EM APPLICATION TO WASTE TREATMENT EXPERIMENT

PURPOSE

In Naha city of Okinawa prefecture in Japan, approximately 1,800 tons per month of fresh waste and accumulated sludge from treatment tanks are vacuumed up to trucks to be transported to a temporary storage and eventually shipped out to open sea to be dumped. London Agreement and other treaties on protection of oceanic environment force waste treatment completed on land.

In this experiment, an experimental plant was set up to evaluate effectiveness of Effective Microorganisms (EM) in waste treatment and to apply the results to the waste treatment plan of Naha city.

OBJECTIVE

1) To set up an experimental plant in a relay facility to evaluate effectiveness of EM in waste treatment.
2) To design an experimental plant, instruct its construction, carry out the experiment, and evaluate the results.

EXPERIMENTAL METHOD (Follow-up experiment)

Experimental Period: April 27 - November 30, 1996

Experimental Site: Urasoe-city in Okinawa prefecture in Japan.

Experimental Plant: See the attached chart.

Experimental Subject: Fresh waste which are trucked in.

Tested Items:

Water Quality (general)

pH, BOD, COD, SS, total nitrogen, total phosphate, colifoms count, color, clarity.

Water Quality (other)

Cadmium, lead, hexa chromium, whole chromium, arsenic, alkylate mercury compound, whole mercury, cyanogen compound, organic phosphate compound, polychlorinated biphenyl (PCB), phenol, fluorine compound, soluble iron, soluble manganese, copper, zinc, N-hexane extract, trichloroethylene, tetrachloroethylene.

Odor

Hydrogen sulfide. methyl mercaptan, methyl sulfide, dimethyl sulfide.

Other

Points of management and operation.

Treatment:
Extended EM and other types of EM materials were placed in a receiving tank and a screening tank as needed. Theoretically, 1-2 litters of extended EM per 1 ton of waste is recommended. (How to extend EM is explained later in this paper.)

Materials Applied:
EM (manufactured by Sankou Sangyou)
MSK101 (predominantly lactic acid bacteria and yeast)
MSK102 (predominantly enzyme)
MSK103 (predominantly photosynthetic bacteria)
EM-X (manufactured by Tropical Resource Plant Research Organization)
EM-X ceramics (manufacture by Amron)
Molasses (manufactured by Sankou Sangyou)

Experimental Steps:
As seed sludge, 1.5 tons of treated sludge from other treatment facility in Okinawa prefecture was introduced and trained for 2 months to adjust to fresh waste, which was used as the control group.

The experimental plant was remodeled to resolve such problems encountered in the first experiment as in the areas of screening, anaerobic treatment, and retention time to compare treatment effectiveness prior and after the remodeling.

Fresh waste was selected over accumulated sludge as experimental subject because fresh waste is more difficult to treat. Sludge is constituted predominantly of fibrous material which are easily removed prior to treatment, and the general quality of sludge is better (lower BOD, COD, SS, nitrogen, and phosphate) than that of fresh waste.

One litter of extended EM mixture specially blended for waste treatment was added to 1 ton of waste. The discharge water was returned to a temporary holding pool of a relay facility. The facility operation was set up as follows to evaluate EM effect: (Note: Received waste was diluted to the extent which makes easy for microorganisms to work, prior to be forwarded into aeration tank. The discharge water is not diluted.)

Aeration Time
April 28 - June 14

Start up operation for active sludge method.
Average treatment volume was 300 litters/day including non-diluted waste (average ratio of fresh waste to water was one to 4-5).
Mixed liquid suspended solid (MLSS) in aeration tanks was set to 6,000-9,000 ppm.
Average aeration time for the first aeration tank was set to 24 hours, and the second aeration tank also to 24 hours.
Retention time (from holding tank to discharge, provided that the diluted waste is 1.5 cubic meter) was 10-12 days.

June 14-July 14

Start up operation with EM application, other conditions being the same as described in above l.

July 15-August 31

Operation with EM application with additional load.

Average treatment volume was 500 litters/day including non-diluted waste (average ratio of fresh waste to water was one to 1-2).

MLSS was set to 13,000-16,000 ppm in aeration tanks.

Average aeration time in the first aeration tank was set to 20 hours (max. 22 hours; min. 14 hours), and the second aeration tank to 16 hours (max. 20 hours: min. 2 hours).

Retention time (from holding tank to discharge, provided that diluted waste is 1.0 cubic meter) was 15-16 days.

September-October

Standard active sludge operation (waste water is diluted by tap water and treated water).

Average volume of treated waste was 600 liters/day (average ratio of waste, tap water, discharge water was one, one, 4).

MLSS in aeration tanks was set to 6,000-9,000 ppm.

Average aeration time in the first aeration tank was set to 12 hours (max. 14 hours; min. 8 hours), and the second aeration tank to 16 hours (max.20 hours; min. 12 hours).

Retention time (from holding tank to discharge, provided that diluted waste is 3.0 cubic; meter) was 5-6 days.

Volume of the total treated waste during the period

The total treated volume during the period amounted to 83 cubic meter. Miscellaneous floating materials were not removed from waste after August 22, and the received waste as a whole was forwarded to holding tank. Surplus sludge was stored in a sludge condensation tank, and its supernatant liquid was returned to holding tank.

RESULTS

Water Quality

See attached Chart-1.

Odor

See attached Chart-1.

Surplus Sludge

Surplus sludge generated during the experiment in order to control MLSS in aeration tanks was temporary stored in a sludge condensation tank to be returned to holding tank as needed. Therefore, removal of surplus sludge for the purpose of cleaning the condensation tank was never made.

Treatment Capacity of the Plant

The experimental plant was designed to treat the waste of 143 persons, and as such, a standard design sets BOD bad to 1.86kg/day. However, in this experiment, the actual BOD load was 6.0kg on the average against the total capacity. Against the aeration tanks, the load was 1.9 times of the standard: 2-3 times overall. In spite of such strenuous condition, BOD was maintained well below the standard value of 5ppm, which indicates that the experimental plant is capable of treating twice the volume it was designed for.

Treatment Cost

Cost of EM and EM Related materials

The total amount of extended EM applied was 90 litters et JPY 12,150.

EM#2 (MSK102) used at the time of bulking was JPY 20,000.

EM-X ceramics was JPY 30,000.

Other EM related materials amounted to JPY 62,150.

Running cost per 1 ton of fresh waste was JPY146.40 (for extended EM).

The cost for EM in this experiment is not low compared to ether experiments: such as. JPY 500.000/year at Shimodakawa Clean Center which treats 60 cubic meter or JPY 100,000 at Kaya city. It becomes less expensive as EM applied continuously over longer period.

Use of Electricity

Average aeration time before EM application was 24 hours for both the first and the second aeration tanks. Three months after EM application, the time was reduced to 12 hours for the first tank and 16 hour for the second tank, and electricity use was reduced by 41%.

In aerobic treatment system such as active sludge method, most of electricity cost is for aeration. The experiment proved that electricity use can be reduced by 41%. It is not reasonable to assume that the same applies to all facilities because of difference in their operation environment, but it will serve as a guideline.

Use of Water

Because of the use of discharge water to dilute fresh waste, amount of tap water or ground

water which are otherwise used for dilution was reduced. Accordingly, water bill was reduced. Requirement of ground water to build a treatment facility had limited feasible site for a treatment facility. However, EM application made such requirement unnecessary.

CONCLUSION

In this experiment, EM was applied to treat highly loaded fresh waste in a traditional multipurpose facility (capacity for 143 persons; where ceramics were used as contact material). Generally speaking, a multipurpose treatment facility is designed to treat waste & water of BOD 200-250ppm; therefore, it is inadequate to treat fresh waste of BOD over 1,000ppm. However, in this experiment. such inadequate facility was used to prove EM effect. The results are as follows:

1. Good discharge water level of BOD 5ppm was achieved without using chemical agents and in a low function level facility. EM has proved to be an effective biological agent in waste treatment system.
2. Chemical agents which are required in the current ordinary treatment system to remove nitrogen and to maintain lower coliform count, were not needed. Application of EM alone achieved the same effects.
3. Generation of surplus sludge was far less than initially designed, and use of electricity was reduced by 41%. Running cost has been drastically reduced.
4. It seems reasonable to assume that removal of total phosphate and desired COD level will be achieved by increasing the amount of discharge water to be returned to dilute fresh waste.
5. Foul odor was eliminated, which created healthier and more comfortable environment for the facility employees and the surrounding area residents.
6. To Be Studied Further
   - How to control total phosphate and COD level.
   - How to control amount of sludge more precisely.
   - Design a plant to control phosphate, COD, and sludge.

EXTENDED EM

In order to reduce cost, EM is recommended to be extended in application. EM#1 (or a mixture of EM#2, ~3, #4) is used as seed.

EXTENDED EM FOR WATER TREATMENT

Basically the same as regular extended EM which uses molasses as feed to cultivate EM. For water treatment use, however, the untreated (waste) water is added in addition to molasses to facilitate easy transition of feed from molasses to untreated waste. Ways of extension differ depending on density and type of load. EM treated water is also added to facilitate extension. (Waste water may include feces, urine, laundry discharge water, factory discharge water. The amount of seed EM to be used and the way of extension may need to be adjusted.)

HOW TO EXTEND EM

Material

EM, molasses, water (untreated water, pond water), EM-X

Container

Tank (air-tight container) Heater, thermostat (to maintain liquid temperature warm)

Process

Materials are mixed to meet the type and density of bad of the subject water to be treated and kept in an air-tight container for the minimum of 2 weeks, maintaining liquid temperature over 20 centigrade. See below for general guideline for type and density of load. Addition of 0.1% of EM-X may help to facilitate extension process.

BOD Level and EM Extension

Subject type	Level (ppm)	EM	Molasses	Water (Undiluted: Treated: Plain)
Domestic waste	10-200	0.5	0.5	10: 30: 59
Factory discharge	200-1500	1.0	1.0	10: 40: 49
Single-purpose tank (e.g. food processing factory discharge)	1500-	2.0	2.0	5: 50: 41
Pond & river	N/a	1.0	0.5-1.0	98: 0: 0

Water quality before and after EM application.

Water quality	Fresh waste	Before	After	Discharge requirement
PH	8.2	7.1	6.9	6.5-8.5
BOD	13,200	46	5	<30 (Max 40)
COD	8,780	230	79	<30 (Max 40)
SS	13,100	36	2.4	<70 (Max 90)
Coliform count	181,500	12,000	1,800	<3,000 AVG
Cadmium	0.01	<0.001	<0.001	None
Lead	<0.05	<0.01	<0.01	None
Hexa chromium	<0.05	<0.02	<0.02	<60 (Max 120)
Whole chromium	<0.05	<0.02	<0.02	<8 (Max 16)
Arsenic	0.05	0.02	0.02	<0.1
Alkylate mercury compound	Not detected	Not detected	Not detected	<1
Whole mercury	<0.005	<0.0005	<0.0005	<1
Cyanogen compound	<0.01	<0.01	<0.01	<0.1
Organic phosphate compound	<0.1	<0.01	<0.01	<0.5
PCB	<0.005	<0.0005	<0.0005	<0.1
Phenol	15.2	<0.01	<0.01	<15
Flourine compound	<1	0.2	0.2	<0.005
Soluble iron	0.04	0.29	0.11	Not detected
Soluble manganese	<0.05	0.09	0.01	<0.003
Copper	<0.05	0.05	0.02	<30
Zinc	4.95	0.15	0.12	<5
N-hexane	77.8	0.7	<0.5	<3
Total nitrogen	2,590	173	65.5	<5
Total phosphate	185	61.5	40.8	<10
Trichloroethylene	<0.005	<0.001	<0.001	<10
Tetrachloroethylene	<0.005	<0.001	<0.001	<2
Clarity	0.2	6	15.4	<0.3
Color	17,600	550	170	<0.1

Notes:

mg/litter (ppm) except for pH, coliform count (#/ml), clarity, color.

Discharge requirement is in accordance with the capital order (No.35 in 1970). “Discharge Standard for Toxic Material” and “Discharge Standard in General”, and additional discharge water requirements for Naha water area in Okinawa prefecture.

Odor before & after EM application.

	Before 14-Jun-1996	After 31-Oct-1997
Hydrogen sulfide (odor)	11.8 5<	0.78 4
Methyl mercaptan (odor)	0.075 4<	<0.0071 <3.5
Methyl sulfide (odor)	0.01 2.5<	0.001 <2
Dimethyl sulfide (odor)	0.01 2.5<	0.001 <2