Nutrient Recyling-Modern Energy Management

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We are hearing from all sides about pollution. It is as if the word was new and that pollution is a modern phenomenon. Terms like "recycled" and "biodegradable" are used by the press and the public as something new and something that we must get with. As a result, animal agriculture is under public suspicion and the industry is being pressured to relocate livestock facilities.

I think it appropriate that we consider carefully the basic causes of this problem. What are the parameters and what can and cannot be done about them? My purpose today is to discuss these as related to pollution in the area of biodegradables only. I would like to start with a quotation from that contemporary newspaper philosopher "Pogo" who was recently quoted as saying, "We searched and searched and searched and finally found the enemy. It is us." I think this bit of philosophy directly applies to biological pollution and the problems we are facing today.

Pollution is coexistent with life. More specifically, pollution is the result of living organisms getting energy for growth. Ordinarily we think of energy as industrial in nature, such as power and heat, but from a biological point of view, chemical energy is what makes the world go around. Energy for life comes from the chemical degradation of organic matter, and since this is always associated with pollution to really understand the biodegradable pollution problem, it is essential to look at the energy source of life.

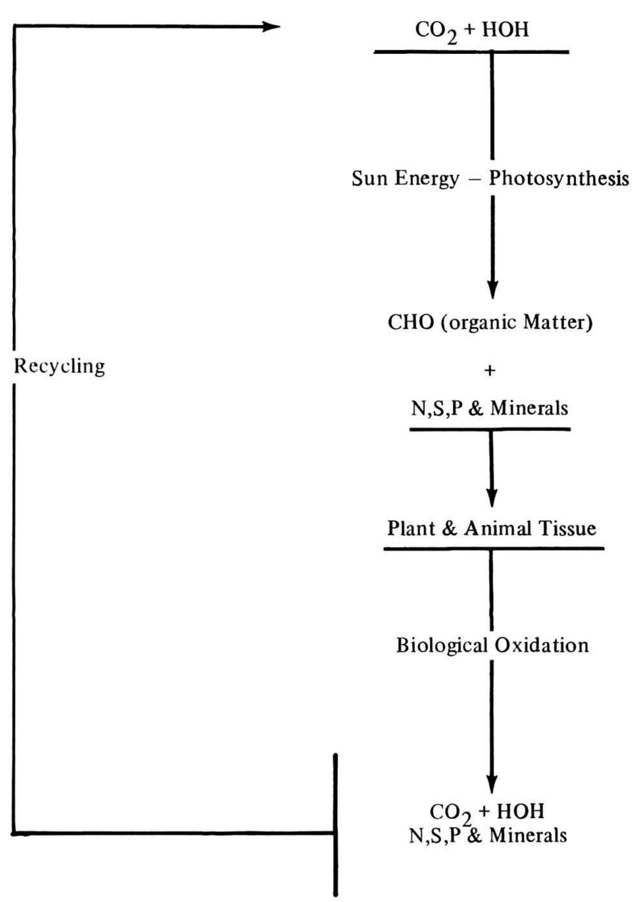
Where does the energy come from that supports life? Obviously, it comes from the sun. Energy captured in the photosynthetic process from sunlight is the fundamental energy support for all life on this planet.

Biological recycling, even though it is newly discovered by the press and general public, has been going on since the first photosynthetic cell was established. Chart 1 diagrams recycling as it has occurred through the ages. Even though "biodegradable" and "recycling" are new terms to the press, these processes have been going on since the world began.

A fundamental point I would like to make concerns the energy changes during recycling. Chart 1 shows that carbon dioxide and water, activated by energy from the sun, are synthesized into complex organic compounds. These are eventually degraded back to carbon dioxide and water. These elements are needed as structural units in all forms and types of living cells. However, the true significance of the photosynthetic process is in the chemical energy which is captured in the complex organic compounds produced. While Chart 1 shows recycling as a series of organic chemical changes, its true meaning is the

CHART I

BIOLOGICAL RECYCLING

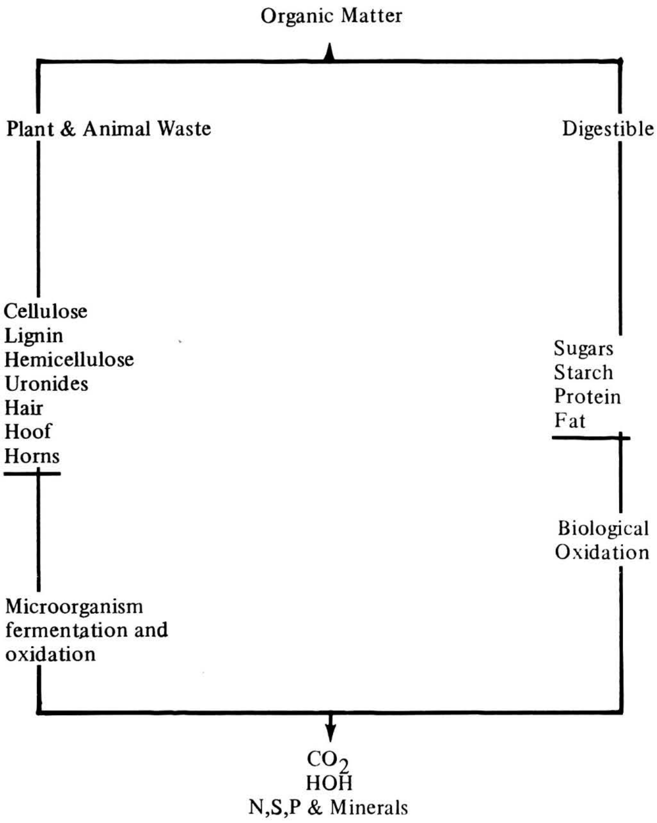


recycling of energy. Energy captured from the sun is stored in organic compounds and then released as the organic compounds are oxidized.

We are inclined to look at biological oxidation as something that can occur spontaneously. Actually, biological oxidation is the means whereby a living cell obtains chemical energy from an organic compound. It is something that must occur to support life and will not occur unless a living cell

CHART 2

BIOLOGICAL OXIDATION



needs energy. Chart 2 is an outline only, but it shows the general idea.

All organic matter produced by photosynthesis must be recycled. Only part of this is acceptable as food for large animals and man, and only part of that is digested. This digested material is biologically oxidized in the tissues—eventually to carbon dioxide and water. The undigested residue, animal waste, along with the plant waste material, must also be recycled. Biological oxidation by microorganisms is nature's way of recycling these organic wastes. Note that the greater part of the energy captured from the sun resides in these plant and animal waste materials.

We might summarize the information in these two charts by saying that organic matter is created to store chemical energy. Carbon dioxide and water, in a reducing environment, are complexed, along with other essential elements, into the variety of organic compounds occurring in nature. The energy necessary to create the reducing environment comes from the sun. The chemical energy stored in the organic matter is released via biological oxidation and is converted back to carbon dioxide and water and the other essential elements. This process has been going on since the world began. Only part of the plant matter with its stored energy can be utilized by man and his associated animals. This is the part referred to as digestible food. However, all must be recycled. Apparently, this is the major role of microorganisms in nature. This is also the basic pollution problem.

CHART 3

COMBUSTION

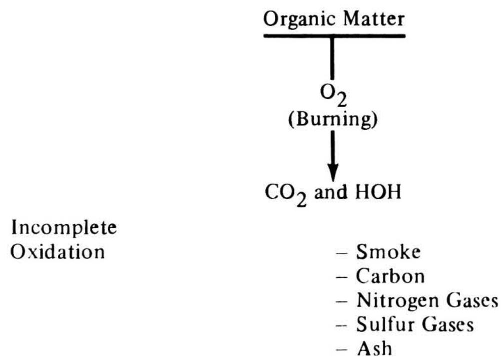
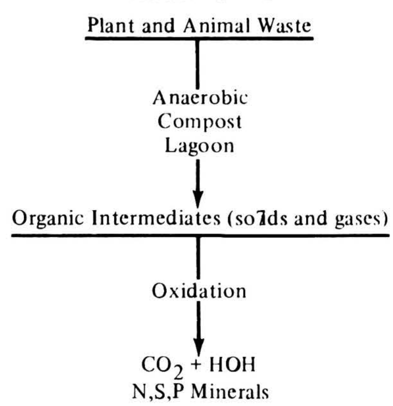


CHART 4

"NATURE'S WAY"



We all know that organic matter will burn and that the chemical energy stored in it is then released as heat (Chart 3). This heat is equal to the energy released in the living cell during biological oxidation. Compared to biological oxidation, burning is a cataclysmic action. If it occurred in the living cell, the heat released would actually destroy the cell. "Nature's way" or biological oxidation is a step-wise release of energy which results in a series of intermediate chemical compounds. The cell, by this step-wise oxidation, releases small increments of energy, all of a size which it can use.

But it is these intermediate chemical compounds, used to store energy in the step-wise degradation, which constitute the pollution problem. Chart 4 illustrates the usual way nature decomposes waste material through a combination of aerobic and anaerobic oxidative steps.

I have heard many environmentalists state that we want to get back closer to nature to let "nature take its course." "Nature's way" is illustrated in this chart. I submit that "nature's way" is entirely unsatisfactory to the public. The intermediate compounds produced are the pollutants. I believe that the environmentalists really want "controlled nature's way" illustrated in Chart 5. Controlled

CHART 5

"NATURE'S WAY – CONTROLLED"

Plant and Animal Waste

Aerobic only
Oxidation Ditch
Sewage Disposal Units

CO_2 + HOH
N,S,P, Minerals

aerobic decomposition prevents the accumulation of the intermediate compounds (pollutants) and complete oxidation to carbon dioxide and water occurs. However, in this controlled oxidation, air must be forceably induced into the system, and this is expensive.

The biological recycling illustrated in Charts 4 and 5 have one thing in common. Unless the organisms utilizing the energy in these waste materials for growth are themselves utilized by man or his supporting animal population, the energy is lost. The waste organic matter is recycled, but since the larger part of all energy captured in the photosynthetic process is stored in these waste materials, a large part of the potential energy which could be used to support man is dissipated and lost.

Since nature's way is not acceptable today, let us review some methods that are available for getting rid of the organic matter and eliminating the pollution problem. We have already mentioned burning (Chart 3). Unfortunately, ordinary burning does not eliminate pollution. Note that under natural conditions there are considerable pollutants released into the air. There are pollution-free burners available today, however they are expensive to install and operate. Consequently, burning is not an acceptable method for eliminating pollution. The heat generated can be used in industry, however there is some question as to the efficiency of conversion since material must be collected and prepared for burning. We have also mentioned controlled microbial oxidation (Chart 5). Waste materials can be eliminated in this way, however the energy contained in them is dissipated and the method is expensive.

CHART 6

ORGANIC FERTILIZER

Organic Matter

Oxidation by Microorganisms

CO_2 + HOH
N,P,S, Minerals

An obvious solution, one that has worked since the beginning of time, is to use the organic matter as fertilizer (Chart 6). Here the organic matter is anaerobically and aerobically decomposed in the soil environment, and the nutrients released are available for subsequent plant growth. Microorganism action eventually releases carbon dioxide which contributes to soil structure, and the cellular material produced is a food source for other forms of life growing in the soil.

However, there has been a shift in numbers and distribution of livestock during the last 30 years. I think that we can say, without question, that it is impossible to separate livestock from people. People are needed in livestock operations, and people accumulate where livestock facilities are located. The pollution resulting from large concentrations of livestock are objectionable to the people that are associated with the facility. Historically, animals have been scattered over the land, and recycling of animal waste, as well as plant waste, was carried on naturally in the soil. Until recent years, the concentration of livestock was never great enough to create much of a pollution problem, and the people exposed did not unduly complain. Today, economics has forced the concentration of livestock into large units so that waste disposal is the major problem facing the industry. I do not really need to point out that 115 million cattle, producing approximately 4 pounds of waste material (dry matter basis) per day, create 230 thousand tons each day. A large feedlot (100,000-head) will produce 200 tons per day.

There are also economic considerations against using raw manure as fertilizer. The plant nutrients contained in one ton of manure can be purchased as commercial fertilizer for $2-5. This will generally not cover the freight cost from the livestock unit to the field where it can be applied. Also, commercial fertilizer may be much more efficiently applied. Salmonella organisms, which are constant companions of livestock, can be disseminated by using raw fertilizer. This is particularly objectionable to vegetable growers, where FDA requires a salmonella-free product.

CHART 7

BUILDING MATERIAL

Organic Matter

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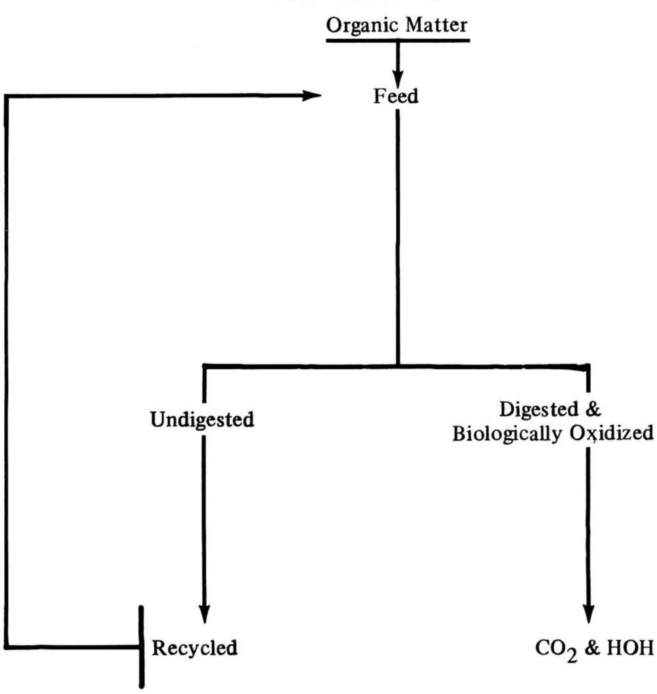
Lumber
Paper (wood pulp, straw)
Masonite (sawdust & bark)
Plastics (corn cobs)
Ecolite Bricks (compressed manure)

Many waste materials can be used as building materials (Chart 7). From a philosophical point of view, however, even the building materials must be eventually recycled. I am sure that many new and amazing methods of using plant and animal waste in the building trade will be developed in the future. However, I think that even the most optimistic will admit that this method of disposal will solve only a small part of the pollution problem.

CHART 8

RECYCLING AS FEED

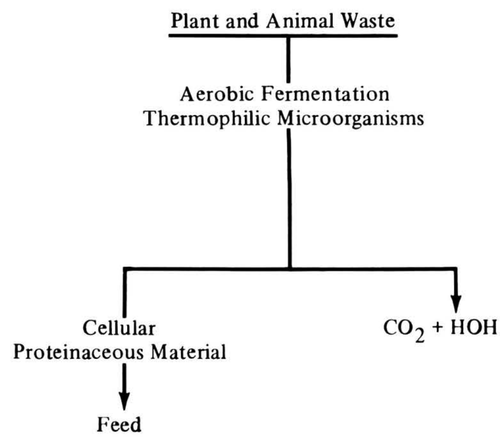


In the last few years, we have heard a great deal about recycling animal waste (Chart 8). Judging from the numerous reports in the trade journals, work is progressing in this area. There are many bacteriological and pesticide residue problems associated with raw animal waste, therefore it will apparently be necessary to process in some way. By far, the greatest part of the waste material is cellulose and lignin. Lignin is not digested to any degree by any animal and must be recycled by microorganisms. Free cellulose is partially digested by rumen microorganisms. Cellulose and lignin are closely associated in nature, consequently each subsequent passage yields less and less free cellulose. I look forward with interest on discussion regarding this point later on in the meeting.

Chart 5 illustrates controlled aerobic decomposition by microorganisms. A nutrient reclamation or nutrient recycling approach could be a

CHART 9

NUTRIENT RECLAMATION



controlled oxidative system in which the energy of oxidation is used by selected microorganisms, and the organisms are then harvested and used as a source of feed for animals (Chart 9). In this framework, the chemicals are recycled and the energy in the organic waste is captured in the microorganism cells and contributes to man's welfare as feed for livestock.

While the recycling method illustrated in Chart 9 may prove to be a workable economic solution, it will not solve pollution problems as they are reflected in the industry today. Livestock housing facilities and management techniques practiced in the industry today permit wide dissemination of a considerable part of the pollutants which are voided by the animals. In order to solve the pollution problem, it is essential that all pollutants be collected and managed. This will require a major modification in the housing facilities used and management procedures practiced in the future. The public objects to the dissemination of any of the pollutants and, to solve the pollution problem, we must have a system of production which will permit the collection of all pollutants. Obviously, the recycling of pollutants is a necessary complementary activity if all pollutants are collected.

Perhaps all or none of the solutions mentioned here may prove viable in the future. There is one fundamental point that can be made. We must find a solution to the pollution problem and the recycling of pollutants on a manageable economic basis if the industry is to continue to supply animal by-products to the public at a relative cost consistent with experiences of the past. As an example, approximately fifteen years ago, feedlot operators were paid $3-5 per ton for the solid manure collected from the pens. Today, it costs to gather this material and remove it from the corrals. Not only does the collection cost, but the ultimate disposition of the manure is in doubt. Many feedlots have "mountains" of manure piled in areas adjacent to the feedlot.