

# **Purification of Waste Water with Effective Microorganisms and its Utilization in Agriculture**

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## **Abstract**

The potential of using Effective Microorganisms (EM) to purify waste water, including that of a sewage system, for recycling purposes was evaluated. The studies were extended to examine the potential of using treated sewage sludge as a fertilizer in crop production.

Long term application of EM reduced the adverse characteristics of waste water. The quality of the treated water was high, which indicated its potential use for reuse without health hazards. It also enhanced crop growth as measured by its effects on cucumber. Application of EM products to tap water also eliminated the ill effects generally found in chlorinated water. The treated city water was more effective in promoting plant growth.

Application of EM to sewage sludge enhanced its value as a fertilizer. Plant growth was enhanced in contrast to application of untreated sludge, which had toxic effects. The value of EM in sanitation programs and the potential of recycling wastes after treatment for nature farming at a low cost is presented on the basis of these studies.

## **Introduction**

Urbanization in global terms is a concept that cannot be ignored. The lack of employment opportunities in the rural economies, greater attraction of the cities, the dreams and aspirations of rural youth and all contributing to the migration of people into cities. This creates many problems, economically, socially and environmentally.

While the economic and social problems need policies at the highest levels of decision making, the environmental problems are faced by the local authorities. Furthermore, the problems created by mass influxes of people into cities are more visible to the people. The collection of garbage, foul smell and the out flow of city sewage are all problems that need immediate solutions to make cities habitable for humankind, and preserve at least a moderately clean and disease free environment.

The problems of waste water in cities, along with sewage disposal are being studied by many countries (Sudo, 1995). Most methods offer treatment with toxic chemicals, which in turn makes the treated product more harmful than when contaminated with biological substances (Kurihara, 1990). In most cities of the world, this treated water is discharged into waterways or the ocean, thereby polluting the environment in an indirect manner.

Solutions of Effective Microorganisms, developed in Okinawa in the 1970's have been used for environmental management. These solutions, which contain naturally occurring microbes (Higa, 1996), have the ability of reducing the biological toxicity of waste water, while overcoming the foul odors. Hence, EM have been used in many instances in Japan, especially in Okinawa for the cleansing of waste water from urban utilities.

Although EM is used in such instances very successfully, no scientific reports have been presented on this aspect. Hence, a research project evaluated the efficacy of EM on overcoming pollution in waste water, thereby making it usable for agriculture. The specific objectives of the study were to determine the effect of EM on the quality of waste water, and the potential of utilizing treated water and sludge of a urban sewage plant on plant growth.

## **Materials and Methods**

The program of research carried out at the University of the Ryukyus, Okinawa, Japan from August 1995 - January, 1997 consisted of three experiments. The waste water and sewage was obtained from the waste disposal facility at the Gushikawa City library, which caters for approximately 500 people every week day and over 100 people on weekends. The facility maintained at this library uses the active sludge method and has the capacity of collecting the wastes of 160 humans. Its system contains a primary tank, second tank and a third, which collects water filtered from the

second tank.

EM had been used for treating waste water in this library from 1992. The treatments that had been used were as follows :

February 1992 -The addition of 10 liters of EM1 and 2 liters from EM2 and EM 3 to the second tank of the sewage system. Thereafter, 2 liters of EM1 and .0.5 liters of EM 2 and 3 has been added to the same tank every three months.

This practice is being continued at present.

### **Experiment 1. The Effect of EM on the Quality of Waste Water**

Samples of water (2 liters per sample) were drawn from the three different tanks of the sewage system of the library at monthly intervals beginning from August, 1995 to January 1997. Thus 18 samples were procured from the primary tank, treated tank and the final tank collecting filtered water. Each sample was analyzed three times for the following, using standard procedures, described in detail by Okuda (1997): Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Suspended solids and total nitrogen and phosphate concentrations.

Thus a total of 54 samples were analyzed, each being considered a replicate.

### **Experiment 2. Plant Growth as Affected by Treated Waste Water**

This experiment conducted in a green house used cucumber (*Cucumis sativus* L) as the test plant. Uniform seedlings of this species were transplanted into vinyl pots filled to the top with 2 kg of a red clay Soil. Each pot was supplied with 2 g of a standard basal fertilizer, containing 15:15:15 N:P:K at a rate of 10 g per pot prior to planting. The treatments adopted were as follows:

- Irrigating pots with EM treated waste water from the library secondary sewage tank.
- Irrigating with untreated sewage water.
- Irrigating with tap water treated with EMX and EMX ceramics (100 g of EMX and EMX ceramics per 100 liters water).
- Irrigation with untreated tap water.

These were replicated 12 times within a Randomized Block Design.

Each pot was supplied with 300 ml of each type of water once in 3-4 days for a period of 40 days. On the 40th day, when plants were at the V7 growth stage, the following parameters were measured using techniques described by Okuda (1997): Plant height, leaf number per plant, plant dry weight, chlorophyll and ascorbic acid content of leaves and root activity measured in terms of reduction of Alpha Naphthyl Amine.

### **Experiment 3. Influence of Sewage Sludge on Growth of Tomato Plants**

This experiment using tomato (*Lycopersicon esculentum* L - Var Momotaro) was carried out in a green house. Uniform seedlings of tomato were transplanted into vinyl pots containing 3 Kg of red clay soil. Each pot was supplied with 15 g of the fertilizer mixture used in Experiment 2, prior to establishing the plants.

The treatments, replicated 10 times were as follows:

- Addition of 0.5 Kg of untreated or treated sludge per pot.
- Addition of 1.0 Kg of untreated or treated sludge per pot.
- A control where no sludge was added to the soil.

Thus this experiment had 5 treatments within a Randomized Block Design.

Untreated sludge was added to the soil of all pots at predetermined rates, 10 days before planting and mixed well. Thereafter, EM dilution 1:1000) was added at a rate of 200 ml per pot to those where the sludge was to be treated. This treatment was carried out one day before planting. The pots containing the untreated sludge received the same quantity of water at the same time.

The plants were maintained for 50 days until flowering (R1 growth stage). On the 50th day, the plant survival was determined and carefully uprooted. Thereafter, plant height, numbers of leaves and fresh weight of leaves were determined.

The data of all experiments were subjected to statistical analysis for determination of differences between treatments.

## Results and Discussion

### Experiment 1

The effects of EM on the pH and biological properties are presented in Table 1. Application of EM reduced the pH to near normal conditions from 7.63. Hence application of such water to crops would not produce alkali conditions. More importantly, the BOD and COD values show the benefits of treating waste water with EM. Application of EM to the second pond reduced the BOD and COD values of water by 93 percent and 20 percent respectively. The total solid content, was also reduced by 94 percent, due to the microbial breakdown of organic matter.

**Table 1. Effect of EM Treatment on Waste Water of the Gushikawa City Library.**

Type of water	pH	BOD (mg/L)	COD (mg/L)	Suspended solids (mg/L)
Primary tank	7.63	104.5	34.10	91.08
Treated water	7.00	6.9	27.00	5.17
Filtered water	7.08	1.8	9.00	2.56
Sx	0.31	2.76	5.02	1.98

Filtering the water to the third pond, gave a large period for EM to reduce the adverse effects of sewage water. Hence, although alkalinity increased marginally, the BOD, COD and suspended solids were reduced further, making the water more acceptable for recycling.

The presence of nitrogen is a major problem that inhibits the reuse of waste water. However, application of EM into the second pond reduced the nitrogen and phosphorous contents significantly (Table 2). The rate of reduction of nitrogen was 64 percent in the treated water and 88 percent in the filtered pond, in comparison to that of untreated water. Similar values were also observed with phosphorus, and the reductions of nitrogen and phosphorus were 55 percent and 82 percent in the treated and filtered ponds respectively. These reductions could be attributed to the microbial utilization of these nutrients, thereby making the water suitable for recycling for agricultural purposes.

**Table 2. Nitrogen and Phosphorus Content of Treated Waste Water**

Type of water	Nitrogen (ppm+SE)	Phosphorus (ppm+SE)
Primary tank	58.74+10.5	17.86+6.9
Treated water	21.11+4.6	8.00+0.9
Filtered water	6.89+2.2	3.11+0.6

### Experiment 2

The survival and growth of cucumber plants were enhanced by treating water with EM, The highest number of plant survival was observed when tap water was treated with EM ceramics, which was significantly greater than that observed when plants were grown with untreated tap water. Both treated and untreated waste water produced survival rates which were marginally lower than that observed with the use of treated tap water.

The impact of using untreated waste water was clearly visible in terms of leaf number and plant dry weights. This could be attributed to the toxic effects of untreated waste water, which stunted plants, thereby affecting dry matter accumulation.

The vitamin C and chlorophyll contents of cucumber leaves were highest with the use of treated waste (Table 4). In contrast, the use of treated or untreated tap water produced the lowest values. These high values in waste water could be attributed to the nutrients that promote growth of these plants (Table 3).

**Table 3. Growth of Cucumber Plants as Affected by Treated Waste Water.**

Treatment	Plant survival (No. of plants)	Leaf (No. of plants)	Dry weight (g/plant)
Untreated waste water	10	8.55+0.51	3.17+0.35
EM treated waste water	11	9.67+0.44	4.08+0.24
EM ceramics treated water	12	9.60+0.37	4.03+0.27
Untreated tap water	-	-	-

**Table 4. Influence of Water Treatment with EM on Vitamin C and Chlorophyll Contents of Cucumber Plants.**

Treatment	Vitamin C (mg/100g dry wt)	Chlorophyll ( $\mu$ g/g leaf)
Untreated waste water	152+12.7	1263+63.7
EM treated waste water	171+97.9	1041+1015
EM ceramics treated water	79+12.7	1101+249.4
Untreated tap water	67+21.4	1086+80.5

Root activity illustrates the growth vigor of plants. Hence, the application of treated waste water produced the highest root activity, measured in terms of the reduction of Alpha Naphthyl Amine (Table 5). The lowest value was observed in untreated waste water, which again could be attributed to the presence of toxins which could inhibit plant development.

Hence, the study illustrated that water treated with EM could be used for enhancing plant growth under green house conditions. However this needs further verification, although the results look very promising for agricultural enterprises.

**Table 5. Effect of EM Treatment of Waste Water on Root Activity of Cucumber as Measured by Reduction of Alpha Naphthyl Amine.**

Treatment	Reduction of Alpha Naphthyl Amine ( $\mu$ g/g/hr)
Untreated waste water	0.37+0.23
EM treated waste water	0.85+0.19
EM ceramics treated water	0.71+0.15
Untreated tap water	0.68+0.16

### Experiment 3

Disposal of raw sewage is a problem in most cities. In some countries, it is used as a fertilizer. However, the application of untreated sewage could cause problems of toxicity.

The study on the treatment of sewage sludge prior to application illustrated that EM reduces toxic problems. It also promotes growth of tomato plants. The plant heights, number of leaves and leaf weights were significantly enhanced by treating sewage sludge with EM (Table 6). Application of 1 kg of treated sludge promoted growth to the greatest extent, due to the nutrient content of this material, which is not significantly affected by the microbial solution. In contrast, application of untreated sewage sludge reduced growth of tomato plants to the greatest extent.

Therefore, the possibility of treating sewage with EM and subsequent use as a fertilizer was illustrated by this study.

**Table 6. Effect of EM Treatment of Sewage on Growth of Tomato Plants.**

<b>Treatment</b>	<b>Height (cm/plant)</b>	<b>Leaf (No./plant)</b>	<b>Fresh weight of Leaves (g/plant)</b>
Addition of 500g of untreated sewage	12.5	5.3	1.4
Addition of 500g of treated sewage	26.4	9.2	3.7
Addition of 1kg of untreated sewage	11.6	5.1	1.6
Addition of 1kg of treated sewage	32.7	9.4	4.6
Bare soil	24.5	8.2	2.5
Sx	9.65	0.21	0.87

### **Conclusions**

Disposal of waste water and sewage is a problem in most countries. However, treatment with EM, as done in many institutions in Japan overcomes this problem. Application of EM to waste water reduced its toxic effects. Hence this water could be used for crop production. Similarly, sewage sludge could also be effectively treated with EM and used for crop production. While these studies need further validation with different crops, they highlight a significant potential of overcoming a problem that humankind and urbanization faces at the present time.

### **References**

- Higa, T. 1996. Effective Microorganisms - Their role in Kyusei Nature Farming and sustainable agriculture. In Proceedings of the Third International Conference on Kyusei Nature Farming. Ed. J.F. Parr et al., USDA, Washington, USA : 20-24.
- Kurihara, H. 1990. Water quality of reusing waste water. Jour. of Japan Sewage Works Association 27:38-41.
- Sudo, R. 1995. Aspects of policy on waste water treatment of the Government of Japan.