BOKASHI AG

An Advanced Alternative Environmentally Friendly Method for Organic Waste Processing

Bokashi (Acidic Anaerobic) Fermentation

Environmental Impact Statements

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Lawrence R. Green MD PhD

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Introduction:

All urban and agricultural centers need to find effective ways of handling the mountains of waste they produce on a daily basis. Most urban centers recognize that landfills can no longer be used efficiently because they are costly, polluting and difficult to manage.

Agricultural centers have to contend with large amounts of animal waste and manure and this has become a major problem that can be difficult to manage.

Many are concerned about the amount of gases produced in composting this waste, about methane gas produced in and around manure collections, and about the phosphate and the potential and known nitrogen run-off that has an impact on water quality that will foul waterways and kill fish and harm aquatic life.

Landfills do not provide an acceptable solution. Although manure has for many years been frequently used in agriculture to enrich the soil, it is now recognized that these practices of spreading manure over the surface previously accepted carry risks and unacceptable phosphate and nitrogen fouling of waterways.

A less appreciated risk related to improperly treated manure is the potential to spread coliforms and pathogens that can harm and contaminate wells and food sources on or near by farms using manure improperly treated.

More efficient environmentally friendly solutions are needed to treat all forms of waste.

Fortunately, there is a very efficient and effective way of treating all forms of green waste using naturally derived micro flora and fungi. The method outlined in this paper (Bokashi fermenting waste) resolves most of the problems linked to waste processing.

Some Key Environmental Issues to Resolve:

When we speak of recycling green waste we are concerned about major environmental issues having to do with;

- Air Quality
- Water conservation
- Water quality – minimizing phosphate and nitrogen run-off
- Water quality – eliminating coliform and pathogen pollution
- Heat generation and contributions to potential global warming
- Minimizing demand for petrol fertilizers
- Reducing Transport Traffic, trucking long hauling to processing centers ● Minimizing pest pressure without dependence on pesticides and fungicides ● Efficient use of lands minimizing waste.

- Soil fertility – methods of improving and supporting biologically active soils minimizing or eliminating the need to add phosphates and nitrates

We provide in this paper a brief description with comparative attributes to competing technologies underscoring the environmental benefits to bokashi (acidic anaerobic) fermenting green waste. There are many benefits.

Bokashicycle NVC LLC has both domestic and foreign filed patents for green waste recycling and this technology has significantly evolved enormously over the last 50 years and even more so in that last decade. It is a well recognized and practiced method of processing green waste world wide.

Because most US environmental agencies have had little experience with Bokashi fermenting and are only now in the US beginning to learn about this process, it is natural and expected that questions will arise.

The Department of Energy and Environmental Protection has been helpful and supportive in accepting alternative potential solutions to green waste processing. In so doing, they seek answers to the following questions when evaluating the merits of a bokashi fermenting project.

DOE and Environmental Protection Questions:

1. **Describe how this proposed demonstration project (1) is necessary to research, develop or promote methods and technologies of solid waste management, that are consistent with the goals of the state solid waste management plan;**

2. **Does not pose a significant risk to human health or the environment; and**

3. **Is consistent with the federal Water Pollution Control Act, the federal River and Harbors Act, the Federal Clean Air Act or the federal Resource Conservation and Recovery Act.**

It is the objective and goal of this paper to provide sufficient statements and descriptions of this process to adequately address each of the above questions set forth by the Department of Energy and Environmental Protection.

Although much research and experience has shown that bokashi fermenting very efficiently and cost effectively eliminates serious environmental issues linked to all other competing technologies, it is important to proceed on an industrial scale documenting that the same beneficial attributes related to bokasi fermenting at a smaller scale are observed as more and more waste is processed in this manner.

Glossary of Useful Terms:

In this paper we will refer to a few useful terms which are simply defined as indicated below. Most terms, for example coliforms and pathogens are well known and common so we are defining just a few fundamental terms that will help in understanding how bokashi fermenting works and its impact on the environment.

Organic matter - refers to any material derived from plant material and has generally high amounts of carbon, hydrogen, nitrogen and lesser amounts of sulfur. Since animals live off of plants they are part of the organic matter on the planet.

Green waste – any organic matter.

Feed stock – refers to the type of green waste being processed or fermented. Food waste, manure, marijuana waste, yard waste are all examples of waste recycled in various forms.

Acidic - a measure of acid conditions normally expressed in terms of hydrogen ion concentration. Acidic is in the range below 7 to 0 (most acid content), and above pH7 is neutral and then alkaline.

Anaerobic - means conditions where oxygen is eliminated or excluded.

Fermentation - is a process that involves typically micro organisms that are capable of breaking down and altering food or green (plant derived) materials, examples being yogurt, cheese, beer, or wine production.

Bokashi - a Japanese term that translates as "fermented" organic material. Kim chi, soy sauce, wines are products that are made by fermenting. The manner in how material is broken down or fermented is dependent on the kinds of microbes and conditions used.

Acidic Anaerobic fermentation - is the technical scientific term that involves Bokashi fermenting as it is done with specialized microbes where oxygen is excluded. The microbes secrete enzymes which break down complex molecules in the organic matter resulting in many metabolites.

Enzymes - complex molecules that have evolved to cleave or disrupt various chemical bonds in larger molecules very quickly and efficiently. Enzymes are the tools microbes use to obtain energy and materials to create other complex molecules.

Metabolites - when large molecules are broken apart into smaller and smaller building blocks, metabolites are formed. These are the many and complex pieces that are formed as the larger molecules are "digested" by enzymes.

Struvite - a naturally forming mineral that precipitates (forms stones) in soil when magnesium, phosphate and ammonia are present. Struvite acts as a time release material allowing both phosphorous and nitrogen to feed plants on a continuous basis because it is

only slightly soluble in water. It thus locks phosphate and nitrogen in the soil preventing harmful run-off into waterways, wells, and lakes. Struvite will not form with nitrates, the common form of nitrogen fertilizer and will not form unless magnesium, phosphate and ammonia are all present at the same time.

Comparative Attributes – Bokashi vs Competing Methods:

One solution in green waste is to compost the organic waste. Another solution is to digest the waste in a methane producing plant (AD technologies). Composting takes a long time, requires a lot of effort and equipment, is not particularly efficient, and ties up land that could be used more efficiently in other ways. AD methane producing plants are very expensive and hard to manage and ultimately toxic in the environment.

A third alternative, Bokashi (acidic anaerobic) fermentation is the simplest, least costly, and fastest way of recycling organic waste. It is an anaerobic process with specialized microbes and requires only 10 days to reach its end point and the bio-pulp obtained has a high market value.

Unlike the composting process and AD technologies which contribute significantly to greenhouse gas production, Bokashi fermenting virtually eliminates all greenhouse gases related to organic waste cycling. Virtually all of the carbon returns to the soil where it is sequestered.

Bokashi fermenting can be done all throughout the year, is very scalable, produces neither heat nor gases, and eliminates nuisance factors like odors and vermin linked to composting sites.

Most importantly, this technology can dramatically reduce the community's dependence on petrol derived products. The fermented bio-pulp when mixed with soil establishes healthy high organic content soil free of pathogens and no additional fertilizers are required.

Farm lands can thus be greatly improved and run more efficiently by cycling the bio-pulp through the soil. When waste is processed and recycled to the land, true sustainable agricultural practices are easily achieved. This cycling process conserves water too and the nutrients produced by bokashi fermenting are avidly fixed in the soil reducing ground water nutrient leaching which has been a difficult problem to resolve in the farming communities.

Table 1: Attribute Comparison for Composting Anaerobic Digestion and Bokashi Fermentation

Attribute	Composting	Anaerobic Digestion	Bokashi Fermentation
Decomposition Time	~ 6 months	~ 30 days	~ 20 days
Reduce Landfill biomass	●	●	●
Requires Energy Tending	●	●	○
Contributes to global warming	●	●	○
Expensive to support and implement	●	●	○
Pathogen in Process Growth	●	●	○
Odor Problems	●	●	○
Attracts pests	●	○	○
Technically complex	○	●	○
Carcinogenic by products	○	●	○
Conserves Water	○	○	●
Scale Up/Down Flexibility	○	○	●
A sustainable practice	○	○	●
Simple to implement and maintain	○	○	●
Capital Investment	High	High	Low
Labor cost	High	High	Low
Land use requirements (footprint)	High	Low	Low
Capital Re-investment Requirements	Moderate	High	Low
Operational Costs	High	High	Low
Waste (Biomass) limits	No dairy, fats, meat	●	○
Nutrient value end product to plants	Moderate	Moderate	High
YES =	●		
NO =	○		

It is important to more carefully examine the attributes related to methods used to recycle organic waste before any one method is adopted. These attributes are summarized in Table 1above. **Bokashi fermenting is by far the superior least toxic and most cost effective way to solve the organic waste problem**.

Curbside diversion programs using bokashi fermenting in a residential setting are easy to implement. The home owner takes responsibility to process all organic waste in the home so none of the waste ever gets to the curbside. Cities no longer have a need to pick up the organic waste saving labor and fuel and time.

Cities adopting a bokashi fermenting plant can process industrial/commercial organic waste easily in a small space and no longer have to ship the waste to a facility where much of the material will be oxidized in a composting operation.

Organic waste should be processed locally where it is produced. Cycling the end product (bio-pulp) to the surrounding gardens, farms and parks is a positive welcome benefit. The soil organic content, so badly depleted over years of neglect can easily be restored resulting in truly sustainable practices.

Conserving water, cleaning up the soil, and reducing greenhouse gases in a cost efficient process that takes little effort and time makes a lot of sense. Bokashi fermenting is the only one of the 3 options that is easy to implement, costs little to put in place, cleans up the air and water and restores soil needed to grow products we consume free of chemicals and toxins.

Fermenting – Environmental Observations & Benefits:

When we speak of recycling green waste and fermenting we are in the following observations referring to acidic anaerobic fermenting of waste.

A great amount of research is on going but all of the following observations have been documented and established in a variety of ways and are summarized with brief explanations based on current undestandings of how this is accomplished or happens.

Air Quality Statement:

Green waste placed in a fermenting unit never touches the ground and all oxygen is excluded during the approximately 2 weeks it is in process and broken down into metabolites. The specific soil derived microbes and flora and fungi involved in this process are proprietary but all are derived from native soils. No chemical additives or toxic materials are included in the bokashi culture mix.

Experience has shown that the weight of material entering the fermenter is virtually identical to the weight of material at the end of the fermenting cycle. There is no loss of weight of any consequence. Unlike composting where oxidation and heat and the escape of many gases into the atmosphere, bokashi fermenting conserves mass and eliminates greenhouse gas production.

No methane is produced due to the rapid drop in pH which is a well known inhibitor of methanogens the organisms responsible for methane production.

We know of no other competing technology that converts green waste to a useful product minimizing gas production.

Nitrogen is trapped as the ammonium ion and does not escape into the atmosphere as ammonia because the end product pH is at about pH 4 which is far too acidic to allow any appreciable ammonia degassing.

Water conservation:

Because no heat is produced in this process, and the water released with cellular disruption remains in the fermenting bin, all water is conserved. Some water forms with fermenting too.

This is very important as water is not lost to the atmosphere. Water is both conserved and manufactured in this process. No competing technology does this.

It has also been shown that the formed bio pulp when either directly mixed with soil or when separated into tea and cake (both loaded with micro nutrients) by dewatering is then applied to soil, an expanded diverse population of flora and nutrients supporting the soil food web forms.

The biologically activated soil greatly increases the soil's avidity for water because in part the many living organisms have water trapped within the intra-cellular compartments buffering the flow through and loss of water in the soil.

Because cell turnover and the sharing of nutrients between micro flora and plants is ongoing, this results in less water demand to maintain healthy plants. The impact is currently estimated at reducing water requirements by at least 20% in arid environments when used in farming applications.

Water quality – minimizing phosphate and nitrogen run-off:

There are many contributing factors that lead to a dramatic reduction in both nitrogen and phosphate run-off into waterways.

Unlike composting where most of the nitrogen is in the form of nitrate (negatively charged ions), nitrogen ends up at virtually 100% ammonium ion (positively charged ions) in part due to the reducing environment in this fermenting process and because many carboxylic acids form trapping nitrogen as the ammonium ion.

Negative ions are repelled by clay particles and rapidly move with water.

Clay particles in the soil are negatively charged. Thus ammonium ions are electrostatically tightly held and bonded to clay particles in part minimizing run-off. This attraction minimizes or reduces nitrogen loss.

It is also well known that both phosphate and ammonium ions in the presence of magnesium naturally precipitate to form a very insoluble mineral, **Struvite** (see glossary of terms).

Struvite is a problem for companies that have to maintain pipes and valves as it naturally precipitates in water pipes and around valves blocking and destroying their efficient operation. It costs water departments thousands of dollars to do these repairs every year.

But in agriculture it is a huge advantage to have struvite in the soil because it holds both the nitrogen and phosphate as a mineral deposit where it formed in the soil near plants and it does not leach effectively to contaminate waterways.

Both the plants and the expanded diverse microbes, fungi and flora living in the soil are competing for nitrogen and phosphate needed for proper cellular activity so in this form with its slow delivery back to the soil it reduces the demand for petrol derived fertilizers and additional phosphates while working against leaching into the waterways.

Most growers find in short time they no longer need to supplement soil by heavy loading with nitrogen based fertilizers and phosphates which always rapidly move with water and account for much of the current problem in managing formally clean waterways.

Water quality – eliminating coliform and pathogen pollution:

There are many documents and studies showing that bokashi fermenting is highly lethal to most pathogens including coliforms and E. coli in general.

This killing effect is so efficient that colonies are frequently obliterated in 48 to 72 hours and it is thought to be due in part to naturally forming antibiotics produced by fungi competing with non pathogenic bacteria, partly due to free radical nitrites formed transiently as nitrates reduce to ammonium forms, and certainly in part due to the extreme environmental changes (sharp reduction in pH and exclusion of oxygen).

Studies done by the FDA and USDA have also shown that the combination of trace amounts of butyric acid at lower pH are particularly lethal to E. coli and coliforms contaminating meat products.

Butyric acid is always formed in trace amounts in this fermenting process and the pH is always ending at the acidic end of the spectrum assuring that the same pathogen killing conditions are established.

No Heat generation eliminates potential global warming Contribution:

Bokashi fermenting generates no significant heat during its entire process from beginning to end and normally takes place at ambient temperature. Lower temperatures only slow the process and higher temperatures increase the rate of enzymatic activity. There is no heat contribution to this process effecting the environment.

Minimizing demand for petrol fertilizers:

In addition to the many flora, fungi, and microbes involved in this process and the variety of metabolites complex molecular structures that are highly beneficial for plants form. Humic and folic acids form, cytokines, auxins, giberellins and most likely a number of other useful growth hormones that positively benefit plants form in the fermenting environment.

There are many nitrogen fixing organisms involved in this process and their number and diversity clearly expand as waste is metabolized. Experiments in soil monitoring show both nitrogen and phosphate are well maintained even after heavy rains when levels transiently drop.

Within a matter of hours the tested levels rise suggesting that nitrogen fixing activity is in part accounting for stabilization of soil structure.

Growers have consistently reported higher yields and healthier plants using the end products obtained by fermenting green waste and some of them have stopped using supplemental chemical fertilizers.

Reducing Transport Traffic, trucking, long hauling to processing centers:

Bokashi fermenting green waste requires no windrow use and conserves very much land freeing it for other uses.

Because it takes a small foot print to process a large volume of waste and produces no notable foul odors nearby an operating plant, it can be done close in where waste is produced and near urban centers without complaints.

By decentralizing process centers and establishing recycling facilities close in where it is produced, long haul transport and trucking is reduced significantly. Because no diesel fuel is required for windrow machinery, turning waste, or mixing waste and trucking is minimal, fuel savings are substantial.

This is also a benefit to improved air quality by eliminating diesel use requirements.

Minimizing pest pressure without dependence on pesticides and fungicides:

Growers using green waste fermented and recycled products report consistently a great reduction in pest pressure.

This may be in part to healthier plants more able to resist opportunistic infections and attacks by pests. It is also likely due to the filling of viable habitat with symbiotic beneficial organisms thus excluding habitat for pests and opportunistic organisms that feed on plants.

Efficient use of lands minimizing waste:

As noted above, because the process takes a small foot print, requires no windrow processing and can be done by decentralizing waste processing centers placing them closer in where waste needs little transport distance, land is conserved.

Biologically active soils with healthy plants produce more food and plant material on less land which is an important factor improving yields without demanding more land in the process.

Soil fertility:

Soil fertility is a measure of the ability of soil to support healthy plants over and over with each replanting of crops or plant material. It is well known that soils with a vibrant diverse population of micro flora, fungi, spring tails, spirochetes, earth worms etc. (the diverse soil food web) are fertile and support plants well.

The quality of soil and improved diverse populations are well observed when fermented green waste is brought back to soil and many growers have experience with rapid improvements in soils that had been previously observed as poorly performing.

Routinely growers report on soils relative devoid of earthworms before being treated with fermented end products recovering quickly with observed improved tilth and numbers of earthworm populations after treatments are in place.

Summary:

The goals of solid waste management are generally to minimize polluting air, soil and water in such a manner as to also minimize risks and hazards to operators and processors with the least amount of adverse impact on populations while conserving resources. All evidence to date shows that Bokashi (acidic anaerobic fermenting) does this most efficiently and cost effectively with many beneficial outcomes.

It is also one of the few technologies that requires minimal energy and time to accomplish the task of recycling green waste be it food waste, manure, or yard waste.

No significant risk to humans has ever been identified using this technology and its products used in agriculture have never been shown to in any form be toxic to handler, process operators, or populations in the vicinity where it is applied in agriculture.

In addition to efficiently recycling waste, it releases no significant gases into the atmosphere and it does conserve water and reduces the demand for watering plants in soil treated with end products of fermentation.

Both phosphate and nitrogen are far more avidly locked into soil (struvite precipitation) and bound up with clay particles minimizing runoff into waterways.

Much is to be discovered and gained by promoting and supporting new technologies that bring these benefits to the front line where they can be properly evaluated against other competing technologies. Large scale operations are essential if we are going to solve the many problems related to recycling green waste.