An Experiment Using EM Treatment Methods to Treat Raw Sewage

1. Goals

In Naha City every month approximately 1800 tons of raw sewage and septic tank sludge are collected by night soil collection trucks, held temporarily in storage tanks, then transported by ship to be dumped in the ocean. Since the signing of the London Treaty and other international agreements, regulations regarding ocean pollution have become more stringent, thus making it necessary to carry out sewage treatment on land.

In the present experiment we built a plant to use EM (Effective Microorganisms) in the treatment of sewage. Our aim was to investigate the results and thereby contribute to the formulation of policy regarding the construction of treatment facilities for raw sewage and septic tank sludge in Naha City.

2. The Operation

1.) Outline of the operation: To set up within existing sewage facilities an experimental EM treatment plant and conduct an experiment on the treatment of raw sewage.

2.) Related operations: Basic design of the experimental plant, supervision of its construction, conducting the experiments, and analyzing and evaluating the data.

3.) Experimental methodology

Secondary Experiments.

(1) Experiment period: April 27, 1996-November 30, 1996

(2) Experiment site: 20-550 Serikyaku, Urasoe City, Okinawa Prefecture.

(3) Experimental plant (See flow chart)

(4) Materials: Raw sewage brought in from outside

(5) Categories investigated

a. Water quality (general): pH, BOD, COD, SS, total nitrogen, total phosphorous, e. coli, color, clarity.
b. Water quality (other): cadmium, lead, chromium (VI), total chromium, arsenic, alkyl mercury compound, polybiphenylchloride , phenol, flourine compounds, soluble iron, soluble manganese, copper, zinc, N hexane extract, trichloroethylene, tetrachloroethylene.
c. Odor: Hydrogen sulfide, methyl mercaptan, methyl sulfide, methyl disulfide.
d. Other supervisory, operation methods

(1) Treatment Methods

EM extended liquid and other varieties of EM were put into receiving tanks and screening tanks. The basic amount used was 1-2 liters of extended liquid per 1 ton of raw sewage.

(Note: The way of making EM extended liquid is discussed later.)

(7) Materials used

EM (manufactured by Sanko Sangyo)

MSK101 (lactic acid bacteria and yeast)

MSK102 (enzymes)

MSK103 (photosynthetic bacteria)
EM-X (Tropical Plant and Resources Research Institute, Inc.)
EM-X ceramics (Amron Co.)
Molasses (Sanko Sangyo)

(8) Experimental Methods

From a certain sewage treatment facility in Okinawa Prefecture, 1.5 tons of starter sludge was transported in, and was mixed with raw sewage for approximately 2 months in order to serve as a contrast for pre- and post- EM treatment. For the first experiment improvements were done to the plant to deal with impurities, anaerobic treatment, and holding periods, and a comparison was done of the capability of the plant to treat sewage both before and after these improvements were made. Raw sewage alone was used as material for the experiment because septic tank sludge, compared with raw sewage, already had an extremely low reading for BOD, COD, SS, nitrogen, phosphorous, etc., and because the fibrous matter which makes up the majority of its content was, before this treatment, already mostly separated out. Therefore, it was decided that it would be difficult to conduct an experiment to contrast raw sewage treatment and sludge treatment, and the experiment was conducted on raw sewage alone.

The EM treatment consisted of adding one liter of extended EM liquid to each ton of raw sewage. It should be noted that the treated water was sent to a transit facility for temporary storage. Further, in order to ascertain the effects of the use of EM on treatment, the following operations were carried out during the stated time periods.

Note: The addition of EM to the raw sewage took place before the sewage entered the aeration tank; the concentration was adjusted to the optimum level for the microbials to perform decomposition. The dilution process thus did not take place on discharge water.

*Operations taking place within set periods

A. From April 28-June 14.
Began operations using standard activated sludge method.
Average amount of treated sewage: approx. 300 liters/day (ratio of 1:4-5 raw sewage to tap water) (Note: Includes no dilution)
MLSS set point for aeration tank: 6,000-9,000 ppm
Average aeration time: No. 1 aeration tank 24 hours
No.2 aeration tank 24 hours
Amount of time in the system (Number of days from the regulating tank to discharge: 1.5m^3 of diluted sewage): 10-12 days

B. June 14-July 14
Beginning EM treatment again.
Average amount of treated sewage: approx. 300 l/day (ratio of 1:4-5 raw sewage to tap water) (Note: Includes no dilution)
MLSS set point for aeration tank: 6,000-9,000 ppm

Average aeration time: No. 1 aeration tank 24 hours
No.2 aeration tank 24 hours
Amount of time in the system (Number of days from the regulating tank to discharge: 1.5m³ of diluted sewage): 10-12 days

C. July 15-August 31.
Heavy load operation method. (A dilution of raw undiluted water or treated water) EM treatment.
Average amount of treated sewage: approx. 500 l/day (ratio of 1:1-2 raw sewage to treated water) (Note: Includes no dilution)
MLSS set point for aeration tank: 13,000-16,000 ppm
Average aeration time: No. 1 aeration tank 20 hours (Maximum 22 hrs; minimum 14 hrs.)
No.2 aeration tank 16 hours (Maximum 20 hrs.; minimum 12 hrs.)
Amount of time in the system (Number of days from the regulating tank to discharge: 1.0m³ of diluted sewage): 15-16 days

D. September-October
Standard Activated Sludge Method (A raw water dilution of treated water and tap water.)
Average amount of treated sewage: approx. 600 l/day (ratio of 1 part raw sewage to 1 part tap water to 4 parts treated water.)
MLSS set point for aeration tank: 6,000-9,000 ppm
Average aeration time: No. 1 aeration tank 12 hours Maximum 14 hrs; minimum 8 hrs.)
No.2 aeration tank 16 hours (Maximum 20 hrs; minimum 12 hrs.)
Amount of time in the system (Number of days from the regulating tank to discharge: 3.0m³ of diluted sewage): 5-6 days
*Total amount of treated matter (raw sewage) during the experiment =approximately 83m³.

After August 22nd impurities were not removed from the raw sewage, and the sewage was placed all at once in the regulating tank. During the sludge concentration adjustment, excessive sludge was stored in the sludge concentrate tank; afterwards the top layer of liquid was returned to the regulating tank.

4. Results

1.) Water Quality—see separate page
2.) Odor—see separate page
3.) Concerning excess sludge:
During the period of the present experiment, when adjusting the sludge concentration (MLSS) in the aeration tank, the excess sludge was temporarily held in the sludge concentrate tank. Afterwards it was returned to the regulating tank. For this reason there was no removal of excess sludge.
4.) The Plant's Treatment Capacity:

The plant used in the present experiment was designed to be a 143-person capacity tank. The design standard for ordinary compound treatment tanks calls for a BOD load of 1.86 kg/day. In the present experiment the final BOD load amount was an average of 6.0 kg. in a ratio with the total volume. For the aeration tanks the volume load was 1.9 times the design standard with a 2-3 times heavier load than the standard throughout the rest of the system. Under these conditions the BOD fell to 5ppm, within the accepted standard value. This indicates that if used in a regular treatment plant the treatment capacity would reach twice that of the design standard.

5.) Cost of treatment

e. Various Em-related expenses [1997 rate: 125 yen=$1]

Total amount of EM extended liquid used: 90 liters---------12,150 yen
EM2 used in bulking (MSK102)---------- 20,000 yen
EM-X ceramics used in the experiment----------30,000 yen
Total expenditures for EM-related materials in the experiment --62,150 yen.
Running cost per ton of raw sewage (EM extended liquid only) ----146.4 yen.

This time the total amount of the EM used was not particularly low. In the case of the Shimotagawa Cleanup Center, for instance, the annual cost of EM (including ceramics) for treating 60m³ per day was approximately 500,000 yen. In Kanoya City the annual cost was around 100,000 yen. With continued treatment we anticipate a further decrease in cost.

a. Amount of electricity used: aeration time (average)

Before EM use: No.1 aeration tank 24 hours
No.2 aeration tank 24 hours
Three months after beginning EM treatment:
No.1 aeration tank 12 hours
No.2 aeration tank 16 hours

Reduction in electric use in aeration = approximately 41%

In activated sludge method in aerobic water treatment facilities the majority of electric use is for aeration. The present experiment showed that it is possible to reduce this cost by 41%. Differences in treatment methods and environmental conditions, however, preclude applying this cost reduction directly to other facilities. However, in facilities using the activated sludge method it is clear that this figure can serve as a guidepost when EM is used.

b. Amount of water used:

Through the re-use of treated water in the dilution process, this method can greatly reduce the amount of ground water or tap water which would normally be used as dilution, and thus save water. Naturally this leads to a reduction in the amount of water used and can lead to a reduced water bill.

Facilities which primarily use ground water are limited by local conditions, but the results of the present experiment indicate that use of EM will make the treated water have a high functional value. From these results it may be surmised that treatment facilities can be easily constructed without being limited by local conditions.

5. Conclusion

The present experiment involved treatment of hard-to-treat raw sewage, and employed EM technology and ordinary compound sewage tanks (with connections made between them; approx. capacity = 143 people.)

In general, compound sewage tanks are designed to handle an influent flow of BOD 200-250 ppm and are not sufficient to handle raw sewage with a BOD of 10,000 or above. However, in this experiment in order to test EM's capabilities, we went ahead and used them in an experimental plant.

Under these conditions we conducted the experiment using EM treatment method on raw sewage with an average BOD index of over 10,000 ppm. The results are shown below.

1.) The experiment made clear that even in facilities whose capability to treat water is low, and in facilities that do not employ high level treatment (i.e. using chemicals in the treatment process), the introduction of EM can produce high quality treated water with a BOD of 5 ppm.

(EM treatment>> The only high quality bio-treatment technology.)

2.) Although it is customary in existing treatment technologies to use chemicals, in the present experiment it was shown that the use of EM alone made it unnecessary to use nitrogen reduction chemicals or chemicals to reduce the e. coli level to acceptable standards.

(EM treatment >>An environmentally friendly technology)

3.) By producing much less excess sludge than design standards, and through a 40% reduction in electricity used for aeration, it is clear that the EM treatment method is an extremely effective treatment technology.

(EM treatment>>Greatly reduces running costs)

4.) Though during the experiment we were unable to reach our goals regarding COD and the removal of phosphorous, by returning a larger amount of treated water back into the system, it is expected that these goals can be reached.

(EM Treatment>>Stabilizes treated water quality)

5.) Since the introduction of EM reduces odors, it is easier to maintain a healthy environment in the entire facility and maintain the health of the workers, all of which is linked to increased efficiency and environmental protection.

(EM Treatment>Excellent ability to reduce odors leads to preservation of the local environment and protection of workers' health)

We were not able to confirm the following items during the period of the experiment:
(1) A method to reduce phosphorous and COD to regulated levels.
(2) Accurate amounts of sludge production.
(3) Whether at the level of an actual treatment plant this would be a high-level treatment process (to remove phosphorous).

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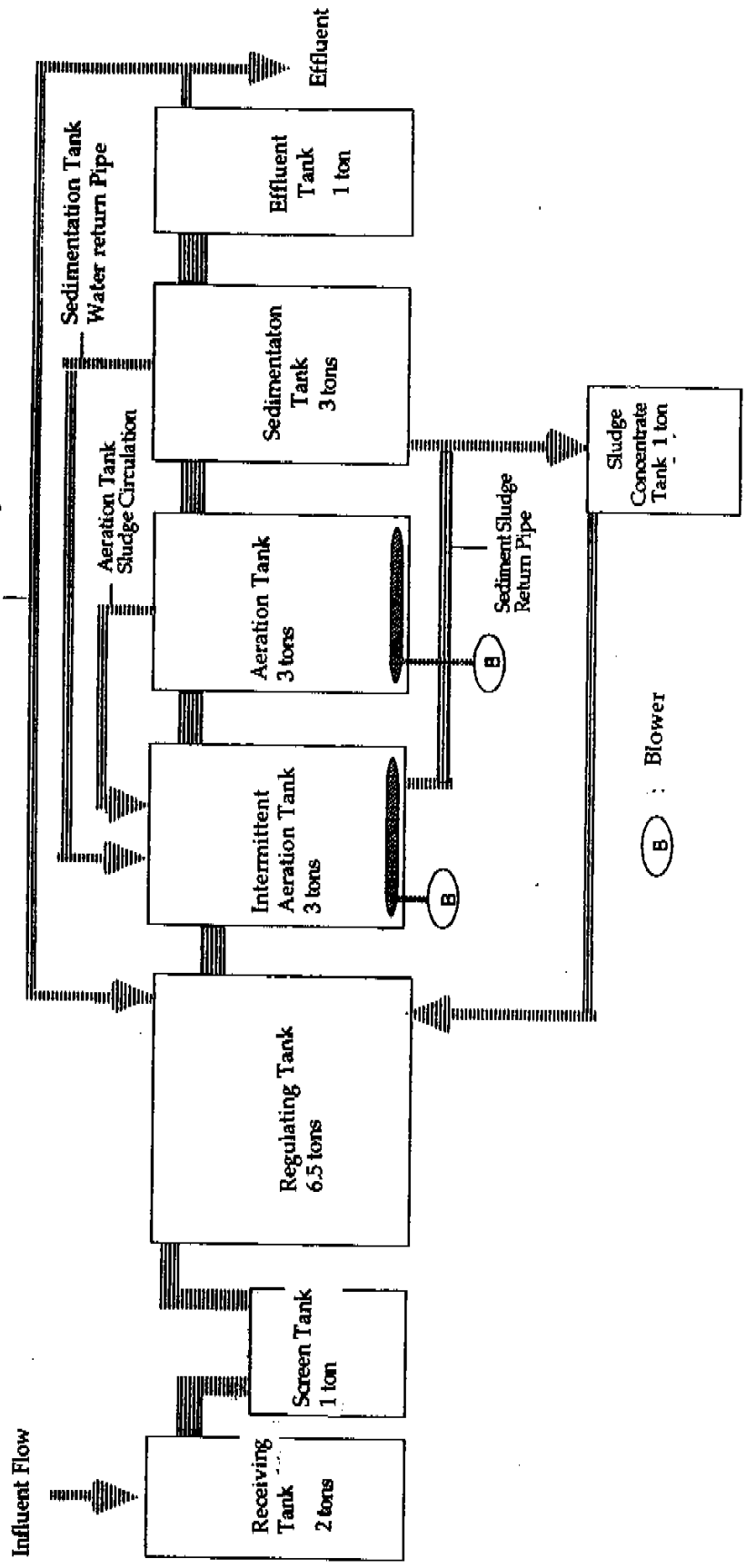
Treatment Flow Chart, Raw Sewage Experimental Plant, Naha City

(Second Experiment: After Equipment Improvements)



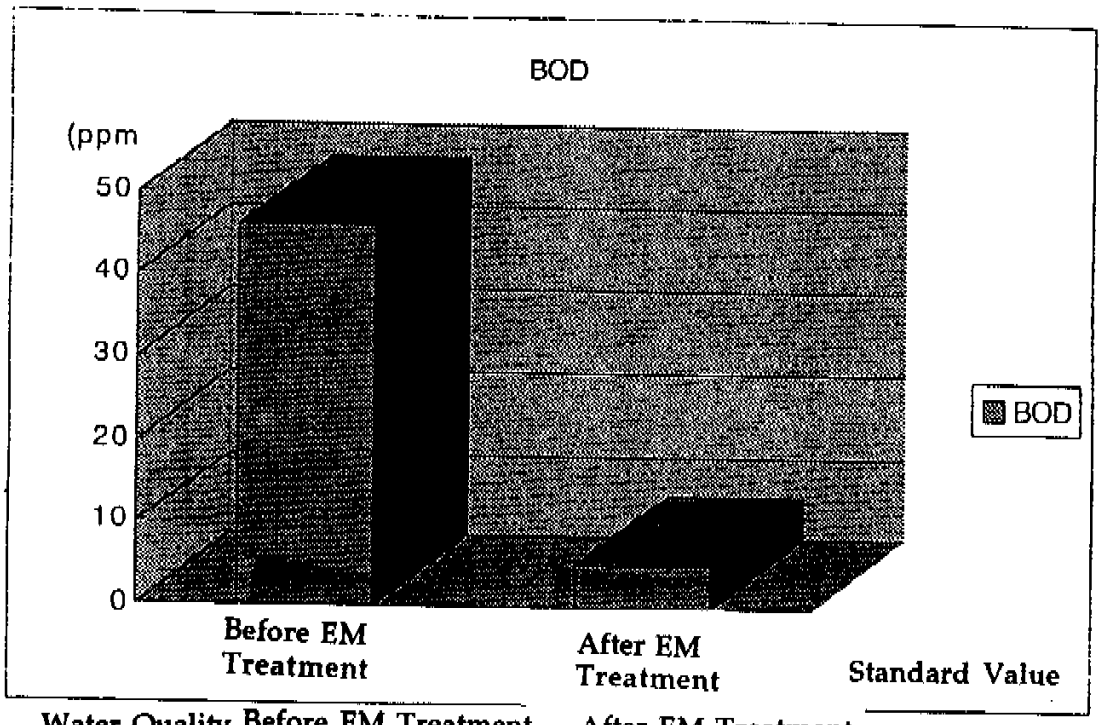
Data Before and After EM Treatment of Polluted Water (Raw Sewage)

Water Quality	Raw Sewage	Pre-EM Treatment	Post-EM Treatment :	Discharge Standards
p H	8.2	7.1	6.9	6.5～8.5
BOD	13200	46	5	<30 (MAX40)
COD	8780	230	79	<30 (MAX40)
S S	13100	36	2.4	<70 (MAX90)
E. coli bacteria	181500	12000	1800	<3000 : AVG
Cadmium	0.01	<0.001	<0.001	None
Lead	<0.05	<0.01	<0.01	None
Chromium (VI)	<0.05	<0.02	<0.02	<60 (MAX120)
Chromium	<0.05	<0.02	<0.02	<8 (MAX16)
Arsenic	0.05	0.02	0.02	<0.1
Alkyl mercury compound	Undetectable	Undetectable	Undetectable	<1
Mercury	<0.005	<0.0005	<0.0005	<1
Cyanide	<0.01	<0.01	<0.01	<0.1
Organic Phosphorous	<0.1	<0.01	<0.01	<0.5
P C B	<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	Undetectable
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	2590	173	65.5	<5
Total Phosphorous	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	17600	550	170	<0.1

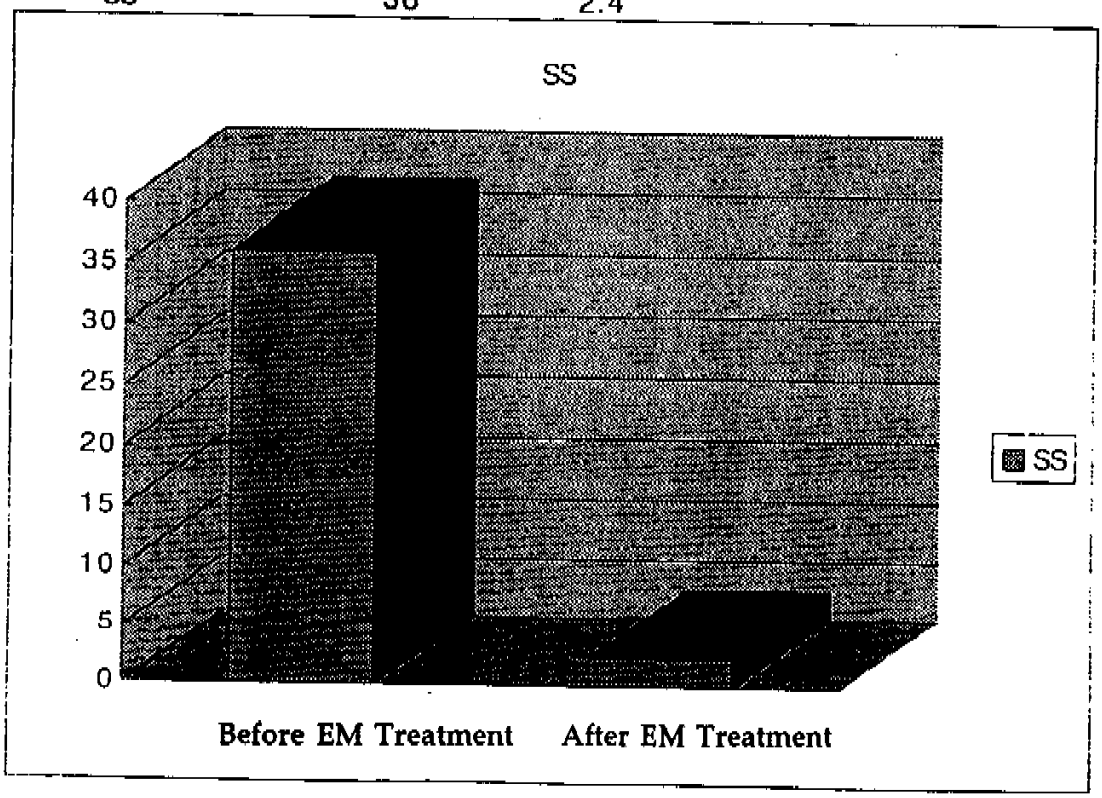
Note:

- All measurements are in mg/liter (ppm) with the following exceptions: E. coli bactera (part/ml), clarity (cm), color (degree).
- Discharge Standards are based on: Directive 35 of the Cabinet (1971) which sets standards for discharge water, "Discharge Standards and Toxic Substances," "Dicharge Standards and the Social Environment," and standards set by Okinawa Prefecture concerning discharge standards in the area around Naha Harbor.

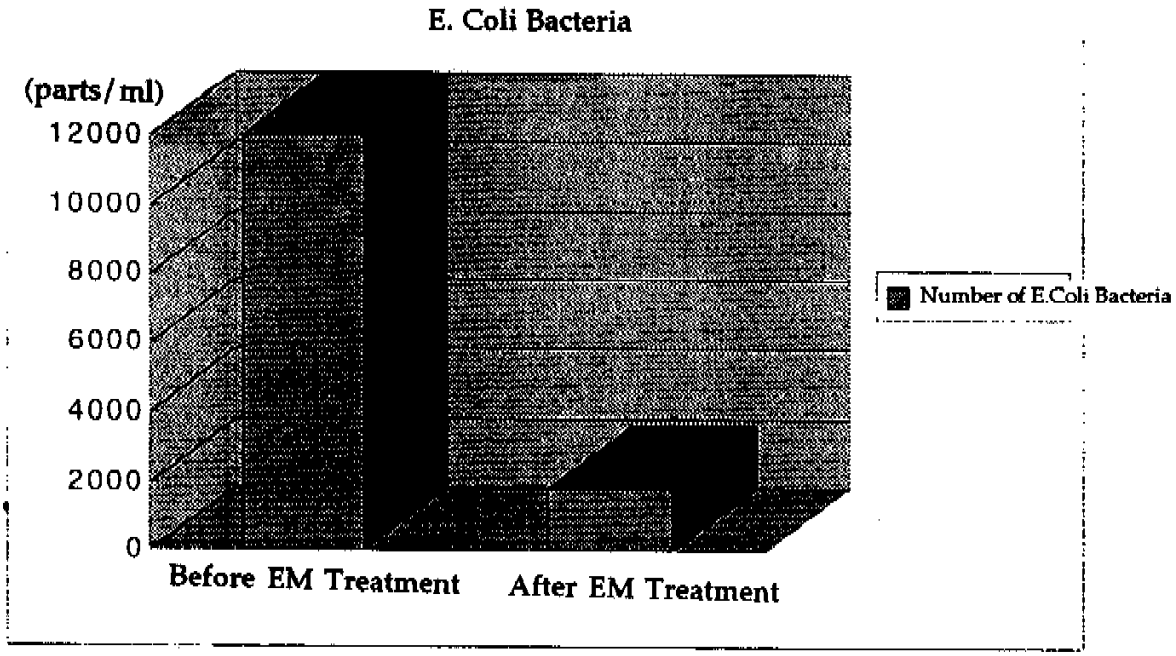
Water Quality	Before EM Treatment	After EM Treatment
BOD	46	5



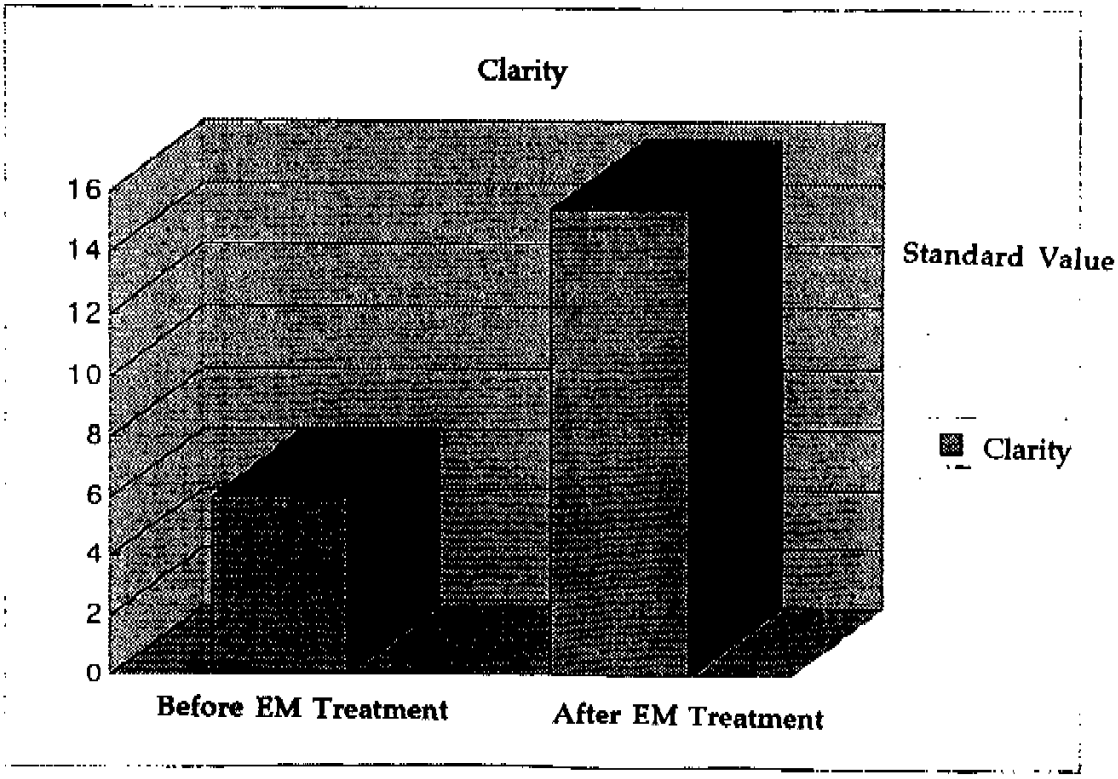
Water Quality	Before EM Treatment	After EM Treatment
SS	36	2.4



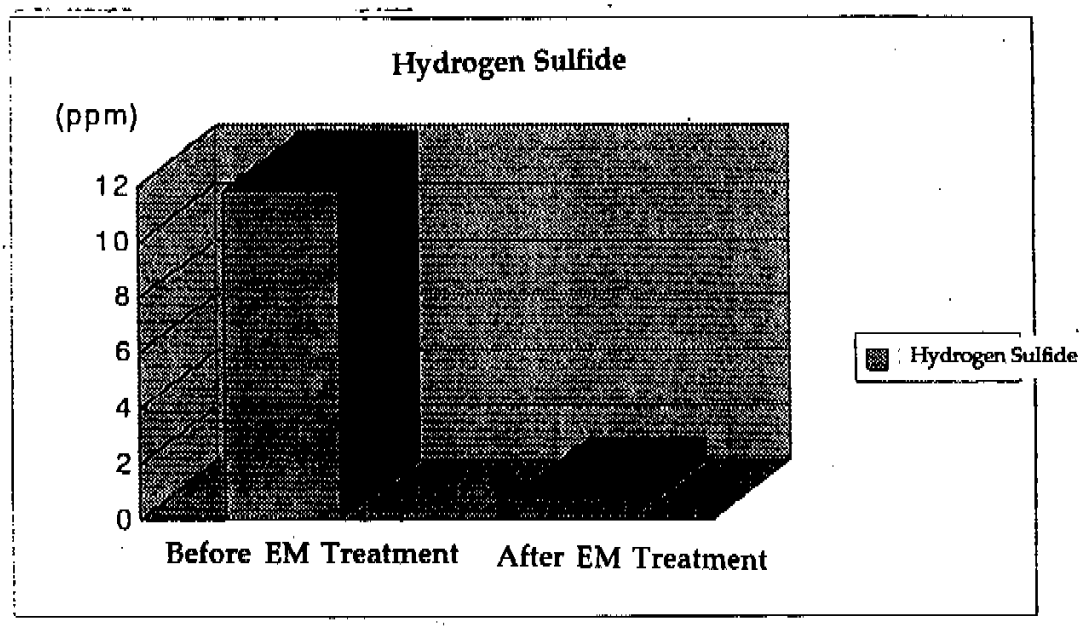
Water Quality	Before EM Treatment	After EM Treatment
E. Coli Bacteria	12000	1800



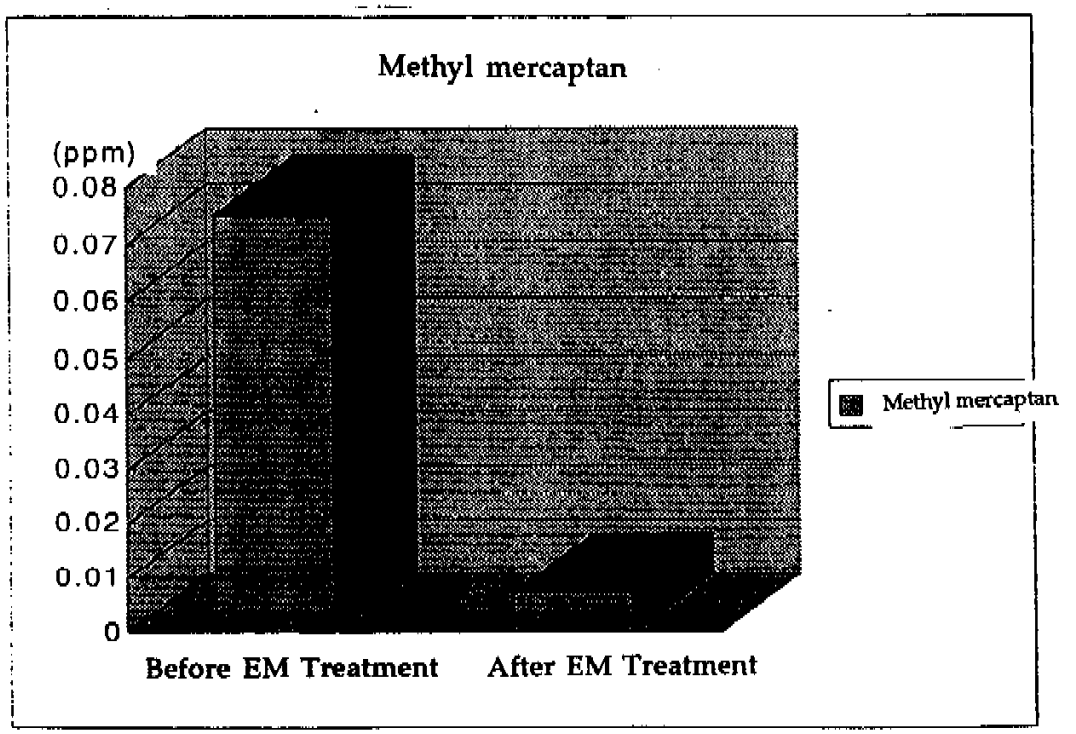
Water Quality	Before EM Treatment	After EM Treatment
Clarity	6	15.4



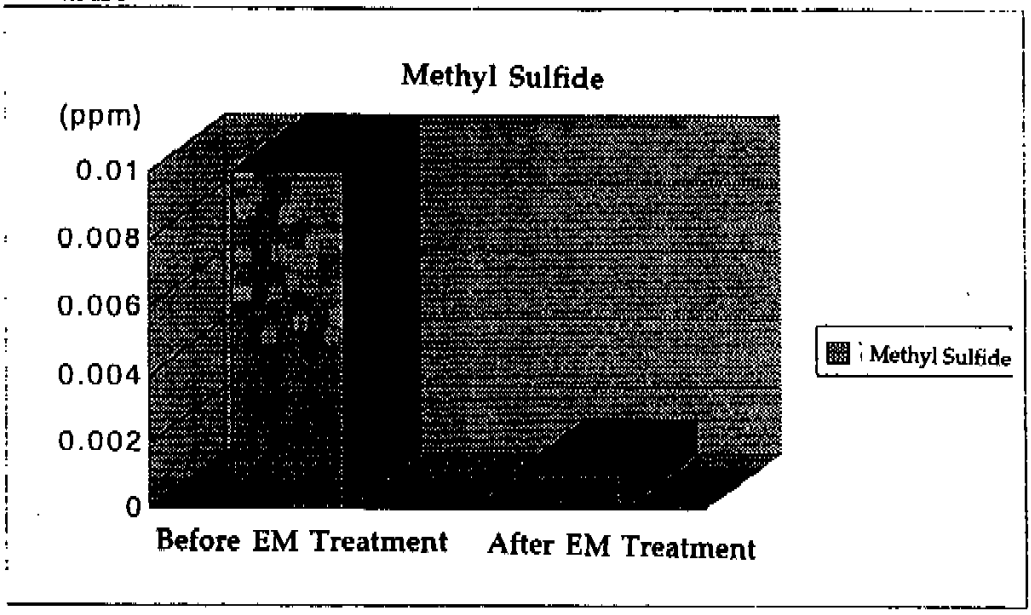
Odor	June 14, 1996 Before EM Treatment	October 31, 1996 After EM Treatment
Hydrogen Sulfide	11.8	0.78
Strength of Odor	Over 5	4



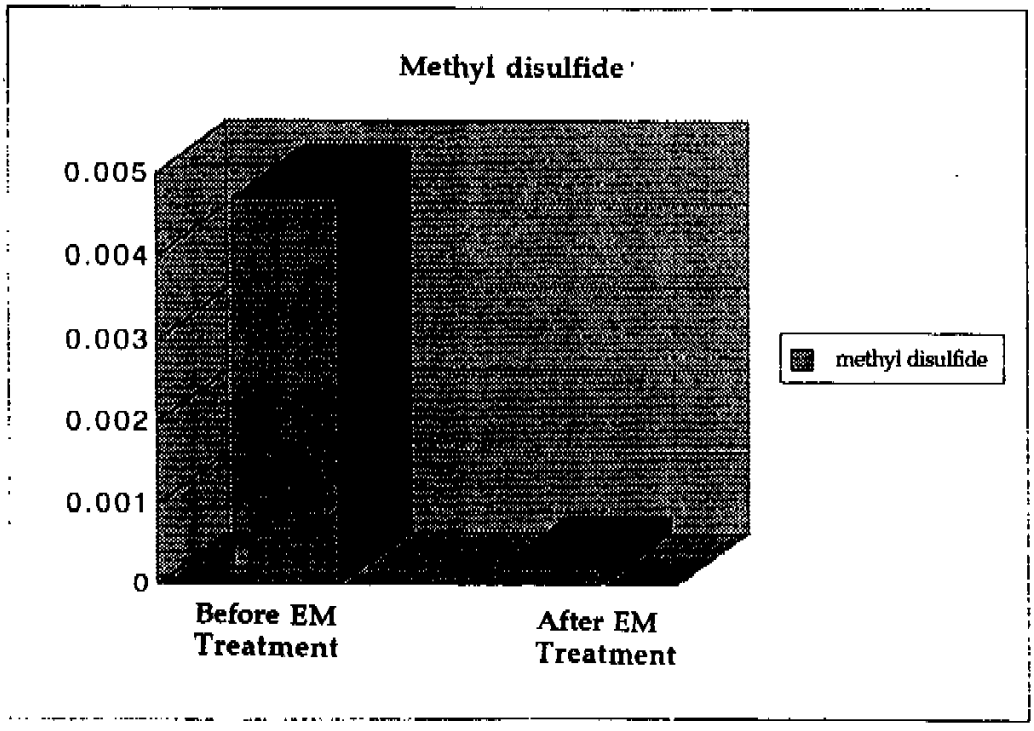
Odor	June 14, 1996 Before Treatment	October 31, 1996 After Treatment
Methyl mercaptan	0.075	0.0071
Strength of Odor	Over 4	Less than 3.5

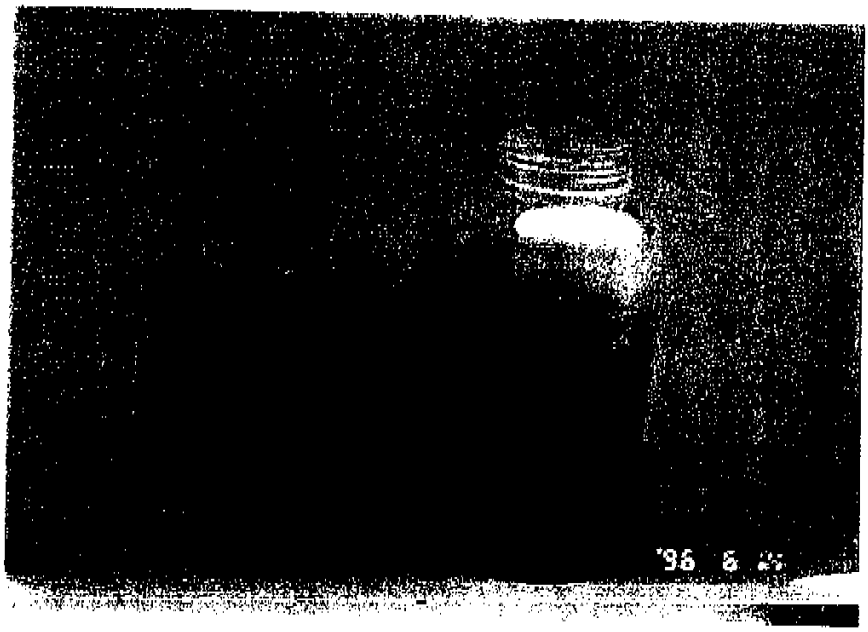


Odor	June 14, 1996 Before Treatment	October 31, 1996 After Treatment
Methyl Sulfide	0.01	0.001
Strength of Odor	2.5	Less than 2

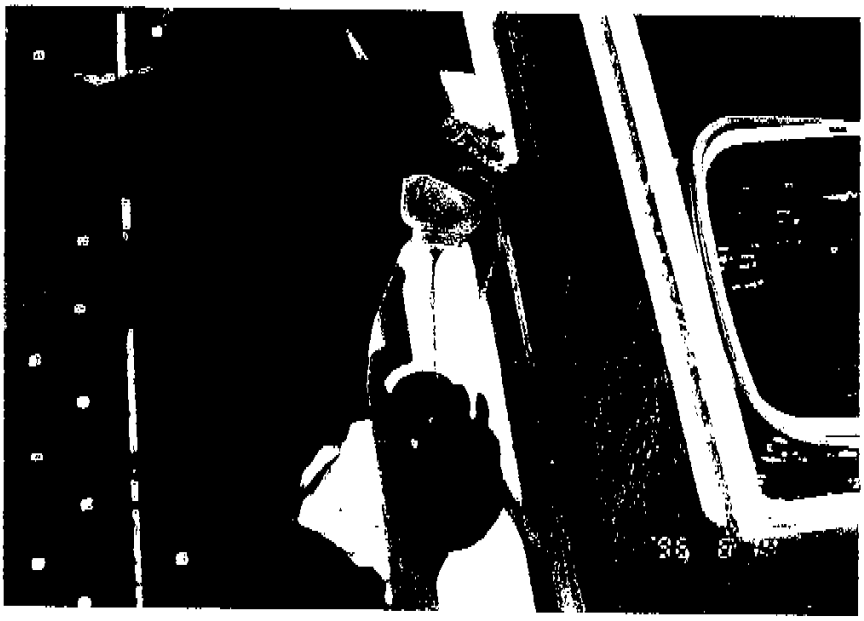


Odor	June 14, 1996 Before EM Treatment	October 31, 1996 After EM Treatment
Methyl Disulfide	0.0047	0.0002
Strength of Odor	2.5	Less than 1

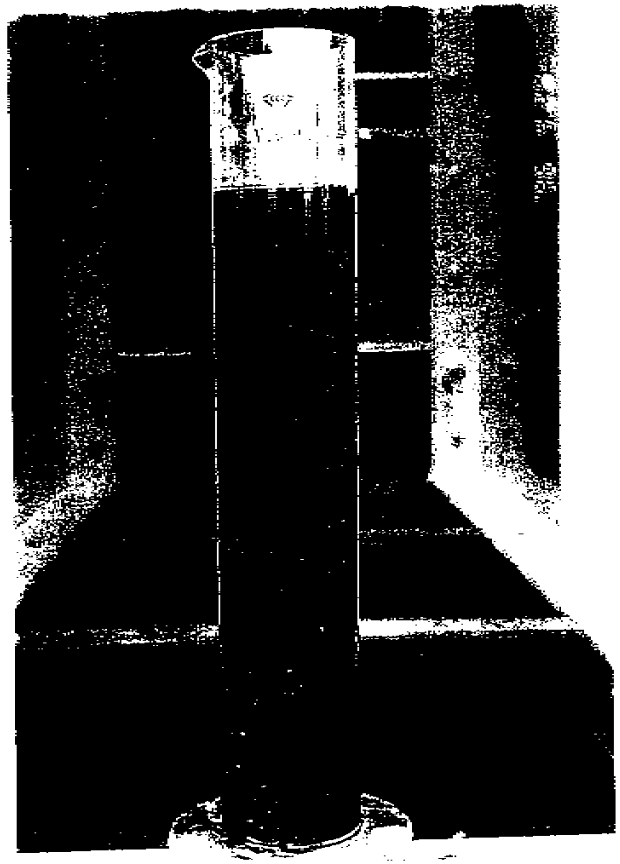




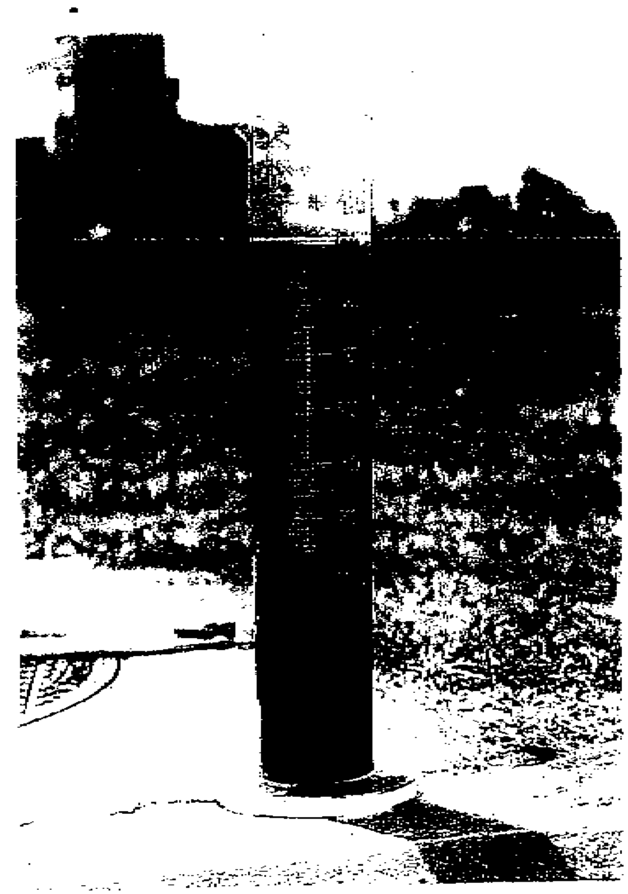
EM Extended Liquid



Putting in EM Extended Liquid
(Into the Receiving Tank)

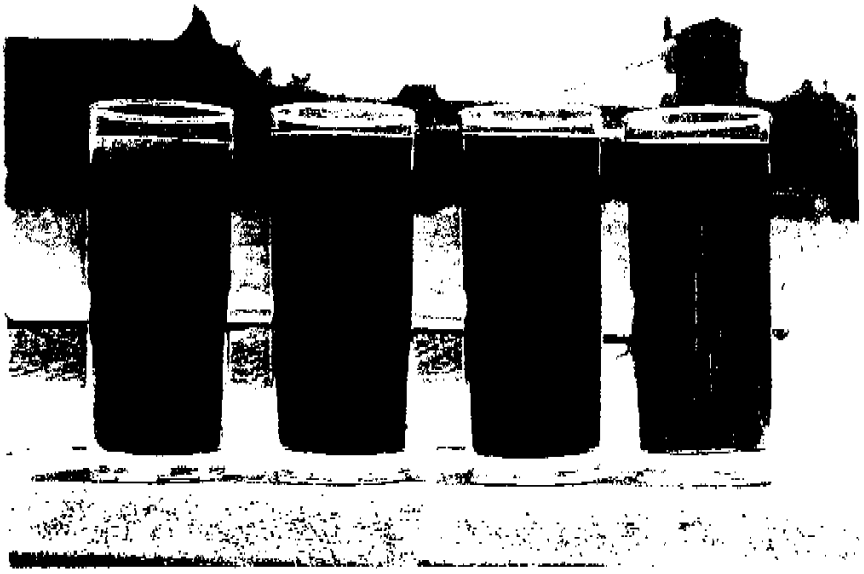


Separation Before EM Treatment

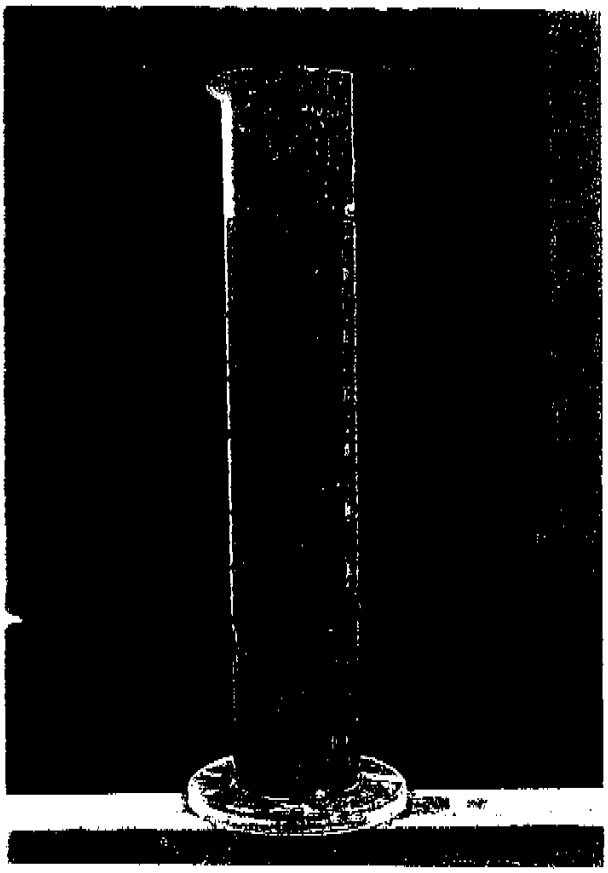


Separation After EM Treatment

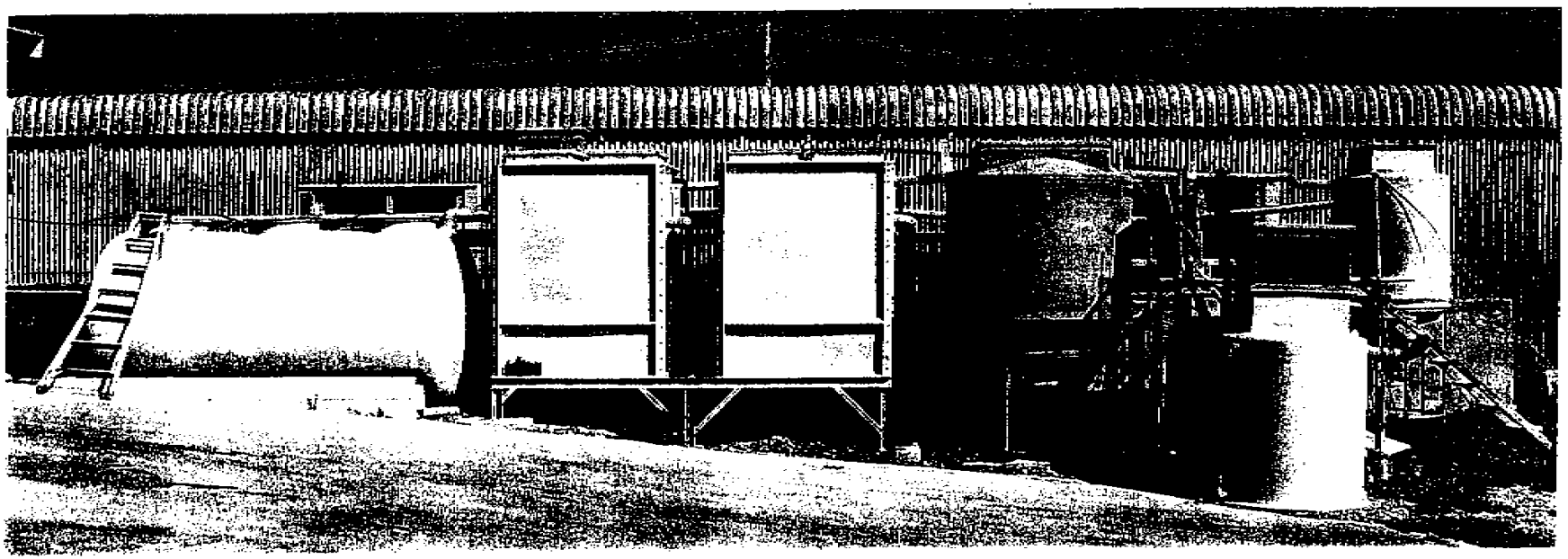
SV30 Comparison (No. 1 Aeration Tank)



Before EM Treatment (On the right is treated water)



After EM Treatment



View of the Entire Sewage Treatment Plant