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PROTECTING THE ENVIRONMENT: ANIMAL WASTE MANAGEMENT THROUGH INTEGRATED BIOSYSTEMS AND RECYCLING

by

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Introduction

The thrust of world food production in the past 50 years 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. However, the challenge of Agriculture in this millennium is how to increase food production and minimize costs without degrading the environment.

Increase in population and income is changing food preferences and expanding the demand for animal products such as milk, eggs and meat. The pressure to meet up with this demand has resulted in the intensification of livestock production, particularly poultry and dairy. Intensification is characterized by large flock size in relatively small geographical areas. Other characteristics are huge turn out of animal waste (faeces) that are often inefficiently disposed, compromise on animal welfare and the environment. Nutrients, particularly, Phosphorus (P) in animal waste contributes to soil, air and water pollution.

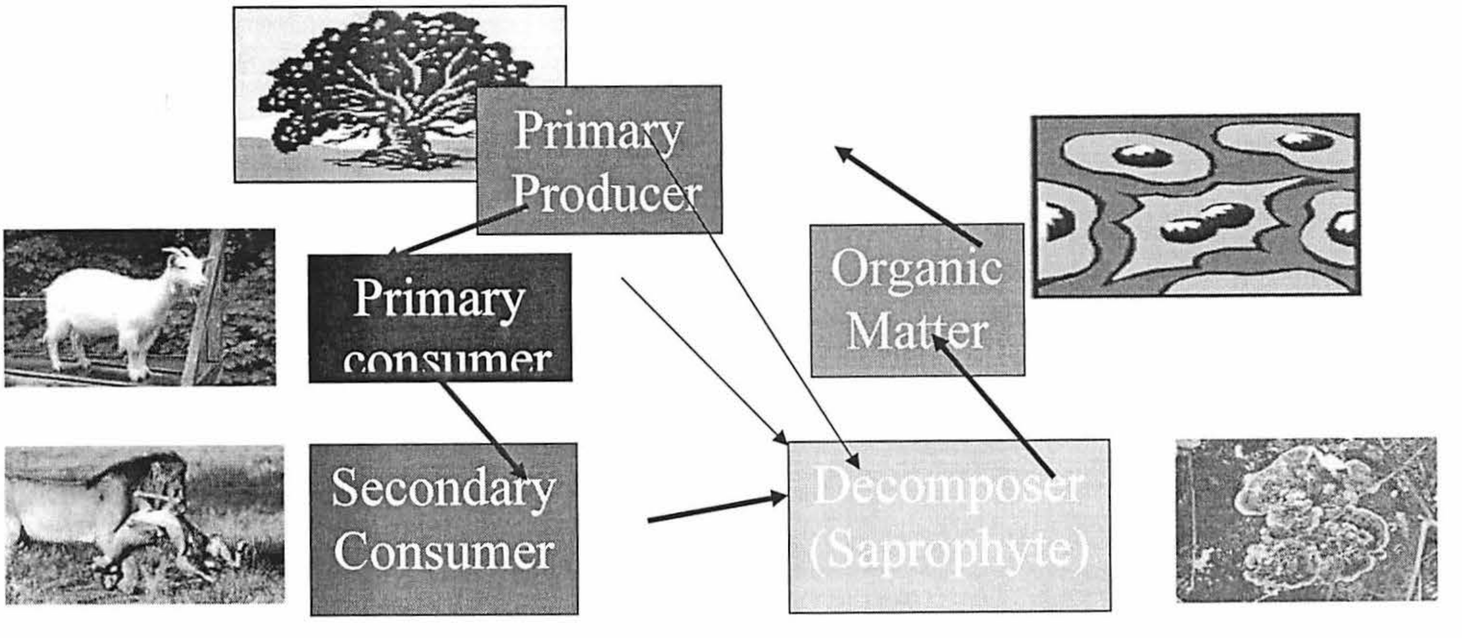
Recycling of animal waste and integrated biosystems approach are possible solutions to the challenge posed by the accumulation of livestock waste. Integrated biosystems involve the utilization of waste from one live system for the production and multiplication of another. This principle illustrates the interdependence and interrelationship between organisms and their environment. It is a model of the natural environment, a system where there is zero wastage of material resources. The purpose of this paper is therefore to situate efficient animal waste management through integrated biosystems into God's design for the natural environment.

The Natural Environment

Created beings are interdependent. God created the heavens and the earth and hence the environment (Gen 1:1). He committed the care of the garden of Eden to Man. Man was to live in harmony with his neighbours (plants and animals). Man, plants and animals are therefore related by sharing a common Creator. Plants and trees bearing seeds were assigned to humans to eat, while other plants (possibly grass and leaves) were assigned to animals. Man was to care for the garden and the plants were to serve as food for him and the animals. This signifies the interdependence and interrelationship that God intended among all created beings. Even after the fall, man was still to till the ground and to eat from it (Gen 3 : 17-19, Lev. 26 ; 3). Ecosystems in the natural environment reveal this interrelationship between organisms and the environment (Tayo, 2001).

The ecosystem is made up of biotic and abiotic components. All components function together to maintain a balance in the environment. According to Wikepedia 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. 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. Plants are generally the 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. The flow of material in a typical forest environment is represented by the figure below.

Figure I: A Simple Food Web



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.

The Environment and Human Activities

The impact of human activities on earth resources has increased over the years. The present age in geological history may be described as the "Anthropocene Epoch" because of the significant role that human activities are playing in global change (Crutzen and Stoemer, 2000). Under the auspices of the International Council of Science (ICSU), scientists have since 1987, through several programmes such as International Geosphere-Biosphere Programme (IGBP) been working to understand the interactive physical, chemical and biological processes that regulate the entire earth system, the unique environment that this provides for life, the changes that are occurring in this system and the manner in which they are affected by human actions (Anon, 2004). Human activities such as changes in technology, economic advances, changes in land use and land cover (urbanization, agriculture and forestry) are driving global change.

Animal agriculture affects the environment through its contribution of animal waste. The elements found in animal wastes, nitrogen (N), potassium (K) and phosphorus (P) are of social concern (Kojima et.al., 2005). Monogastric livestock are usually fed with concentrates (mainly grains and oil seed cake). P is available in grains as phytate and about 50 – 70% of total P in concentrates is in the form of phytate (Morse et. al., 1992). Phytate is not easily broken down during digestion in the absence of enzyme phytase. In monogastrics such as poutry, phytate is only partially available for absorption because of low intestinal phytase. The result is a high P manure which contributes to eutrophication of lakes by causing algal bloom, oxygen depletion and increased production of potent green house gases. Ruminants also excrete P mainly in their faeces. Furthermore, application of manure to farms often leads to build up of P in the soil as manure is applied to meet crop need of nitrogen and the P:N ratio in manure is higher than the P:N ratio need of crops (Tayo and Tan, 2007).

High protein in feed causes excretion of nitrogen in the faeces. Poultry excrete about 65 to 70% of their nitrogen and phosphate intake (Knowlton and Herbein, 2002). About 50% of the nitrogen excreted is lost to the atmosphere as ammonia and it contributes to both air and water pollution. Ammonia has acidifying effect on the ecosystem. Nitrous oxide (a green house gas) formed during nitrification process is also harmful to the environment. Potassium accumulation in soil by manure application damages the health of cattle through foraging (NRC, 2001).

The need to find alternative ways of utilizing these abundant nutrients therefore becomes imperative.

Recycling and Integrated Biosystems

Integrated biosystems (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 byproducts of one operation as inputs for another. The management of wastes and residues is central to the design of IBS and it encourages holistic system of interconnection and interdependence among components in the system. Some of the main features of the 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

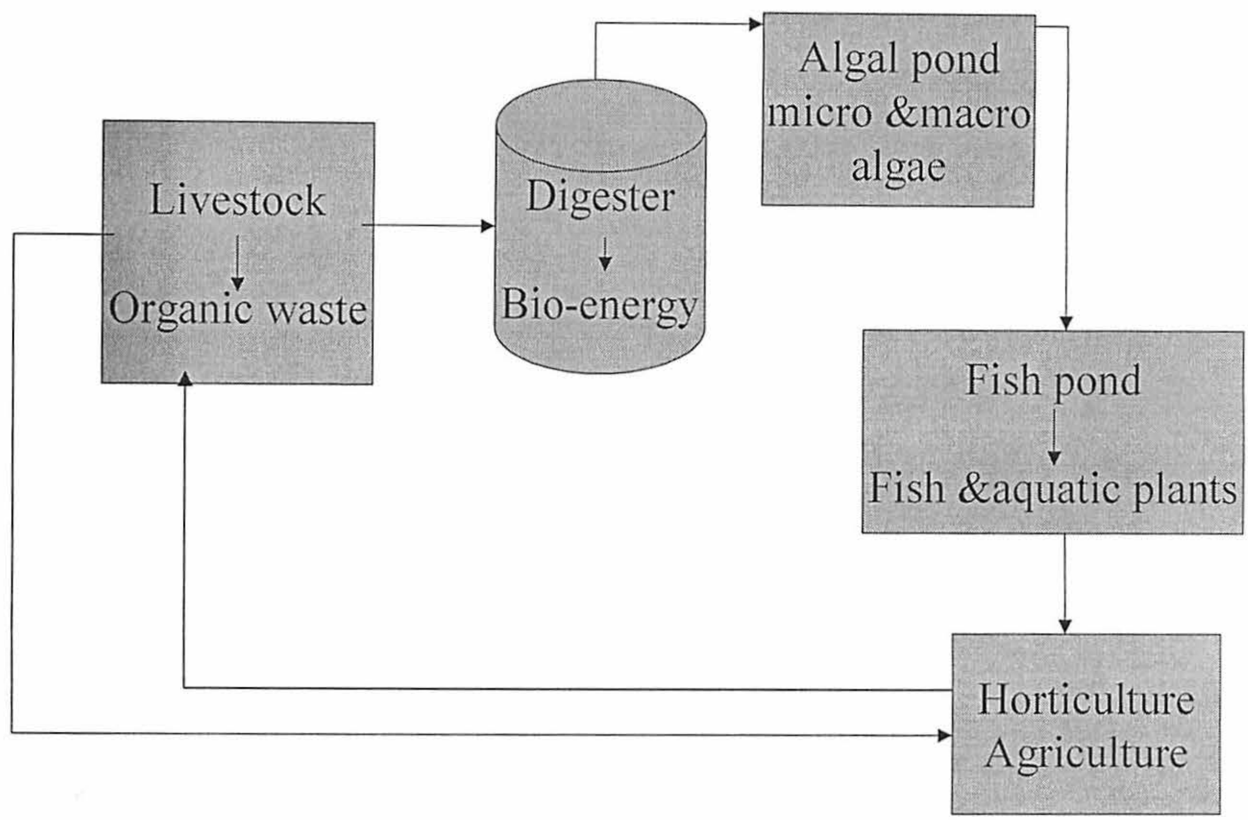
1. Simple integration e.g. using livestock manure as organic fertilizer
2. Cyclic integration e.g. livestock – manure – fodder crop –feed – livestock
3. Multiple integration e.g livestock – organic waste - biofuel - aquaculture-horticulture

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

The Multiple Integration Model

An example is the integration of livestock (eg intensively managed poultry), fish and crop farming. Animal wastes from the poultry are channeled into specially constructed bio-digesters for a 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 colourless 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, 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 kilogramme (kg) of chicken manure can give up to 70l biogas (Eyo, 2006). Biogas can be used as a 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 on-going research in integrated biosystems. Effluent from micro algal pond is further channeled into fishpond since it still contains mineralized nutrients and phytoplankton, which could serve as food to the fish. Finally excess water from the fish pond is used to irrigate farms especially in horticulture and in arable farming. Furthermore sludge from micro algae pond can serve as fertilizer on crop farm.

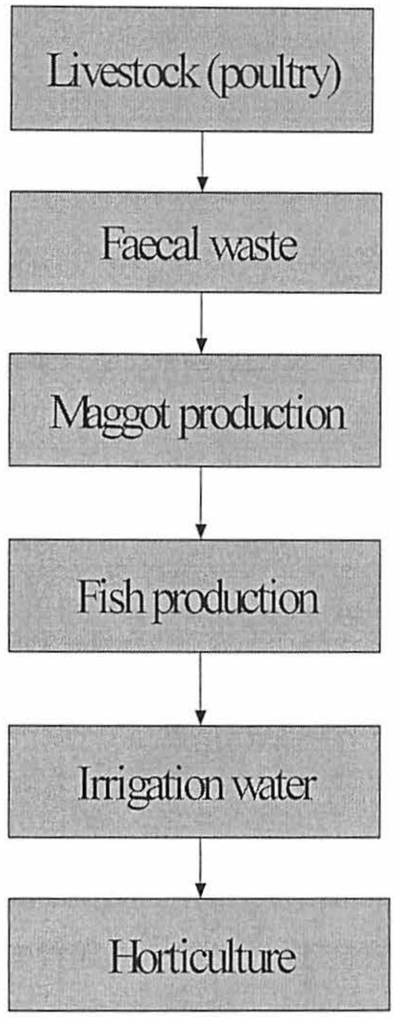
Figure II Integrated Biosystem (Livestock-Fish-Horticulture Model)



Simple integration

A typical example of the simple integration is the production of maggots in a 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 after about 4 to 6 days. They are harvested by washing the content of bags in a pond and separating maggots using nets or baskets. Maggots are then oven dried and milled as magmeal for fish or protein concentrate in poultry feed. The figure below represents the process

Figure III Maggot production in a Simple IBS



Maggots are larval stage of housefly 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 920maggots between 4 to 6 days.

Limitations of IBS

IBS is flexible and dynamic but at present it is limited by the following

1. It requires site-specific adaptations. The same system may not be appropriate for every location. The situation and facilities available must determine the system to be adopted, therefore allowing flexibility.
2. Further research to improve and simplify the efficiency of IBS technology is necessary. Some of the processes have not been perfected especially on an industrial scale. Current researches are focused on possible products derivable from organic wastes and optimum nutrient utilization.
3. Issues of health and pathogen control need to be standardized and established so that consumers will be confident to adopt and utilize products.
4. Cost effectiveness of process must also be considered, the initial capital outlay may be high. The possibility of using locally available materials should be considered.

Man as Steward of the Environment

The environment belongs to God as Creator, however, by committing the care of this world to man, he has made man a steward of the environment. God still holds humans responsible for the way we treat the rest of the creation (Gibson, 2008). God shall destroy those who destroy the earth (Rev. 11:18). 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 the resources, who cares for them and has not abdicated his ownership (Nwaomah, 2007). Though after sin, God allowed the killing of animals for sacrifice and meat, yet he gave guidelines that show care and concern for animals (Exod 20:10, 23:4-5, 22:1 and Deut 25:4). God did not preserve only Noah and his family in the ark but also, representatives of all animals. The act of concentrating animals for life in small areas generates wastes that overload the system and has the potential of destroying aquatic life. Often times greed and the desire for more profit has led man to overstretch natural resources in order to increase production. Stepping out of the boundary given by the creator of these resources will always result in chaos. This is not God's design for the environment. The issue of environmental protection concerns all humans; it is our responsibility as

Christians. Adventists' stewardship is holistic and not limited to the use of our time, talent and body; we are to be the green Christians, preserving and maintaining the environment.

Recommendations

The issue of animal waste management is real and cannot be avoided because animal husbandry will continue to expand. However steps can be taken to control pollution emanating from the waste. In addition to IBS, the following suggestions are offered to minimize the menace of pollution.

a. Nutrition management practices: studies have shown that livestock, particularly dairy, are often fed in excess of their requirements (NRC, 2001). This is usually carried out in a bid to increase their milk production. Adjusting the nutrient supply to meet the requirement will greatly reduce the loss of nutrients to the environment since the amount of nutrients consumed influences the amount excreted.

b. Semi-intensive system of livestock production should be encouraged: when animals are not permanently restricted in a small area, they can graze on open fields at regulated periods thus dispersing their manure on a larger area. The amounts and sources of nutrient losses from feedlot can be affected appreciably by the type of confinement system (Adriano, 1975).

c. Siting of livestock farms should be controlled by policies, to prevent the concentration in particular areas. In some developing countries, siting of livestock farms is uncontrolled and could be quite close to residential areas.

d. There is 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 wastes.

e. Improving nutrient utilization by livestock: More studies should be conducted on how to improve nutrient utilization by non-ruminants, particularly, phytate P. Transgenic animals with ability to synthesize phytase can be developed. Furthermore; cereals can be improved for low phytate P content.

f. Manure should not be applied based on crop's nitrogen need only, for example the N:P ratio in the feedlot is 1:1 while the N:P ratio is 5:1 for crop requirement. The P need of the crop must also be considered in manure application and soil test carried out before applying manure.

g. Limiting the consumption of animal products by following God's original plan for man's diet will reduce the pressure on intensive livestock production and invariably on livestock waste generation. "He who created man and who understands his needs appointed Adam his food saying;" I have given you every herb yielding seed and every tree in which is the fruit of a tree yielding seed, to you it shall be for food (G en 1: 29). According to White (1976), those who eat flesh are but eating grains and vegetables at secondhand, for the animal receives from those things the nutrition that produces growth. The life that was in the grains and vegetables passes into the eater. We receive it by eating the flesh of the animal. How much better to get it direct by eating the food that God provided for our use.

Implication to Adventist Education

Environmental Management studies should be included in the curriculum of Adventist Schools because of our belief in the stewardship of the environment. In Colleges and Universities where Agriculture is taught, the practice of environment friendly activities should be encouraged. In Babcock University, vegetable crop production is largely organic, that is, organic fertilizer (basically poultry manure) is used to fertilize the vegetable plots. This reduces the problem of poultry waste disposal and encourages recycling. Furthermore, in the same department, integration of faith and learning is achieved in the teaching of Agriculture by involving students in Agricultural practices that will not pollute the environment. At the penultimate year, students of Agriculture spend a whole year on the farm to experience hands on training. The department of Agriculture also engages staff and students in field trips to farms where integrated biosystems is practiced. This is with a view to establish multiple integrated biosystems on the university farm where methane will be produced for power generation. Impact assessment study of livestock production is one of the research projects currently being undertaken by the department.

Recycling animal wastes is not without its challenges (for example processing of manure before use) but research activities can help to improve the efficiency of the process. Furthermore, because of the growing interest in global warming, climate change and the environment, research grants and fellowships are available internationally on environment based research projects. Our Schools can take advantage of these opportunities and contribute to studies that can improve our environment.

Conclusion

The potential effect of livestock waste on the environment has continued to generate attention. The increase in population growth and changes in food preference in developed and the developing countries is putting pressure on livestock production encouraging expansion and huge turn out of animal waste. As stewards of the environment, Man must therefore explore solutions to the current challenge posed by animal waste management. The concept of IBS to utilize wastes as resources is an imitation of the natural law that governs the natural ecosystem. It agrees with the system built in by God for continuity and stability in the system and it will continue to provide relevant solutions to the problem of waste management.

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