UNIVERSITY OF ILORIN

THE ONE HUNDRED AND EIGHTY-THIRD (183RD) INAUGURAL LECTURE

THE UNRECOGNISED ARE ALSO IMPORTANT

BY

PROFESSOR PAUL OJO FATOBA
B.Sc., M.Sc., Ph.D. (OAU)
DEPARTMENT OF PLANT BIOLOGY,
FACULTY OF LIFE SCIENCES,
UNIVERSITY OF ILORIN

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The Vice-Chancellor
Professor Sulyman Age Abdulkareem
BChe, MChE (Detroit), PhD, ChE (Louisville), FCSN, COREN R Engr.(ChE)

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PROFESSOR PAUL OJO FATOBA

B.Sc., M.Sc., Ph.D. (OAU)
PROFESSOR OF PLANT BIOLOGY
DEPARTMENT OF PLANT BIOLOGY,
UNIVERSITY OF ILORIN, ILORIN, NIGERIA

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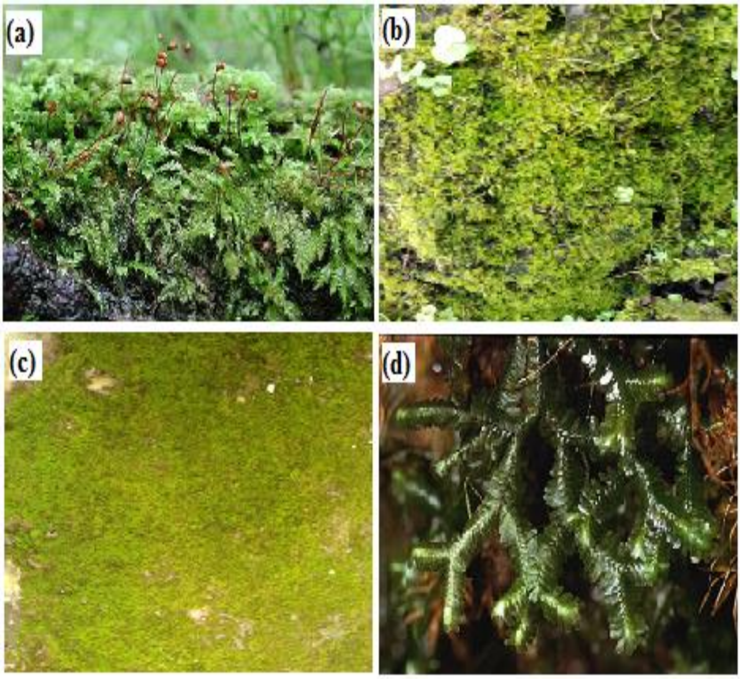

Samples of bryophytes growing on different substrates (a) *Brachythecium starkei*

(b) *Pelekium gratum* (c) *Barbula lambarenensis* (d) *Bazzania stolonifera*

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Other Members of Academic Staff,
Other Members of Administrative and Technical Staff,
My Lords: Spiritual and Temporal,
Members of My Family, Nuclear and Extended,
Distinguished Invited Guests,
Gentlemen of the Print and Electronic Media,
Great University of Ilorin Students,
Ladies and Gentlemen.

Preamble

Please permit me to start this lecture with this simple prayer, "In the name of the Father, and of the Son and of the Holy Spirit, Amen". I am highly delighted, humbled and grateful to the Almighty God and my Saviour, Lord Jesus Christ, for the grace for the journey so far and making me to reach this enviable position, the peak of my career. It is through His Grace that I have survived till today to present this Inaugural lecture. It is with great pleasure that I present the 183rd Inaugural lecture of

University of Ilorin. I am deeply humbled and privileged by your presence today as I deliver this Inaugural lecture.

An Inaugural lecture provides a golden opportunity for a Professor to give an account of what he has contributed to the pool of knowledge in his area of specialisation. Inaugural lecture means different things to different people. However, this Inaugural lecture is specially designed to appreciate God for the protection, guidance and opportunity accorded me to know this day. What shall I give unto the Lord? All I wish to say is “Thank you, Lord”.

I joined the then Department of Biological Sciences in 1994 through the assistance of the late Professor S. O. Oduleye. May God grant his soul eternal rest, amen. The Department comprised three units: Botany, Microbiology and Zoology, each awarding a degree programme. The Department was split into three full-fledged departments in 2004 and I belong to the Department of Botany, which was later changed to Plant Biology.

Today’s Inaugural lecture is the first in the Department of Plant Biology and the 6th by a Botanist/ Plant Biologist at University of Ilorin. The earlier lectures were given by Professors Olofinboba (late), Oyewole, Oladele (Late), Morakinyo and Etejere in the former Department of Biological Sciences. Today’s Inaugural lecture is the first on Lower Plants (Bryology) and also the first on Environmental Biology.

I therefore wish to thank the Vice-Chancellor and indeed the University for giving me this opportunity to present the 183rd Inaugural lecture of this University. It is an opportunity to give the account of my research activities in the last twenty-five years since I joined the service of the University as an Assistant Lecturer.

This is the day that the Lord has made, let us rejoice and be glad in it. I give thanks, glory, adoration, honour and thanksgiving to God who has made this day possible for me to stand before you to give account of my journey so far in this University, University of Ilorin. Since it is expected of all Professors of this University to give inaugural lecture, here I am to satisfy this requirement. What can I offer to the Lord for all His goodness to me? I will bring a wine-offering to the Lord to thank him for saving me. In the assembly of all his people, I will give him what I have promised (Psalm 116:12 – 14).

My journey started about sixty years ago when I was born to the family of the late Pa Christopher Fatoba and Mama Veronica Fatoba of Ijan Ekiti, Ekiti state. My parents had no formal education but I was given the foundation education which I built up to the highest degree, Ph.D. This was made possible with the assistance of God and God-sent people. To this effect, I am dedicating this inaugural lecture to my late father, Pa Christopher Fatoba. May God grant his soul eternal rest, amen.

Due to the poor financial standing of the family, I had to settle down to teaching in Primary school, though as an auxiliary teacher. I worked in the Barclays Bank (now Union Bank) for two years, from where I gained admission into University of Ife, now Obafemi Awolowo University, Ile-Ife. My dream was facilitated by Alhaji Sulaiman, the then Branch Manager of Union Bank who later became the manager of Muritala Muhammed way branch in Ilorin, who told me categorically that “In spite of your brilliant performances at trainings and office work, I will not recommend you for any promotion and in addition, you will be killed soonest, if you remain in the bank”. The message was taken with mixed feelings but it turned out to be a blessing. Thank you, Alhaji for the love and wise advice. May God bless you and your children.

I had a short working experience in Adeyemi College of Education, Ondo. This opportunity was made possible by the roles played by Drs A. M. Makinde and J.Fapohunda, now Professor and Miss M. T. Omolere, now Mrs M. T. Fatoba. Thank you for the love shown. It was late 1993 that the late Professor S. O. Oduleye, then on Sabbatical leave in the college, interacted with me and later facilitated my appointment as Assistant Lecturer in the Department of Biological Sciences, University of Ilorin, Ilorin. Professor Oduleye, may your soul rest in perfect peace, amen. Professor A. Sani was also instrumental to my coming to Unilorin, he brought my temporary appointment letter to me in Ondo. Oga, thank you for contributing to my joy that is being celebrated today.

The title of this inaugural lecture: "The unrecognised are also important" was coined from my experience in the journey of life and the plant studied (Bryophytes). Recognition and importance are two key words. These two words are related as recognition is usually given to whoever is important. However, this is not correct as every person is important and should be recognised. This can be supported by the Holy Bible.

God created man, other living creatures and the non living components of the world in six days (Gen. 1: 1-11) and rested on the 7th day (Gen. 2:1-4). God made man in his likeness (Gen. 1:27) and God looked at everything that he has made and he was very pleased (Gen.1:31). In summary, God created everything and everything was well created. Therefore, there is the need for all to recognise everything around us because everything created is important. Moreover, when God created man, every man was given at least one talent. This talent also attests to the relevance of everybody. The onus is now on how well one uses the gift(s). Bearing this in mind, there is the need to appreciate everything around us, the living and the non living. Although, God created everything and all these things interact and make available the resources and factors that are required for the survival of man. Ecologically, every organism occupies a niche (function) in the ecosystem. By extension, every organism in the environment contributes to the survival and maintenance of the environment hence the need for each organism to be recognised.

Whatever or whoever one recognizes means that it, he or she is important. That is, man recognises whatever or whoever is important. Importance or recognition is accorded to a man that is rich, powerful, in position of power or wicked. No wonder that the Yoruba adage says “Irinisi ni isonilojo’ which literarily means that “You are treated in the way you present yourself”. Generally, money, position, age and title are some of the indices that command or call for recognition. Moreover, a Yoruba adage further strengthens this idea ”Eni buburu ni ojo tie” which is literally translated as “A bad person has his own day”.

Mr Vice Chancellor,sir, the unrecognised are also important. For example, the dynamics of this world is being kept moving through the activities of the seen and unseen, plants and animals, living and non living things. Therefore, there is the need to accord everything and every person due recognition because everybody and everything are important. Even if only for the purification of the atmosphere, all plants deserve recognition.

Research Interest

Mr Vice Chancellor, Sir, my research interests are into three areas: (i) Bryology; ii) Environmental Biology; and (iii) Ethnobotany. Basically, I am a Bryologist by training, by application, an Environmental Biologist and I havediversified into herbal medicine. Bryology is simply the study of bryophytes (lower plants). The living world is made basically of plants and animals. As a Plant Biologist/ Botanist, I am interested in plants. Following the evolutionary trend, plants stand as follow: viruses (living or non-living), bacteria, fungi, algae, lichens**, BRYOPHYTES** and pteridophytes which are referred to as seedless plants or cryptogams; gymnosperms; and angiosperms which are both seed bearing plants or phanerogams. The study of each group of plant is known as Virology, Bacteriology, Mycology, Algology, Lichenology, **Bryology** and Pteridology, respectively. Each of these groups of plants belongs to specific divisions with peculiar or unique features.

From the trend highlighted above, bryophytes belong to the plant division, Bryophyta and their study is Bryology. Bryophytes are therefore the plant group that occupies the intermediate position between the lichens and formed through the symbiotic association between an alga (unicellular or filamentous) and a fungus (ascomycetes or basidiomycetes) and the pteridophytes .They are the second largest group of plants after the angiosperms. This is a group of plants with chlorophyll, better studied with the aid of hand lens because they are mesoscopic. This means that they are larger than the microscopics (viruses, bacteria, fungi, algae and lichens) but smaller than the macroscopics (pteridophytes and spermatophytes). They are cryptogamic, thalloid or leafy but with structures that look like roots called rhizoids and they are never truly differentiated into leaves and stems. The rhizoid is mechanical in function and never absorptive.

Bryophytes consist of three divisions: Anthocerotophya; Marchantiophyta or Hepaticophyta; and Bryophyta; three Classes: Anthocerotae; Hepaticae; and Musci; and over thirty six Orders. All these three Divisions are not similar in any way except that they share a similar life cycle. Their origins have been traced to green algae, specifically *Ulothrix* based on pigmentation and filamentous nature. Bryophytes grow in communities as cushions, turfs/ turves, carpets or mats, this has greatly contributed to their survival. These plants source for water and nutrients from their substrate through an external capillarity system (epi-organ, inter-organ or intra-organ (Ectohydrics) or by internal conduction as manifested by the endohydrics equipped with the hydroids and leptoids that function as xylem and phloem, respectively

Bryophytes are ubiquitous or cosmopolitan, growing in xeric, hydric and mesic environments on different substrates: tree barks (corticolous); soil (terricolous); concrete or rocks (saxicolous); rotten logs or decaying woods (epixylic); leaves (epiphyllous); termitaria; cattle dung or water (aquatic). These plants are able to colonise these substrates due to suitable pH, availability of moisture, nutrients and propagules. Their success on these substrates can be attributed to their ability to grow on substrates that are inhospitable to higher plants, thus excluding competition.

Bryophytes are naked (without cuticle), small in size, poikilohydric (adjust their water requirement with the available water in the environment) and have the ability to tolerate, detoxify or accumulate pollutants. All these features contribute to their survival in the environments they occur. Gimingham and Smith (1971) reported that bryophytes will grow uninterruptedly if water is supplied. However, they cannot complete their life cycle without water, hence are regarded as the amphibians of the Plant Kingdom.

Bryophytes are very important for the survival of life and to their environments. They are space vehicles, trapping CO_2 and releasing O_2 thus purifying the environment and acting as carbon capture or sinks. They are very important in this respect as they are next to angiosperms in respect of diversity and richness. Due to their community nature and growth forms, they help in preventing or controlling water erosion and can be used as lawns. Moreover, they possess very important phytochemicals such that people refer to them as reservoirs of active principles. In the light of these, they are sources of antibiotics and drugs. They are consumed as food (vegetables) by man and animals in the Arctic and Antarctic. Ecologically, they are used for metallic prospecting, pollution monitoring and geological prospecting. In spite of these unique values, bryophytes are bypassed without any recognition, trampled upon without any care just because their importance is not known. Mr Vice Chancellor, sir, "The unrecognised are also important''

My contributions to the study of bryophytes

The occurrence and establishment of bryophytes have been a matter of speculation. Bryophytes possess the gametophyte that is dominant and haploids. This thus places a barrier to the development of new species as any mutation accident will lead to the extinction of the species because there is no opportunity of sheltering the affected gene(s). Bryophytes reproduce asexually (through gemmae, tubers, bulbils, fragile leaf tips and persistent protonema), vegetatively by regeneration (leaf, stem, rhizoids, seta, and capsule) and sexually (oogamy). Bryophyes are considered to form a group marked with great antiquity and evolutionary conservatism (Crum, 1972; Iwatsuki, 1972; Wyatt and Anderson, 1984). The reproductive biology of bryophytes is so in contrast to other terrestrial plants, that one cannot extrapolate the reproductive mechanism of the latter onto the former (Longton and Schuster, 1983). Sexual reproduction plays a minor role in the reproductive processes in most groups of bryophytes. Although, spores germinate on the experimental cultures that resemble natural substrates, the successful establishments of gametophores from spores in the field remain questionable (Longton and Miles, 1982; Miles and Longton, 1992).

Based on these assertions, the effectiveness of spores in the establishment of mosses on natural substrates was investigated. Spores suspensions made from the mature spores of *Hyophila involuta* and *Bryum coronatum* were poured onto sterilised concrete blocks, and monitored. It was observed that the spores germinated into protonema but only those of the *B. coronatum* developed into gametophores, produced gametangia and sporophytes at the same time with those in the natural populations. The study showed that *B. coronatum* can be propagated by spores while *H. involuta* cannot and, thus, is asexual (Fatoba, 1996).

Bryophytes grow on different substrates such that some are substrate-or phorophyte-specific. In order to identify the relevance of substrates to spore germination, the effects of tree barks and decaying woods (substrates) on spore germination of *Bryum coronatum* and *Trichosteleum papillosum* were investigated. Miles and Longton (1990) opined that the facility required for gametophores establishment from spores artificially planted in the field differs critically between species but is related to other aspects of their life history strategies. Decaying wood of *Tabernamontana pachysiphon* at three different stages of decay (early, middle and late) and tree bark of *T. pachysiphon* tree were oven dried, ground and incorporated into Parker's medium (Klekowski, 1969) solidified by 1.5% agar. The result showed that the substrates affected the spore germination of the two species. *B. coronatum* had greater percentage germination on agar only and 0.8g/l of tree bark, D_2 and greater than 0.8g/l (Table 1) suggesting that the required nutrients are likely to be available in later decayed wood. *T. papillosum* is an epixylic moss. This is further confirmed by its performance on all the treatments with the substrates supplemented with middle stage (D2) and late stage(D3) 0f wood decay and the very low spore germination in the Control. This study confirmed that the type of substrates affect spore germination and the growth of bryophytes (Fatoba, 1996).

Table 1: The % spore germination of mosses on the agar-substrate media

Moss	Amount of Substrate (mg/l)	% Spore Germination			
		T_B	D_1	D_2	D_3
Bryum coronatum	0.0 (agar)	80.6	80.6	80.6	80.6
	0.8	82.7	47.1	83.2	67.7
	1.6	58.4	55.1	57.9	85.2
	2.4	60.5	57.1	69.1	76.4
	3.2	65.7	49.6	68.6	72.1
Trichosteleum papillosum	0.0 (agar)	26.9	26.9	26.9	26.9
	0.8	11.4	54.6	76.2	82.3
	1.6	28.2	20.5	67.2	75.3
	2.4	24.5	13.8	70.6	78.0
	3.2	7.3	11.9	69.8	82.2

T_B –Tree Bark, D_1----Early Stage of Decay, D_2---Middle Stage of Decay, D_3—Late Stage of Decay

The procurement of nutrient and water by bryophytes was investigated because true mosses are ectohydrics without roots and cuticles. Fatoba (1997) investigated the nutrient status of throughfall/ canopyfall in the mature secondary forest of Obafemi Awolowo University campus. It was discovered that Mg, K, Na, Ca, $NO_3^- - N$ and $PO_4^{3-} - P$ were leached from the canopy of the vegetation in appreciable quantities far more than the freefall (rainfall) to satisfy the needs of saxicolous, terricolous and epixylic mosses (Fatoba,1997). This study compared favourably with the findings of Bates (1978), Wittig (1986) and Okeke and Omalika (1991). Furthermore, the results showed this trend of nutrient enrichment: $K^+ \geq Mg^{2+} > Ca^{2+} \geq Na^+ >>> NO_3 - N > PO_4^{3-} - P$ from the onset of the rainy season, March to May, but the trend changed from June to October to $Mg^{2+} > K^{+} > Na^{+} > Ca^{2+} >>> NO_3^{-} - N > PO_4^{3-} - P$.

Fatoba (1997) assessed the nutrient status of the stem flow in relation to the mineral nutrition of corticolous mosses and epiphytic flora in a tropical rainforest of Southwestern Nigeria. The result showed that the mineral nutrients of stem flow vary with plant species such that the rough- barked species tend to release more nutrients than the smooth-barked. It was found that K^{+} was the most leached at the beginning of rainy season but Mg^{2+} took over the lead when rain became intensive. Potassium, magnesium, nitrate-nitrogen, phosphate-phosphorous, sodium and calcium were found in the stem flow, though in varying quantities. The least leached was phosphate-phosphorous which was present in traces. Calcium and magnesium concentrations increased as the rainy season progressed and with increase in rain days and total rainfall. The Mg^{2+}, Ca^{2+}, $NO_3^{-} - N$ and PO_4^{3-} - P concentrations correlated positively with total rainfall (Fatoba, 1997).

The induction and development of gametangia and sporophytes of moss species are affected by environmental factors (Longton, 1972). Most of these plants require differential optimal temperature for the induction of sex organs. In line with this, the effect of photoperiod on the development of gametangia and sporophytes in *Bryum coronatum* Schwaegr and *Hyophila involuta* Hook Jaeg was investigated. The two populations were subjected to five different photoperiod regimes: 6 hours; 8 hours; 10 hours; 12 hours and natural light period (Control). The maturity indices of the two moss populations were calculated thus:

$$\text{Maturity Index} = \frac{\text{Index rating} \times \text{Number of gametangia/ sporophytes}}{\text{Total number of gametangia/ sporophyes}}$$

Fatoba (1997) observed that photoperiod less than 12 hours failed to induce gametangia formation and subsequent sporophyte formation in *Bryum coronatum.* In *H. involuta*, neither 12 hours nor less than 12 hours per day was effective in initiating gametangia. The 6, 8 and 10 hours exposure reduced the photosynthetic pigment. The treatments where the photoperiod was not regulated produced gametangia and sporophytes copiously. It was found that the photoperiod is an important factor in the induction and development of sex organs and sporophytes in these plants. This confirmed the findings earlier reported by Chopra and Bhatla (1981) and Chopra (1984).

Reproduction is an important aspect of the life of any organism as it ensures survival of the species. In the light of the relevance of reproduction to the continual existence of bryophytes, reproductive phenological studies were carried out on three selected tropical African mosses in South-western Nigeria. Phenological study may be used to investigate the factors that are paramount to the development of a given stage in a species. It also helps in interpreting physiological responses such as the control of gametangial initiation (Chopra and Bhatla, 1983). From literatures, some species of bryophytes produce sex organs every year while some never produce. The species that produce sex organs exhibit a pattern of developmental stages. There are four different stages in gamete production: Juvenile; Immature; Mature; and Dehisced, each with an index of 1, 2, 3, and 4, respectively. Moreover, sporophyte formation involves nine different stages: Swollen Venter (SV); Early Calyptra in Perichaetia (ECP); Late Calyptra in Perichaetia (LCP); Early Calyptra Intact (ECI); Late Calyptra Intact (LCI); Early Operculum Intact (LOI); Late Operculum Intact (LOI); and Operculum

Fallen and Fresh. The indices are 1 to 9, respectively. All these stages are involved in the computation of the phenology of a species.

Fatoba (1998) investigated the reproductive phenology of *Hyophila involuta, Bryum coronatum* and *Barbula. lambarenensis* growing in the secondary forest of Obafemi Awolowo University campus. It was found that the selected mosses exhibited a clearly defined seasonal cycle of gametangial development which starts at the onset of the rainy season (March/April). Fertilisation could be assumed to have taken place in June in *H. involuta* and in July in *B. coronatum* and *B. lambarenensis.* These assumptions were based on the occurrence of mature antheridia and archegonia and early stages of sporophytes during these months. Development of gametangial took 2 – 3 months, while sporophyte development was 6 months for *B. lambarenensis* and seven to eight months in *Bryum* and *Hyophila* species. The maturation cycle lasted for eight months in *B. lambarenensis* and nine to ten months in *B. coronatum* and *H. involuta*. The reproductive cycle occurs every year in *Bryum* and *Hyophila* but at alternate years in *Barbula lambarenensis.*

The occurrence of plants in a particular environment is not by coincidence but a response to so many factors, environmental or innate. On this note, the distribution of bryophytes has been described as cosmopolitan as they occur virtually in all habitats. Some factors have been identified as being important in the distribution of bryophytes. The pH, moisture and nutrient status of substrates, availability of propagules and nature of substrate or phorophytes are some of these factors.

Therefore, investigation into the relevance of nutrients statuses of the substrates in the distribution of mosses was undertaken. This research involved the chemical analyses of decaying woods and tree barks that accommodate the mosses. Identification of mosses encountered on the substrates collected were *Trichosteleum papillosum* Hornsch.) Jaeg., *Stereophyllum leucoimoides* Brenth & Par. and *Thuidium gratum* (Pal) Jaeg. (on decaying woods), and *T. gratum*, *Fissidens glauculus* C.M. and *Calymperes afzelii* SW (on tree barks) (Fatoba, 1999). The results of the study showed that the nutrient statuses of the substrates are important in the occurrence of bryophytes. Furthermore, *T. papillosum* and *S. leucoimoides* were obligately epixylic while *T. gratum* could be either corticolous or epixylic. From the study, it could be inferred that decaying woods of 20 - 45 ppm Na, 40 – 70 ppm Ca and less than 1.50 ppm NO_3^- – N, 35 – 45 ppm Na, 75 – 150 ppm Ca and less than 3 ppm NO_3^- – N and 28 – 50 ppm Na, 40 – 200 ppm Ca and less than 2 ppm NO_3^-–N would support the growth of *Trichosteleum papillosum*, *Stereophyllum leucoimoides* and *Thuidium gratum*, respectively. The result also suggested that Na, Ca and NO_3^- – N are important in the occurrence of these mosses.

Some mosses grow on substrates that are inhospitable to higher plants, such as rocks, hence there is the need to study the ecology of mosses growing on sandcrete materials. Fatoba (2000) undertook an ecological survey of mosses growing on sandcrete materials in Kwara state in a bid to identify these plants and the chemical status of these substrates. Two hundred sandcrete materials with mosses growing on them were collected, moss species growing on them identified, and the pH, calcium, magnesium, potassium and sodium contents of the substrates quantified titrometrically and by flame photometry. It was found that *Barbula lambarenensis, Bryum coronatum* and *Hyophila involuta* were the moss species growing on collected sandcrete material. Furthermore, the substrates were all slightly alkaline (7.62 – 8.22). The ecological range of *B. coronatum* could be delimited from those of *H. involuta* and *B. lambarenensis* by the Na, Ca, Mg and K contents of the substrate while *H. involuta* and *B. lambarenensis* colonised same substrate but can be delimited by the pH status of the substrates (Table 2).

Table 2: Comparative Analysis of the Chemical status of Sandcrete Substrates

Species (n = 133)	pH	Ca	Mg	Na	K
H. involuta vs B. coronatum	1.59ns	3.65**	2.10*	7.14**	3.49*
B. lambarenensis vs B. coronatum	1.79**	0.30ns	0.36ns	0.82ns	0.05ns
B. coronatum vs B. lambarenensis	0.67ns	3.02**	2.82*	5.87**	1.78*

* and ** denote significant mean at 0.05 and 0.01 α-level respectively.
ns denotes non-significant mean.

This study further confirmed the relevance of the pH and ionic composition of the substrate in the occurrence, distribution and luxuriant growth of mosses. This observation is in agreement with the findings of Hopkins (1964) and Parsons (1968).

Reproduction is an important feature in the development, establishment, maintenance as well as the spread of population in all living organisms. In bryophytes, this process is accomplished by the production of genets (products of sexual reproduction e.g. spores) (Harper, 1977). Generally, sexual reproduction is effective in maintaining a degree of genetic flexibility in the majority of bryophytes involved in out crossing, however, spores produced by inbreeding species are similar to the asexual propagules as no genetic flexibility is involved (Mishler, 1988). Very little information is available on the spore sizes and output of tropical African mosses. Production of large number of spores has been observed as a compensatory factor for low fruiting frequency in some species populations.

In the light of the paucity of information on spore output and size of tropical mosses, Fatoba (2000) investigated the spore output and sizes of seven tropical African mosses: *Bryum coronatum* Schwaegr; *Hyophila involuta* (Hook) Jaeg; *Octoblepharum albidum* Hedw; *Calymperes afzelii* Sw; *Barbula lambarenensis* (Hook) Spreng; *Stereophyllum radiculosum* (Hook) Mitt.; and *Thuidium gratum* P. Beauv.) (Jaeg) through the use of Haemacytometer Chamber (Longton and Miles, 1982) and Ocular micrometer calibrated with stage micrometer at x10 objectives, respectively. The selected moss species were collected from different locations within Ile-Ife ($07^0$12'N $04^0$40'E) and Ondo ($07^0$5'N, $04^0$55'E) situated in the tropical rainforest belt of southern Nigeria. The study observed numerical and significant differences between sites and years.

All the seven selected species were isosporous (same-sized spores) except *Calymperes afzelii* that was anisosporous (different- sized spores) (Fatoba, 2000). Moreover, all the selected species produced spores copiously except *B. lambarenensis* that produced few spores (Table 3). Variations in spore output were observed between years in the seven moss populations, between localities and between species. These variations can be attributed to differences in the microclimate.

Table 3: Spore output and sizes of some selected tropical African mosses

Species	Study site	Mean spore output (x 10^3)	Spore size range (mm)
Bryum coronatum	Ife	585 ± 100 – 625 ± 110	7.8 -11.7
	Ondo	570 ± 85 – 605 ± 119	
Hyophila involuta	Ife	312 ± 64.4 – 335 ± 41.2	9.1 – 13.0
	Ondo	315 ± 66.9 – 330 ± 58.7	
Octoblepharum albidum	Ife	250 ± 40.8 – 270 ± 53.8	14.3 – 20.8
	Ondo	250 ± 47.1 – 262.5 ± 37.7	
Calymperes afzelii	Ife	250 ± 40.8 – 258.5 ± 46.9	7.8 – 22.1
	Ondo	265 ± 47.4 – 270 ± 48.3	
Barbula lambarenensis	Ife	345 ± 49.7 – 365 ± 58	1.3 – 6.5
	Ondo	345 ± 40.5 – 360 ± 51.6	
Stereophyllum radiculosum	Ife	260 ± 51.6 – 270 ± 42.2	13.0 -16.9
Thuidium gratum	Ife	310 ± 39.4 – 320 ± 35	3.9 -11.7

The growth of plants is associated with their success in any ecological zone. To this effect, the growth performances of *Trichosteleum papillosum* and *Thuidium gratum* were monitored on their natural substrate in the secondary mature forest in Obafemi Awolowo University, Ile-Ife (Fatoba, 2001). The growth increment was measured using white thread and meter rule. Fatoba (2001) observed that the moss species exhibited very slow growth and growth only occurred during the rainy season when moisture and nutrients were readily available. *T. papillosum* exhibited continuous incremental growth while *T. gratum* had its maximum incremental growth in September when rainfall was highest. The study further revealed highly significant positive correlations between their growth performance and number of rain days and total rainfall. *T. papillosum* had an annual incremental growth range of 0.8 – 8.1 mm while *T. gratum* had 2.5 -6.3 mm.

Chlorophyll contents of the leaves may limit photosynthesis and plant growth. Adelusi and Adenegan (1991) affirmed that chlorophyll can be used as an index of organic matter production. Raeymaker and Longwith (1987) reported that the determination of the chlorophyll contents in plant is a useful estimate of the primary productivity and has been used as bioassay of environmental stresses in eco-physiological researches. Fatoba and Ogunbiyi (2003) monitored chlorophyll accumulation in three acrocarpous moss species in their natural habitats in Araromi Opin, Ekiti Local Government Area of Kwara State. Moss samples were separately collected monthly, chlorophyll extracted with 99% Dimethyl sulfoxide (DMSO) and the chlorophyll concentrations determined spectrophotometrically. Chlorophylls a and b were calculated using Arnon (1949) formulae and the total chlorophyll with Strain and Svec (1966) formula.

The results from the study revealed that chlorophyll content increased from the onset of rainy season (April to July (first peak), reduced in August and increased in

September (second peak) in *Barbula lambarenensis* and *Bryum coronatum*. Chlorophyll a increased from April to August but reduced in September in *Hyophila involuta*. Chlorophyll a was found to be more than chlorophyll b and chlorophyll a/b ratio of 1.7:1 was found for *B. lambarenensis*, 1.8:1 for *Bryum coronatum* and 1.5:1 for *Hyophila involuta*. The total chlorophyll content of *Bryum coronatum* (5.65±1.27mg/g) was statistically the same ($p>0.05$) with that of *Hyophila involuta* (5.61±3.73mg/g) but were statistically ($p\leq0.05$) lower than that of *B. lambarenesis* (8.81±5.33mg/g). The implication of this result is that the higher the chlorophyll content, the greater the amount of light absorbed by the leaves. The study concluded that mosses are efficient space vehicles enhancing the purification of the environment thus contributing to the survival of man.

Fatoba and Udoh (2008) investigated the effects of some heavy metals: Pb; Cu; Cd; Fe; and V furnished through different salts on the chlorophyll accumulation in *Barbula lambarenensis.* Ten different regimes of moss populations were separately and appropriately irrigated with 1000 ppm and 2000 ppm of the heavy metal solutions with the control irrigated with distilled water. The result of the study showed that the metals caused some damage to the chloroplast leading to change in colour from bright green to light green, yellowish green or brown (chlorosis).The study concluded that the two concentrations of these metals are toxic to the moss plant. The effect is concentration dependent. The result further confirmed the use of *B. lambarenensis* as bio-indicator of heavy metals.

Fatoba *et al*. (2010) researched into the effects of petroleum products on the chlorophyll accumulation in *B. lambarenensis*. Seven regimes of the plant were irrigated with borehole water for two weeks to bring about hydration of the plants. Dual Purpose Kero (DPK) commonly known as kerosene, Premium Motor Spirit (PMS) known as petrol and Automobile Gas Oil (AGO) known as diesel were used as irrigants at other days for twenty weeks. The 100% DPK, PMS and AGO were used for irrigation for two weeks followed by irrigation with borehole water. Chlorophyll a, b, and total chlorophyll of the moss were extracted with 80% acetone and their concentrations determined with the use of Spectrophotometer model camspec 105. Chlorophyll a, b and total chlorophyll concentration determined with the use of Arnon (1949) and Strain and Svec (1966) formulae. The 50% concentration of the petroleum products increased the chlorophyll contents although it was statistically same with the control at $p \leq$. 0.05. The trends of the chlorophyll contents are as follow:

50% concentration; Control > DPK > PMS.> AGO (numerically)
100% concentration: (chlorophyll a) Control ≥ AGO ≥ PMS ≥ DPK
(Chlorophyll b) AGO, DPK, Control, PMS
Total chlorophyll AGO, DPK, Control PMS

Petroleum products (100%) followed by water had more severe effects on chlorophyll accumulation. All the 3 products reduced the chlorophyll b and total chlorophyll but increased chlorophyll a contents.

Bryophytes as biopesticides

The high cost, toxicity, undesirable effects on non-target organisms, resistance of the strains and non environmental friendliness have rendered the chemical method of the pest control unpopular hence a shift to the use of biopesticides. Fatoba and other researchers investigated the biocidal effects of some tropical moss extracts against maize stem borers. *Calymperes afzelii* SW, *Thuidium gratum* (P.Beauv) Jaeg, *Bryum coronatum* Schwaegr and *Barbula lambarenensis* powders were evaluated for their *in vivo* insecticidal activity against maize stem borers. Aqueous solution containing 5 g of each pulverised moss sample in 100 cm^3 distilled water was used to smear the surface of 2-month old maize plant shoot with the aid of paint brush at 3 day intervals for 3 weeks with Tricel treated as the control. Aqueous extracts of *C. afzelii* and *B. coronatum* showed encouraging toxic activity /deterrent activities and promptness that were better than, or just as good as, with Tricel, the control inorganic insecticide. The trend of effect is as follow:

C. afzelii >*B. coronatum* > *T. gratum* =*B. lambarenensis*

C. afzelii, *B. coronatum* and *T. gratum* significantly ($p < 0.05$) reduced the incidence of stem borers in the most preferred internode III while *B. lambarenensis* like Tricel restricted the incidence of the borer holes to internodes III and IV. The study concluded that these moss plants would be good bio-pesticides for the control of stem borers in maize (Ande *et al*., 2010). This would be of advantage considering their availability, low cost, ease of application and environmental friendliness. The unrecognised are also important.

Food is a vital resource in the world as the availability of food on the table translates to peace of mind, survival and national development. It must be borne in mind that most of the foods consumed in Nigeria are carbohydrate and less of protein, thus resulting in malnutrition and kwashiorkor in children. The cheapest source of protein is cowpea (24.8% protein) (Davis *et al*., 1991). Sequel to this background, Fatoba and Akolo (2010) investigated the effects of some cryptogamic extracts on the primary productivity of *Vsigna unguiculata* in the bid to enhance its productivity. This is based on the fact that natural products from some plants offer great potentials for the development of new and potent pesticides. The hot and cold aqueous extracts of *Barbula lambarenensis*,(moss), *Dryopteris flix-max Nephrolepis davalloides, Phymatodes scolopenta* and *Platycerium angolense* (pteridophytes), *Azadrachta indica* (angiosperm) and karate 2.5EC (chemical) were appropriately used to irrigate the cowpea plants twice a week during flowering. It was found that of all the treatments other than the cold extracts of *B. lambarenensis,* extracts of *Dryopteris* and *Nephrolepis* showed better performance in respect of number of pods,, number of seeds per pod, number of pods per plants, filling potentials and weight of seeds per plant than the untreated control. Whereas, hot aqueous *B. lambarenensis*, both extracts of *P. scolopenta*, *P. angolense* and *A. indica* *c*ompared favourably and even better than the regime treated with karate (Table 4). The study concluded that production of cowpea will be enhanced with the use of these biopesticides. The unrecognised are also important.

Table 4: Effects of cryptogamic extracts on the primary productivity of cowpea

Extract	Number of pods/plant	length of pods	Number of seed/pod	Number of seeds/plant	Mean weight of seed/plant
B. lambarenensis (hot)	5.3±1.5[b]	15.7±6.8[a]	7.6±0.5[c]	40.28[c]	16.5±1.0[a]
------------------ (cold)	1.0±0.0[e]	4.8±0.0[c]	0	0	2.1±1.3[a]
Pteridophytes					
D. flix-max (hot)	1.0±0.0[e]	8.0±0.0[b]	0	0	2.0±1.1[e]
---------------- (cold)	1.0±0.0[e]	7.9±0.0[b]	0	0	1.6±0.8[e]
N.davalloides (hot)	1.6±0.8[e]	12.7±0.0[a]	6.0±0.0[c]	9.6[e]	11.5±0.0[bc]
----------------- (cold)	2.6±1.5[d]	14.0±0.0[a]	8.5± 0.7[b]	22.0[d]	16.5±1.0[a]
P. scolopenta (hot)	4.0 ±2.3[c]	16.5±1.9[a]	11.5±0.7[a]	46.0[b]	13.3±2.0[b]
----------------- (cold)	1.6±1.1[e]	14.9±4.0[a]	9.5±2.6[a]	15.2[e]	14.7±1.0[ab]
P. angolense (hot)	5.0±3.3[bc]	15.2±0.3[a]	10.3±1.5[a]	51.5[b]	12.7±0.9[b]
------------- (cold)	6.5±3.8[b]	14.7±1.0[a]	11.5±3.6[a]	74.8[a]	10.3±1.5[c]
A. indica (hot)	9.3±4.7[a]	14.2±2.5[a]	7.8±4.3[b]	72.5[a]	17.1±2.1[a]
-------------- (cold)	8.5±4.7[a]	13.4±4.2[a]	9.6±3.2[a]	81.6[a]	15.2±1.7[a]
Karate (chemical)	3.8±1.8[c]	13.3±2.4[a]	6.3±3.3[b]	23.9[d]	14.3±1.1[ab]
No treatment	2.8±1.3[d]	13.5±2.4[a]	4.9±0.7[d]	13.9[e]	5.0±0.6[d]

Values with the same superscript are statistically the same at $p<0.05$.

Biopesticides are better than chemicals as they are natural, biodegradable, more effective, non toxic and environmentally friendly. Fatoba and his co-researchers investigated the effectiveness of moss plants as biopesticides against *Sitophilus zeamais*. The tropical moss powders effectively inhibited the insects (pests) hence are insecticidal and can therefore be used to increase the shelf life of maize and other grains (Wahedi *et al.*, 2012).

Bryophytes as bioindicators and biomonitors of environmental pollution

Although bryophytes are not recognized, they are very important in the survival of man. This group of plants ranked second after angiosperms in their diversity. Mosses show a fair degree of plasticity and adaptation to different climates (Longton, 1979) and to different environmental conditions (Proctor, 1979). Aside from being space vehicles (purifiers), they are vital as indicators of environmental pollution. In this capacity, bryophytes can ordinarily indicate the presence or absence of a metal (metallic prospecting) or pollutants (indicator). Moreover, some of these plants accumulate the pollutants in many folds in the extracellular spaces with/without much damage (accumulators or hyper-accumulators).

In order to affirm these facts, Fatoba and co-researchers investigated the potential of *Barbula lambarenensis* as a bioindicator of environmental pollution The research was carried out to ascertain the tolerance of this moss to 1000 and 2000 ppm of Pb, Zn, and Fe through the irrigation of different populations of the moss using distilled water for the control. The study revealed that rather than the different metallic solutions causing death, colour change from green to white/brown (chlorosis) was observed, which suggests that *B. lambarenensis* can be used as the bioindicator of Zn, Pb and Fe (Ajibade *et al*., 2002)

Fatoba and Oduekun (2004) assessed the metal deposition in Ilorin metropolis using mosses as bioindicators. Moss samples were collected from ten different strategic environments in Ilorin. The Cu, Cd, Ni, and Cr contents of these moss plants were determined using Atomic Absorption Spectrophotometric method. The results showed that Ilorin was free from Cr pollution while the other three metals were present in very low concentrations (Table 5). The result may be linked to few industrial activities in Ilorin.

Table 5: Mean concentration of some heavy metal loads (ugg^{-1}) in sampled moss plants in Ilorin

Location	No of Sample	Cd	Ni	Cu	Cr
Detergents Ind.	8	90±28	650±93	50±1	0.00
Unilorin (mini campus)	14	70±52	730±190	50±43	0.00
ITC	6	40±0.00	1400±219	120±33	0.00
RAJRAB Pharmacy	6	30±27	470±52	70±10	0.00
Mark Petrol Station	2	80±0.00	1000±0.00	0.00	0.00
Tanke	6	60±18	570±52	80±40	0.00
Fate	4	60±12	500±116	0.00	0.00
Unilorin Permanent site	14	70±36	1666±346	30±33	0.00
NNPC	4	70±12	1051±454	110±17	0.00

The studies on the location and forms of the metallic contents in mosses may give meaningful understanding of the biomonitoring of contaminated environments (Brown and Brumelis, 1996). It is on this note that the pollution status of a mega cement factory in South west Nigeria was investigated by Ogunkunle and Fatoba (2012). The heavy metal load in *Barbula* *lambarenensis* around the factory was used to infer the heavy metal pollution load. The moss plants collected were digested and the Pb, Cu, Cr, Cd and Zn contents of the extracellular, intracellular and particulate fractions were determined.

The results of this research showed that Pb, Cu and Zn had higher concentrations in the intracellular compartment while Cr and Cd were more concentrated in the extracellular compartment of the moss plant. The solubility of these metals across the cell membrane (ratio value) were 41% (Cu), 43% (Cr) and 43% (Cd) which showed that they were more soluble hence their high bioavailability and toxicity. Solubility of Pb (49%) and Zn (54%) were relatively low leading to low toxicity. In intracellular bound, Pb and Cu rated highest while the particulate fractions had the least recorded concentrations. The moss plant was found to be moderately polluted in all the studied locations with the Contamination Factor (CF) range of 1.14 – 1.84. The CF and Pollution Load Index (PLI) were between 1 and 3 suggesting slight to moderate pollution. PLI >3 shows severe pollution. The metallic loads obtained were 11.9±4.58, 5.6±1.62, 3.0±.83, 1.8±0.31 and 2.4±0.78 mg/kg for Pb, Cu, Cr, Cd and Zn, respectively, all greater than the control.

Fatoba *et al.* (2012) further investigated the relevance of mosses in pollution monitoring by assessing the heavy metal deposition in the atmosphere. Mosses with their substrates were collected from the guinea savanna and tropical rainforest biomes of Southern Nigeria during the dry season. The moss samples were identified and the plants and the substrates digested and analysed for the Pb, Cu, Zn, Fe, Cd and Cr contents. The heavy metal loads of the moss samples and the substrates were correlated.

Mosses identified were *Barbula lambarenensis* and *Hyophila involuta* (most occurred), *Thuidium (*now *Pelekium) gratum, Octoblepharum albidum* and *Calymperes afzelii*.

The metallic loads are as follow: Pb (0.22 – 10.68, 0.00 – 12.21ugg^{-1}); Cu (2.22 -26.62, 4.87 -28.21ugg^{-1}); Zn (9.75 – 65.43, 10.48 -74.18ugg^{-1}); Fe (111.6 – 961.9. 126.7 – 978.2ugg^{-1}); Cd 0.01 -2.70, 0.01 – 1.83ugg^{-1} and Cr (0.00 – 1.73, 0.00 – 1.07ugg^{-1}) for mosses and substrates, respectively. When these concentrations were correlated, high and significant r values (except for Pb) were obtained: r =0.39; r= -0.85; r= -0.66; r= -0.62; r= -0.94 and r= -0.73 for Pb, Cu, Zn, Fe, Cd and Cr, respectively. The results showed inverse relationship and further confirmed the ability of mosses as biomonitors (Fatoba *et al*., 2012). The Vice Chancellor, Sir, the unrecognised are also important.

The atmospheric metal depositions in the industrial areas of Lagos and Ogun States were investigated by Fatoba *et al.,* (2012). Moss samples were collected from industrial areas of Lagos and Ogun states to assess their levels of pollution. The results revealed that Ogun state was more polluted than Lagos state with Cd, Ni, and Cu while Lagos State had more of Pb but the Ag, As and Cr (<1mg/l) loads of the 2 states were statistically the same at $p<0.05$. The results further showed that the Pb, Cd, Cu and Ni concentrations were less than 10mg/l while Ag, As and Cr were less than 1 mg/l (Fatoba *et al.,* 2012) However, these concentrations are above the recommended limits of FEPA, NESREA and European Committee suggesting that both Lagos and Ogun states are highly polluted.

The use of *Barbula lambarenensis* as bioindicator of heavy metals was investigated by Fatoba and other co-researchers. This approach was sought because of its reliability and ease at getting data. The moss samples were collected from Abuja, Ilorin and Kaduna. It was found that Zn load of the moss was higher, Pb, Cu and Ni loads were moderate while Cd and Cr were relatively lower across the study cities. All the metals were highest in Abuja followed by Ilorin then Kaduna (Ogunkunle *et al.,* 2015). The observed results can be hinged on the level of industrialisation, urbanisation and human activities in these cities.

Fatoba and his co researchers assessed the environmental quality around industrial areas of Jos and Kaduna using heavy metals concentration in waste water (effluent) and moss samples. Analyses of the effluent showed that the heavy metal concentrations decreased with distance from the source. The study further showed very high heavy metal contamination of the industrial areas (Oyedeji *et al*., 2016). Mr Vice Chancellor, Sir, we can see that the unrecognised are also important.

Environmental Biology

Industries are sited in a locality for the production of domestic and commercial goods, and for employment. However, the industries produce some additional products which usually are detrimental to the environment (Figure 1). The wastes produced are usually released into stream water or/and rivers without pre-treatments. In many cities/towns/villages, the untreated waste waters are used to raise vegetables during the dry seasons. It is in light of this that the effects of soaps and detergent wastes were investigated on the seed germination, flowering and fruiting of *Solanum lycopersicum* (tomato) and *Abelmoschus esculentus* (okra) by Fatoba *et al.* (2011). The wastes were collected before discharge into the water bodies, analyzed for heavy metal loads and were serially diluted with borehole water to give 100%, 75%, 50%, 25%,10%, 5% and 1% solutions.

Sources of pollution: (a) water (b) land (c) air

These different solutions were differently used to irrigate tomato plants twice a week. The seed germination, flowering and fruiting of the crop were monitored. Fatoba *et al*. (2011) observed that only the waste waters containing less than 50% and 25% waste supported the germination of okra and tomato, respectively. Only the okra and tomato irrigated with 1%, 5% and 10% waste water flowered after 37 days and 76 days after planting, respectively while only those irrigated with 1% and 5% fruited after 42 days and 81 days after planting, respectively, 1%-irrigated regime tomato ripened after 96 days just like the control. The 5% treated ripened 2 days later. The 1% and 5% produced greener colouration than the control throughout the study period. Therefore, 5% and lower concentration of the waste of soap and detergent industry enhansced the production of these two vegetables.

The effects of different concentrations of Cd and Pb were investigated by Fatoba *et al*. (2012) on the growth and productivity of *Arachis hypogaea* and *Gycine max.* The results showed that both Pb and Cd had toxic effect on various growth indices and productivity of A*rachis hypogaea* and *Gycine max.* Increase in the concentrations of Pb and Cd to 40 ppm significantly ($p<0.05$) decreased seed germination and number of leaves. The seeds produced accumulated a lot of Cd and Pb with an increase in their concentrations. This study further showed the danger in consuming ground nuts and cowpeas irrigated with untreated effluents or wastewater. Therefore, there is the need to treat wastewater before its use in farming.

Furthermore, in search for the safety of vegetables consumed, Fatoba *et al.* (2012) investigated the heavy metal accumulation in the fruits of tomato and okra irrigated with 0 – 100% industrial waste effluents from Global Soap and Detergents factory and Dangote Cement factory. The results from the study showed that okra and tomato irrigated with only borehole water (control), 1% and 5% of Global Soap and Detergent waste and 1% Dangote wastewater fruited. Other investigated concentrations were detrimental to the growth and fruiting of the two vegetables. The presence and accumulation of Pb, Hg and Cd in the fruits of tomato and okra were observed and this called for serious attention as this will pose serious threat to lives of consumers.

Fatoba *et al.* (2012) quantified the .heavy metal contents of *Lycopersicum esculentum* now *Solanum* *lycopersicum* and *Capsicum chinense* irrigated with treated and untreated detergent and soap waste water. The research found high concentrations of Mn, Cu, Cr, Pb and Cd particularly in the untreated waste water. It was found that elevated concentrations of metals bioaccumulated in these vegetables due to the use of waste water . This information should be taken serious as the bioaccumulation of metals may lead to ill health and untimely deaths.

The pollution loads and the ecological risk assessment of soil heavy metals around a mega cement factory in South west Nigeria were undertaken by Fatoba and his co researchers. Cement production entails the release of particulate pollutants to the environment because the high dust emissions and heavy metals released are later deposited in the soils. The Pb, Cd, Cu, Cr and Zn contents of the soils around the West African Portland Cement Company factory (Lafarge- Cement WAPCO) were 6661mg/kg, 613.4mg/kg, 547.9mg/kg and 188.5mg/kg, respectively, all above the International Standard limits.

Some models have been put in place to determine the degree of the pollution of an area. Nemerow Pollution Indices (Ps) indicated that the area was exposed to serious pollution with heavy metals. Single Potential Ecological Risk Index (PERI) showed that the soil contamination from Cd had very high potential ecological risk which translates into a high value of Comprehensive Potential Ecological Risk (RI) value (11,488.3) for the entire area around the mega cement factory. The study suggested bioremediation of the soil to avert potential environmental disaster (Ogunkunle and Fatoba, 2013). The study revealed very high Cd load which calls for serious concern in the environment due to its mobility and load in the soil. Table

46 shows the grades of ecological risks of heavy metal pollution.

Table 6: Risk grades of single and comprehensive potential ecological risks of heavy metal pollution

E_r	Single potential ecological risk	RI	Comprehensive potential ecological risk
<40	low potential ecological risk	<90	Low potential ecological risk
40 ≤ Er < 80	Moderate potential risk	90≤ RI< 180	Moderate ecological risk
80 ≤Er ≤ 160	Considerable potential risk	180 ≤RI< 360	Strong potential ecological risk
4160 ≤ Er < 320	High potential risk	360≤ RI <720	Very strong ecological risk
4≥ 320	Significantly very high	≥ 720	Highly strong ecological risk

(Hakanson, 1980)

The potential health risk for the soil heavy metal contamination of Sagamu due to the cement production was successfully assessed by Fatoba and his research group. The research work was premised on earlier report of substantial heavy metal load in dust and air samples of Sagamu. Industrialisation brings about urbanisation and pollution/ contamination (Gbadebo and Bankole, 2007). The production of cement in this environment portends serious threats to the environment. The potential non-carcinogenic health risk of the exposure of the children and adults population of Sagamu to heavy metal contamination through soil ingestion pathway was based on the use of target hazard quotient (HQ), a ratio between the estimate dose of a contaminant and the reference dose below which there will not be any appreciable risk (USEPA, 2000). It was found that the highest risks for both adults and children were largely linked to Cd and Cr. Cumulative hazard quotient index (T HI = 25.739 and 47.995) for adults and children, respectively put them at a serious risk of chronic non-carcinogenic health problems (Ogunkunle *et al*., 2013). Fatoba and co-researchers investigated the effects of cement dust pollution on the leaf epidermal features of *Pennisetum purpureum* and *Sida acuta.* This is to assess the potentials of these plants as bioindicators / biomonitors. The anatomical leaf epidermal features of these 2 plants growing around the cement factory were examined with the aim of identifying the leaf epidermal modifications that enhance their tolerance and continued survival in the stressed environment.. The study revealed significant modifications in the stomatal size, density and index of leaves of *S. acuta* exposed to cement dust pollution. Reduced stomatal size and increased stomatal index may be taken as adaptations of the plant to a polluted environment. Additional observation showed the presence of tetracytic stomata and absence of trichomes on the adaxial surface as opposed to the paracytic stomata and bulliform cells as seen in the Control (*Pennisetum purpureum*). This is an evidence to show that plants are indicators of environmental conditions.

On the abaxial surface of *Sida acuta* exposed to cement pollution, there were unicellular, stellate and large glandular trichomes as opposed to large glandular and stellate trichomes observed on the control. *P. purpureum* showed no anatomical modifications to the cement dust pollution around the studied area. The species may be quite resilient to cement while *Sida acuta* appeared sensitive to cement and had various anatomical modifications (Ogunkunle *et al*., 2013).

The air pollution tolerance index (APTI) and anticipated performance index (API) of some tree species for biomonitoring of environmental health were assessed by Fatoba and co researchers. APTI is very important in screening tree species for biomonitoring of environmental pollution. This study was carried out to evaluate the potentials of some tree species commonly growing in Unilorin campus for green belt development. The study revealed that APTI alone was not adequate/suitable for this purpose but can identify the species or sensitive plants for biomonitoring. The combination of the two parameters identified *Vitellaria paradoxa* (API =4) as a good performer in green belt development. *Terminalia catappa, Acacia nilotica* and *Prosopis africana* (API = 3) are moderate performers suggesting the usefulness of these plants in green belt development.

The APTI of the tree species were higher in the Students' residence area. The mean APTI indicated *T. catappa* has the highest tolerance (12 – 30) to air pollution among the tree species while the least was *Vitellaria paradoxa* (7 – 80). The low APTI less than 15.0 value recorded for the four tree species indicated moderate levels of air pollutants within the University campus. The APTI of 7.80, 9.56 and 10.95 for *V. paradoxa, P. africana a*nd *A. nilotica*, respectively indicated that these plants are sensitive to air pollution, hence are bioindicators. Tree species with high APTI values are tolerant to pollution (Tsega and Devi-Prasad, 2014). The relevance of this study is that the trees that we see always on campus have so much data that can only be understood or interpreted by Botanists only. This shows that these plants are very important and need to be recognised.

The importance of vegetables cannot be underestimated. There is the need to have them on tables always. Their availability can be made possible during dry season by irrigation. However, the availability of water is crucial to achieving this goal. The effect of the use of water from Asa River in the cultivation of *Amaranthus cruentus* (amaranth) and *Corchorous olitorius* (Jute mallow) were investigated by Fatoba and co-researchers. The bioaccumulation and associated risks of Pb, Cd and Zn were investigated in the two vegetables that are widely consumed in Nigeria. The study revealed that the soil irrigated with the water from Asa River was polluted with Zn, Pb and Cd. The Pb and Cd were contributed by the polluted water used for irrigation. The metal concentration in Amaranth and Jute mallow varied in the order of Zn> Pb >Cd and Zn > Pb = Cd, respectively. Jute mallow was found to be an excluder of Pb, Cd and Zn and their concentrations were below the toxic threshold levels. In contrast, the concentrations of Pb and Cd in amaranths were found to be above the recommended safe levels, hence posing health risks to humans. The pathways of these metals were found to be through the foliar route except for Zn that was through the root uptake. The study concluded that man should be careful of the vegetables consumed during the dry season (Ogunkunle *et al*., 2015).

Pollution has increased considerably in recent years as a result of increasing human activities such as burning /combustion of fossil fuels, industrial and automobile exhaust emissions. A study was conducted to evaluate the contribution of vehicular emissions on road side and vegetation by Fatoba and co-researchers. The study quantified the heavy metal concentration in roadside soil and vegetation in relation to distances from Ilorin to Ibadan road. It was found from the soil and plant analyses that the highest soil Zn was 11.7ugg^{-1} and Pb as 45.98ugg^{-1} at Iwo and Ogbomoso, respectively. Eyenkorin had the highest Cd concentration (17.10 ugg^{-1}), Cr (10.23 ugg^{-1}), Ni (15.95 ugg^{-1}) and Cu (2.07 ugg^{-1}) . The highest Zn, Pb and Cr were recorded in plants sampled at Ogbomoso while the highest Ni concentration (1.95 ugg^{-1}) was found in plants sampled in Eyenkorin and Cu (2.07 ugg^{-1}) in Iwo. However, the Zn and Cu concentration in plants were within the permissible limits (Oyedeji *et al*., 2015). Mr Vice Chancellor, Sir, the unrecognised are also important.

One of the ways by which the environment can be polluted is through oil spills especially in the Niger Delta area of Nigeria. The implications of such oil spills on soil and diagnostic (plants) species were assessed by Fatoba and co-researchers. The ecological impact auditing of the study area was carried out through soil and plant (*Andropogon gayanus*) analyses. The study revealed that the Pb (19.7 - 128ugg^{-1}), Cd (2.2 – 1.00 ugg^{-1}), Cu (18.7 – 120.8 ugg^{-1}), and Zn (4181.3 – 309.3 ugg^{-1}) levels in the top soil exceeded the International Standard of 70 ugg^{-1} and 63 ugg^{-1}, respectively at close proximity to the point of spill (0 - 200 m). The levels of Pb (4.5 -8.1 ugg^{-1}) and Cd (0.25 – 3.5 ugg^{-1}) in the diagnostic species exceeded the World Health Organisation limit of 2.0 and 0.2 ugg^{-1}, respectively. This suggests that the Pollution Load Index was severe contamination. The Pb, Cd, Cu and Zn in the top soil correlated with those in the plant which suggested that the sources of these metals in the plants were definitely from soil and same pollution source (Fatoba *et al.,* 2015).

The metallic pollution status of surface water and aquatic macrophytes of dams in Ilorin, was undertaken by Fatoba and his co-researchers to assess the quality of the water and health status of the environment. The study quantified the Pb, Cd, Ni and Mn concentrations in the water and the macrophytes in Asa, Agba, Unilorin and Sobi earthen dams. The trace metal contamination of surface water in earthen dams was assessed using Metal Index (MPI) and Metal Pollution Index (HPI). The MPI results revealed gross metal contamination of the surface water by Pb and Cd (> 6.0 for both metals) in the four earthen dams while Agba and Sobi dams were slightly contaminated by Ni (MPIs =1.43 and 1, 14, respectively). All the earthen dams were considered safe for Mn contamination (MPI < 1.0)

Considering the HPI, the four earthen dams fell within the critical pollution threshold for the trace metals (HPI > 100), but Asa dam (HPI =2682.4) was the most contaminated. The study found that *Ceratophyllum demersum, Pycreus lanceolatus* and *Pistia stratiotes* were moderate accumulators of Mn and can be used as bioindicators of Mn pollution. The study concluded that the dam waters are polluted by Pb, Cd and Ni which can pose human health risks to the users of the water (Ogunkunle *et al*., 2015).

The mineral nutrients content and growth performance of *Ocimum basilicum* and *O.gratissimum* in response to bitumen contamination were assessed by Fatoba and co-researchers. Seedlings of these two plants were transplanted into soils amended with 15 ml/kg, 45 ml/kg, 72 ml/kg and 90 ml/kg of bitumen and no bitumen (Control) after two weeks of growth in the nursery. Results generated from the growth parameters showed *O. gratissimum* had higher shoot height, number of leaves and leaf area in all the treatments but *O. basilicum* showed growth retardation with eventual death at 90 ml/kg bitumen

(Ogunkunle *et al*., 2015). It was observed that bitumen contamination influenced the levels of Ca, Fe and Mg in *O. basilicum* with Mg levels varying inversely with contamination while in *O. gratissimum*, it was not defined (Ogunkunle *et al*., 2015).

Fatoba *et al*. (2016) assessed the heavy metal pollution and ecological geochemistry of soil impacted by the activities of the oil industry in Niger Delta, Nigeria. Samplings were made around the SPDC flow station, Kokori and Kolo creek, Niger Delta, Nigeria. The analyses of the Pb, Zn, Ni, Cd and Cr in the soil showed that the metallic contents were higher in the study areas in several orders of magnitude than the control except for Ni in Kokori and Pb in Kolo creek. The levels of index of geo-accumulation (I-geo) showed no pollution to low pollution except Cr in Kolo creek that indicated strong pollution. The Nemerow Integrated Index (NIPI) indicated that the soils of Kokori and Kolo creek exhibited moderate to high levels (strong) of pollution, respectively with respect to Zn mostly contributing to the pollution status of Kokori while Cr, Zn and Ni were the major pollutants in Kolo creek.

The NIPI of 2.95 and 4.04 were obtained for Kokori and Kolo creeks respectively. The comprehensive Potential Ecological Risk (RI) for Kokori and Kolo creek was 100.75 and 107.08, respectively. The RI assessment indicated low potential ecological risk for Kokori and Kolo creek with Cd, Ni and Cr as major contributors (Fatoba *et al*., 2016). The Single Potential Ecological Risk Assessment of metals in the soils revealed that Cd and Cr in Kokori and Cr, Cd and Ni in Kolo creek portend ecological risks. The trend of pollution are: Cd=Cr> Zn=Pb =Ni (Kokori); Cr > Cd =Ni > Zn =Pb (Kolo).

The sources, transport pathways and the ecological risks of heavy metals present in roadside soil environment in urban areas were investigated by Fatoba and co-researchers. The study was carried out to identify the sources and transport pathways of heavy metals in roadside soils, leaves and tree barks. Samples were collected along the route and analysed for Pb,Cu, and Ni using standard methods. The study showed that Pb, Cu and Ni in the roadside soil were found to be mainly from traffic/ vehicular emission whereas Cd in soil was primarily through municipal waste incineration. The Pb, Cd and Ni in leaf samples were absorbed from the soil via foliar uptake, while root uptake was the primary pathway for Cu in leaves. The I-geo indicated that the samples were moderately contaminated. The potential Ecological Risk (PERI) indicated moderate eco risk for 5 routes with Cd being the primary contributor to the risk. Pb concentration was highest in the soil and plant in all routes while Cd was the lowest (Ogunkunle *et al.,* 2017).

Nanoparticles are nanoscopic materials that ranged from 1 to 100 nm in size with physico-chemical properties that can be manipulated compared to corresponding bulk material (Nel *et al*., 2006). They occur naturally (e.g. volcanic dust, mineral composition), incidentally (due to man- made activities e.g diesel exhaust, coal combustion, welding fumes) or are manufactured (carbon nanoparticles, Cu nanoparticle, $Ti0_2$ nanoparticles etc) (Cruffini-Castiglione and Cremonins, 2009). Ma *et al*. (2010) reported that the effects of nanoparticles can be beneficial or detrimental to the growth, metabolism and development of plants. Therefore, increased use of copper-based nanoparticles in agriculture calls for concern on the living organisms. Based on the curiosity, Fatoba and co-researchers investigated the bioaccumulation of Cu and tissue partitioning of selected mineral elements in *Kleine rheinlanderin* under the influence of $_n$Cu. The plant was exposed to different concentrations of $_n$Cu for 49 days. The plants were then assessed for seed emergence, chlorophyll contents, protein contents and mineral content using standard methods. The results showed that the 1000 mg/kg $_n$Cu enhanced seed emergence, chlorophyll a and b but reduced soluble protein content in the plant (Ogunkunle *et al.,* 2017). We further reported that the nanoparticle enhanced the Cu uptake but drastically restricted its translocation to above ground biomass, reduced cobalt, Fe accumulation in both root and shoot, and increased the accumulation of Zn. The study showed that nCu portends both beneficial and detrimental effects on the plant.

Production of metallic nanoparticles is greatly increasing due to their wide range of application in agricultural formulation. Fatoba and his co-researchers investigated the toxicity of $_n$ZnO on *Solanum lycopersicum* (tomato) and the effects of enzymatic and non-enzymatic antioxidants in fruits. Tomato plants were exposed to 300 mg/kg, 600 mg/kg and 1000 mg/kg $_n$ZnO concentrations. Results of the study revealed significant increased Zn uptake. The enzymatic activity through the generation of H_2O_2 and induction of oxidative stress significantly ($p<0.05$) reduced the activity of stress controlling enzymes, Ascorbate Peroxidase (APX) and Superoxide Dismutase (SOD) in the root, Catalase activity (CAT) was greatly reduced (Akanbi-Gada *et al*., 2019). The total phenols, flavonoids, β carotene and lycopene were significantly ($p<0.05$) reduced by at least 4.8% while ascorbic acid was promoted at low $_n$ZnO treatments. The toxic effect of $_n$ZnO on stress enzymes was prominent in tomato roots and there was inhibitory effect on the induction of non-enzymatic antioxidants in the tomato fruits (Akanbi-Gada *et al*., 2019). The results showed that nZnO are both beneficial and harmful to tomato plant.

The implication of farming on abandoned dumpsites was assessed by Fatoba and co-researchers. The heavy metal accumulation in the rhizosphere and tissues of A*maranthus hybridus* and *Corchorous olitorius* cultivated on an abandoned dumpsite. The study revealed that the farmland soil was highly contaminated with Pb, Cr and Cd and these metals were highly accumulated in the vegetables (Ahmed *et al*., 2018). The metals' concentrations exceeded the maximum permissible limit in soil but were still within the allowable limits in the plants' tissues. Consumption of these vegetables portends health hazard which may eventually lead to morbidity and mortality.

Community Service within the Campus

Deforestation is the removal of plant cover/vegetation, thus exposing the soil surface to direct sunlight. The implication of this act is desertification, making the area deforested to be prone to food scarcity, erosion, flood, ecosystem unbalance, loss of biodiversity, leaching and global warming. Therefore, the afforestation project embarked by Unilorin Management is a step in a right direction. The plants are carbon sinks and their carbon storage potentials increase with age. Apart from research work and lectures, I was involved in the planting (*Citrus* and teak) and management of the (*Citrus*, teak and date palm) plantations on the Campus. This project is worthwhile, hence the need to maintain the plants.

Man struggles so as to be recognised, have his daily meal, take care of the family, give his children befitting education, have car(s) and possibly build a house. These necessities look unattainable if the salaries received by the civil and public servants and the stringent conditions attached to getting loans from the banks are to be considered. These problems have been solved with the introduction of cooperative societies for interested members. This act has helped in solving these social and important needs and in reducing the pressure on the University Management. In the bid to assist cooperators in the provision of these facilities, I became the third President of Unilorin Scientific Cooperative and Multipurpose Society, after Professor Sylvia Malomo, the current DVC (Academics) and Dr A. S. Idowu. I have contributed to the growth of the cooperators and the stability on the Campus. My contributions are well documented in the minds of our great members.

Conclusion

Every living organism is created by God for a purpose, hence is important and needs to be accorded appropriate recognition. This is to say that the unrecognised should be recognised because they are important. Afforestation is the most appropriate approach to arrest climate change as the green plants are the space vehicles and have the capacity to act as carbon sinks, thus reducing the greenhouse gas (CO_2).

Recommendation

Mr Vice-Chancellor, sir, since it is customary in a public lecture of this nature to make some recommendations, I, therefore, recommend thus.

i. Plants are very important in the purification and the making of the environment clean and safe.

Afforestation should be embraced by both Government and Nigerians .We should do away with unnecessary deforestation and in case a tree is felled, at least 2 stands of such a tree should be planted

ii. There should be prudent use of forest resources so as to reduce the loss of biodiversity.

iii. The industries should evolve strategies that are environmentally friendly by reducing the emissions of gaseous pollutants and particulate matters, and by treating the industrial wastes before their release into the environment.

iv. Farming along the roadsides should be discouraged and any farming activity should be at least 20 m away from the road.

v. We should learn to recognise everything around us because they are all important. This would help in decoding the messages in them. Plants complain and have some coded messages.

vi. The teak stands along the main road should only be weeded while others should be left so that the seedlings and saplings can survive thus increasing the stands and the smothering of the weeds. All the teak stands need to be pruned so as to increase their economic value.

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