ESCUELA DE AGRICULTURA DE LA REGIÓN TROPICAL HÚMEDA

KITCHEN WASTE MANAGEMENT WITH EM.

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Project presented to Panfilo Tabora, Ph.D. as requirements for internship credit.

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1 INTRODUCTION.

Our planet is one big integrated living organism. Perfect natural systems work in cycles. Somewhere in the evolutionary process, the human species, stepped out of the natural recycling circles towards “development”, causing global imbalance. The ability to manipulate the environment, made our dominance possible, but created a much stronger enemy: modern life.

Today we face problems like garbage disposal, water contamination, soil degradation, famine, sickness, desertification, climate change (global warming), natural resource degradation and other environmental adversity. These are all generated by present misconceived ideas and philosophies that the human race has taken upon itself. We do not consider ourselves as part of nature any more, but as the “chosen species” that has the right to pillage and plunder our environment as we please. The values that we follow are far from the ones that allowed thousands of ancestral generations (human and non-human) to strive on this planet.

The agricultural practices of modernity are focused on greed and economical profit. These two concepts do not even exist in natural law, where everything is shared and recycled. The effects of this attitude generate catastrophic consequences to our survival chances, for destroying our habitat means destroying ourselves.

To modify this chaotic situation which mankind finds itself, we need to start by checking our consciousness. The only way to change modern life is to alter the basis of modern, mechanist, individual, environment-degrading thinking. We need to start to experience nature as a miracle, not a resource, and enjoy being an active and essential part of our planet. However most importantly is the respect for natural laws in order to achieve development with equilibrium.

Practices like: organic agriculture, garbage recycling, and natural resource conservation, are steps towards the long lost “recycling circles”. The continuos use of organic matter is adequate for reaching equilibrium in a productive agricultural system.

The proper management of our organic waste is fundamental for a sustainable development. This work reflects the necessity to solve our organic waste problem. By giving proper treatment to kitchen disposal (daily basis, clean waste), transform it into useful fertilizer. It will be used as a productive resource in small family orchards and communities. Thus reestablishing the natural nutrient cycle, promoting a safer environment, improving food quality and stimulating ecological thinking within the community.

The “recent” Efficient Microorganism technology can help in the process of kitchen waste reutilization. Along with its ecological basis, EM optimizes organic processes. Perfect for high energy, high nutrition and clean organic compost elaboration.

Starting a change in modern life style is something difficult, but it’s our responsibility to do it. Recycling organic garbage is a small step in solving the problem, however not less important. We owe a better world for future generations and for life on this planet.

2 OBJECTIVES.

2.1 GENERAL OBJECTIVES.

Develop an efficient way to use and recycle kitchen waste.

2.2 SPECIFIC OBJECTIVES.

1) Produce an efficient, easy-making, high nutrient, clean, organic fertilizer from kitchen scraps.

2) Safely recycle food residues and nutrients, preventing environmental and health problems.

3) Stimulate social and environmental awareness.

3 BIBLIOGRAPHY REVISION.

"Throughout history, we have viewed waste as out-of-sight, out-of-mind. In the earliest part of the Roman Empire, waste was viewed as something dirty, something to keep out sight of senators and the privileged class" (HEIMLICH, 1991). That's why we have such preconceived ideas about organic matter and its reuse.

"In 1960, each citizen in Switzerland produced 150 kilos of garbage per year; In 1990 the figure almost tripled to more than 400 kilos..." (UNESCO, 1990). "America produces an average of over a half a ton of garbage per person every year- about three and a half pounds a day. And the figure is still growing. Food waste currently makes up an astounding 8% to 12% of the garbage we send to the landfills. That's around 320 million pounds of left food every year" (TEWG, 1990).

"In a world of diminishing resources and increasing needs, each opportunity for reuse of waste materials must be examined" (ROHLICH et al, 1982). "We can no longer afford to treat earth, and its resources, as if they were disposable. Recycling is a fundamental way of affirming this. The EPA calls recycling collecting, reprocessing, marketing and using materials once considered trash" (TEWG, 1990).

According to NAVARRO et al (1995), the organic residues created by our lifestyle should be studied, analyzed and transformed. This would permit considering residues a resource and reducing environmental threat. This effort is also related to improving health and life quality.

"Most ecological problems are linked to the fact that our waste is practically never part of a cycle. The forest has solved the problem quite simply because it practices a cyclic economy: waste from plant or animal serve as food for another" (UNESCO 1990).

The practice of returning organic materials into the system is not new. Many societies around the world use organic fertilization in agriculture. "In the Peoples Republic of China, about two thirds of the total soil nutrients are reported to be derived from organic wastes" (ROHLICH et al, 1982). However NAVARRO et al (1995), States that with the advent of technology, the use of chemical fertilizers, contributed to the abandon of ancient organic fertilization techniques.

The organic matter has maximum importance in the chemical, physical, and biological relations in the soil (BONILLA, 1992).

Organic matter is made out of lignin, carbohydrates, proteins aminoacids and peptides, fat, wax, resins, vitamins, hormones, organic acids, quelates and others. These substances have different decomposition rates. The speed in which organic matter will decompose depends on its constitution (ARIAS cited by VIQUEZ & PELAEZ, 1998).

According to GUAZELLI (1995), the main consequences of organic fertilizing are: less costs with expensive insumes, absence of plagues and sickness, greater crop rentability healthier life conditions and quality food.

"Organic matter provides energy to soil microorganisms, with out it there would be no biological activity, organic matter decomposition..." (BAIER et al, 1994).

High energetic organic matter makes up kitchen waste. Fruit peels, bread, pasta and other hundreds of dejects. The uses of these as fertilizers have high potential to success. However kitchen waste is also a source of bad odors, sickness (man and animal) and environmental pollution, if not treated properly. Korean experiences with EM treated urban organic wastes, have been successful in fertilizer production and sanity controlling, (LEE, 1995). According to KINJO et al (1993), milk and cassava industrial residue in Brazil, has been successfully treated with EM, reducing malodors, water contamination and fly populations.

The use of EM is an alternative for transforming food scraps into fertilizer. "The use of microbial inoculants provides for a more rapid and efficient conversion of raw organic materials into compost. It also ensures that these materials and especially putrefied materials, are hygienically treated through the action of beneficial microorganisms." (LUBKE, 1995).

"Effective microorganisms or EM is a mixed culture of beneficial microorganisms that can be applied as inoculants to shift the microbial diversity of soils and plants in ways that can improve soil quality, and the growth, yield and quality of crops. The microorganisms comprising EM are neither exotic nor engineered types; but are naturally-occurring species that have been isolated from natural environments world wide and selected for their specific beneficial effects and compatibility in mixed cultures.(HIGA, 1995).

The use of EM on composting and productive processes can increase crop quality and quantity. WIDIDANA & HIGA (1995), state that EM does contain an array of beneficial microorganisms That can enhance the growth and yield of plants including phosphate-solubilizing bacteria, *Lactobacillus spp*., Yeast, fungi, cellulolytic bacteria and *Streptomyces sp*..

According to PATI & CHANDRA cited by WIDIDANA & HIGA (1995), foliar application of EM results in a larger number of beneficial microorganisms at the leaf surface or phylosphere, influencing positively photosynthesis and N-fixing capacity.

Since we are dealing with organic matter we should be aware of the importance of the microorganisms. The humification of organic material is a completely microbiological process (HIGUEIRA). Thus the great utility that EM represents in a compost/recycling process.

4 MATERIALS & METHODS.

Earth is located in the Costa Rican coastal Atlantic region, altitude of 59msnm, average precipitation ranging 3032mm a year, medium temperature of 25,8 C, radiation of 15,21MJ/m2 and 1.18m/s monthly wind velocity (VIQUEZ &PELAEZ, 1998). The project was executed from September 1999, to March of 2000. Food residue was obtained from Earth's cafeteria, the amount of food waste resembled the quantities produced by a four member family. The intention is to create a model of organic trash recycling that is simple and efficient for a family to operate. The residues were fermented with EM in order to produce a solid-liquid fertilizer that can be added to the soil and/or sprayed on the leaves.

The food was macerated with a grinder. According to the treatment (see 4.1 materials), plastic bottles (2000 ml) were filled with a mixture of food, EM, water and molasses. The effect of light was also evaluated, in order to test the phototrophic bacteria and its influence in the activation process. The level of liquid in the bottles prevented the presence of air allowing the system to be totally anaerobic for 2 weeks. The macerated food mix placed in the test bottles had 50% water volume and 50% of solid food. EM was added to a concentration of 10% (bottles volume). The mixtures were sealed for two weeks and later opened and tested for pH. The phases were separated by decantation and filtered with an old sock. The solid part was dried with sawdust and coconut fiber.

Gas control was done once by opening the bottles very quickly in order to prevent explosions.

4.1 TREATMENTS AND MATERIALS

-18, 2000 ml plastic bottles.

-900 ml Molasses

-3600 ml of EM

-Food.

Treatments (with three repetitions each):

1. Control (Light), 25% food and 75% water (TL).
2. (Light) 10% EM, 5% molasses, 25% food and 60% water. (L1)
3. (Light) 10% EM, 25% food and 65% water. (L2)
4. Control (Dark), 25% food and 75% water (DL).
5. (Dark) 10% EM, 5% molasses, 25% food and 60% water. (D1)

6. (Dark) 10% EM, 25% food and 65% water. (D2)

The kitchen waste consisted mostly of rice, beans, banana peals, watermelon, bread, and meat. The use of all kinds of kitchen waste materials is very important for the success of the technology.

Testing of the agricultural uses was evaluated with corn plants in field conditions. The liquid part was sprayed in a dilution of 1/100 directly on the leaves for three weeks. The pH analysis was done EARTH's Natural Science Lab. Data collected includes height of plants and plague attack. The height of plants was collected by measuring five randomly sampled plants.

The dried solid part was used as organic inoculant-fertilizer in substrate for cucumber (*cucumis sativus)* seedlings. To dry the material sawdust and coconut fiber was added to the solid liquid phase in order to capture humidity. The mixture obtained was stored for approximately one month in a closed recipient. This resting period for the solid part is very important since it will allow the actinomycetes and filamentous fungus i n EM to develop and start stabilizing the sample, After this period the sample is put to dry in order to facilitate manipulation and use. Germination of plants was evaluated.

During all of the phases of the project, practicality and hygiene must be observed. In order to guarantee these parameters the activities were executed in a dorm room area.

5 RESULTS & DISCUSION

Three days after setting up the experiment, the gas build up could already be observed especially in treatments L1 and D1. The treatments containing molasses were the first and only to exhibit an extremely intense gas build up, by the 7th day treatments L1 and D1 had huge amounts of internal pressure and gas build up. This can mean that the molasses has an initiating effect that could help the EM organisms dominate, which guarantees the mediums stability. The other treatments also showed gas build up, however not to be compared with the intensity of the molasses treatments. Treatments L2 and D2 had greater gas build up than the control bottles. On the 9th day some gas release was done by opening the bottle once really fast, then closing.

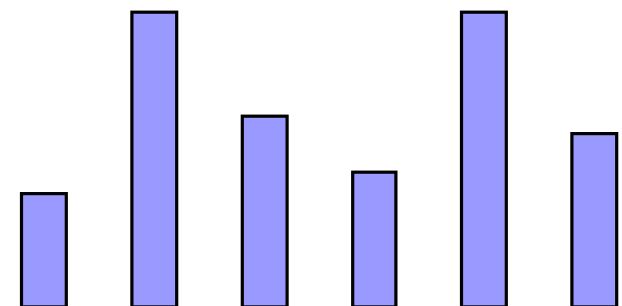
The harvest of the experiment started after two weeks. On the first day all of the gas was taken out. Next day, the pH readings were done along with microscopic observations. Finally on the third day, the separation of the phases was executed. The phases were prepared and stored as described before.

All treatments presented the formation of different phases. There was a superior phase mainly constituted of foam and big food pieces. The biggest phase was the liquid part present in the middle of the bottle separating the two other phases. The Bottom phase contains food solids and has a brownish color. The colors may vary according to the content of food and presence of molasses (see pictures).

Chart 1. Analysis of the liquid fermentation after two weeks.

Treatments	pH	Odor
L1 r1	3.37	Pleasant
L1 r2	3.37	Pleasant
L1 r3	3.37	Pleasant
L2 r1	3.57	A mix between pleasant and rotten.
L2 r2	3.53	A mix between pleasant and rotten
L2 r3	3.59	A mix between pleasant and rotten
TL r1	3.44	Rotten food.
TL r2	3.46	Rotten food.
TL r3	3.46	Rotten food.
D1 r1	3.39	Pleasant
D1 r2	3.39	Pleasant
D1 r3	3.40	Pleasant

D2 r1	3.55	A mix between pleasant and rotten.
D2 r2	3.57	A mix between pleasant and rotten
D2 r3	3.57	A mix between pleasant and rotten
TD r1	3.45	Rotten food.
TD r2	3.43	Rotten food.
TD r3	3.42	Rotten food.



	L1	L2	TL	D1	D2	TD
pH	3.37	3.56	3.45	3.39	3.56	3.43

Figure 1. Average pH

Chart 1 and Figure 1, indicates that all of the treatments responded very well to the fermentation period. The pH levels were satisfactory (bellow 4). However the best treatment was the one containing EM + molasses (L1 and D1), it presents the lowest pH which indicates a very safe range of biological stability. Low levels of pH ensure that the medium will be safe from pathogens and possible rotting. The odor shown in the treatments with molasses surpassed the other treatments, it obtained a sour sweet swell that resembles the odor of fermented beverages.

Microbiological activity as well as pH levels are more adequate in the treatments containing molasses. This is showing the importance of the rapid microbiological activation to obtain a safe product. The molasses allow the EM microorganisms to take over the environment very quickly, avoiding future problems of contamination with other undesirable microorganisms.

This phase demonstrated that the activation of EM together with food waste is a possible alternative to guarantee a safe management of kitchen wastes. The other treatments don’t qualify as options due to the smell, which is a powerful indicator of the microbial quality. The bad odor exhaled by treatments L2, TL, D2, and TD represents a doubtful colonization by the microorganisms.

The stages for preparing the liquid fermentation of waste could be adapted to practical conditions fairly easily. The use of a blender to macerate the food would facilitate the work. The whole process is relatively fast and could be linked to a Bokashi management in order to obtain two different products from food waste management.

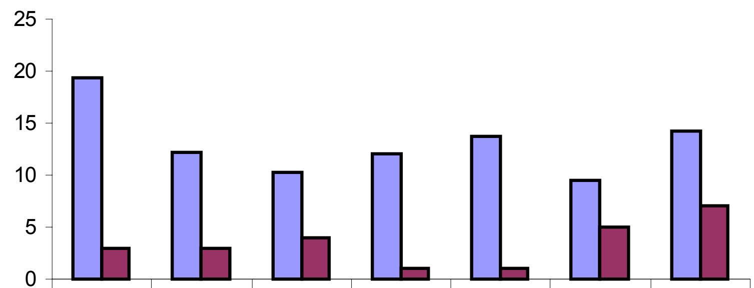
While air drying, the solid part that presented best appearance was treatment I1 ad d1. The control samples suffered termite attack and exhaled bad odors. The dried up solid phase was mixed with soil in a 3:2 ratio. There was some fly infestation due to the extremely humid weather during the period. The coconut fiber along with the sawdust propitiated a very good substrate for seedlings as we can note in chart 2.

Chart 2. Biological testing of the solid phase.

	Number of plants germinated from a total of 36.		
treatments	6 days	9 days	total
L1	34	33	33
L2	27	29	29
TL	27	35	35
D1	33	38	38
D2	22	23	23
TD	31	34	34
Control	10	27	27

All of the treatments contained a superior performance compared to the absolute control. Even though treatment D2 had a lower level of total germination the plants showed a much greater vigor (see photo). The fact that the absolute control only contained soil as medium for the plants shows the beneficial effects of the solid phase in plant development. The molasses treatments had excellent results in germination, as well as the controls. However treatments L2 and D2 showed less results.

As a substrate for seedlings or as a solid fertilizer this product (EM and molasses) can be used as an efficient method to manage wastes and recycle nutrients. The positive microbial effect of the EM plus the aeration propitiated by the solid phases, induced an excellent germination of the cucumber seeds.



	d1	d2	td	l1	l2	tl	ta
plant height (cm)	19.3	12.2	10.2	12.1	13.7	9.5	14.2
spodoptera fugiperda	3	3	4	1	1	5	7

treatments

Figure 2. liquid phase analysis.

Figure 2 shows that the treatments containing EM were relatively on average with the absolute control, which suffered no spraying. Treatment d1 however had the greatest height in the whole experiment. The control samples (tl and td) showed less development than the EM treatments. However the most remarkable result obtained is related to the plague infestation by *Spodoptera fugiperda.* The treatments containing EM had a positive effect preventing the attack of the plagues. The liquid phase can be used as a natural spray in order to protect the plant and even collaborate in its development. The beneficial interactions between the EM microorganisms and the plants is the probable reason for the resistance to plagues, the EM can shift the microbial activity to a beneficial spectrum, reducing the intensity and quantity of plague damage.

Both liquid and solid phases of the kitchen waste activated with EM, showed practical possibilities to be used in practical conditions. This technique can be applied in both small and large scales. It seems to be an efficient method to manage wastes, cycle nutrients and reduce plague attack within small rural and urban properties. The use of EM is once more proven to be a safe and reliable alternative to deal with environmental problems.

The quantities of nutrient present within the liquid fermentation vary according to the quality of the food waste used. However, since food is normally rich in nutrients and energetic compounds the quantities of nutrients in the products of its fermentation will also be high.

Chart 3. Nutrient content of liquid phase in comparison with other organic materials (%).

	d1	d2	td	l1	l2	tl	fle	frijol	mays	manure	coconut fiber	sewage
N								6.00	4.00	1.60	0.90	2.00
P	0.02	0.02	0.02	0.02	0.02	0.02	0.24	0.32	0.22	0.52	0.04	0.86
K	0.18	0.65	0.01	0.15	0.03	0.01	1.03	3.32	2.49	1.49	0.66	0.00
Ca	0.07	0.01	0.05	0.08	0.05	0.02	0.88	1.78	0.71	1.56	0.14	1.78
Mg	0.03	0.01	0.01	0.03	0.02	0.02	0.21	1.00	1.00	1.10	0.10	0.50

Chart 4. Nutrients present in solid phase + sawdust (%)

	ad1	ad2	atd	al1	al2	atl	fle
N							
P	0.09	0.08	0.09	0.08	0.1	0.12	0.24
K	0.79	0.52	0.54	1.03	0.78	0.55	1.03
Ca	0.72	0.42	0.44	0.96	0.62	0.45	0.88
Mg	0.25	0.12	0.11	0.31	0.28	0.19	0.21

Source: WOLF, B.; JONES, J.B.; MILLS, H. 1990 Tables of interpretative plant analysis. Adaptation of IGNATIEFF, 19??; JURADO y BUSTAMANTE, 1983; MUÑOZ, 1983; VAZ et al., 1976; SALLEDO y BARRETO, 1982; BERROGAL, 1988; ALVARADO, 1994.

The results shown in chart 3 indicate that the liquid phases extracted from the experiment have a very low quantity of nutrients. This can be explained due to the dilution that suffered this material. All of the treatments contained 25% of food which was made up by 50% water and 50% of solid food material. This implies that the concentration of food can be a major point in increasing the amount of nutrient within the phases. On the other hand a greater concentration of food material can have a negative effect in the practicality of the method, causing problems of phase separation and extreme gas build up.

The quantities of nutrients shown in chart 4 for the solid mixes with sawdust indicate that these treatments have a greater quantity of nutrients relative to the liquid phase. This is due to the quantities of nutrients present in the sawdust and the coconut fiber. Its also important to note that most nutrients are immobilized in the form of live microorganisms, decomposing the carbon rich materials.

Also charts 3 and 4 demonstrate that there might be a very positive interaction between the EM microorganisms and the plants in which the material were tested.

Since the nutrient content is not responsible for plant reaction it might be the microorganisms and their positive and beneficial interactions with the plants stimulating defenses against plagues and plant growth as shown in Figure 2.

The microbial effectiveness of EM is once more proven, the phases originated from the activation of EM with kitchen waste can be used as an important biological stimulator and protector for plants in several ways. During germination or during early plant development the phases from the experiment were applied to obtain better results. This technique of recycling nutrients can have a very effective result since the absorption of nutrients by the leaf is fast and efficient. It can be very useful for small properties in waste management, ensuring alimentary security, and cycling nutrients.

The practicality of the method is proven by the fact it was done within dorm rooms. It didn't provoke bad odors or caused disturbance of the environment by any chance. However transforming great quantities of kitchen waste into "activated EM" demands great knowledge and skill, it also could represent a storage problem. The ideal is to use this method with a solid Bokashi system which is less time consuming and very efficient. Therefor obtaining a very efficient management of a household kitchen waste. Its very important to realize that the nutrient cycling within small units is very important to modern society. One of the major problems that the world face today is the impoverishment of fertile land that can be translated into nutrient loss by environmental weathering and bad agricultural practices.

Home gardens are very important in some parts of the world like in China and in Cuba. The Chinese for centuries have succeeded to manage nutrient cycling with amazing efficiency. Domestic waste recycling along with home gardening are great steps towards society's sustainability. These are ways to consume less, produce safe home grown food, preserve the environment, and increase environmental awareness.

This method of fermenting wastes is an alternative for domestic waste management. Stress the importance of nutrient cycles within family units is extremely important for a more sustainable development. This project represents one more option when recycling and managing wastes with microorganisms.

6 CONCLUSION.

Liquid fermentation of kitchen wastes with EM and molasses proved to be a viable alternative for domestic recycling. The process of fermentation produced two phases (liquid and solid) that can be efficiently used in agricultural practices.

The fertilizers produced by the fermentation (liquid phase and solid substrate) were, high energy and biologically stimulant. Low levels of nutrient were observed in the solid ad liquid phase.

The EM activation with molasses and food waste was a clean process that didn't represent any health hazard problems. It is a very good method for nutrient cycling within small properties.

As a domestic practice with nature friendly concepts the recycling of kitchen wastes with EM does stimulate environmental awareness.

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8 ANNEX

8.1 ANNEX 1. PHOTOS.

Photo 1. Fermentation of kitchen waste with EM, treatments.

Photo 2. Gas build up in molasses treatments.

Photo 3. Liquid phase.

Photo 4. Testing of the liquid phase in Mayse plants.

Photo 5. Drying of the solid phase.

Photo 6. Testing of the solid phase in cucumber seedlings.