APPLICATION Of EM TECHNOLOGY FOR TREATING ENVIRONMENTAL PPLLUTION CAUSED BY GARBAGES IN VIETNAM

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1. General situation in wastes and garbage in Vietnam

The issue of environmental protection in the process of economic development, industrialization and modernization is the one which is pressingly dealt with not only in Vietnam but also in all other countries of the world.

The quicker rate urbanization and industrial development, the increasingly bigger quantity of wastes and garbage.

According to the Environment Departrnent's 1997 data of MOSTE, the quantity of wastes and garbage discharged everyday in the whole country is estimated at over 19,000 tons, including:

Industrial wastes	about 10,200 tons
Hospital wastes	about 250 tons
Municipal solid waste	about 9,000 tons

The quantity of wastes and garbage discharged in the past 20 years may reach 130 million tons, including:

Industrial wastes	60 million tons
Hospital wastes	1.5 million tons
Municipal solid waste	64 million tons

With the rate of collection of 50% as presently, the quantity of wastes and garbage accumulated in the environment is 70 million tons. Beside, this figure must be added a big quantity of excrement and liquid waste discharged from urban living quarters in the past 20 years which may account to 125 million tons.
Wastes and garbage are composed of:

Organic matters	40-60%
Construction materials, glass, ceramics	25-35%
Paper, wood…	10-14%
Metals	1-2%
Others	3-4%

According to the Hanoi City Urban Environment Company's data on an average everyday about 2,995 cubic meters of wastes and garbage are discharged, including:

Living quarters' wastes	2,436 cub.m/day
Industrial wastes	312 cub.m/day
Hospital wastes	22 cub.m/day
Harmful and toxic wastes	225 cub.m/day

The density of solid wastes in Hanoi City is 0.416 tons/ cubic meter and its ingredients are as follows:

Organic matters	51.9%
Paper	2.7%
Plastics	3.0%
Leather, rubber, wood	1.3%
Cloth	1.6%
Glass	0.5%
Rock, clay, ceramics	6.1%
Metals	0.9%
Impurities (10mm)	31.9%

The quantity of wastes and garbage discharged everyday in Hochiminh City is 3,500 tons with the following characteristics:

Moisture	60-85%
Organic substances	60-65%
In organic substances	25-30%

Thus, the above mentioned figures show that the high percentage of organic matters constitutes the origin of stinking and foul-smelling products, pathogenic bacteria and fungi, and harmful gas such as H_2S, SO_2, CO_2, NH_3, CH_4…under the decomposition of micro-organisms.

The most usual measure for treating wastes and garbage is to bury them under the ground. Only in Hanoi and Hochiminh City there are some factories for processing wastes and garbage into fertilizer, although they are too small. For instance, the Cau Dien garbage treatment factory in Hanoi, built with the sponsor of UNDP since March 1993, has a garbage treatment capacity of 30,000 cubic meters and produce 7,500 tons of fertilizer per year. And if there is not a good treatment method, dumps will become harmful and dangerous sources of pollutants for surrounding environment and underground water.

This is not only the situation of Vietnam, but also the common situation of other countries, especially developing countries, which are lacking in capital for investing in building big-sized, modem garbage processing factories.

2. Treatment of solid waste with EM

2.1. Application of EM technology in treating buried garbage

In April 1997, while his working visit to Vietnam, Prof. Dr. Teruo Higa visited the Cau Dien garbage treatment enterprise and the Me Tri dump. He guided us in the use of EM for treating buried garbage and increasing the process of transforming garbage into compost in Hanoi City.

Since May 1997, we have conducted the test of using EM, spraying it on over the dump surface with the aim of restricting stink and flies. However, at the same time we have used also lime and chemicals for killing flies. The quantity of powdered lime and insecticides is 4.8 kg and 0.048 kg per ton of garbage respectively. In addition. 2.4 ml of EM1 is used for 1 ton of garbage. As result, the effectiveness of EM is not so high. We consider that lime and insecticides have restricted the effect of EM.

Since January 1998, in the frame of a study thesis assigned by the Ministry of Science,

Technology and Environment. we have conducted the test with more carefulness and with the measurement of necessary technical parameters. Also since January, in the treatment of garbage in Tay Mo dump, lime and insecticides have not been used any more. And the result is very good.

*** Technological procedure of burying garbage**

- Leveling tamping and pressing garbage with caterpillar bulldozer for achieving a density of 550-700 kg/ cubic meter, spraying EM solution on "fresh" garbage with a proportion of 5ml EM/ ton of garbage,
- After each layer of garbage of 0.8-1.0 m thickness, a layer of EM Bokashi (Compost produced from garbage fermented by EM) is spread with a proportion of 0.1 kg/square meter, then garbage is covered by a 10 cm thick layer of soil.
- Lime, insecticides (including chemicals for killing mosquito) are not used.

*** Method of preparation of EM solution**

Secondary EM is prepared from 1 liter of EM1 + 6kg of molasses + 93 liters of water.

1 liters of secondary EM is thinned by 500 times, into 50 liters of EM solution to be spread on garbage. Everyday, about 1,000 tons of garbage are collected to the Tay Mo dump 30,000 liters of thinned EM solution are spread in 6 times:

10:00am – 10:30am	5,000 liters
16:00pm – 16:30pm	5,000 liters
20:00pm – 20:30pm	5,000 liters
21:30pm – 22:00pm	5,000 liters
23:00pm – 23:30pm	5,000 liters
2:00am – 2:30am	5,000 liters

Each cubic meter of garbage is thus spread 12-13 liters of diluted EM solution.

2. 1. 1. Results

Table 1. Gas Contents in Experimental Garbage Basins (24M^3).
(anaerobic condition) (mg/m^3)

		CO	SO_2	H_2S	CH_4
6th Sep 1998	without EM	0.2	3.76	0.36	1.08
	with EM	0.2	3.1	0.26	1.04
15th Sep 1998	without EM	0.39	0.2	0.52	0.057
	with EM	0.28	0.2	0.15	0.015
24th Sep 1998	without EM	0.1	0.1	0.12	0.02
	with EM	Not detected	0.05	Not detected	0.007

Table 2. Analysis of Gas Environment in Tay Mo Dump (February 1998).

	Lot No.	CO_2	SO_2	H_2S	Suspended dust TSP	CH_4
Fresh garbage Not yet treated With EM	1	2.440	0.2824	0.772	2.886	not detected
	2	2.397	0.2105	0.757	2.652	-
	3	2.838	0.2176	0.824	2.230	-
	4	2.120	0.2090	0.880	1.858	-
	5	2.956	0.1988	0.536	1.206	not detected
	average	2.550	0.2360	0.754	2.166	-
Garbage Treated with EM	1	1.137	0.0132	not detected	0.192	not detected
	2	1.040	0.0146	not detected	0.192	-
	3	1.496	0.0120	not detected	0.190	-
	4	1.180	0.0120	not detected	0.194	-
	5	1.328	0.0440	not detected	0.192	-
	average	1.236	0.0192	not detected	0.192	-
Vietnam standards 5937 and 5938, 1995	Tolerable concentration in living quarters	not detected				
	-Maximum in each time		0.5	0.008	0.3	
	-Average day and night		0.3	0.008	0.2	
Environment standards of MOSTE, 1993	Tolerable concentration in production areas	$1^o/_{oo}$	20	10	76	

Date of measurement: 18th Feb. 1998.

2. 1. 1. 2. Observations

The figures in Table 1 show that gas discharged from garbage treated with EM decrease obviously compared with before the EM treatment, and meet the requirements set by Vietnam's 1995 Environment Standards 5937 and 5938.

In addition, while checking the inside of the dump treated with EM, larvae of flies is very little compared with the dump without EM treatment, hence an obvious reduction of flies and mosquitoes in the dump treated with EM.

Particularly, as for economic efficiency, the advantage of EM treatment is as follows:

-Formerly, the daily expenses for treatment with lime and insecticides were:

Powdered lime: 4.8 kg/ton of garbage x 1,000 tons/day x 2,000 VND/day = 9,600,000 VND

Insecticides: 0.048 liter/ton of garbage x 1,000 tons/day x 60,000VND/liter = 2,880,000 VND

Total: 12,480,000 VND

-Presently, the daily expenses for treatment with EM alone (lime and insecticides are not used) are:

Spraying EM = 500 liters of secondary EM/day x 6,000 VND/liter = 3,000,000 VND

Sprinkling E.M Bokashi = 150 kg/day x 1,000 VND/ kg = 150,000 VND

(EM Bokashi = compost transformed from garbage)

Total: 3,150,000 VND

2. 1. 2. The results of garbage treatment with EM

It is highly appreciated by many localities, hence this method has been applied in: Hanoi (1,000 tons/ day), Haiphong (80 tons/ day), Hochirninh City (3,000 tons/ day), Lamdong, Vinhlong, Quangninh, Thaibinh, Thanhhoa, Nghean, Danang, ..

2. 2. Application of EM technology in processing garbage into organic fertilizer

2. 2. 1. Description of compost processing technology

The urban Waste Processing Factory, within the Hanoi Urban Environment Company-The Department of Hanoi Transport and Urban Public works, has been sponsored by UNDP for building a factory of a designed capacity of 30,000 tons of garbage/ year producing 7,500 tons of organic fertilizer per year. Technology of processing compost:

- Putting collected garbage on an electronic scale for weighing and identifying the components of garbage. If the quantity of organic matters is big, garbage are directly put into treatment and processing. And if the quantity of inorganic matters is big, garbage will be buried in the dump.
- Conveying organic garbage, and to the classifier and grinder.
- Mixing with excrement taken out from septic tank and some species of microorganisms which can decompose cellulose.
- Turning upside down repeatedly and pouring into a basin of 150 cubic meters containing capacity .
- Blowing air into the basin aerobic basin with automatic ventilators and keeping warmth with an automatic heating system, ensuring 45^{o}C-65^{o}C and aeration.
- After 21 days, when garbage have been decomposed into humus, taking humus out of the aerobic basin to an anaerobic basin and keeping fermentation in 28 days;
- Screening, mixing additives and packing.

The diagram of processing garbage into organic fertilizer and application of EM technology is as follows:

- When garbage are collected to the enterprise, spraying EM to eliminate stink (a part of garbage may be fermented in the anaerobic condition), thus workers can select garbage by hand in hygienic and better conditions. Garbage are kept in 1 day before the selection.
- After grinding, garbage are mixed with excrement taken out from septic tank (having been treated with EM), EM solution is sprayed 13 liters for 1 cubic meter of garbage, ensuring the moisture of 40%; keeping thus in 3 days.
- Then garbage are fermented in the aerobic basin, adding water to achieve the moisture of 55-60%.

2.2.2. Results

The following are figures obtained in the comparative experiment of aerobic fermentation with and without EM treatment.

Table 3. GAS Contents in Experimental Garbage Basins (Aerobic Condition). (mg/m^3)

Date	Method	CO	CO_2	NOx	SO_2	H_2S
6th Sep 1998	Without EM	4.50	1261.6	0.140	1.23	0.27
	With EM	3.60	503.8	0.080	1.00	0.25
15th Sep	Without EM	0.59	421.0	0.056	0.45	0.29
	With EM	0.23	270.7	0.012	0.23	0.15
24th Sep	Without EM	0.12	199.0	0.029	0.25	0.03
	With EM	not detected	177.0	0.010	0.06	0.01

Stinking and harmful gas have been decreased in the enterprises area since the use of EM. The concentration of these gas in the production area is lower than the tolerable environmental standards regulated by the state of Vietnam.

Table 4. Analysis of Air Environment in The Enterprise (January 1998). (mg/m^3)

	Lot No.	CO_2	SO_2	H_2S	Suspended dust
Garbage fermentation house	1	2.265	0.1093	2.381	0.612
	2	2.310	0.1071	2.086	0.257
	3	2.243	0.1079	0.726	0.215
	4	2.235	0.1080	2.342	0.359
	5	2.278	0.0997	2.346	0.472
	average	2.266	0.1010	1.976	0.383
Garbage Classification	1	2.291	0.1029	2.378	0.572
	2	2.239	0.1447	0.909	0.567
	3	2.204	0.1269	0.723	0.210
	4	2.175	0.0855	0.726	0.471
	5	1.727	0.1048	2.358	0.485
	average	2.127	0.1130	1.419	0.461
Other Localities in The enterprise	1	2.131	0.1388	2.381	0.301
	2	1.906	0.0681	2.086	0.316
	3	1.936	0.0725	2.079	0.324
	4	1.801	0.0647	0.904	-
	5	1.839	0.0789	0.453	-
	average	1.923	0.0850	1.581	0.314
Environmental standards MOSTE, 1993	Tolerable concentration in the production area	$1^O/_{OO}$ (volume)	20	10	76

2 2.3. Observations on the results

The application of EM technology has reduced the fermentation period from 21-25 days to 12 days, the heat at the initial period of fermentation increases to 60-70^{o}C, then reduces to about 45^{o}C, the volume of sinks quickly, stink is eliminated, environmental pollution in the

enterprise's area is minimized.

Especially, the compost processed from fermented garbage and treated with EM, besides necessary ingredients of organic matters and chemicals, is supplemented with useful micro-organisms. On 20th 7, 1997, these micro-organisms were checked by the Vietnam Institute for Agricultural Science and technique. as follows.

Table 5. Quality of Microorganisms in Organic Fertilizer Processed from Garbage with EM Technology.

	Microorganisms density (CFU/gr)
Actinomycete	2.42×10^7
Yeast	1.25×10^8
Mycobacteria	1.21×10^5
Lactobacillus	1.65×10^6
Coliform	3.27×10^3
Photosynthesis bacteria	not identified
Cellulose decomposing bacteria	1.31×10^6

The quality of compost may be raised because of the application of EM technology. At present, experiments continue to be conducted in many crops of Vietnam. It is the hope that, with this technology pollution caused by solid wastes may be solved, at the same time organic garbage may be transformed into valuable microbiological organic fertilizer.

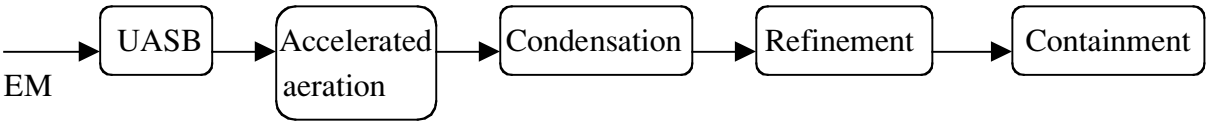
2.3. Application of EM technology in treating liquid waste oozed from garbage

2.3.1. Liquid waste oozed from garbage

It is one of foul smelling products and polluting underground water, air environment and water sources surrounding the dumps.

Therefore in order to ensure environmental standards, this kind of liquid waste must be treated. Experiments on treatment of liquid waste oozed from garbage with EM have been carried out in the Dong Thanh dump of Hochiminh City. The procedure of treatment is as follows.

Liquid waste oozed from garbage is conducted into the physic-biological anaerobic treatment basin with against flow (UASB), EM solution is poured into this basin. Also in this basin, the oxidation of organic occurs under the anaerobic conditions. Stink is reduced, then liquid waste is conducted to the aerobic basin where ventilation is used for enhancing the process of oxidation. The next steps are condensation, refinement and containment. The technological diagram is as follows.



2.3.2. Results

The results of analysis of liquid waste oozed from garbage before and after EM treatment carried out by the center of Environmental Technology within the Polytechnic university of Hochiminh City are as follows.

Table 6. Results of Analysis of Liquid Waste Oozed from Garbage.

Control parameters	Before the treatment	After the treatment	Vietnam standard 5945, 1995 column B
pH	5.22	7.38	5.5-9.0
Total insoluble (SS)	1,380	8.0	100
COD ($K_2Cr_2O_7$)(mg/L)	50,654	26.0	100
BOD_5 (mg/L)	6,810	9.0	50
Total soluble susstances (mg/L)	10,920	580	-
Total alkali (mg$CaCO_3$/L)	4,480	372	-
Nitrate (mg N-NO_3/L)	4.4	0.39	-
Ammonia (mg N-NH_3/L)	590.8	0.56	1
Total Nitrogen (mg/L)	-	3.83	60
Total Phosphorus (mg/L)	-	29.4	6
E-coli (MPN/100ml)	-	0	10,000

2.3.3. Observations

The results of analysis that EM treatment is effective for both solid waste and liquid waste from garbage. After the treatment, such liquid waste may be discharged into canal for field irrigation. In the coming period, this method will be applied for treating liquid waste of the Tay Mo dump of Hanoi City.

Conclusions

Many good results have been obtained in the program of application of EM technology in agriculture animal husbandry and treatment of environmental pollution in Vietnam. However, because of the urgent requirement of environmental situation, our efforts are firstly concentrated in the treatment of solid wastes. Encouraged by the above mentioned success, many localities are applying EM technology in the treatment of dumps, in the treatment of waste water from living quartes and animal production enterprises. EM has helped us to cope with environmental problems caused by wastes and garbage.

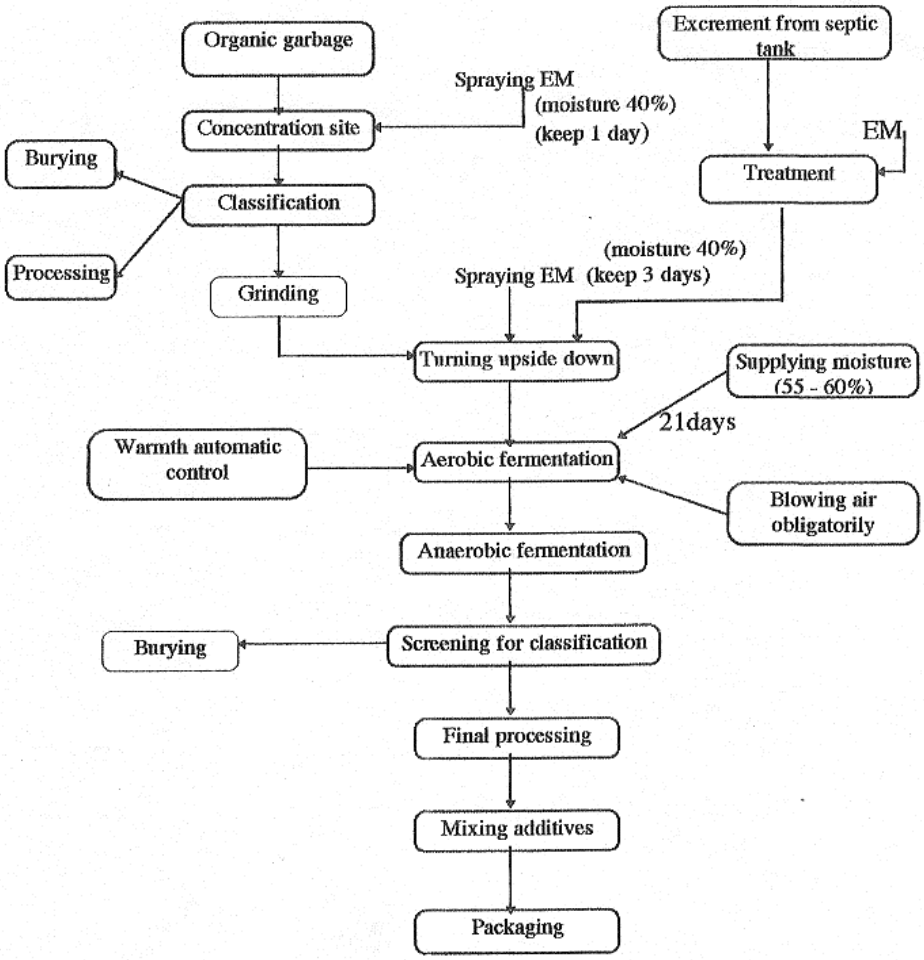


Figure 1. The Diagram of Processing Garbage.