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BioLiquidator

Effluent Fertilizer Guide

This guide was created to increase the understanding of natural fertilizers, and identify where the effluent from the BioLiquidator Alkaline Hydrolysis System fits in.

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In a mutually beneficial relationship, the BioLiquidator offers a reduced cost of carcass waste disposal for those in the animal industries, and reduced costs of agricultural inputs for those in the plant industries.

I. Fertilizer Basics

The fertilizer industry primarily focuses on the macronutrients nitrogen (N), phosphorous (P), and potassium (K). The theory that N, P, and K are the central components for producing healthy plant growth dates back to the 1800s. German chemist Justus von Liebig, known as "the father of the fertilizer industry," was one of the first to study plant nutrition for the benefit of yields. This was the start of nitrogen-based fertilizers. Most fertilizers on the market today feature the percentages of N-P-K on the label, and are typically high in nitrogen for quick results. We are now seeing a much-needed evolution in environmental understanding. While nitrogen, phosphorus, and potassium play an irreplaceable role in plant health and function, it is much more complex than the scope of these three elements. A variety of other nutrients, minerals, and beneficial soil organisms all play essential roles in prolonged plant health.

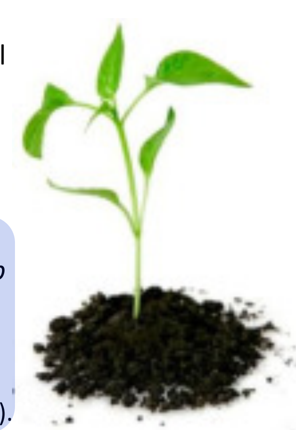
Synthetic vs. Natural

Synthetic chemical fertilizers are responsible for sustaining most of the world's edible plants. In fact, the production of N-based fertilizers consumes just under 2% of the world's annual energy supply (natural gas), and supports at least 40% of the world's population (http://www.fertilizer.org/ifa/Home-Page/STATISTICS, accessed Jan 2009). Unfortunately, over-use and over-application of synthetic chemical fertilizers has lead to an alarming buildup of excess nutrients in our waters as pollutants. Much of the over-application comes from non-farming users such as homeowners.

There is no doubt that synthetic chemical fertilizers serve an important function on a global scale. There is also no doubt that we have unintentionally had, and continue to have an adverse affect on the environment because of our over-dependence on these fertilizers. The use of natural fertilizers is working in the direction of self-sustainability by recycling already present resources that might otherwise be considered waste. In addition to recovering nutrients, there are numerous environmental and yield reasons to consider natural fertilizers. Synthetic chemical fertilizers are used at an overall expense to the environment and can result in the depletion of essential soil elements.

- Nutrients in synthetic chemical fertilizers are designed to dissolve quickly in water to promote rapid results, but this creates an obvious leaching problem.
- The nutrients are designed to be highly soluble and immediately available, but because of this plants never get to use a large portion of the nutrients.
- This promotion of rapid growth can deplete the plant's stored energy, which is biologically reserved for hard times. Overall, the high NPK concentrations discourage natural self-sufficiency.

Natural fertilizers are often criticized for the low N-P-K levels, much because the fertilizer industry has emphasized nitrogen-based fertilizers for such a long period of time. Because of organic matter and increased complexity, the lower N-P-K levels can meet or exceed chemical fertilizers. In fact, the lower N-P-K levels are possibly more beneficial in many applications. An overabundance of N can lead to accelerated topsoil degradation, excessive shoot and leaf growth, reduced root growth, low plant carbohydrate reserves, increased susceptibility to adverse conditions such as weather extremities and attacks by diseases and pests. The atmosphere is 78% nitrogen. This type of nitrogen is not directly available to plants in this form. A healthy soil contains nitrogen-fixing bacteria which convert the atmospheric nitrogen to a form available to the plants. As you can imagine, a healthy complex soil can maintain natural levels of nitrogen for the plants.



> *"Plants can get enough nitrogen easily. Nitrogen is plentiful in a properly functioning natural system. Air is almost 80 percent nitrogen. Many of the microbes in the soil can grab nitrogen right out of the air in the soil and make it available to plants. That's why aeration is so important. Nitrogen is also released in the soil by the feeding of microorganisms on organic matter. That's why compost is so important."*
> Source: http://www.utexas.edu/utpress/excerpts/exgarhow.html, accessed Jan 2009).

When we destroy or deplete the healthy microorganisms in the soils, we impede the self-sufficiency of the environment. Natural fertilizers actually encourage soil complexity and provide food in the form of robust organic matter for the organisms in the soil matrix.

A Slow Release

Synthetic fertilizers produce quick results, while natural fertilizers require patience. It is no wonder that people have preferred synthetic. Synthetic fertilizers will typically produce visible results within 1-2 weeks, and lasting 2-4 weeks. Just prior to crop-harvesting, this might make sense. But remember, it takes a toll on soil quality over time and can pollute the environment with excess nutrients. Natural fertilizers work slowly over time to improve soil health, and will sustain much longer positive effects. Visible results can be observed within 1-3 months, but will last for a very long time – possibly for years. Improving soil structure is an enduring investment.

Common Nutrient Values

Table 1 below can be used to establish baseline nutrient data for comparison of some common, more natural fertilizers. Please keep in mind that there is great variation in nutrient value information available. Values of manures, for example, vary greatly depending on the diet and age of the animals, and the nature and quantity of bedding in the mix. This information was obtained from Cornell University's nutrient guide to gardening (source: http://www.gardening.cornell.edu/factsheets/ecogardening/guidenutval.html, accessed Jan 2009), and was comparable to other data available.

Table 1: Guide to the Mineral Nutrient Value of Organic Materials Percent (%)

Materials:	**Nitrogen (%N)**	**Phosphorus (%P2O5)**	**Potassium (%K2O)**	**Relative Nutrient Availability**
Manure(fresh)				
Cattle	0.25	0.15	0.25	Medium
Horse	0.3	0.15	0.5	Medium
Sheep	0.6	0.33	0.75	Medium
Swine	0.3	0.3	0.3	Medium
Poultry(50%water)	2	2	1	Med. Rapid
Bone Meal(raw)	2 to 6	15 to 27	0	Slow
Bone Meal(steamed)	0.7 to 4	10 to 34	0	Slow Med.
Cocoa Shell Meal	2.5	1	2.5	Slow
Compost(not fortified)	1.5 to 3.5	0.5 to 1	1 to 2	Slow
Cotton Seed Meal(dry)	6	2.5	1.7	Slow Med.
Dried Blood(dry)	12	1.5	0.57	Med. Rapid
Fish Meal(dry)	10	4	0	Slow
Milorganite(dry)	5	2 to 5	2	Medium
Mushroom Compost	.4 to.7	1	.5 to 1.5	Slow
Peat and Muck	1.5 to 3	.25 to .5	.5 to 1	Very Slow
Sawdust	4	2	4	Very Slow
Sewage Sludge(digested)	1 to 3	.5 to 4	0 to .5	Slow
Urea	42 to 45	0	0	Rapid
Wood Ashes*	0	1 to 2	3 to 7	Rapid

* Wood ashes may raise pH

Over-Application

If a little bit is good, is more better? Actually, more is not always better. The term nutrient has a positive undertone because of its association with plant and animal health. Nutrients in concentrated amounts however pollute our water systems. For synthetic chemical fertilizers and natural fertilizers (and those termed "organic" as well), over-application is a problem. It is important that the every-day user of any type of fertilizer be aware that even though it is natural or organic, it is still application of nutrients. Homeowners use 10-times more fertilizers per acre than farmers (source: http://www.epa.gov/greenacres/wildones/handbk/wo8.html, accessed Jan 2009). All fertilizer users carry the responsibility of identifying the proper nutrient application for their particular soil chemistry and surroundings. It is also noteworthy that many of the commercially available *organic* fertilizers contain synthetic fertilizers. To be labeled as organic, only a small percentage needs to be carbon-based, and the rest can be synthetic. Natural fertilizers which recycle materials are easily identified as being majorly composed of animal and/or plant components. These typically contain lower levels of nutrients which helps users prevent applying overwhelming amounts to their environment.

II. BioLiquidator Effluent

The BioLiquidator system uses alkaline hydrolysis to dissolve tissue and convert the tissue and water into a sterile, aqueous solution. This solution is suitable for land application as a natural fertilizer when potassium hydroxide (KOH) is used as the alkali. Sodium hydroxide (NaOH) can also be used as the alkali in this process, but may limit the selection of plants for application due to the high sodium content. A mix of the two alkalis, in appropriate amounts, may also be used to decrease the concern for the salinity of the effluent.

The effluent is a coffee-colored true solution of small peptides, amino acids, sugars, and soaps, with a pH in the range of 10.5-11.5 (dependent upon digestion time and amount of alkali used). The effluent has a very high carbon value which enhances soil performance as a growth medium, and absorbs carbon dioxide which benefits our atmosphere and the plants which use it. Table 2 below shows the general analysis for effluent using the recommend BioLiquidator parameters.

Table 2: Calculated Analysis of the Effluent Component (average values) Using Recommended BioLiquidator Parameters*

Measured Value	Liquid Effluent	Dehydrated (to 50% moisture content)
pH	11	11
Nitrogen (N)	1%	9%
Phosphorous (P)	.33%	3%
Potassium (K)	3.5%	21.6%

*Recommended Parameters: 40:60 Tissue to Water Ratio, and 45% liquid KOH at the rate of 22% the tissue weight OR 90% anhydrous (dry) KOH flake at 11% the tissue weight, and cycle time of 15-18 hours at 92.8°C.

In order to better understand the role of each element, the primary functions in plant development are listed below:

Table 3: Primary Functions of N-P-K in Plant Development

Nitrogen (N)	Foliage
Phosphorous (P)	Root development, flowering
Potassium (K)	Overall health of plants (catalyst in enzyme reactions, helps in protein synthesis, neutralizes organic acid, regulates cellular ionic balance which functions to open stomata→ plant breathing)

Discussion of Effluent Analysis

Each component listed in Table 2 is discussed below:

Nitrogen (N): The nitrogen level is a lower value in this natural fertilizer, however the effluent is rich in organic matter. This organic matter will serve as a food supply for soil microorganisms, which will in turn pull nitrogen from the atmosphere for plant use. The adverse affects of nitrogen-loaded fertilizers have already been discussed. Additionally, this leaves opportunity to amend a naturally nitrogen-rich fertilizer such as manure or composted yard waste. This will be discussed in further detail in the Application Techniques section to follow.

Phosphorous (P): Most of the phosphorous from the digested carcasses is present in the bone ash, as calcium phosphate. Due to the rugged agitation in the BioLiquidator system, some of the insoluble phosphate from the bones is already suspended in the effluent solution. The effluent's phosphorous level is lower, but this is actually beneficial to the soil because phosphorous is an element for which we have special concerns due to the leaching properties. The solid form of calcium phosphate from the bone shadows, however, will release the phosphate over time, and minimize leaching. This also leaves the option to combine the P-rich bone ash into the effluent fertilizer, or to treat the area with only one of the two byproducts based on the soil chemistry.

Potassium (K): Because of the alkali used for the tissue digestion (assuming KOH), the effluent contains a higher level of potassium. Potassium fertilizers are very expensive to produce, and so this element is rarely available in sufficient amounts. In this process, the operator has already made the investment in potassium in the form of potassium hydroxide. The investment is not lost if the effluent is used as fertilizer, as the potassium is recycled back to the environment for the benefit of plants. The alkali KOH is obviously very corrosive, but in the final effluent form, the alkaline hydrolysis reaction has been run to completion, and the K is now available for nutrient uptake from plants.

Potassium deficiency in plants is difficult to visibly diagnose simply because it affects so many areas of plant function and health. Unlike phosphorous, potassium is not a leaching threat because it moves slowly through the soil (however any nutrient is a leaching threat when grossly over-applied). Potassium is known to help with disease resistance, and promotes root growth in transplants and seedlings. For lawn application, potassium reduces the need for "winterizer fertilizer." In any application, it is best applied with a large amount of organic matter, which the tissue digestion effluent contains.

The Role of pH

The pH of the effluent is high due to the alkaline nature of the process. The pH can be adjusted in a variety of ways (bubbling CO_2, or with the inexpensive addition of muriatic acid – available at hardware and homecare stores), but many times the high pH can be beneficial to the soil chemistry. It is general practice in many areas of the world to add lime with a pH of 11-12 to the ground to battle overly-acidic soil (some nutrients, such as phosphorous, are unavailable to plants when the soil pH is unbalanced). Instead of exuding the energy spreading lime, the land operator could simply spread the basic effluent fertilizer, and adjust the pH while providing nutrients and organic material for added benefits. The pH of the effluent adjusts rapidly when in contact with soil or sawdust/compost materials. Of course the amount of adjusting the effluent needs before application should be determined by the soil chemistry and needs of the specific area in which it is to be applied.

> Instead of a noxious agricultural byproduct, the effluent is an inexpensive agricultural input.

Summary of Effluent Qualities

- **Sterile:** Safe for any fertilizing use, even for human food plants
- **Recycled:** Nutrients are returned to the environment as nature intended
- **Complete:** Larger complement of nutrients
- **Soil-Building:** Maintains organic matter in the soil and encourages microbial complexity
- **Long-Lasting Residual Effects**: Slow nutrient release, and therefore increased plant utilization
- **Reduced Leaching Risk:** Lower quantities of leaching-risks, phosphate harbored in solid form (bone ash)

III. Application Techniques

There are numerous methods for application of the effluent, limited only by the user's creativity. If it makes sense logically and environmentally, it is probably an option. As a fertilizer by itself, it is perfect.

Do you already spread solid or liquid manure as a waste management strategy?
It makes sense to limit your labor, and enrich the manure with effluent.
Do you already compost?
It makes sense to use the effluent as a compost additive.
What tools do you have available?
A liquid spreader: Obviously, it is in perfect form already.
A solid-spreader: Mix the liquid with a solid form of organic matter, and allow it to dehydrate to an acceptable level naturally.

As we have established, the byproducts of AH digestion are environmentally-friendly (and beneficial). The versatile uses of the byproducts are also user-friendly. Adapt the application to the tools that you have, and the procedures you already follow. Here are a few methods for application:

Direct Application

The method in which you directly apply the effluent fertilizer is entirely dependent upon the tools you already have, or those which you plan to purchase. We are more than happy to brainstorm with you to find the best method.

What concentration should be used? What should the applied-pH level be? What is the best method for application?

These are all questions that will depend on your environmental surroundings, soil chemistry, and use of the land. Optimal ranges for these parameters that have been determined in the lab setting can help provide a starting point. The truth is, if all fertilizer was applied how it should be, a soil analysis would be conducted before one drop ever touched the soil. Here in the US, a soil sample can be taken to a local extension agency for a free or minimal-cost analysis. Unless there is a reason your terrain may differ from nearby terrain, it is probably likely that the areas surrounding your property are similar (farmers already know that what they grow and how they grow it affects their soil chemistry, but I'm pretty sure my neighbor's lawn is pretty similar to mine, as is the lawn down the street). It would be impossible for me to tell you exactly how much effluent to apply, and at what pH, but it is inexpensive and fairly simple to find out on a case-by-case basis. A little bit of experimentation will take place, but you'll have it tweaked just right after a couple applications.

If NaOH is used as alkali, it would be best to dilute the effluent appropriately depending on the application site. Some crops and many highway grasses are salt-tolerant and would be better candidates as recipients for the effluent. Some salt-tolerant plants include asparagus, squash (zucchini and other types), beets, barley, cotton, sugar cane, and dates. In fact, salt is used in regular practice for growing asparagus, as it controls the weeds and decreases the occurrence of crown and root rot. For less salt-tolerant plants, other factors should be considered. Rainfall helps wash away the highly soluble salt, while leaving behind the other nutrients contained in the effluent. If the area to receive the more saline effluent has sufficient water movement, the salt effects would be minimized.

Small-Scale Direct Application

For small-scale or lawn application, a spray-device with a filter screen (as a standard-integrated part, or home-made addition) would be sufficient. For lawns, it might be recommended to include a very brief water spray (by spray nozzle or sprinkler) after application, just to wash the effluent from the leafy surface to the soils. This may not be necessary, however.




Note: Any photos obtained from product websites serve as examples only, and are hyperlinked to the website from which they were obtained.

Large-Scale Direct Application

Effluent can be sprayed topically, knifed, or injected for large scale application. As with small-scale operation, the optimal dilution and pH for the soil and vegetation will need to be determined.


Topical sprayer


Fertilizer applicator with feed tank


Fertilizer truck designed for minimal tire damage to the field


Liquid manure truck


Liquid injection

MANURE ADDITIVE

With access to manure that is recycled as fertilizer for waste-management, it makes sense to enrich the liquid or solid with effluent. The equipment to spread the manure is already available and in use, so adding some additional nutrients would serve as an added benefit.

As a courtesy to neighbors and to decrease the loss of nutrients to volatilization, many farming operations choose to “knife in” or “inject” the manure into the ground. Not only does this reduce the odor, but it is a more controlled method for application. Please see above photos.

COMPOST ADDITIVE

Composting is a labor-intensive process, however very beneficial for the environment in terms of managing waste and recycling nutrients. Effluent can be added to different types of compost as enrichment. In fact, a formal university study has been conducted on composting tissue digester effluent with yard waste. Recommended concentrations and procedures for managing leachate are available through this study. Please contact us for a copy.

Energy Production

Energy can be produced from the effluent by addition to an anaerobic digester. The effluent is an excellent food source for the bacteria in the digesters, and can be added strategically to maintain balance and optimize energy production. Anaerobic digesters play an important role in energy capture and self-sufficiency. If you do not have an anaerobic digester, you might contact area operations which do. It is possible that they could sustain the effluent, and produce additional energy. The following photos belong to GHD digesters whom we believe have a superior AD design (www.ghdinc.net).

The in-ground vessel retains more heat than above ground

Separated solids utilized as a high quality bedding material

Application of odorless digested liquid produced by the anaerobic digester process

Another option for energy production involves putting the effluent through a different type of energy harvester. When mixed with sawdust and allowed to naturally dehydrate, the mixture can placed in a biomass burner for energy or hot water production. The sawdust/effluent mixture tends to burn longer since it is energy-rich.

Sewage "Disposal"

The presented recycling techniques can all effectively (and beneficially) repurpose the byproducts of the BioLiquidator process. We wish to not refer to effluent removal as "disposal" because in reality it is recycled. One option that is considered a disposal technique for the effluent is sewer disposal. This is an option, which many facilities choose to use for purpose of simplicity. This method however does not go without benefit somewhere. If the facility has access to a larger treatment plant, the effluent does not pose a problem. The liquid serves as a feedstock to the aerobes which digest waste, and can become especially important when implemented during slower times (night time, when less waste is passed through the plant) in order to maintain a healthy concentration of aerobes. In fact, an imbalanced plant could benefit greatly from introducing the micronutrient-rich effluent to the inflow to the plant.

Some treatment plants have an anaerobic digester as well, and could benefit from the energy produced. In a smaller treatment plant, the high BOD could pose a problem. Recycling the effluent in other ways is especially important in areas which lack proper waste disposal methods or facilities. It is important to note that a sewer plant may apply a surcharge for their service in managing the waste.

Keep An Open Mind

Biotechnology is still an emerging science. There may be other applications for alkaline hydrolysis effluent that have yet to be uncovered. Keep in mind that the alkaline hydrolysis technology became affordable for industries with recycling interests just recently. We are constantly discovering more about the recycling potential, and hope the agricultural community will continue to share ideas and learn from each other for forward progress.