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10th INAUGURAL LECTURE

FOOTPRINTS: LIVESTOCK NUTRIENT MANAGEMENT AND THE ENVIRONMENT

Lecturer:

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Thursday, April 7, 2016

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THE TENTH UNIVERSITY
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Preamble

The President /Vice- Chancellor,

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All other Deans of School

Head, Department of Animal Science

All other Heads of Department

Faculty and Staff of School of Agriculture

All other Faculty and Staff of Babcock University

My Lords Spiritual and Temporal

My Royal Fathers

Friends of the University/Special guests

My Family Members, Nuclear and Extended

Students of the School of Agriculture

All other Babcock University Students present

Gentlemen of the Press

Distinguished Ladies and Gentlemen,

I give all the glory to God for the privilege to stand before this audience to present the tenth inaugural lecture of Babcock University, the second in the School of Agriculture and the first in the Department of Animal Science. It is also unique because it is coming about two months after my 50th birthday and 21 years after bagging a PhD.

Mr. Vice Chancellor, Ladies and Gentlemen, my career journey can be summarized in the wordings of the song “All the way my Savior leads me”. Having lived my life as a child within hospital staff quarters courtesy of my “nurse parents”, it was natural for my parents to assume that their first daughter would one day study medicine. However, my phobia for cadaver and blood made me to device an escape route that would satisfy them and still make me feel comfortable. I opted for Pharmacy with the explanation that I will still remain in the paramedical line. A few years later as a higher school certificate (HSC) student, prompted by my Indian tutor, Mrs Scandarajah, I caught an interest in Agriculture and by my final year in the university I chose Animal Science option. The choice was gingered by the obvious appealing similarities between animal and human biochemistry. From that time till date my passion for this field of study has never waned.

The essence of an inaugural lecture is for the presenter to showcase what he professes in his field of study, show the direction of his future research work and to give a message to the world. Permit me therefore to go into the field of animal nutrition as it relates to a current global concern; environmental sustainability by discussing the lecture titled "Footprints: Livestock Nutrient Management and the Environment".

Food Production Today

A few decades ago, it became obvious that to meet the food need of the rapidly increasing human population, drastic changes in agricultural production was inevitable. Even Nigeria was not left out. Every government that has been in place since the early 70s had tried to put agriculture in focus by developing one programme or the other (Tayo, 2003). In the last 5 decades Nigeria has moved from "Operation Feed the Nation" (OFN), "Green Revolution" to Agricultural Development (ADP) programmes in a quest to become self-sustaining in food production. The first goal in the Millennium Development Goals stated that the world's hungry people must be halved by 2015, a tall order which in 2016 is yet to be achieved. The thrust of food production though still towards increase has gradually drifted from just the need to increase food production at all costs to the need to increase technology for food production at minimal cost. Today, however, the challenge of agriculture is how to boost food production at minimal costs with the best technology but with a light or no footprint at all on the environment. No wonder number two of the new Sustainable Development Goals (SDGs) proposed by world's government is addressed to end hunger, achieve food security, improve nutrition and promote sustainable agriculture by the year 2030. The new global goals further address a broad sustainability agenda that include not only sustainable food security, but also a healthy and productive ecosystems and secure sustainable water.

Global demand for livestock and poultry products like meat, milk and eggs is on the increase. Currently, livestock is one of the fastest growing agricultural subsectors in developing countries; its share of agricultural GDP is already 33 percent and is quickly increasing (Thornton, 2010). This growth is largely driven by population growth, urbanization and increasing incomes in developing countries. According to Jones and Thornton (2008), the global demand for livestock products will continue to increase significantly in the coming decades and this increase will be largely based in developing countries.

Mr. Vice Chancellor Sir, it is interesting to note that the livestock industry has responded to the increasing demand of the growing population largely through intensification rather than expansion. Intensification is the production of large flock size in relatively small geographical areas. This is visible all around us in the form of commercial poultry houses and large scale livestock production (fig.1 and 2). Intensification is often characterized by high production intensity, increased use of cereal grains, animal enclosure and large volume of livestock faecal wastes which are often indiscriminately disposed.

Fig 1. Deep litter system of intensive poultry production

Fig 2. Battery cage system of intensive poultry production
Animal Nutrient Management

Nutrition has become very critical due to enclosure in intensive system of management, nutrient requirements of the animals must therefore be met where they are by the producers. Trends in animal nutrient management have been to maximize output of useful livestock products such as egg, meat and milk. Meeting the nutrient requirements to maximize these products is essential to successful animal production system (Tayo and Tan, 2007). Livestock as living organisms require food (feed) in order to survive. Food is the edible material that provides nourishment for the body. When consumed by the animal, it is digested, absorbed and utilized for maintenance, growth and production. The components so utilized are known as nutrients. The six classes of nutrients; carbohydrate, fats, proteins, vitamins, minerals and water are made up of chemical elements that support life. They are required by animals for construction of body tissues, synthesis of products, as well as sources of energy and regulation of body physiological processes.

Carbohydrates

Carbohydrates serve as the principal source of renewable energy all over the world. They are compounds containing carbon, hydrogen and oxygen and in nearly all instance hydrogen and oxygen are in the same ratio as they occur in water. Carbohydrates include starch, sugar, cellulose, gums and related compounds in plants as well as glycogen in animals. In plants, carbohydrate is made up of the soluble (Nitrogen free extract) and insoluble (Crude fibre) components. Sources of carbohydrate in animal feed are grains, roots and tubers.

Fats or Lipids

Lipids are sources and stores of energy. They are compounds that are insoluble in water but soluble in ether. They are more concentrated in energy than carbohydrates and proteins. Lipids are stored in the adipose tissue and excess carbohydrates and protein are converted to lipids in the animal body quite readily. This characteristic is critical in hibernating animals which makes use of their stored energy when hibernating. Lipids are not only energy providers but reserves and are also sources of fat soluble vitamins A, D, E and K, enhances flavor in feed, and they are used as binders to reduce dustiness in feed. In livestock, feed sources include; fish meal, vegetable oil (palm oil) and palm kernel meal.

Proteins

Proteins are complex organic compounds which in addition to carbon, hydrogen and oxygen also contain nitrogen and sulphur. They are found in all living cells and are connected with all activities constituting the life of the cell. Proteins are hydrolyzed to amino acids. Amino acid in excess of dietary need is deaminated while the resulting keto acid serves as a source of energy, while the remaining ammonia is converted to urea and excreted via the kidney as urine. Nitrogen requirements of animals are stated in terms of protein. Sources are soybean cake, fish meal, groundnut cake.

Vitamins

These are organic substances required in small quantities for maintenance and regulation of normal body functions. They form components of enzymes and coenzymes. Vitamins are grouped into soluble vitamins A, D, E K and the water soluble vitamins B and C. Deficiency of vitamins in feed can lead to disordered metabolism characterized by deficiency symptoms. Excess can also lead to toxicity. Vitamins are supplied by: vegetables, fruits, carrots, dairy products and so on.

Minerals

These are chiefly cations or their salts, mineral or inorganic elements which play essential metabolic role in the body.

They are classified into two; major elements (Ca, P, K, Na, Cl, S, Mg) and the micro or trace elements (Fe, Cu, Zn, Co, Mb, Se. Cr, Fl,) a few others have been added to these such as Ni, Arsenic, Tin. The classification is based upon the amounts required in the diet. While major minerals are needed in g/kg diet, trace elements are needed concentration usually less than 100mg/kg diet or in ppm. Some minerals serve as components of the skeleton, Ca, P, Mg and some in acid-base relationships and osmotic regulations. Like vitamins, inadequacy in diet may result in deficiency symptoms and disease while excess results in toxicity e.g. copper and fluorine. Calcium and phosphorus are supplied by bone meal while calcium can be supplied by oyster shell.

Water

Water is very important in animal nutrition because of its functions. The body itself is composed of about 60% water. Water content of animal varies with age, with younger animals having a higher composition compared to the body mass. An animal will die readily if deprived of water than when deprived of food. Farm animals consume 3- 5 times as much water as their dry matter intake.

Water regulates body temperature; it is necessary for digestion, transportation of food, waste products and lubrication. Water balance in the body is regulated by intake and output. Water is supplied through drinking water, water in the feed, and metabolic water, while it is lost through urine, sweat and respiration. A negative water balance causes dehydration.

Apart from water, the organic molecules described as nutrients above are made up of about 40 chemical elements highlighted in Table 1. Food can be limiting. Inadequate quantity and quality of feed is known to be largely responsible for low livestock productivity in the tropics.

Table 1: The 40 specific nutrients required by animals

Amino Acids	Minerals	Vitamins	Fatty Acids
Arginine	Calcium	A	Linoleic
Cysteine	Phosphorus	D	
Glycine	Magnesium	E	
Histidine	Sodium	K	
Isoleucine	Potassium	Thiamine	
Leucine	Chlorine	Riboflavin	
Lysine	Manganese	Niacin	
Methonine	Zinc	Pantothenic acid	
Phenylalanine	Iodine	Pyridoxine	
Threonine	Copper	Biotin	
Tryptophan	Iron	Chlorine	
Tyrosine	Cobalt	Folic acid	
Value	Selenium	B12	

Source: Monogastric Animal Nutrition Principles and Practice (Olomu, 2010)

Today, there are evidences that some other mineral elements belong to the group, oleic acid and arachidonic acid are also essential fatty acids are also included. Absorption and utilization of these nutrients involve the transfer of energy and the inter-conversion of energy.

Energy, though not specifically a nutrient is necessary for the sustenance of life. Energy in animal nutrition is basically from carbohydrate and fat. Livestock derive their energy either from green plants (grasses, legumes, grains and other plant products) or animal products (e.g. fish meal). Plants are generally primary producers (autotrophs). They are capable of producing complex organic substances by photosynthesis using solar energy. Other animals (heterotrophs) depend on plants directly or indirectly. In the natural environment plants and animals are therefore interdependent. The ecosystem in which they exist is made up of biotic and abiotic components. All components function together to maintain a balance in the environment. According to Wikipedia online dictionary, ecosystem is any unit that includes all of the organisms in a given area interacting with the physical environment so that a flow of energy leads to clearly defined trophic structure, biotic diversity and material cycles within the system. Under typical forest environment, essential nutrients are efficiently recycled. Animals, leaves, branches and trees die and return nutrients to the soil through decomposition. These nutrients are absorbed by plant roots and sometimes washed into streams and rivers to support aquatic populations. Hence energy flows from one trophic level to another.

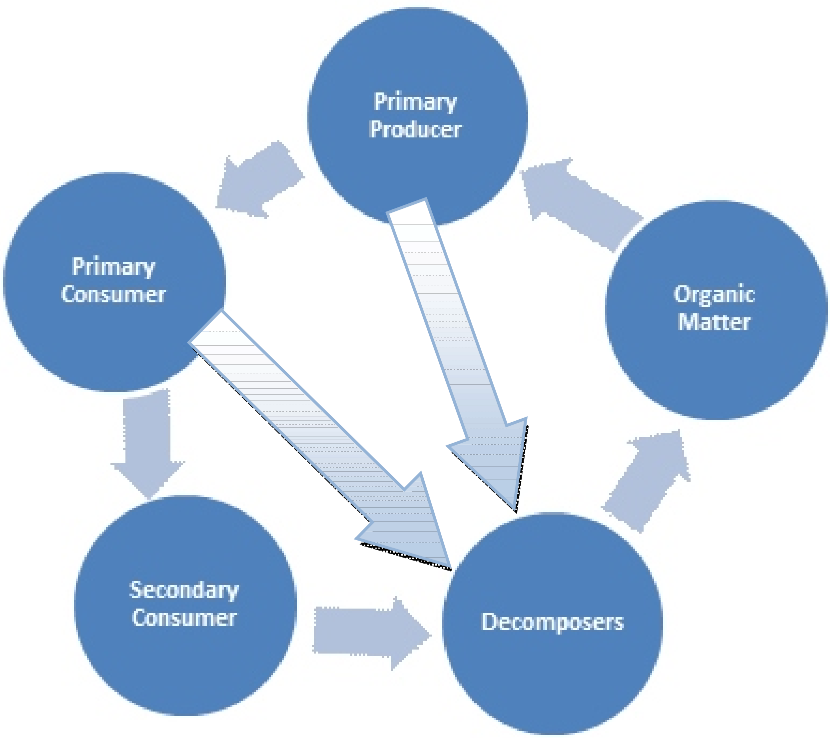

Fig 3. Model of food chain in a typical forest ecosystem (Tayo, 2009)

In the presence of small changes, the system self-regulates itself to bring about equilibrium. Large changes can however result in radical changes in the environment such as is experienced today in the form of climate change. Energy derived from consumption of plants by animals is in chemical form and it is released when organic molecules (carbohydrate, fats and proteins) are oxidized. Energy is the single dietary need of animals because it is required for all processes of life. It is measured in calories and the total energy released as heat when a substance is completely oxidized to CO_2 and H_2O is known as gross energy. Gross energy can be partitioned into the following:

Digestible energy: which is gross energy less energy lost in faeces.

Metabolizable energy: Gross energy less energy lost in faeces, urine and methane.

Net energy: Gross energy less energy lost in faeces, urine, methane and the heat increment of food. This is the energy that is available to the animal for maintenance and production.

Digestible Energy (DE), Metabolic Energy (ME) and Net Energy (NE) can be determined through feeding trials with animals. ME can also be calculated from the chemical composition of feed or by the Total Digestible Nutrient (TDN) method. TDN is the figure that indicates the relative energy level of a feed to an animal. It is derived from the formula; Digestible crude protein + Digestible crude fiber + Digestible WFE + (digestible x 2.25). Energy supplied in excess of maintenance requirement is used for production or stored as fat.

Feeding Standards and Nutrient Requirement of Farm Animals

In livestock feeding, feed is formulated by combining feedstuffs to meet the requirement of each species at a particular level of performance. Nutrient requirement is therefore the amount of a given nutrient required by an animal for maximum performance. Statement of this amount is described in terms of feeding standards. Feeding animals in accordance with the nutrient requirement is important for their maintenance and production. Just as the recommended daily allowance (RDA) in man, animals also have the daily nutrient requirement. To feed animals with balanced ration, in addition to knowledge of the needed nutrients, a knowledge of the nutrient composition of the feedstuffs as well as the nutrient requirement of the animal is needed. Feeding standards may be expressed in quantities of nutrients (g/specific nutrient/day) or in dietary proportion as (g/specific nutrient /kg diet). Units used in expressing feeding standards must however be the same as those used in expressing nutrient composition of the feedstuffs.

Feeding standards are summarized in tables drawn up by research scientists based on volumes of research results on animal nutrition studies. Feeding standards in the United Kingdom are drawn by the Agricultural Research Council (ARC). The Technical Committee on Responses to Nutrients (TCORN) later became responsible for revising the standards. In the US, the National Research Council (NRC) is responsible for this assignment.

Standards may be given for each function of the animal e.g. maintenance and production or combined with a safety factor added to compensate for differences between animals in such a way that animals with exceptionally high requirement will not be underfed. Overfeeding of nutrients usually occur leading to excretion of high level of nutrients in the faeces especially as in case of nitrogen (N) for protein and phosphorus (P). Feeding standards are considered as guides because of differences between animals as well as feed samples. The factorial approach which involves the summation of maintenance, lactation, pregnancy and growth requirements is usually used to arrive at nutrient requirement of animals.

Mr. Vice Chancellor Sir, to discuss some of the issues in animal nutrient management and the environment, permit me to narrow down to mineral nutrition and in particular P nutrition.

Phosphorus in animal nutrition.

The utilization of P particularly by goats has dominated my research work for the past 25years. You may ask why goats and why phosphorus?

- Goats are very hardy animals, they can subsist on any edible material in the arid regions, on mountains and the forest regions.

- They are referred to as the poor man's cattle.

- They are easier to handle because of their size

- The milk is highly digestible and therapeutic. Our studies on lactating West African dwarf WAD goats (Tayo, *et al.* 2001b) revealed goat milk compares well with cow milk and could be of high dietary importance to humans.

- Goat is a good source of meat, milk and other by-products such as yoghurt, cheese, hide and skin. (Anaeto et al., 2010)

Fig. 4. A West African Dwarf kid being bottle fed with its mother's milk

The most common breed in Western Nigeria is the West African Dwarf goat which has been found to be trypano-tolerant. Phosphorus on the other hand is a very important mineral in animal nutrition because:

- it has more known biological functions than any other mineral element.
- Phosphorus (P) along with calcium is important in bone mineralization and growth, about 50% of P in the body is found in bones and teeth.
- It is involved in energy metabolism especially in the formation of high energy bonds such as adenosine triphosphate (ATP).
- P is involved in fatty acid transport, amino acid metabolism, protein synthesis and cellular metabolism.
- P is involved in acid base buffer and enzyme systems.

- It is found as phospho-lipids, phospho-proteins and nucleic acids in cell walls and cell contents.
- P is involved in milk secretion and in ruminants' microbial digestion of cellulose.

Absorption of dietary P occurs in the duodenum and the jejunum by active absorption through synthesis of 1, 25, dihydroxy-cholecalciferol when blood P is low or through passive absorption when sufficient amount of absorbable P is consumed. The requirement for P can be calculated factorially by summing up estimates for maintenance, growth, pregnancy and lactation.

Maintenance requirement

Ruminants excrete P mainly in the faeces (about 95%). This is composed of unabsorbed P from dietary origin (exogenous) and unabsorbed P from saliva, intestinal cells and digestive secretions i.e. endogenous P (Tayo and Tan 2007). One of the most important challenges with P metabolism is how to determine the maintenance requirement. The maintenance requirement which is the requirement that will keep an animal's body composition constant without loss or gain in weight is derived from endogenous fecal P loss. The knowledge of endogenous faecal P and the availability of P in feed consumed by animals is therefore important in determining the mineral's requirement. Different methods have been used by different bodies to determine endogenous P loss (Tayo et, al., 2009) and hence the maintenance requirement. Based on the varying methods and types of feed, different figures were adopted by each country (Table 2) to calculate requirement. The ARC (1980) calculated maintenance P requirement based on a fixed faecal P loss of 10mg kg^{-1} live weight (LW) and absorption coefficient of 0.58 and 0.78 for 12 months old cattle weighing over 300kg and for younger and lighter cattle respectively. The Australian Standing Committee on Agriculture however, based their calculation of maintenance P requirements on a constant endogenous faecal P loss of 20mgkg^{-1} LW and an absorption coefficient of 0.70. In our study with pregnant WAD (West Africa Dwarf) goats using the balance trial method, (Tayo *et al.* 2001a), it was observed that dietary P requirement of WAD goats was lower than the value reported by National Research Council (NRC,1981) for goat of similar body weight; our result was also about 40% of the value recommended for sheep (ARC,1980) of the same body weight. It was noted that the values reported by NRC (1981) were extrapolated from requirements of cattle and sheep and also from limited research on temperate breeds of goats. Similar experience has been reported in swine where sometimes accuracy of the requirements is limited by available data (NRC, 1998).

The differences in P recommendations lie in the maintenance requirement and the absorption coefficient (based on absorption efficiency, features of the feed and P intake).The value adopted by any P recommendation body therefore depends on these two factors.

Table 2. P requirements for dairy cattle.

Maintenance g kg^{-1} BW	Milk production g kg^{-1}	Availability %	Country
0.0286	1.98	50	USA
0.042	1.50	60	Netherlands
0.0207	1.56	58	Great Britain
0.062	1.25	70	France
0.040	1.66	60	Germany

Source: Tamminga, 1992.

Furthermore, achieving a uniform value has been challenging because endogenous faecal P loss cannot be easily quantified by standard chemical procedures since it is found in faeces together with unabsorbed dietary P. Separating the two is very difficult. The isotope dilution method which involves a single parental injection of P^{32} into the body of an animal to distinguish between exogenous and endogenous is the most effective but it is demanding and difficult with respect to handling radioactive materials and disposing the experimental animals. This challenge has resulted in feeding of livestock with P above what is required. P has often been fed in excess of daily requirements in amount that have neither beneficial nor detrimental effect on cow health and performance (NRC, 1978).

Monogastric animals such as poultry and swine naturally excrete high phosphorus in their manure because of their inherent inability to digest plant P. Such P exist in plants as phytate myo- inositol 1, 2, 3, 4, 5, 6 hexakis dihydrogen phosphate, a complex not easily broken down to release P especially in the absence of enzyme phytase. The diets of monogastric animals are compounded from plant based ingredients which include cereal grains and oil seeds. About 50-70% of total P in these concentrates is in the phytate form. Hence P is therefore unavailable and is excreted in the manure. Microbial enzyme phytase present in ruminants enables them to break down phytate, however, even ruminants generally utilize P inefficiently excreting 50-80% of P intake. In the poultry and dairy industry, an additional safety margin is included to the dietary P requirement to ensure that birds and cows do not suffer deficiencies during production. Poultry and livestock faecal wastes are therefore high in P.

Composition of manure and the environmental implication

Mr. Vice Chancellor, Ladies and Gentlemen, before I proceed to the implication of manure P to the environment it is important that we examine very briefly the composition of manure. Livestock faecal waste or manure has been reported to include nutrients (Jongloed and Lewis 1998) pathogens (Geber and Smith, 2005,), veterinary pharmaceuticals (Boxall et al., 2003), and heavy metals (Barker and Zublena, 1995). In 2 different studies on the composition of poultry faecal wastes, (Tayo *et al.,* 2009, and Tayo *et. al.,* 2016) we found out that these wastes were high in Nitrogen (N), P, and heavy metals particularly, Copper (Cu) and Zinc (Zn). Among the elements found in animal faecal wastes, N, P and Potassium (K) are of environmental, social and public health concern. Nitrogen contributes to soil and water pollution as nitrate (NO_3) and to air as ammonia NH_3, a pungent and potentially obnoxious gas, K accumulation in soil manure application damages the health of cattle that graze these lands (NRC, 2001). P is currently one of the most polluting nutrients in areas of animal husbandry concentrations and it is a major fresh water pollutant. Environmental concern about P has been associated with pollution of surface water and algae bloom. Global animal P pollution is therefore a serious and growing challenge. Unfortunately studies (Tayo *et al.,* 2009a, Adeoye *et al.* 2014) have shown that in certain regions in Nigeria, livestock faecal wastes are generally disposed indiscriminately. In one of such studies (Olarinmoye *et al.* 2011), it was observed that 84% of poultry farmers in Remo zone of Ogun state wash poultry faecal waste into gutters, ponds, rivers or heap them on farms and dump sites. This makes it easy for P to be washed into the surface waters. P losses from livestock farms account for as much as 47% of P loading to bodies of surface water, depending on water shed. According to Fisher *et al.*, (2009), non point source may be responsible for more than 90% of the P load to about one third of rivers and streams in the United States. In other areas where livestock faecal waste is utilized as organic fertilizer, application to farmland often leads to the buildup of P in the soils. This is because the N:P ratio need of crops is higher than the N:P ratio in manure. Hence application of manure to meet the N needs of crops eventually results in an over application and accumulation of P in soils. Such P is washed into surface water; ponds, rivers and lakes through run-off and it is associated with rapid algae growth or bloom (fig. 5). The decomposition of these algae consumes dissolved oxygen in water, jeopardizing the life and productivity of fish, clams, crabs and other aquatic life (fish kills), a process known as eutrophication. (fig. 6).

Fig. 5 Algae bloom on a lake (Shutterstock. Com)

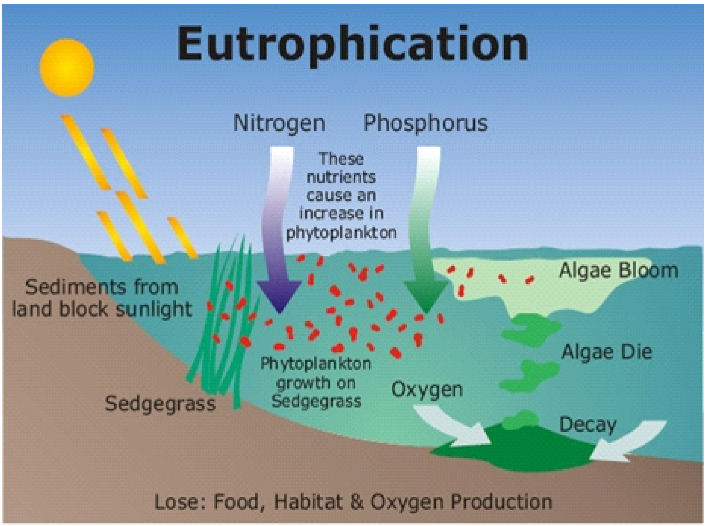

Fig 6 Process of Eutrophication (Source: America.pink)

Beyond the faecal wastes from commercial farms, abattoirs are also filled with animals lined up for slaughter. Faecal and paunch wastes are dumped on sites within the abattoirs. Our study (Tayo et al. 2016) of 4 abattoirs in Lagos and Ogun States revealed that 8,723.45kg of intestinal content are generated per day and indiscriminately disposed by dumping, flushing into rivers and burning (figs 7-9). Some workers in the abattoir dump the wastes on the abattoir site and later sell part of it. The Nigerian Tribune newspaper of May 26, 2013 reported the woes of residents in the neighborhood of Oko-Oba abattoir in Lagos because of the filth and stench. Only one of the abattoirs sampled (Agege abattoir) had a section for semi automation and processing of wastes through sewage system before it is released into the environment (fig 10). Where wastes are dumped into pits as slurry, methane gas-a green house gas is produced. Green house gases have been reported to be partly responsible for global warming.

Fig. 7. Paunch content at an abattoir

Fig. 8. Manure heap at an abattoir

Fig 9. Typical heaps of manure and bones on an open dumpsite at an abattoir. (Tayo et al., 2016)

Fig 10. Sewage system at Agege abattoir (Tayo et al., 2016)

One may wonder why this is an issue in Nigeria especially when we have not experienced fish kills. Mr. Vice Chancellor Sir, it has been noted (Steinfeld *et al.,* 2006) that environmental laws and programs are usually put in place after significant damage has already occurred. Focus is often placed on protection and restoration, rather than on the more cost- effective approaches of prevention and mitigation. A report by the Guardian newspaper on Thursday, March19, 2015 stated that “the first ever smog in Nigeria occurred on October, 12, 2005 with clouds of choking foams enveloping Lagos skyline for about 6 hours. Environmentalists say it was nature's red light warning against the model of inefficient and blind development, Senior Lagos officials argued that it spurred decision makers in the state to give environmental issues better attention. Researchers related that Lagos 18million residents inhale daily a deadly mix of particulate matter (PM), asbestos, surphur dioxide (So_2), Nitrogen oxide (NO), Carbon dioxide (CO_2) and partially unburnt hydrocarbons. These substances contribute to the death of 7million people, one in eight of total global deaths is as a result of air pollution exposure".

Findings by Lagos Metropolitan Area Transport Authority (LAMATA) indicated that aside transport, dumpsites which could include manure dumpsites are also sources of air pollution. The question is: must we wait until we begin to see the effect of indiscriminate livestock nutrient management and manure disposal. No, not at all. What then is the solution?

Mitigating livestock manure pollution

Manure of itself is a valuable asset if its nutrients and organic matter are recycled through proper land application. Animal manure is much more abundant than human waste, yet while the disposal of human wastes is regulated, the disposal of animal wastes is largely unregulated. According to Oluyemi and Roberts (1979), a laying bird produces between 63- 70kg droppings per year, going by the over 150million poultry in Nigeria (Adesina, 2014), the estimated output of poultry droppings is between 9.45-10.50million tons annually. This huge volume can be converted to wealth through several means.

Manure as organic fertilizer

When properly processed through composting or drying to destroy pathogenic bacteria such as E. coli, manure can be used as fertilizer. On a commercial farm with mixed farming, an integrated system where zero waste principle is practiced can lead to a cleaner environment. A model of this is the integrated biosystem (IBS) found in fig.11.

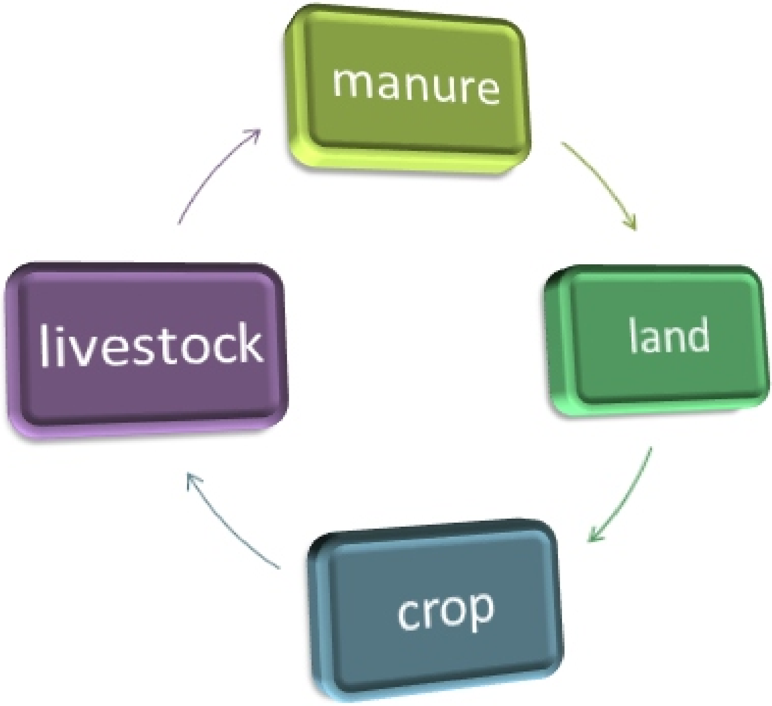

Figure 11. Model of Integrated Biosystem

IBS in a broad sense connect different food production activities with operations such as waste management and fuel generation (Waburton *et al.*, 2002). It encourages the dynamic flow of materials by treating wastes and by-products of one operation as inputs for another. The management of wastes and residues are central to the design of IBS and it encourages holistic system of interconnection and interdependence in the system. Some of the main features of IBS are:

i. Minimizing resource inputs by redirecting waste outputs within the system.

ii. Contain material flows in the system
iii. Treat production and consumption as a continuous cyclical process rather than a linear one.

iv. Maximize efficiency of natural conversion processes (e.g. microbial decomposition) and nutrients and water retention. (Waburton *et al.,* 2002).

The aim of this integration in animal husbandry is sustainable animal production for enhanced profitability and environmental protection. Examples of integration process include:

1. Single integration e.g. using livestock manure as organic fertilizer.

2. Cyclic integration e.g. livestock - manure - fodder crop feed livestock.

3. Multiple integration e.g. livestock organic waste biofuel aquaculture horticulture.

A single IBS model may produce several products such as biogas, microbial protein, animal feed, ethanol and antibiotics.

Simple integration

A typical example of the simple integration is the production of maggots in fish- poultry integration. The process involves the collection and bagging of animal waste under warm and moist conditions to encourage maggot production. Maggots are produced about 4 to 6 days and harvested by washing the content of the bags in water. Maggots are separated using nets or baskets and then oven dried and milled as magmeal for fish or protein concentrate in poultry feed. The figure below represents the process.

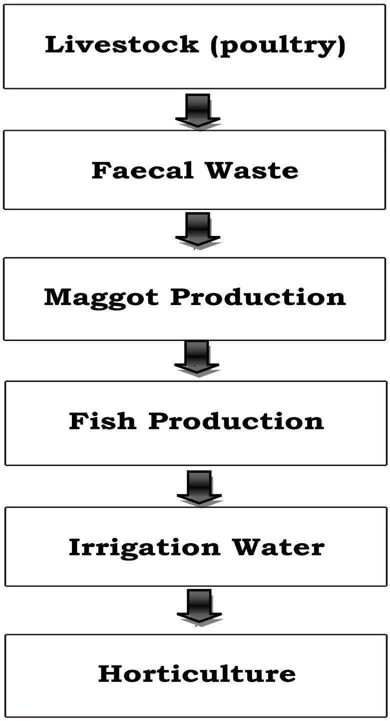

Fig. 13. Maggot production in a sample IBS (Tayo, 2008)

Maggots are larval stage of house fly and are made up of about 50 to 60% protein. Mag-meal can replace some parts of fishmeal in livestock feed. In fish feeding, it has been found to be safe and to increase growth performance (Ajani *et al.*, 2004, Ogunji *et al.*, 2007, Ogunji *et al.*, 2008). 1kg chicken manure can produce 920 maggots between 4 to 6 days. However, there are still some limitations to the use of IBS because the processes have not been perfected. There is need for further research to improve and refine the technology especially on industrial scale.

The multiple Integration Model

An example is the integration of livestock e.g. intensively managed poultry, fish and crop farming. Animal wastes from the poultry are channeled into specially constructed bio-digesters for 2-phase digestion. Bio-digesters play the important role in converting organic wastes to biofuel, reclaimed water and relatively pathogen free fertilizer. The thermophilic digestion destroys most of the pathogenic and spore forming bacteria and the mesophilic digestion at ambient temperature produces biogas which can be piped into gas tanks at this stage. Biogas is a mixture of colorless flammable gases produced by anaerobic fermentation of organic waste materials. It consists of about 50 to 70% methane, 30 to 40% carbon dioxide and traces of elements of hydrogen, nitrogen and hydrogen sulphide (Eyo *et. al.,* 2006). The process at this stage is similar to the natural anaerobic digestion that takes place in the rumen of ruminant animals during which methane and volatile fatty acids are produced. A kilogram (kg) of chicken manure can give up to 70litres biogas (Eyo *et. al.*, 2006). Biogas can be used as source of energy on the farm or for cooking. Methane can also be used for the production of other industrial chemicals like methanol. The resultant slurry after digestion is channeled into ponds where it stimulates algae production because of the high level of bio-available nutrients present. To prevent the growth of toxic algae, ponds are intentionally inoculated to initiate the growth of beneficial algae. Micro algae are now utilized in the production of bio-diesel, bio-coagulants, nutriceuticals and even antibiotics. The aspects of generating new products from microalgae and of trying to improve the efficiency of biodigesters are areas of ongoing research in integrated biosystems. Effluent from micro alga pond is further channeled into fishpond since it will still contain mineralized nutrients and phytoplankton, which could serve as food to fish. Finally excess water from the fish pond is used to irrigate farms especially in horticulture and in arable farming (fig. 12). Furthermore sludge from micro algae pond can serve as fertilizer on crop farm.

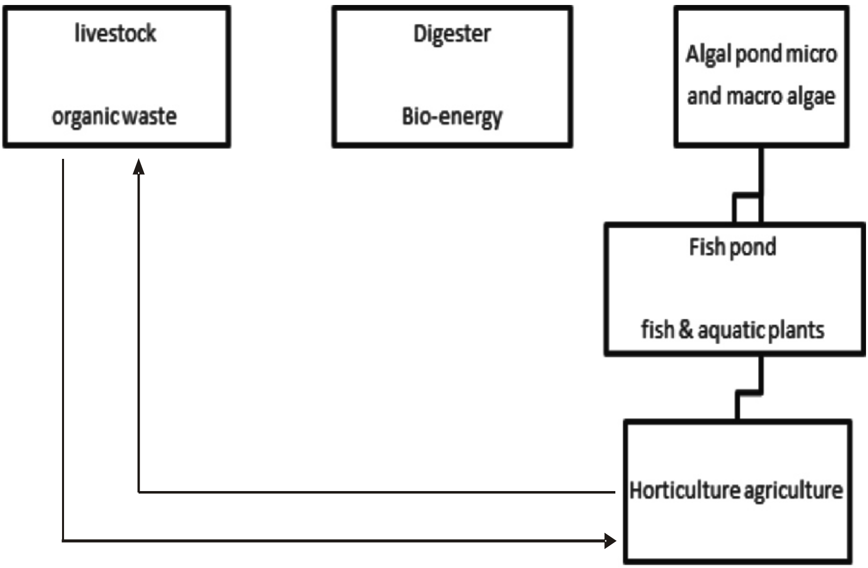

Fig 12. Integrated Biosystem: Livestock- Fish-Horticulture Model (Tayo, 2008)

Current researches are focused on possible products derivable from organic wastes and standardization to reduce issues of health, pathogen control and cost. In line with this, our research team in the School of Science and Technology came up with a research idea to combine Arbuscular mycorrhizal (AM) fungi which has been found to improve the uptake of nutrients from the soil with poultry manure (PM).

Further studies (Nwangburuka et. al., 2012, 2014) have confirmed the benefit of AM-PM combination in improving the yield of vegetables by facilitating the uptake of nutrients particularly P. A research grant was recently approved for our research team by ADRA Africa to further improve and disseminate this technology for adoption by women farmers in Ijebu Ode and Ikenne Local government areas. To the glory of God in addition to my teaching and research activities, I have also served both BU and other University communities as follows:

My contributions to Babcock University Community

Head, Department of Agriculture 2000 - 2004:
This was the pioneering stage of the department of Agriculture. As HOD, I facilitated the following activities with the few pioneer faculty at the department:

- Hosted the first NUC accreditation visit which earned us an interim accreditation. This was a spring board from which we leaped to a full accreditation on the second visit.

- Planned and co-ordinated the department's first Agric week during which the Ogun State Commissioner for Agriculture was in attendance.

- BU was granted a donation of 50 ha farmland at Eyinwa in Odogbolu Local Government area by Ogun State Government through the Commissioner on our request during the Agric week. The farmland now serves as the teaching and research farm (crop production) for the School of Agriculture.

- Introduced the practical component of the General Studies course in Agriculture (GEDS 221) offered by all

200 level students at BU. A component that has been lauded and recommended by various NUC teams that visited BU.

- Organized the first tree planting exercise at BU, a program which in the subsequent year gave birth to the greening of BU environment by the then Dean of Student Affairs; Late Pastor E. Boateng.

Member, Babcock University Administrative Committee 2000 -2005.

Member, Babcock University Board of Trustees 2000 - 2005

Member, Babcock University Examinations Committee 2000 - 2006.

Fig 13. Tree planting at Andrews park BU by Ogun State Commissioner for Agriculture 2003

Member, Farm Management Committee 2004 2006

Editor in Chief, Acta Satech Journal of Life and Physical Sciences 2005 2006.

Member, BU Graduation Planning Committee 2008 - 2011

First female Dean, School of Science and Technology 2008 2011, during which:

- I encouraged research by setting up the faculty research committee.

- Introduced the monthly faculty seminar where faculty members were given the opportunity to present their research activities.

- Initiated the School of Science and Technology research fair which became an annual event and subsequently grew to the annual BU research fair.

- Organized the first BU Bible and Science seminar for members of the School of Science.

Member, BU Appointment and Promotion Committee 2008 2012

Member, Curriculum Development Committee 2008 2012
Sponsor, BU Ruby Graduating Class 2012

Member, Colloquium Planning Committee. 2002 2004, 2013

Member, Adopt A Student Committee. 2008 2009, 2013

Editor, Shepherdess International Newsletter 2001 - 2003

President, Shepherdess International BU Chapter 2004

Director Research Innovation and International Cooperation 2012 till date:

- Initiated the publication of BU research brief, a monthly newsletter that showcases BU research activities.
- Facilitated the setting up and training of Babcock University Health Research Ethics Committee. (BUHREC).

- Facilitated the setting up and take off of BU inaugural lectures committee.

- Worked with my colleagues in Research office and within the University to develop research policy and IP documents for BU.

Member Babcock University Health Research Ethics Committee 2013 till date.

Member BU Inaugural Lecture Planning Committee 2014 till date.

In addition, I have also been involved with other institutions outside Babcock University as:

Post-doctoral fellow, Academy of Sciences for the Developing World (TWAS) and the Chinese Academy of Sciences, (CAS) 2006 2007.

Life member of the Nigerian Society for Animal Production, (NSAP).

Member, Animal Science Association of Nigeria (ASAN).

Member, Organization for Women in Science for the Developing World, Italy (OWSD).

A registered Animal Scientist

Mentor, African Women in Agricultural Research and Development 2013, headquarters World Agro Forestry Centre, Nairobi, Kenya.

External examiner for Post graduate degree and External assessor for professorial promotion in other universities. Reviewer for local and international journals.

Recommendations

The issue of animal waste management is real and must be addressed because the livestock industry will continue to expand. In addition to IBS, the following suggestions are offered to minimize the menace of pollution:

a. Livestock farmers should be encouraged to recycle animal wastes and possibly practice zero waste on the farms.

b. Nutrient management practices: A reduction in the recommended amount of P have been made in several countries. Adjusting the nutrient supply to meet the requirement will greatly reduce the loss of nutrients to the environment since the amount of nutrients consumed influence the amount excreted.

c. The Nigerian Institute of Animal Science should compile the nutrient requirements of indigenous and exotic livestock as well as the nutrient composition of livestock feedstuffs in Nigeria and make it available for use.

d. Ranching and grazing tracks should be encouraged for ruminants, this will not only reduce the incessant clashes between farmers and the Fulani herds men but it will also prevent indiscriminate fouling of the environment with animal dung

e. Siting of livestock farms should be controlled by policies, to prevent concentration in particular areas. Such farms should not be close to residential areas.

f. There is also a need to establish policies and develop technologies that will bring animal waste in line with the assimilative capacity of the land. This will prevent the overloading of soil with nutrients from animal waste.

g. The Federal Government should put in place laws that control livestock movement, management and abattoir operations in line with best practices obtainable worldwide, such policies should be maintained and effected

h. Improvement of nutrient utilization by livestock: more studies should be conducted on how to improve nutrient utilization by non-ruminants, cereal grains can be improved for low phytate P content.

i. Manure should not be applied based on crop's nitrogen need only, the P need of crops must be considered in manure application and soil test carried out before applying manure where possible.

j. In Colleges and Universities where Agriculture is taught, environment friendly practice should be included in the curriculum to prepare students for field practice.

Biblical Worldview of Livestock and the Environment

As an Adventist educator with a passion for integration of faith and learning, this discourse cannot be concluded without examining the topic from the worldview of the Holy Bible. God created the heavens and the earth including animals and He has made man a steward of His creatures and the environment (Gen 1:1-31). The dominion over animals and the instruction given to man to multiply and subdue the earth is not a license for unrestrained exploitation. In fulfilling the God given mandate, man is not sovereign or autonomous, he is to live and act under the boundaries of responsibility given by the creator of these resources, who cares for them and has not abdicated His ownership (Nwaomah, 2007). God still holds humans responsible for the way we treat the rest of the creation (Gibson, 2008). Though after sin, God allowed the killing of animals for sacrifice and meat, yet He gave guidelines that show care and concern for animals. Solomon in the book of Proverbs admonished that "A righteous man regards the life of his beasts but the tender mercies of the wicked are cruel" (Prov. 12:10), and that everyone should "be diligent to know the state of his flocks and look well to his herds" (Prov. 27:23). God did not preserve only Noah and his family in the ark but also, representatives of all animals. The issue of environmental protection concerns all humans; stewardship is holistic and it is not limited to the use of our time, talent and body. A warning against destroying the earth is found in Rev. 11:18. All are to be the green professionals, preserving and maintaining the environment as we seek to provide food for the growing population.

Conclusion

The increase in population growth and changes in food preference in developed and the developing countries is exerting pressure on livestock production, encouraging expansion and huge turnout of animal waste. Animal manure management is crucial to creating a sustainable livestock industry which in turn can lead to availability of animal protein in terms of quality and quantity. Therefore solutions to the current challenge posed by animal waste management should be explored. The concept of on farm nutrient management, recycling and integrated bio-system to utilize wastes as resources may provide relevant solutions to the problem of waste management. Recycling animal wastes is not without its challenges but further research activities can improve the efficiency of the process. With the growing interest in global warming, climate change and the environment, research grants and fellowships are available internationally on environment based research projects. Researchers should take advantage of these opportunities and contribute to studies which can boost food production without destroying the environment.

Acknowledgment

Mr. Vice Chancellor Sir, I give glory to God Almighty who took my hands to draw the picture of my career journey. As he drew, we took a step forward, each time I looked back the picture looked meaningless. Today however, as I stepped aside to take a long look, it is clearer, it is fixing together and making sense. Can I take glory for it? NOT AT ALL. All glory must be to the Lord, for he alone is worthy of all praise, no man on earth should give glory to himself.

I am grateful to God for the life of my late father, David Oladele Akanbi Afolabi, who inspite of his meager resources and several other dependants provided his children with a good foundation by sending us to private Nursery and Primary schools in the early 70s. Many would have thought that daughters are not worth this extra investment, but this man sacrificed to give us the best he could. How I wish he could witness today, nevertheless he lives on in our hearts. I am grateful to my mother, Comfort Adunola Afolabi who gave my father a hundred percent support and also became fully

responsible for my education up to PhD level after my father's death, may you live long to enjoy the fruit of your labour.

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Debo Adeyewa, Vice Chancellor Redeemer University, both are from my family compound of Omoyajowo, Inisha, Osun State, and are making their mark in the academic world, thank you very much for your support and encouragement.

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Lastly, I wish to appreciate my immediate family, my daughters Oluwatofunmi, Oluwatoni and Oyinkasola. They have been my friends, my mirror and my admirers for their love and support, for coping with mum's absence whenever duty calls for it, my husband Prof Ademola Stephen Tayo is a man in a million. I thank him for allowing me to soar beside him without feeling threatened. I thank you for giving me a level ground to grow thus facilitating the height I have reached in my career. The best is yet to come. To my friends, family and well-wishers present today, I say a big thank you.

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PREVIOUS INAUGURAL LECTURES

1. "Seventh-day Adventist Church in Nigeria since 1914: An Impact Analysis."
   Lecturer: Prof. David O. Babalola
   Date: Thursday, December 2, 2010

2. "The Truth about Truth: Postmordernism and Its Epistemological Implications for Christian Education."
   Lecturer: Prof. Ademola Stephen Tayo
   Date: Thursday, February 5, 2015

3. "Food for Thought in Thoughts for Food: Conceptual Genius of Local Ingredients in Global Diets and Food Habit of African Population."
   Lecturer: Prof. Yetunde Olawumi Makinde
   Date: Thursday, April 2, 2015

4. "One Kingdom, Many Kings: The Fungi-once Sidelined and Maligned, now Irrepressible and Irresistible."
   Lecturer: Prof. Stephen Dele Fapohunda
   Date: Thursday, May 2, 2015

5. "The Hand that Handles the Scalpel."
   Lecturer: Prof. Iheanyichukwu Okoro
   Date: Wednesday 10th June, 2015

6. "Parasitic Infections: Challenges of Control and Eradication in Public Health."
   Lecturer: Prof. Dora Oluwafunmilola Akinboye
   Date: Thursday, 15th October, 2015

7. “The Oracle, Intellectual Property and Allied Rights, the Knowledge Economy and the Development Agenda.”
Lecturer: Prof. Bankole Sodipo
Date: Tuesday, 17th November, 2015

8. “Challenges of University Education Quality in Nigeria: Placing the Emphasis where it Belongs.”
Lecture: Prof. James Ahamefule Ogunji
Date: Thursday, 4th February, 2016

9. “Factionalism, Rampaging Economic Vampires, and the Fragile State.”
Lecturer: Prof. Ayandiji Daniel Aina
Date: Wednesday, March 9, 2016

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