred on the effects of parent materials on soils of eastern Nigeria. The Abstract below is from one of the most well known journals in Africa. Before the journal went online there was never any month that went by without my receiving requests for the reprint from various parts of the world. I understand parent material as the origin of the soil and understanding the origin of any thing is neccassry in getting the best way to deal with such a thing. I remember what my supervisor and mentor, Professor F.O.R. Akamigbo told Emma Ude, a very close friend and classmate and I about the external examiner's comment on our thesis – these projects would qualify for masters degree projects in many universities.

Influence of Parent Materials on the Soils of Southern Nigeria F.O.R. Akamigbo and C.L.A. Asadu,

Summary; *The study was spread to major geological formations and landforms regions of eastern Nigeria with the exception of the deltaic materials found in the salt and fresh water swamps bordering the Atlantic Ocean. South-eastern Nigeria is roughly located by latitudes $4^o30'$ and $7^o00'$ North and longitudes $6^o00'$ and $9^o00'$ East. Auger borings were made to identify the lithologies and ten profile pits dug on each formation. Six contrasting formations were studied.Soil parameters investigated included texture, Cation exchange capacity (C.E.C.), exchangeable bases, exchangeable acidity, soil reaction (pH) and available phosphorus. Textures range from sand to clay with the exception of silt dominated textures. C.E.C. and total exchangeable bases are generally low; the exchangeable acidity is markedly variable while soil reaction is acidic.A Chi-square statistic reveals significant relationship between the underlying lithologic materials (geologic material) or parent materials and soil texture, soil exchangeable bases, soil reaction and soil exchangeable acidity, but no relationship is revealed for available phosphorus and C.E.C. The implications of the result are discussed.* ***Source****: East African Agric. and Forestry J. 48: 81-91(1985).****Kenya***

Another work was on the use of abrupt changes in selected soil properties to assess lithological discontinuities in soils of Eastern Nigeria. ***Asadu, C.L.A. and F.O.R. Akamigbo, 1987. Pedologie XXXVII-1:42-56, Belgium;*** which showed that possibilities exist in

our tropical environment to have lithological discontinuities in our soils. The implication is that we should not assume that the parent material of our soils in a particular place is normally uniform.
Three papers were published on our studies on the effects of topography, another factor of soil formation, on soil properties.

Influence of Topography on Some Soil Parameters in Selected Areas of Anambra State, Nigeria.
F. O. R. Akamigbo and C.L.A. Asadu
ABSTRACT: *The influence of topography on the development of soil parameters (properties) as thickness of solum, soil texture, profile drainage, content of organic matter, soil reaction(pH), exchangeable acidity and available phosphorus, was investigated. Three profile pits were dug along each of the four toposequences studied after making several auger borings to establish changes along the toposequences. Routine analytical procedures were conducted for the properties under consideration. Results indicate that topography in combination with other soil forming factors affected the depth or thickness of soil solum, particle size distribution, organic matter content, cation exchange capacity, total exchange-able bases and exchangeable acidity.***Source:** Nigerian Journal of Soil Science, 6:35-46 (1986)**Nigeria**

The Predictive Abilities of Eleven Soil Weathering Indices on the Sequence of Soil Occurrence on Slopes in Eastern Nigeria
C.L.A. Asadu
Summary: *Eleven selected weathering indices were assessed for their predictive abilities in detecting the sequence of soil occurrence on the slopes of nine toposequences in Eastern Nigeria. The toposequences were all located on weathered sedimentary materials of Tertiary and Cretaceous age. Selected physical and chemical properties of the soils were used to calculate the various indices (ratios). The predictive abilities of the methods used were assessed from their respective probabilities in consistently predicting similar soils on the same topographic position at different locations.The investigations revealed that six*

methods consistently predicted older soil profiles at the mid-slope positions and the other five predicted similar soil profiles at the upper-slope positions. Only one method predicted youngest profile at the upper-slope position. Five methods each predicted intermediate soil profiles at upper slope and toe-slope positions while six methods predicted youngest profiles at the toe-slope positions and four methods predicted youngest profiles at the mid-slope positions.The predicted sequence was slightly different when the methods were considered together on each toposequences. The conclusion drawn was that the different methods considered were not equally predictive in the sequence of soil occurrence on the slopes in the area studied, hence any method adopted any place should be tested since differences in parent materials and slope percent seemed to have affected the results.

Source: East Afri. Agric. and For J.53: 45-56 (1987).**Kenya**

The above studies were on two factors of soil formation namely parent material and topography. The next studies were on characterizing soils in various environments in still attempts to properly grasp soil knowledge. These abstracts had to do with land orientation and soils for crop production.

2. Soil Characterization

A Comparative Characterization of Two Foot-Slope Soils in the Nsukka Area of Eastern Nigeria

C. L. A. ASADU

Abstract: A comparative study of two foot-slope soils on similar parent materials in the Nsukka area of eastern Nigeria was carried out to determine their characteristics, ascertain their differences, and find out reasons for the differences. The differences were related to the thickness of the Ap horizons, sand and clay contents, organic matter contents, exchangeable bases, cation exchange capacity, exchangeable acidity, and gibbsite contents in the less than 2-μm clay fractions and the available phosphorus. The major reasons for the differences were related to the differential rates in certain soil formation/degradation processes resulting from

differences in the cultural practices in the two sites and the longer period of land cultivation on the University of Nigeria, Nsukka (UNN), and farm than on the Community Secondary School (CSS) farm. The parent material of the soil tended to influence the soil properties on equal basis. The soils were classified, respectively, as fine-clayey kaolinitic, isohyperthermic Rhodic Kandiustalf (Haplic Lixisol) and fine-loamy, silicious, isohyperthermic Rhodic Kandiustult (Haplic Acrisol).

Source: Soil Science 150: 527-534.(1990).**USA**

A Comparative Study of Soils Inside and Outside Ogbunike Cave in Eastern Nigeria

C.L.A Asadu and H.C. Agudosi

Abstract: *A comparative study of the "Ogbunike Cave" soils in Eastern Nigeria revealed that significant differences exist between properties of soils outside the cave and those inside the cave. There were also differences between the properties of soils inside the cave which were exposed to the atmosphere and those inside the cave but were not exposed (in tunnels). The differences observed were both in the morphological (soil depth and horizon development), physical (particle size distributions and textural classes) and chemical (total exchangeable bases, acidity, CEC, organic matter and available P) properties. These differences were attributed to the degree of exposition of the different parts of the cave to factors of soil formation such as rainfall, insolation, vegetation, human and microbial activities and the influence of parent material. These factors influenced soil formation and degradation processes such as illuviation/eluviations, organic matter accumulation, leaching and erosion. Due to the extensive evidence of erosion menace in the area and the general topography as well as the prospects for tourism, the cave should be developed as a tourist centre and cultivation around the cave by farmers should be discouraged.*

Source: Discovery and Innovation **6:367-371(1994). Kenya**.

The Characterization of Selected Yam-Growing Soils in Southeastern Nigeria II. Chemical and Mineralogical Properties

C.L.A. Asadu, F.O.R. Akamigbo, H.C. Ezumah and F.I. Nweke,

Abstract *Studies were conducted in south-eastern Nigeria to determine the chemical and mineralogical properties of soils used for yam (Dioscorea species) production in the area. The locations prominently known for yam production and which were on three different geological formations (parent materials) were chosen for the studies. The sites were at Zaki-Biam on Undifferentiated Basement Complex, Abakaliki on Shales of the Asu River Group and Atani on Alluvium deposited by the River Niger. The chemical properties determined included soil pH, exchangeable bases and acidity, Cation exchange capacity (CEC), organic matter and available phosphorus. X-ray diffraction analysis was carried out on less than 2 microns clay fractions obtained from the representative pedons.The studies revealed that the soils varied in such chemical properties as acidity, base status and CEC as well as in the clay mineralogy. The reasons for the variations were attributed to differences in parent materials and climate. The soils of the locations best known for yam production in the zone (Zaki-Biam) were found to be moderately acid and had high base saturation with generally low CEC when compared to other soils from Abakaliki and Atani. Generally, the dominant minerals in clay fractions were kaolinite, quartz, degraded-mica, vermiculite and interlayered materials. However, there were no interlayered minerals and gibbsite was totally absent in Zaki-Biam soils. Again the interlayered minerals were greatest in Abakaliki soils while most of the detected vermiculite were from Atani soils. From the studies it was concluded that yams could tolerate a wide range of variation in soil chemical and mineralogical properties in the locations studied especially under the management techniques used by the farmers.*

Source: The Nigerian Agricultural Journal 24: 55-69. (1990), Nigeria

Variations in Soil Physical Properties in a Cleared Forestland Continuously Cultivated for Seven Years in Eastern Nsukka, Nigeria

Asadu, C. L. A.; S. C. Obasi, and A. G. O. Dixon.

Abstract: *In this study, soil physical properties were evaluated in the top 40 cm of cleared forestland that had been subjected to continuous cultivation for 7 years to ascertain selected crop or crop combinations that influenced the soil physical properties the most. There was no significant effect of crop treatment on particle-size distributions over 6 years of cultivation. In year 7, clay values were significantly ($p = 0.05$) greater in plots grown with solely cassava (SC) and solely maize (SM) than in the plots grown with solely pigeon pea (SP). The soil depth effects over the 7 years were significant on the clay content. The mean values of bulk density, pore-size distribution, and hydraulic conductivity obtained from each plot fluctuated over the years. The bulk density values in 1998 ranged from 1.29 to 1.43 g cm^{3}, but from 1999 to 2004, the range was from 1.12 to 1.40 g cm^{3}. Thus, bulk density generally decreased when compared with their respective values in 1998. The greatest decrease of ≈ 22% was in 2000. More than 70% of the macroporosity values were significantly less than their respective values in 1998. The greatest decease of 72% was obtained from SM plots in 2001. All the microporosity was significantly more than the 1998 values. All the increases were >100% of the original values. These increases were reflected in the variations of total and saturated hydraulic conductivity (Ks) values. However, in 2004, Ks values decreased in the plots grown to C + P, SP, and SM. Generally, the C + M + P mixture appeared to be the most consistent in improving micro- and total porosities and Ks among the crop treatments .**Keywords:**Bulk density, crops, cultivation, forest soil, Nigeria, particle sizes, porosity*

Source**: Communications in Soil Science and Plant Analysis, 41: 123 – 132. (2010).**USA

3. Research on Agricultural uses

Having convinced myself that I have understood the meaning of "soil" at least to the extent that I can now research on its agricultural uses, I did a lot of field trials and surveys on soil-crop relations. My PhD thesis also captured agronomic studies a lot. There are more than twenty journals articles in this section. As one of the retired pioneer professors (Professor W.O. Enwezor) in my department would normally emphasize; whether you are studying Agricultural Economics or Extension, Animal or Crop or Soil sciences; what **matters at the end of the day is what we are able to place on the dinning tables of mankind**. Based on this I presented as many as ten abstracts in this section to emphasize the relationship between crops and soils. I have also presented the best crop mixture for our farmers in this part of the country based on a long-term collaborative work with IITA, Ibadan. This crop mixture needs to be extended for adoption by farmers.

Evaluation of six cultivars of white yam (Dioscorea rotundata) across three yam-growing areas in southeastern Nigeria
C.L.A. Asadu, F.O.R. Akamigbo, F.I.Nweke and H.C. Ezumah
Summary: *A split split-plot experiment was conducted in the 1986 and 1987 cropping seasons in three major yam-growing areas in southeastern Nigeria to assess the performance and yield stability of six cultivars of white yam (Dioscorea rotundata Poir), Location, fertilizer and cultivar, as well as some of their interaction effects, significantly affected tuber yields. The best location for yam production, based on the overall performance of the cultivars, was the sub-humid Guinea savanna, followed by the humid forest-regrowth and then the transitional forest-savanna zone. Except for two cultivars, which performed best in their source locations, all other cultivars yielded best at a different location. Thus, at present, these cultivars are not grown in those areas to which they are best suited. This makes it desirable to test exogenous cultivars in new areas. In terms of yield stability, however, the two cultivars originating from the humid forest-regrowth area gave the most stable yields across the three diverse environment considered.*

Although they did not give the highest tuber yields at all the locations, their overall yields were above the mean yields for all the cultivars. The most suitable cultivars were recommended for each ecological zone, on the basis of the observed interaction effects.
Source: Journal of Agricultural Science (Cambridge) 127: 463-468, 1996. **UK.**

Soil Management for Conservation and Sustainable Rice Production in an Irrigated Area of Eastern Nigeria.

Charles L.A. Asadu

Abstract: *A comparison of soil management techniques in the different irrigation zones of Lower Africa Irrigation Project (LAIP) in eastern Nigeria showed that heavy use of machinery led to increase in bulk density and decreases in field water infiltration rate. The relative proportion of clay in the irrigated fields increased as a result of irrigation, suggesting that mobilized clay from uncemented main and distribution canals is carried and deposited in the rice fields. Both irrigation and the use of machinery have had substantial negative effects on soil nutrient levels, and there is a danger of this process continuing. Soil management for sustainable production in the area should centre on applying organic matter in combination with inorganic fertilizers, monitoring the soil properties on yearly basis before the cropping season for fertilizer and lime recommendations, and varying the depth of tillage to increase or maintain the effective soil depth.* **Source:** Outlook on Agriculture 25:151- 156. (1996) **UK**.

The optimum time of yam-mound remoulding for cassava introduction in yam fields in eastern Niger

C.L.A. Asadu

Abstract :A study conducted in eastern Nigeria to determine the best time for yam-mound remoulding for cassava introduction, showed that the best period was between two and three months after the planting of yams in April. This recommendation was based *on both the performance of yam and cassava as well as the estimated revenue from the yields of both crops. The study also showed that mound-remoulding could reduce the number of times farmers weed, from three to one and reduce erosion by improving the infiltration capacity of the yam mounds, since the soil material used in remoulding is often loose. The thin layer of earth on the mound after re-moulding serves as earth mulch which covers yam roots often exposed by the torrential rainfall which is characteristic of the study area.* ***Keywords**: Yam-mound remoulding; Cassava introduction; Earth-mulching*. ***Source:*** Tropical Agriculture (***Trinidad***) 74(4):308-312 (1997). **West Indies.**

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Factors Affecting the Fertility Status of Soils Growing Cassava in Sub-Saharan Africa

C. L. A. Asadu, F. I. Nweke, and I. J. Ekanayake

Abstract: *The soils of cassava-growing areas of sub-Saharan Africa were sampled in 1991 during the second phase of the Collaborative Study of Cassava in Africa (COSCA) in order to assess and document their fertility status. About 500 fields specifically grown to cassava or cassava-based crop mixtures were sampled and the soils analyzed for nineteen physico-chemical soil properties. The soil data reported in this paper were obtained from Cote d'Ivoire, Nigeria, Tanzania, and Uganda. The variations in soil properties as may be attributed to differences in climate, altitude, depth of sampling, and cassava intercropping systems were also analyzed. The soils used to grow cassava in these four countries were generally of medium to high fertility status. Here low, medium, and high fertility classes refer to soil nutrient levels where response by cassava to the application of such nutrients is definite, may be obtained, and not expected, respectively. The fertility status across the agroecological zones ranges from high to low in the order: nonhumid>highland humid>subhumid>lowland humid. Similarly, soils from 0 – 20 cm depth contained significantly higher nutrients than those from 20 – 40 cm depth. Generally, soils grown to sole cassava or where cassava was considered a major or minor crop were statistically* *similar in terms of their nutrient contents. The nutrient ratings obtained from three scales suggest that the cassava-growing soils are not 'marginal' in terms of both nutrient content and availability. Low Levels of organic matter and total nitrogen (N) were the major soil constraints identified. Research need to address these because the low nutrient reserve is essentially due to low organic matter levels in the soils.*

Source: Communications in Soil Science and Plant Analysis 29 (1&2): 141-159.(1998).**USA**.

Comparative evaluation of the contributions of soil physicochemical properties to variations in the yields of four major staple food crops in eastern Nigeria.

C.L.A. Asadu , A.G.O. Dixon, R. Okechukwu

Abstract: *The contribution of soil variables to the variations in the yields of cassava (Manihot esculenta), yam (Dioscorea rotundata), maize (Zea mays) and pigeon pea (Cajanus cajan) were evaluated over 2 years in this study. The data were from three replicates of two randomized complete block design experiments sited in a newly cleared forestland and on previously cultivated land both in Nsukka, eastern Nigeria. The 28 soil physicochemical properties and six crop yield parameters measured were partitioned between location and year before applying a stepwise regression procedure to analyze them. The study showed that soil variables accounted for >70% of the variation in cassava root yields and harvest index. Both soil physical and chemical properties contributed but the former (particularly macroporosity, microporosity, total porosity and bulk density) contributed most. Selected soil variables also accounted for >70% of the variation in yam tuber yield and shape index of tubers especially in 1998. In both crop years chemical properties appeared to dominate over the physical ones. Soil variables accounted for between 51 and 99% of the variation in maize grain and stover yields. The only exception was the figure of 44% obtained at the forest location in1998. Soil pH, total exchangeable acidity and microporosity were particularly*

important contributors to the variations in both maize yield parameters. The contributions of soil variables to pigeon pea yield parameters were low (<50%) except in 1999 at the forest location where seven soil variables accounted for over 85% variation in seed yield. It was obvious generally from the study that soil variables were important determinants of yield variations in the four crops. It was also shown that physical properties should always be included in this kind of analysis. Also the number of soil variables which were of significance generally increased when the level of soil properties was low, as was the case with the cultivated site versus forest site, and 1999 versus 1998 analysis. Thus increasing the number of soil variables used and partitioning them into more homogenous units helped to improve the results obtained using the procedure. ***Keywords**: Staple crops; Yield variation; Soil variables; Stepwise regression; Nigeria.*
Source**: Soils & Tillage Research. 65 (2): 141-155. (2000). **UK.

Performance of Seven Crop Combinations in Two Soils of Different Land-Use History in Eastern Nigeria
Dixion, A.G.O. and C.L.A. Asadu

***Abstract**: Crop yields obtained from crop mixtures grown in a newly cleared virgin forestland were compared with those from a previously cultivated farmland to assess the crops' performance between the two sites without additional soil amendments. Generally a greater number of soil physicochemical properties were considered agronomically better in the forest than in the previously cultivated land. These soil properties may constitute the driving force for significantly ($p \leq 0.05$) higher crop yields in the forestland and include: macroporosity, bulk density, saturated hydraulic conductivity, coarse sand content, pH, soil organic matter, total N, exchangeable acidity and Fe as well as base saturation. In both years, the highest cassava root yields were obtained from either cassava + maize + pigeon pea or cassava + maize intercrops (not from sole cassava plots even though the only significant ($p \leq 0.05$) difference obtained was between cassava + maize + pigeon pea and all four crops combined, and at the*

cultivated farmland (UNN farm) only. This suggests that it is even disadvantageous to grow cassava as a sole crop in the area. Cassava root yield reduction in 1999 relative to 1998 was higher (70%) in the UNN farm than in the forestland (40%). There was no significant difference due to crop combination on yam tuber yield in both locations in 1998. However, in 1999 sole yam plots gave significantly higher yields than cassava + yam + maize + pigeon pea plots. Increase in tuber yields was obtained in 1999 over 1998 in both locations but it was smaller (<3%) in the forest than in the UNN farm (27%). There was no significant difference due to crop combination on maize grain yield. The pigeon pea yields obtained from sole pigeon pea plots in the forest locations in both years were generally significantly ($p \leq 0.05$) higher than those obtained from the other plots. With the land equivalent ratio (LER) obtained ranging from about 1.16 to 3.48 the study shows clearly that it was much better to grow the test crops in mixtures than in pure stands. The number of crops in the mixture should, however not exceed three as an additional crop led to depressed LER. The recommended intercrop mixture was cassava + maize + pigeon pea. ***Keywords****: Land use, soil properties, intercropping, land equivalent ratio.*

Table 10: Summary of land equivalent ratio (LERs) obtained in both locations for the two years (**Source:** Agro-Science Journal 2(2): 70-80. 2001. **Nigeria)**

Intercrop system	1998 Forest	1998 UNN farm	1999 Forest	1999 UNN farm
Sole Cassava	1	1	1	1
Sole yam	1	1	1	1
Sole maize	1	1	1	1
Sole pigeon pea	1	1	1	1
C + P	1.16	1.43	1.65	2.25
C + M + P	2.37	2.36	3.61	2.57
C + M + P + Y	2.09	2.27	3.48	3.66

C = cassava, P = pigeon pea, M = maize, Y = yam

Soil nutrient and cassava yield variations under continuous cultivation of three crop mixtures in south eastern Nigeria

C. L. A. Asadu and A. G. O. Dixon

Abstract: *A research farm at University of Nigeria, Nsukka, Nigeria, which was under cultivation for > 25 years before it was fallowed for 8 years, was cleared in 1998 and grown to three common crop mixtures for 4 years. The aim was to assess the performance of the cassava component in terms of root yield and harvest index under continuous cultivation relative to soil nutrient variations. The crop mixtures were cassava + pigeon pea, cassava + pigeon pea + maize, and cassava + pigeon pea + maize + yam. Incorporation of crop residues from each of the respective plots into the soils and the use of a legume (pigeon pea) served as means of restoring soil fertility. The experimental design was a randomized complete block design replicated thrice each year. Changes in eight selected soil fertility indicators, namely, pH, total N, organic matter, available P, and exchangeable Ca, Mg, K, and Na were monitored for the period. An analysis of the nutrient contents of the soils under the crop mixtures indicated narrow variations over the four years, except in the cases of exchangeable cations where coefficients of variations of ≥ 25% were obtained. Comparatively, year-to-year variations were more substantial though not consistent. This is because in some years some nutrients decreased while others increased relative to the values obtained in the preceding year. Except in 1999 when cassava root yields from all the crop mixtures decreased substantially (>60%) relative to their 1998 respective values, the trends in other years were not consistent in all the crop mixtures. The mean yields obtained were generally below the expected mean yield for the same cassava variety in the area. The study also showed that all the soil parameters selected contributed to the variations in cassava yields, though they were not consistent in each year and in each crop mixture. However, regression analysis between the relative changes in soil nutrients and cassava yield variations showed significant contributions of total N ($P = 0.01$), and Mg (P*

= 0.001). Thus, adequate management of these soil factors is required to enhance the performance of cassava in the crop mixtures. ***Keywords**: Soil fertility; Cassava yield variations; Crop mixtures; Regression; Nigeria.* ***Source:** Tropical Agriculture (**Trinidad**). 82 (1): 1-7.* **West Indies**

The Effects of Four Rations of Inorganic Manures on Soil Physicochemical Properties and Maize Yield.

Asadu C.L.A. and Nwajiaku I.M

ABSTRAC: *This work was carried out to assess the potential effects of combined use of organic and inorganic fertilizers on the physiological properties of an Ultisol and maize yield. The experiment was carried out first in the greenhouse and then evaluated in the field. In the greenhouse seven treatments namely 0.4t/ha N.P.K, 10t/ha pig dung, 0.2t/ha N.P.K + 5t/ha pig dung, 0.25t/ha N.P.K + 2.5t/ha pig dung, 0.30t/ha N.P.K + 1.25t/ha pig dung, 0.35t/ha N.P.K + 0.65t/ha pig dung, control were evaluated using a completely randomized Design (CRD) replicated four times. The inorganic fertilizer used was NPK 15:15:15 while the organic manure was pig dung. The results indicated significant differences ($P \leq 0.05$) in plant height, leaf area and dry matter as well as in most of the soil physicochemical properties ($P \leq 0.05$). At the end of the greenhouse experiment, the best combined ratios of organic and inorganic fertilizers with the uncombined ones were used for field evaluation. For the field evaluation these five treatments namely, N.P.K at 0.4t/ha, pig dung at 10t/ha, 0.25t/ha N.P.K + 2.5t/ha pig dung, 0.30t/ha N.P.K + 1.25t/ha pig dung and control were involved using a Randomized Complete Block Design (RCBD) replicated three times. The results also indicated significant differences ($P \leq 0.05$) in the plant height, leaf area, dry matter, maize cob, grain yield and weight of the chaff with pig dung only (10t/ha) being the most superior in all the agronomic properties evaluated followed by one of the combined ratios of organic and inorganic fertilizer (0.25t/ha N.P.K + 2.5t/ha pig dung). From the study the use of only organic manure showed outstanding effects, but 0.25t/ha N.P.K + 2.5t/ha pig dung*

combination was a comparable alternative. Keyword: Organic manure, compound fertilizer (NPK), soil physicochemical properties, maize yield.**Source**: Agro- Science 10. 1-6 (2011) **Nigeria**

One of the most important findings in this area of research came from my long-term collaborative research on sustainable agricultural system in an Ultisol of eastern Nigeria. In this research four popular crop mixtures namely yam+ cassava + maize + pigeon pea, cassava + maize + pigeon pea' cassava + maize + pigeon pea, cassava+ pigeon pea as well as sole crops of each were grown for four years and it was found that the best options for both climate variation resilience and soil nutrient maintenance is cassava +maize+ pigeon pea. This mixture was therefore recommended for adoption by farmers in southeastern Nigeria. The promotion of this crop mixture for adoption by farmers is being proposed and sponsors are welcome.

Soils and Environment

Soil fertility management and the impact of soils on other aspects of environment also drew my attention and more than fifteen publications came from such evaluations. Nine Abstracts are presented including an analytical review of land use and soil management. This is one area multidisciplinary researchers are most needed.

Edaphic, Socio-Economic and Cultural Changes Due To Irrigated Rice Cultivation in Eastern Nigeria. C.L.A. Asadu, E.C. Okorji and F.O. Onah

Abstract: *In this study the impact of an irrigated scheme on the soils, socio-economic and cultural aspects of communities within the project site was assessed. The properties of the soils from both irrigated and adjacent unirrigated areas were determined and compared. Data for other aspects were obtained using special designed questionnaires.The mean difference in soil properties obtained at 0-20cm depth in relation to particles-size distribution, bulk density, field infiltration rate, organic matter, total N, exchangeable Na, available P and Fe were found to be statistically significant. The likelihood of the irrigated soil being silted*

*up in future was inferred from the silt accumulation rate. The study also showed that with the introduction of the irrigation scheme, there have been an increase of about 32% in the number of people engaged in farming especially rice production as their primary occupation and a reduction of more than 50% in the number of people engaged in trading, civil service, fishing/hunting and artisanship as their primary occupations. Again since the irrigation, output of rice has increased at about 450%, land area under rice by about 240%, yield of rice per hectare by about 190% and total holding per household by about 155%. These have led to a significant increase in the annual income and standard of living of the people. The respondents agreed that the construction of roads to link the rice fields, the communities and the major roads to the urban towns is the most important infrastructure provided by the irrigation authority. The cultural value systems of the people have not significantly changed since the irrigation was introduced despite increase in the number of immigrants in the area. There has been an increase in incidence of water-borne diseases.***Source***: Global Journal of Pure and Applied Sciences. 3 (1): 3-11.(1997). Nigeria.*

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Cattle grazing and environment in eastern Nigeria: impact on soil physical properties.

Charles L.A. Asadu, Osmond O. Ike and Barth O. Ugwoke

Abstract:*The physical properties of soils in fields grazed by cattle for at least fifteen years were compared with adjacent arable crop fields in eastern Nigeria to asses the impact of grazing on such properties as particle-size distribution, pore-size distribution, hydraulic conductivity and bulk density. The four locations selected for the study were Adada, Nsukka, Okpatu and Ikem. An analysis of variance indicated that the location effect was significant on all the soil physical properties ($P \leq 0.001$), while the effect of grazing was significant on silt content ($P=0.01$), macro porosity, total porosity, bulk density and hydraulic conductivity ($P \leq 0.001$). Similarly the location x grazing interaction effect was significant on all properties except in the contents of clay, fine sand, and total sand. The study also showed that those soil properties affected by grazing were generally improved in ungrazed rather than grazed fields. It was concluded that if grazing were not controlled, these soil properties would continue to deteriorate and that this could lead to extensive soil erosion in the area.* **Source:** Outlook on Agriculture .28: 87- 91 (1999).**UK**.

Factors Affecting the Organoleptic Characteristics of Palm Wine from Nsukka Area, Eastern Nigeria

C.L.A. Asadu

ABSTRACT*: The Organoleptic characteristics of oil palm wine tapped in Nsukka area of eastern Nigeria were studied in order to ascertain how they vary over the year and the factors that may be responsible for the variations. The organoleptic qualities considered were taste, colour, flavour/scent, ability to intoxicate as well as that of retaining quality over time. The locations used were designated A, B and C. Location B is about 5 km east of Nsukka while location A and C are approximately 10km south and 25km north of location B respectively. The study revealed that palm wine from both locations B and C were equally rated for their ability to intoxicate and retain quality over time. Wines from both locations were rated significantly ($P< 0.05$) higher in their ability to intoxicate than palm wine from location A while wine from same location A was rated better than those from both locations B and C in terms of ability to retain quality over time. Other quality characteristics seemed to be the same for wines from all the three locations. The most important factor considered to influence the quality characteristics was soil type. The soil properties, which appeared to make positive contributions, included pH, exchangeable K, Ca, Mg and base saturation while exchangeable Na and available phosphorus seemed to have negative influence. Another factor that influenced the quality characteristics positively was rainfall distribution. Well-distributed rainfall (about 1500mm per annum over 10 months as obtained in location C) seemed to promote the quality of palm wine.* ***Key words:*** *Palm wine, Nsukka, Organoleptic properties, causes of variation.* **Source**: Global Journal of Pure and Applied Sciences. (2000).**Nigeria**.

Land use and soil management situations in Nigeria; An analytical review of changes

Charles L. A. Asadu, Peter I. Ezeaku and Godwin U. Nnaji

Abstract: *The estimated land area of Nigeria is 904,000km^2 with a population of over 120 million. The use to which land is put differs from one location to another, especially when the immediate needs of the society or community concerned are not the same. However, the different uses of land revolve around agriculture (crop and animal production), industry (both oil and non-oil) and social needs such as the provision of infrastructure. This analytical review shows that about 65% of the land*

area of Nigeria is under various forms of food (crop and animal) production and forest plantation. This categorized as follows: food crop production, 42%; extensive grazing and livestock projects, 21%; plantation (crop, forest, teak), <2%; and agriculture in denuded areas, <1%. From 1975-95 (the only available records there were substantial changes in land area under intensive and floodplain agriculture (16%), extensive grazing and livestock projects (13%), plantation (>450%) and crop production in denuded area (>150 %). All the forest and grassland regions diminished in area over this period. These probably led to a > 1,000% increase in areas under gullies and salty marsh, and >500% in area occupied by sand dunes. Even though these degraded areas occupy <10% of the land area of the country, the rates at which they encroach on more useful land a dangerous omen for the country's land resources in general and agriculture in particular. Possible soil management solutions to avert these situations are discussed. The paper also highlights the fact that failures in implementation and/or fragmented approaches are the major problems of land use policy in the country, and that these need to be addressed for sustainable development to take off. ***Keywords:*** *land use; degradation; soil management; Nigeria*
Sources: *Outlook on Agriculture 33:27-37.(2004). UK*

Assessment of sewage application in south-eastern Nigeria Part 1: Impact on selected soil morphological and physical properties

C.L.A Asadu, C. Ucheonye-Oliobi and C. Agada

Abstract: *This work investigated the impact of long-term application of sewage sludge/effluent on morphological and physical properties of a sandy Ultisol (Arenic Kandiustult) in Nsukka, Nigeria. Soil samples were collected from the surface (0-20cm) of a sewage-amended soil and from unamended control fields, after which two representative profile pits were also sited on the sewage-amended plot and two on the control fields. Soil samples were collected at specific intervals from these pits. Morphologically, both soils were deep and well drained, with no concretions or mottles. The colour variation ranged from dark reddish to brownish black for the first layer of the profile pits in the area amended with sewage sludge, to reddish brown and red in* *others. In unamended soils, the color ranged from dark reddish brown in the top layer to reddish brown and red in others. Texture was generally sandy loam over sandy clay loam in amended soil and sandy clay loam in unamended soil. The structure was generally weakly granular in the top layer, but moderately subangular in other subsurface layers. The entire area is on a gentle slope of <5%. Soil organic matter, bulk density, total porosity and aggregate stability were enhanced significantly ($p < 0.05$) in the sewage-amended soil compared with the non-sewage amended soil. Changes in the saturated hydraulic conductivity, field capacity and micro- and macro- porosities were not significant. The results indicate that application of sewage sludge and effluent has little impact on the morphology of these soils. However, it had a positive impact on the physical properties of the soils. But it should be used with caution because of its known negative effects on heavy metal accumulation in soils when used at high rates and for long periods.* ***Keywords:*** *sewage; soil morphology; organic matter; bulk density; total porosity; aggregate stability; Ultisol*

Source*: Outlook on Agriculture 37 (1) 57-62 (2008).* ***UK***

Assessment of sewage application in south-eastern Nigeria Part 2: Impact on soil chemical properties, trace and heavy metals

C.L.A Asadu, B. Ukadike and C. Agada

Abstract*:The impact of sewage sludge and effluent on soil and underground water after about 40 years of application was evaluated in this study, with a particular focus on selected soil chemical properties, some trace element (Zn, Cu) and heavy metal (Pb and Cd) accumulation, mobility in the soil profile and possible contamination the underground water. The chemical properties of the soil studied included pH, exchangeable cations and acidity, cation exchange capacity (CEO), available P, organic matter and total N. Long-term disposal of sewage sludge and effluents on the soils significantly ($P < 0.001$) increased the exchangeable bases, exchangeable acidity, available P, soil organic matter, total N and*

CEC, but significantly lowered the pH of the soils. The fertility status of the sewage-treated soil was thus enhanced. The study also showed that both trace elements and heavy metals were significantly ($P \leq 0.05$) higher in the sewage-amended soils than in the unamended soils. The accumulation of the trace and heavy metals in the former implies that the agricultural utilization of the sewage sludge and effluent on underground water quality, but contamination by Pb is possible in the future.

Keywords: *sewage impact; soil exchange properties; heavy/trace metals; underground water; Ultisol* **Source**: *Outlook on Agriculture 37 (1): 63- 69.(2008).* ***UK***

The Impact of Cement Kiln Dust on Soil Physico-Chemical Properties at Gboko, East Central Nigeria.

Asadu, C.L.A and C. Agada

Abstract: *The effects of cement kiln dust on selected soil physico-chemical properties after 25 years of cement production by the Benue cement factory in Gboko, Nigeria were evaluated by comparing the cement-dust affected soils with non-affected soils. The study showed that at both soil depths of 0-20 and 20-40 cm exchangeable calcium, sodium, hydrogen, magnesium as well as soil organic matter, was significantly ($P \leq 0.05$) higher in the affected soils than in the non-affected soils, the former depth at ($P \leq 0.05$) and the latter at ($P \leq 0.01$). Data from the four representative soil profiles also indicated that some of the soil properties were enhanced by the cement dust. The study also showed that the highest quantity of the cement dust obtained in the farm plot was 0.72t/ha/yr, a quantity too negligible to cause any negative effects on soils and crops. Thus, presently the cement dust from the factory enhanced the majority of the selected properties of the soils and may manifest positively on crop performance around the area in future hence if properly harnessed may contribute to soil fertility management in the affected soil areas.* ***Source:*** J. Soil and Envi. Research Vol 8 (2008). **Nigeria**

Soil Fertility Recovery in a Cleared Forestland Cultivated and Fallowed for Seven Years

C. L. A. Asadu, S.C. Obasi, A.G.O. Dixon, N. Ugele, and G.U. Chibuike

Abstract:*Continuous cultivation of a piece of land leads to decline in soil fertility. Conversely, fallowing is one method used in restoring the fertility status of degraded farmlands. In this study, soil chemical properties were evaluated in a cleared forestland continuously grown to cassava (Manihot esculenta Crantz), pigeon pea (Cajanus cajan) and their combination for seven years. After the years of continuous cultivation, the land was fallowed for seven years to evaluate its natural nutrient recovery capacity. The study showed that the solely cassava plots were able to recover more exchangeable K and Mg during the fallow period. Values of pH and exchangeable acidity on these plots were also higher than those on solely pigeon pea plots and plots grown to cassava + pigeon pea (C + P). Plots grown to SP were able to recover more organic matter, available P and exchangeable Na than other plots, while, the C + P plots recovered more total N, exchangeable Ca and cation exchange capacity. Compared to the year the forest was cleared, exchangeable Ca, Mg, K and Na were able to recover to about their original values, while, total N and available P could not. Thus, nutrient recovery rate by fallowing is a function of the cropping history. Key words: Cassava, pigeon pea, cultivation, fallowing, soil fertility.*

Source: *Journal of Agriculture and Biodiversity Research 2 (5): 110-116. 2013*

Effects of Animal Faeces and Their Extracts on Maize Yield in an Ultisol of Eastern Nigeria

Asadu, C.L.A. and Igboka, C.R.

Abstract. *In this work, the potential use of organic wastes in improving the productivity of the low-base status of an Ultisol was evaluated in the green house using a completely randomized design. There were twelve treatments replicated four times* *including the control. The treatments were solid poultry droppings, piggery dung and cow dung and their extracts obtained after soaking for one week, two weeks, and more than two weeks. These treatments were properly applied to 2kg of potted soil (equivalent of 15 t per ha) and planted with maize grains at a rate of two grains per pot and thinned down to one seedling after germination. The results showed that extract from poultry droppings soaked for more than two weeks gave the highest yield of maize dry matter (18.30 g per plant), followed by extracts from pig dung soaked for more than two weeks which yielded (18.14 g per plant) and solid poultry dropping (17.47 g per plant) while solid cow done or its extracts gave the lowest yield of (5.08 g per plant) but all were significantly higher than control (1.84 g per plant). All the treatments significantly increased the soil organic matter, exchangeable bases, cation exchange capacity and the available phosphorus. With the increase of soil nutrients following the application of the organic wastes, all amendments increased maize performance over control. The recommended best form of the animal manure for optimum maize growth was the liquid form especially that of poultry that was soaked for more than two weeks.* ***Key words:*** *Animal faeces, maize yield, Ultisol*

Source: Journal of Agriculture and Sustainability 5 (1): 1-13. (2014)

Yam Yield Variations From Three-Year Continuous Cultivation Under Sole And Mixed Cropping Systems In An Alfisol Of Eastern Nigeria

Asadu, C.L.A and A.G.O. Dixon

ABSTRACT: *Sole Yam (SY) and Yam+ Cassava + Maize + Pigeon Pea (Y+C+M+P) mixture were grown continuously for three years in an Ultisol brought into cultivation as a virgin forestland. The objective was to compare yam yield variations as affected by residue management without external input of nutrients (Zero external input). All the crop residues especially the above ground vegetation (leaves from yam, cassava and pigeon pea and the entire for maize except the cob) were incorporated into the soil*

as sources of nutrients. The tuber yields from SY plots were in 1999 and 2000 significantly higher ($p < 0.05$) than those obtained from Y+C+M+P but in 2001 there was no significant difference between the yields. Again decreases in tuber yield were above 45% between 1999 and 2000 in SY and Y+C+M+P. Between 2001 and 2000 yield decrease in Y+C+M+P was <5% but in SY plots, it was 25%. The shape index of tubers was neither significantly affected by cropping systems nor over the three years as the overall variations ranged from 0-9%. Thus variation in yam tuber yields from sole yam plots and mixtures tended to narrow down with time. ***Key words:*** *Yam, Cropping systems, Alfisol, Eastern Nigeria.*

Source: *Scientia Agriculturae 3(3): 82-85 (2014)*

With the examples above I think I have tried to use the vast knowledge embedded in the bachelor of agriculture degree programme and that of soil science to show that I passed through the faculty and the department and both passed through me too. It was when I was wading through most parts of these various areas that one of our most amiable professors in the Faculty, Professor SAND Chidebelu, gave me a nick name:*Soil Economist*; a name which I whole-heartedly accepted. At the early days of the International Society of Tropical Root and Tuber Crops -AB, Professor F.I. Nweke asked me to represent him in Uganda and present the COSCA project. The COSCA project was more than 70% socioeconomics. When I returned to IITA after the presentation, Professor Nweke asked me how it went; I only told him that I tried. In less than one hour we met late Professor M. Dahniya who was the then President of ISRTC-AB, and Professor Nweke asked him how did this boy presented COSCA project?. His answer; “he did very well; I could not believe that he majored in soil science when he was presenting”. This comment tallied with the name Professor SAND gave me and the overall philosophy of the founding fathers of the faculty-university.

Now back to the title of my lecture. Please critically look at the questions raised on the title.

THE SOIL WE DO NOT KNOW

Where is the soil we do not know? Do you know where we can find the soil that has the following properties?

1. soil that is resistant and resilient to these forms of degradation without proper management?

a. erosion
b. leaching
c. salinization
d. climate change
e. flooding
f. soil-borne pests and diseases

2 . soil that can degrade

a. glass
b. plastics
c. graves made of concrete

3. soil that can support the following on sustainable basis without amendment

a. crop production
b. animal production (grazing)
c. forestry

If you know where the soil exists, please do not let us soil scientists know. Why? You would have succeeded in throwing all soil scientists in the world out of job.

FACT SHEET

I wish to borrow some important facts from Oladipo (2013) with some modifications.

Please know that:

- there are more living individual organisms in a tablespoon of soil than there are people on the earth

- almost all of the antibiotics we take to help us fight infections are obtained from soil microorganisms

- agriculture is the most essential industry on earth

- over 90% of the world's food comes from soil
- soil is a nonrenewable natural resource
- the best china dishes are made from soil
- about 70% of the weight of a text book or glossy paged magazine is soil
- putting clay on your face in the form of a "mud mask" is done to cleanse the pores in the skin
- "*Soil, and specifically sound soil management, is essential in our continued quest to increase the production of food, feed, fiber, and fuel while maintaining and improving the environment, and mitigating the effects of climate change. Being the essence of all terrestrial life and ecosystem services, we cannot take the soils for granted. Soil is the basis of survival for present and future generations.*

It is very crucial to note that soil degradation in the face of changing climate will lead to a vicious cycle of land degradation, biodiversity loss and increased climatic events that will further reduce food production and enhance food insecurity. The summary of the vicious circle is presented in Fig.8.

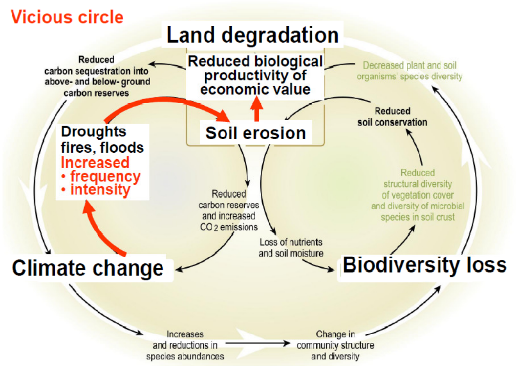

Fig. 8; Schematic representation of vicious circle associated with land degradation. **Source:** Safriel, 2011.

CONCLUSION

This lecture contains how the soils we know are formed, their characteristics which are due to factors and processes that led to their formation. The important roles soil play in the development and survival of a nations are highlighted with the emphasis that soil is life as man was made from soil (Genesis 2:7). Through misuse and disrespect we kill the soil and the consequences are grievous for any nation. The eleventh commandment is very clear on this. Some practices that can help resurrect a dead soil are presented. The research highlights span through some factors that give rise to soils, soil characteristics, uses and management of soils for sustainable agricultural production, soils and environment. For the dominant soils of southeastern Nigeria (alfisols and ultisols), cassava + maize + pigeon pea crop mixture is highly sustainable and recommended for adoption by the farmers. T**he soil we do not know** is a mirage or even an aberration**.** The characteristics of such a soil are currently unattainable. Soil scientists will continue to search for such a soil but less frantically to ensure job security.

ACKNOWLEDGEMENTS

This is the time to give due respect to all that deserve it. There is an adage that says *'Man proposes but God disposes'*. In this respect everything that had happened around me including this presentation is due to God's intervention. I sincerely thank the almighty for my journey so far and pray that he continues to guide my actions, against all temptations as I am very weak. I wish to sincerely thank my parents, Onyishi Onah Asadu (of blessed memory) and Obuloko Nkwoja Asadu for providing the avenue through which I was brought into this world. I know that they didn't choose to give birth to me neither did I know how it happened. It was God's decision. They, however, played the role of a modest and honest family and I have been battling to leave up to the tenets of their teachings- fear of God, honesty, chastity, simple life style, hard work, transparency and zero tolerance to quarrelling and fighting.

The role of my uncle, Onyishi Ani Asadu (the eldest man in my village now just like my father was), in my entire life, especially in my education. This role is central to this acknowledgement. He bore almost the entire expenses from my secondary school to the university. He knows that his investment was not wasted. That opened the gate for education career in the large family. As the first graduate in the family I can easily count more than ten graduates in the family including Dr.

(Mrs) E. Ezema (Nee Asadu) of the Department of Computer Science, UNN. I attribute this to the motivation I gave to them based on my own exposure. Most of them are girls as they appeared more obedient and followed my advice. Almost all are married now. The wives of my uncle (Obulokos Theresa, Agnes and Ester) made substantial contributions too as they always made sure that my stomach ‘didn’t riot’ when I sat down to read in those days. I must thank other members of the extended family namely Messrs. Emma Asadu, Matthew Asadu, Late Messrs. Joseph Ugwuanyi and Michael Ugwuanyi. My immediate elder brother, Mr. Moses Asadu, also made substantial contributions to my career likewise Mr Patrick Ezema. I thank all our in-laws for accommodating my sisters.

In the entire village of Amori, many also influenced my early life especially Mr. C.C Ottih, a retired Chief Supervising Principal, who found admission for me at Adada Secondary School, where he taught. He gave me some pieces of advice that helped me a lot. The same applies to late Professor JOC Ozioko (the first Professor from Nsukka town) especially when I came back as a graduate assistant. By family extension, I hereby thank my in-laws Chief and Mrs Anthony Odo and all their children as well as my co-in-laws Sir and Lady Steve Agbo, Messrs Emma Ezugorie (Ambassador) and Philip Ifejirika, Jude Ozioko for their continued support since my family linked up with theirs over 20 years ago.

I thank the Department of Soil Science for offering me admission while I was awaiting result because my first choice Department, Agricultural Economics, couldn’t despite my outstanding performance in the UNN entrance examination. Because of this, I took a firm decision to read Soil Science and I have no regrets whatsoever. The Department of Soil Science had some very stern and strict lecturers. The relationship some had with students then was like that between the cat and the rat. My set was actually about twenty in number but almost all of us graduated in Soil Science thereby disproving the impression that their strictness was ‘wickedness’. For the first time in the entire faculty, two of us obtained first class honours. This feat was like walking naked in Iceland at the Faculty that year.

I must appreciate all the lecturers namely Professors W.O. Enwezor, I. Unambah-Oparah, M.E. Obi, C.C. Mbah, Late JSC Mbagwu and NN Agbim, Drs B'isho Nwadialo and Otu Onofiok. The last but the most influential on my academic career, is Prof. F.O.R. Akamigbo. Apart from supervising my first degree project, he was also a co-supervisor in both my M.Sc and PhD degree projects. I owe him a lot and to reflect this one of the halls in my school has been named after him. If I have any other opportunity to do more, I will certainly do that. Thank you sir.

Late Professor Mbagwu was among the few lecturers that gave us hope that one could research and publish profusely in Soil Science and also travel around the world as a soil scientist. He was so liberal in his mentoring that he had some of our CVs off-heart. He completed a form for me which enabled me attend my first college on Soil Physics at ICTP, Trieste, Italy. He was able to list my publications in the form. He informed me after the form had been completed and I must say that it was that visit that opened my new chapter in Soil Science research. May his soul rest in perfect peace. Amen!

I wish to thank all my present colleagues in the Department namely: Prof. C.A. Igwe, Drs Peter Ezeaku and Godwin Nnaji (my first two PhD candidates), S. Obalum, Ify Uzo (Mrs), Messrs C. Jidere, J. Ene, B. Unagwu (London), Mrs. Okebalama (Ghana), Ms. Chibuike and Ms Ude. Dr. Ezeaku is the current Head of Department. I equally thank all the non-academic staff of old Messrs J. Ugwuanyi, Barr Chris Ezema, Mrs T. Ugwu and Joy Chigbu (all retired); late Messrs Eshette, Motoe, Obeta, Agada, Ekpete, Umeagudosi, Aloy Ekpete; Messrs Onwukwe,Onyemobi, B. Umeh, F. Okengwu, APA Odo, (my father-in-law), Attamah, Ibe, A and Messrs DG Ibe, Onwurah, Ossai all retired from the Farm Operations. I thank the servinig non-academic staff Mrs Nwabusi, Ali, Onovo Ugwu, Iwueze, Ngozi, Austin, Tony, Marta, F. Eze and M. Omeje

I must thank God especially because in over 30 years of my teaching and research in this university, I have not had any problems with my students. Apart from many undergraduates and PGD's, I have been able to graduate four PhD's, many M.Sc's and I have many in the pipeline. In fact some who had problems with their supervisors were moved to me and they graduated. My impression is that God is in charge. My first four PhD's; Drs P. Ezeaku, G. Nnaji, Afu and P. Ukaegbu are here.

My close relationship with Prof. F.I. Nweke, my second mentor started in 1980/1981 session when I was elected the President of National Association of Agric Students (NAAS) UNN branch. He was the staff adviser. The activity of that session alone will be more than this entire acknowledgement if I were to report it because it was that year that the Faculty had the best Agric week ever - attracting the then Minister of Agriculture (Hon. Awotosi), then Commissioners Ekpete, Igwe, etc NTC, CRIN, NIFOR etc UNN. So let me say that he showed me the way outside UNN for my research. He is still doing that. My PhD work on yam was sponsored by his yam study project and that marked my first contact with IITA. He was a co-supervisor. He introduced me to Dr. H.C. Ezumah, a man who mixes humility with hard work. Dr Ezumah was also in the team that supervised my PhD project and my exposure to agronomic research was from him.

After the yam study programme came the Collaborative Study of cassava in Africa under the leadership of Professor Nweke. It was this project that took me to four African countries. I just have to list here those Natural coordinators within the project. Late Dr B. Ugwu and Dr Gab Okwor, Professor M. Akoroda all in Nigeria, Dr Otim-Nape (Uganda), Professor Ramatu Alhasan and my amiable Kisiedu who gave us the name COSCARIANS (Ghana), Dr B Bukaka (Congo DR), Mr Mbuba (Congo BR), Dr Regina Kapinga (Tanzania;now in Bill-Milinda-Gates), Dr Ngeve (Cameroun) etc. I remember Professor Okorji as we traversed COSCA villages in Nigeria and Uganda interviewing farmers, harvesting cassava and collecting soil samples and when we were flying back and our plane had a problem and had to fly back to Congo BR. Who says God is not alive.

I must also thank the following IITA scientists who were involved in COSCA and other projects I have worked on- Dr D. Spencer then director RCMD, Dr R Asiedu, Dr R. Okechukwu, and recent collaborator Dr S. Hauser, etc

I must specially thank Dr Asiedu and Okechukwu for their support in yam cultivar evaluation I did here at UNN. I must repeat here that two of them helped to sponsor the seventeen participants from this university to the ISTRC-AB and the first Ghana yam in 2013. I also thank Dr Hanser for his help to enable me register for the Ghana yam. One person I must not forget in my association with IITA is Mr Ben Ilesami – Soft spoken but very intelligent and calculative. All the staff of COSCA are appreciated likewise the laboratory staff led by Dr Uponi who did most of my soil analysis. To cut the long story short what I have done to ensure that I will ever remember them like Professor Akamigbo is that the first building in my school is named **Professor F.I. Nweke Premier Block** and the Agric/Biology lab, **Dr H.C. BioAgric Laboratory** . Dr A.G.O. Dixon of IITA was so liberal in supporting my work on cassava as you can see from the few Abstracts I listed that in order to commemorate this, my school chemistry/Physics laboratory has been named **Dr AGO PhsiChem Laboratory.**

I thank Professor E.M. Igbokwe (our DVC, Administration) for recommending me to Dr L Are, the Chairman of the Board of University (Oxford) Press (UPL) plc, Ibadan for me to participate in writing a text book in certificate agricultural science for senior secondary school students. I was hinted by one of the senior editors of UPL during this years author's Forum on June 25, that the book is now the best selling in the country.

I send my warm greetings to members of the ICTP Associate and Federation Office led by Professor Giradi for providing the enabling environment for me to enjoy the Associateship programme. Professor C. Chidume is hereby remembered for making us (Nigerians) feel at home each time we visited Trieste, ICTP. IT was during one of my visits to Trieste that I had the opportunity to visit the Vatican with help of Fr. Bishop Goddi Onah, the present catholic bishop of Nsukka Diocese when was serving as a Professor in Vatican university, Rome. The experience is still very fresh in my mind and I remain grateful to him for hosting me.

I appreciate the opportunity given to me by the Dresden University, Germany to participate in a soil management course in 2000. Dr Nick Idoko introduced the programme to me and that made me to apply and I succeeded. I am grateful. I also wish to rember my former co-tenants at Obolo road especially Barr Igbokwe Aro's and Dr R. Mamma's families who did a lot for my family during those days I was always travelling.

It is absolutely difficult to mention the names of all my friends that I encountered thus far. However, I now have to mention Prof Fab Onah who wrote and read my citation. The entire members of the family are my friends including Rev Fr. Saba Onah. It is a long standing relationship and the only way you can get a glimpse of the idea is that my second building in my school is named **Professor Fab.O. Onah Multipurpose Block**. The Rev father has been virtually in all the activities organized in the school with Fab. Presently with the permission of the Rev father in charge of Edem Nru parish, he is now celebrating Sunday masses for the students in the school. God will reward you abundantly.

I must not forget my professional body, Soil Science Society of Nigeria led by Professor V Chude. When its annual conference was held here (UNN) in 2012. I was the LOC chairman. In an address by the Vice-Chancellor, I requested for a tractor and a bus for our faculty fourth year programme from the Hon minister of Agriculture and Rural Development. The minister, Dr Adesina, there and then granted our requests. Being among the audience I could hear double opinions. The first and loudest

"They have bought politics here – how can?"

"You know Asadu was in IITA with him, it is possible he can do something even if it was either".

The summary is that within six months through the effort of Prof Chude, the SSSN president and my class mates in Abuja, both the bus and the tractor with all implements were delivered to the faculty. These have brought some ripple effects? The faculty was able to win some WAAP projects on cassava multiplication, because of the availability of tractor and implements. The bus has been used for many trips by the fourth year students and all academic trips in the faculty since then. The most important of the academic trips was the attendance of the ISTRC-AB and the first yam conferences in Ghana last year. I hope the beneficiaries of the trip supported by IITA are here. So you can see why I owe a lot to SSSN. I also appreciate the society's recognition as a follow of the society last year. I can also see many of the active members here.

Members of the UNN Alumni Association, lions and lioness, how can I forget you? Those of you here both national and local officers are highly recognized and I very much appreciate the local branch led by Barr Nduka who recommended me for A Lion of Highest Achievement(ALOHA) award by the national body last year. May God reward you too. UNAA is a major stakeholder in this university and you will agree with me that the era of sitting on the fence is over. All hands must on deck. Lions and Lionesses!

I also have not forgotten the staff and students of Hillview Unique Schools (Secondary, Primary and Nursery Schools) Edem Nru Nsukka led by Mr V. Akubue and Chief C. Ozioko the respective principal and headmaster of the schools where I am trying to catch them as young as possible. I must mention the benefactors of the schools: Prof Fab Onah and his brother Rev father Saba Onah. Professors F.I. Nweke and F.O.R Akamigbo, Dr Julius Agbo, Chief Barr Okey Ezea, Hon Nia Nwodo (Ike Nsukka), Mr Laremo (London), Professor E.C. Okorji, Dr

P.I. Ezeaku, Chief Okwor of Ikem. Professor G. Oforma, Mrs. Kate Nwachukwu, Mr Ifeanyi Akamigbo, Dr Dom Ngwoke, Engr Inno Ike (south Africa), Barr O.C. P. Odo and family, Arc C.S. Eze, Dr C. Onyenago, Chief Ikechi C. Ozioko etc. These persons have either given outright scholarships, donated materials or supported best students in their choice of subjects in the school and almost all of them are still running.

The Vice-Chancellors of Michael Okpara University of Agriculture and Delta State University as well as my professional colleagues there deserve commendations for giving me the opportunity to serve in their universities as a visiting professor. I must mention Professor Erutor (DELSU) and A Asawalam (MOAU) in this respect. The colleagues from MOUA, you are welcome. ASUU strike prevented me from reaching my targeted contributions, I hope for another opportunity.

The prominent alumni of the Department especially Professors U.C. Amalu, A. Asawalam, Peter Nnabude, Nnena Ottih, Messrs E. Ude, Orih VC, Uche Egwnatu etc are welcome back to the Den.

I know members of several organizations I belong are here. Time will not permit me to recognize you by your names one by one. I sincerely welcome all of you.

The last but may not be the least. I thank my family for understanding my ways and even following greater part of my ways. My wife (Anthonia with tear rubber PhD), I must confess that from early days of our marriage knew that I was always on the road for that was the height of the COSCA study, so she never complained. Thanks to Professor Nweke for an early advice to her when he told her that Eugene (i.e. Prof Okorji) left for Tanzania a day after his weeding with IJe, and that she should not tie Charles (me) back. It has been well with us and the children, Nonso, Baby (Ogochukwu), Uchenna, the twins (Chibueze and Chiwetalu) and Uzo including Ms Nkiru Ugwu who has been with the family from the cradle. Whatever trouble they have been giving us is equal and opposite to the one we have been giving them. (Newton's third law of motion), implying stability in the family at any time. I thank all of them so far and plead with them to continue the good work because it is in their own interest too.

Nonso and Uchenna helped to type part of this presentation and, commend them for that specifically

Thanks for listening and God bless

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