# EFFECTIVE MICROORGANISMS (EM) AND WASTEWATER SYSTEMS

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*Presented as an oral paper to*

Future Directions for On-site Systems: Best Management Practice
Proceedings of On-site '03 Conference

**Reference:** Szymanski, N. and Patterson, R.A. (2003Effective Microorganisms (EM) and Wastewater Systems in *Future Directions for On-site Systems: Best Management Practice. Proceedings of On-site '03 Conference* by Patterson, R.A. and Jones, M.J. (Eds). Held at University of New England, Armidale 30th September to 2nd October 2003. Published by Lanfax Laboratories Armidale. ISBN 0-9579438-1-4 pp 347-354

# EFFECTIVE MICROORGANISM (EM) AND WASTEWATER SYSTEMS

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## Abstract

The use of effective microorganisms (EM) for reducing volumes of sewage sludge has often been suggested as feasible in either wastewater treatment plants or on-site wastewater treatment systems such as septic tanks. The organisms are supposed to eliminate the volumes of sludge produced, with the benefits of reduced sludge handling, and consequently lower costs and decreased impacts upon the environment. This project aimed to test the hypothesis that EM is beneficial in reducing sludge volumes. Two areas of experimentation were undertaken, one at a controlled experiment at the Coffs Harbour Wastewater Treatment Plant (CHWTP) and a second on five domestic septic tanks in the Armidale-Dumaresq area (northern NSW).

Results from CHWTP showed a significant decrease in pH levels with increased EM dose, improved settlement of the sludge, but a significant increase in $BOD_5$. There was a significantly higher level of solids in the treated tanks compared to the control. The lack of consistency between the tank treatments with respect to quality and quantity of sludge remained an issue. The septic tanks indicated a pattern of similar conditions following a final application, suggesting domination by a particular type of microorganism. However, there was no reduction in suspended solids content in the effluent. It is concluded that there were not sufficient changes to sludge volume (CHWTP) or suspended solids (septic tanks) to indicate a clear benefit from the use of EM in wastewater.

## Keywords

Bokashi, effective microorganisms, wastewater sludge.

## 1 Introduction

A major problem facing municipalities throughout the world is the treatment, disposal and/or recycling of sewage sludge. Generally sludge from municipal waste consists mainly of biodegradable organic materials with a significant amount of inorganic matter (Elliot 1986). However, sludge exhibits wide variations in the physical, chemical and biological properties (Colin *et al.* 1988; Bruce 1990). At the present time, there are a number of methods being used to dispose of sewage sludge from disposal to landfill to land application.

Although there are many methods used, there are numerous concerns raised regarding the presence of constituents including heavy metals, pathogens and other toxic substances. This requires the selection of the correct disposal method focussing on efficient and environmentally safe disposal. New technologies are being produced to assist in the treatment and disposal of sewage sludge, conforming to strict environmental regulations. One of these new technologies being proposed is the use of Effective Microorganisms (EM).

The technology of Effective Microorganisms (EM) was developed during the 1970's at the University of Ryukyus, Okinawa, Japan (Sangakkara 2002). Studies have suggested that EM may have a number of applications, including agriculture, livestock, gardening and landscaping, composting, bioremediation, cleaning septic tanks, algal control and household uses (EM Technology 1998).

Effective Microorganisms is a mixture of groups of organisms that has a reviving action on humans, animals, and the natural environment (Higa 1995) and has also been described as a multi-culture of coexisting anaerobic and aerobic beneficial microorganisms (EM Trading 2000). The main species involved in EM include:

- Lactic acid bacteria – *Lactobacillus plantarum, L. casei, Streptoccus lactis*
- Photosynthetic bacteria – *Rhodopseudomonas palustrus*, *Rhodobacter spaeroides*
- Yeasts – *Saccharomyces cerevisiae*, *Candida utilis*
- Actinomycetes – *Streptomyces albus, S. griseus*
- Fermenting fungi – *Aspergillus oryzae, Mucor hiemalis* (Diver 2001).

Organic materials within wastewater originate from plants, animals or synthetic organic compounds, and enter wastewater via a number of routes including human wastes, detergents, and industrial sources (Taylor *et al*. 1997). In the current wastewater treatment process (either municipal or domestic on-site) microorganisms play a significant role in the treatment of domestic sewage. Many different organisms live within the wastewater itself, assisting in the breakdown of certain organic pollutants (Taylor *et al*. 1997).

Within on-site systems (e.g. septic tanks), microorganisms play a significant role in the decomposition of organic wastes, however, some microorganisms can cause health concerns to humans. These include bacteria and viruses present in the wastes produced (Harris *et al.* 2001).

The basis for using these EM species of microorganisms is that they contain various organic acids due to the presence of lactic acid bacteria, which secrete organic acids, enzymes, antioxidants, and metallic chelates (Higa & Chinen 1998). The creation of an antioxidant environment by EM assists in the enhancement of the solid-liquid separation, which is the foundation for cleaning water (Higa & Chinen 1998).

One of the major benefits of the use of EM is the reduction in sludge volume. Theoretically, the beneficial organisms present in EM should decompose the organic matter by converting it to carbon dioxide ($CO_2$), methane ($CH_4$) or use it for growth and reproduction. Studies have suggested that this is the case for both wastewater treatment plants and also septic tanks. This is highlighted by Freitag (2000), who suggests that introducing EM into the anaerobic treatment facilities helped to reduce the unpleasant by-products of this decomposition and also reduced the production of residual sludge. These factors tend to suggest that theoretically EM should assist in the treatment of wastewater by improving the quality of water discharged and reducing the volume of sewage sludge produced.

## 2 Testing of Effective Microorganisms

Literature suggests Effective Microorganisms significantly reduce volumes of sewage sludge produced while removing the associated odours. Therefore, this tends to suggest an improvement in the digestibility of sludge and other solids in septic tanks and therefore the efficacy of septic systems. The main hypothesis of this project is that the application of EM will result in a trend towards a reduction in the level of solids, and hence a reduction in sewage sludge. The reduction of solids in a septic tank are best monitored in the short term, by changes to the total suspended solids (TSS), total dissolved solids (TDS) and total solids (TS) in the effluent discharging from the septic tank

The primary objective of this project was to determine if effective microorganism (EM) technology reduces the volume of sewage sludge. There were two aspects to this project:

experimentation of sewage sludge from a wastewater treatment plant (situated at Coffs Harbour) and domestic sewage sludge produced and treated on-site within septic tanks (based around the Armidale-Dumaresq area). Only the latter part of the project is reported here. A secondary objective was to monitor the associated changes in pH, electrical conductivity and other physico-chemical indicators of changing characteristics within the tank in relation to the application of EM.

### 2.1 Activating the Effective Microorganisms (EM)

EM is available in a dormant state and requires activation before application. Activation involves the addition of 7 L of chlorine free water and 1.5 kg of brown sugar to 3 L of dormant EM one week prior to application.

These ingredients were mixed together in either a 15 L or 20 L container and stored in an area with minimal temperature fluctuations. A major influence on the survival of microorganisms is the temperature of their environment, with significant temperature fluctuations impacting upon their survival. The pH is also a determining factor. It was indicated that the pH of the EM should be approximately 4.5 (Newton, G. 2002 *pers. comm*.).

### 2.2 Septic Tank Experiment

Five septic tanks in the Armidale-Dumaresq region were treated and sampled to determine the effect of the EM upon the suspended solid content of the wastewater. These septic tanks were chosen for their similarity in size and wastes, and relative closeness for ease of monitoring. The only difference between the tanks was the number of persons served by the single tank. Two further tanks were discarded due to the need for pumping out (restricting sampling).

An initial dose of 6 L of activated EM was applied to the septic tank at the inlet inspection port. Three litres were then added one week later, with 350 mL doses applied once each week after that for the next three weeks. A total of 10 L over the four weeks.

It has been suggested that activated EM may be applied to the toilet or any other drain leading to the tank. However, for ease of sampling and addition, the activated EM was applied directly into the septic tank at the inlet port. The activated EM should also be added a number of days prior to washing of clothes due to large influxes of water and temperature fluctuations. However, this was not a factor that could be controlled. Hence the addition of activated EM was undertaken on the same day each week (Saturday). Samples were taken from the outlet pipe of each septic tank once per week before application and were analysed for pH, electrical conductivity (EC), total alkalinity, total solids (TS), total suspended solids (TSS) and total dissolved solids (TDS). This testing was undertaken as outlined in (APHA 1995) and methods used are given in Table 1.

**Table 1: Testing methods used for analysis of septic tank samples.**

| Parameter | Method | Units |
|---|---|---|
| PH | APHA:4500 H+ | Units |
| Electrical conductivity | APHA:2510 | dS/m |
| Alkalinity | APHA:2320 | mg/L |
| Total Solids (TS) | APHA:2540B | mg/L |
| Total Suspended Solids (TSS) | APHA:2540D | mg/L |
| Total Dissolved Solids (TDS) | Calculation | mg/L |

As reported by Lanfax Laboratories, using $19^{th}$ Edition of Standard Methods (APHA, 1995).

# 3 Results of Septic Tank Monitoring

Six samples were taken over an eight-week period, one initial sample before the first dose, a sample each day of the following doses and a final sample three weeks after the last dose.

## 3.1 pH

Figure 1a shows the comparison between the pH levels of the five septic tanks. This figure suggests that there was no trend evident between the different septic tanks during application of EM, however it can be seen that all but one septic tank (Murdock) had very similar pH following completion of the application of EM. Results also suggest that after completion of the trial, the pH tended to drop to an environment of lower pH.

## 3.2 EC

Analysis of the electrical conductivity again suggests that after completion of application, very similar conditions were obtained. However the septic tank monitored on the Murdock property again showed its presence as an outlier. Figure 1b also highlights a similar trend in fluctuations between the Shanahan and O'Connell septic tanks, suggesting increased EC during applications of EM. A general trend of decreasing EC after completion of dosages is also illustrated.

## 3.3 Total Alkalinity

Similar to the previous two parameters, no common trends throughout the sampling period were found, however, conditions tended to be more variable following final application . This is in addition to a trend of decreasing alkalinity following the application period. Again the properties of O'Connell and Shanahan showed similar trends, along with the outlying results from the Murdock property. The data obtained is shown in Figure 1c.

## 3.4 Total Solids

The results obtained from the analysis of TS indicated that there was no obvious decrease in the solids content in the septic tanks. Results suggested that conditions were more similar following the final application of EM. Some concern was raised over the Cleland property in terms of trends, which failed to follow the trend towards a similar condition. However it still exhibited low solids conditions. There was also some indication that the initial addition of EM resulted in an increase in suspended solids within the water fraction of the septic tank. These results can be seen in Figure 1d.

### 3.5 Total Suspended Solids

Analysis of TSS failed to indicate any significant trends, including the trend of similar conditions following completion of application of EM. Nonetheless, it can be seen from figure 1e that a number of the tanks had fluctuations in suspended solids content (i.e. Shanahan and Murdock in addition to Patterson and O’Connell). There was one concern with the Patterson/O’Connell trend, which indicated a considerate difference in results following the third application of EM. The results indicated that there was no trend in decreasing or increasing suspended solids within samples.

### 3.6 Total Dissolved Solids

Following analysis of both TS and TSS, determination of Total Dissolved Solids (TDS) is possible through the relationship:

$$TS = TSS + TDS$$

Figure 1f illustrates that the main trend obtained from the results was a decrease in the level of TDS after the final addition of EM. It also highlights the phenomenon of similar conditions within a number of septic tanks, occurring within the O’Connell, Murdock and Shanahan septic systems.

## 4 Discussion of Results

A significant trend observed from the results was that following completion of the EM application, similar conditions were observed for all parameters except TSS. This phenomenon occurred following highly variable initial conditions. This suggested that following a period of EM application, conditions that might favour survival of the EM may be created. Throughout the monitoring and application period, conditions within the septic tanks were highly variable, which would have been influenced by the quality of sewage.

Again following this period of application, another trend arose, with decreases in pH, EC and Total Alkalinity, which may in turn have resulted from the reduction in EM application. Observations from results suggested that sludge volumes may be reduced through the application of EM, however will not occur until completion of application. With respect to solids, initial increases may have resulted from breakdown of organic matter within the septic tank, leading to an increase in entrained solids. Machmeier (2000) supports a similar notion, stating that additives may chemically stir up the sludge in the septic tank and consequently may explain the variable results of pH, EC and total alkalinity.

Another view states that disturbances in microbial populations at one trophic level may impact upon the whole community, ultimately influencing performances of septic tanks (Linich 2001). This may also explain the similarity trend, through selection of dominant microorganisms creating particular conditions.

Linich (2001) also reported that a change in microbial populations may impact upon pH, other intermediates and the overall efficiency of a septic tank. This tends to support the results obtained, through continual changes in the conditions within the septic tanks. However it fails to explain the similarities in trends between two totally different septic tanks. Contrary to this opinion is a study suggesting that the addition of EM increases the reliability of ‘notoriously fragile’ microbial ecosystems through competitive exclusion of pathogenic microorganisms, hence favouring the beneficial microorganisms present (Banerji, Wood & Farrelly undated).

This study suggests from results obtained that suspended solids will be reduced. Higa (1993) supports this statement through the example of the Gushikawa City Library, which when treated with EM has reduced the need for solids handling.

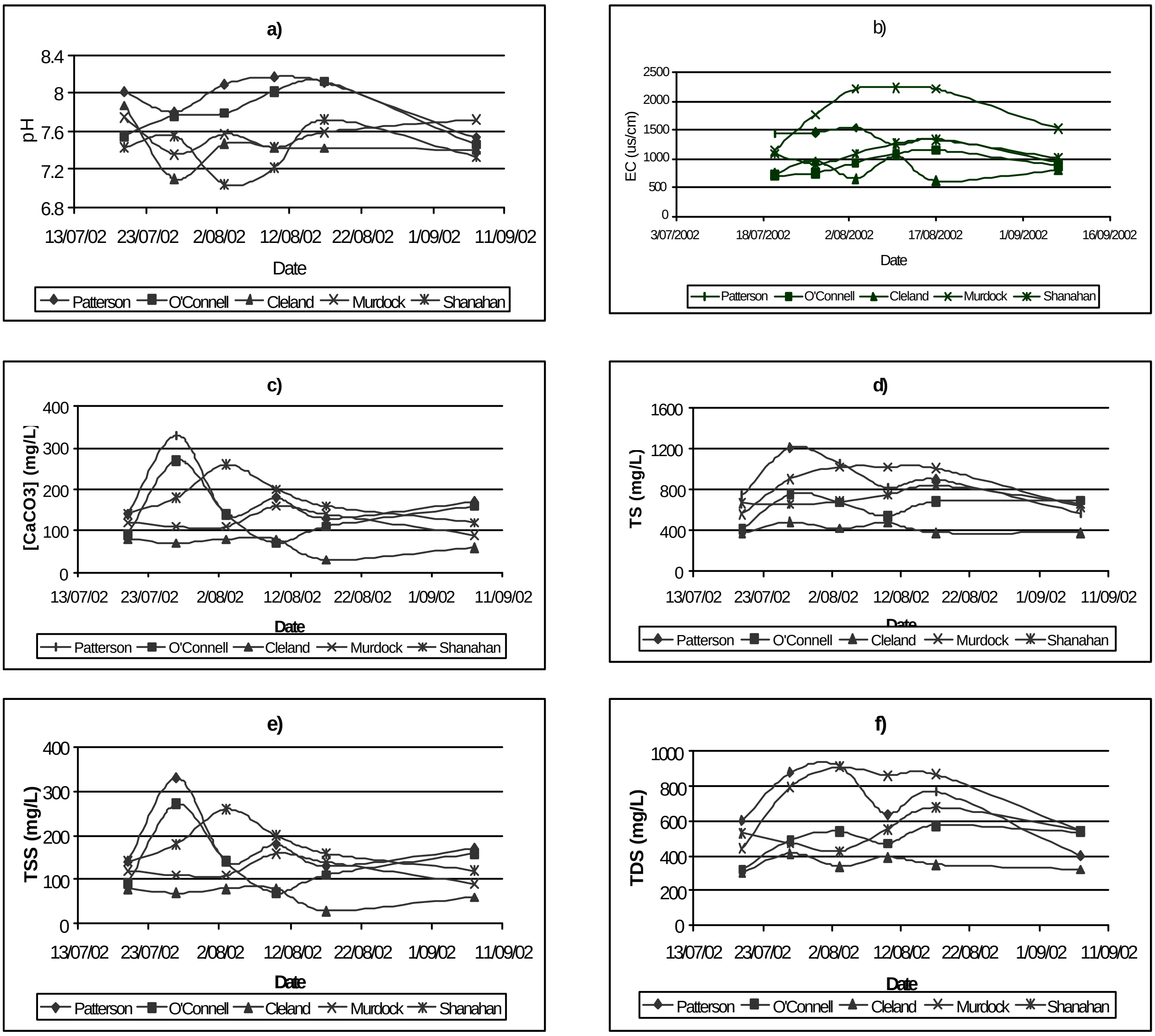


**Figure 1: Comparisons of monitored septic tanks for a) pH, b) EC, c) Alkalinity, d) Total solids, e) Total Suspended Solids, f) Total Dissolved Solids**

Results obtained from the project supports claims of reduced solids, however this trend occurs two weeks after the final application of EM and hence, it is believed that there is some impact made upon the solids content of the septic tanks by EM. This is supported by Machmeier (2000) who suggests in a study (titled *The effect of bacterial additives on septic tank performance*) undertaken by a PhD student at the North Carolina State University, "that there was no practical value from using bacterial septic tank additives". This is also supported by The Health Commission of Victoria (1983 quoted in Patterson 1994) that the addition of various commercial preparations, used to assist bacterial actions within septic tanks is unnecessary. However literature on both studies fail to explain the phenomenon of the similarity in conditions raising interesting questions regarding the effectiveness of this additive.

Further research is required, with sampling being undertaken more regularly (e.g. 1 sample per week), to determine changes between the applications of EM, and monitoring for a longer period (continued monitoring for 5 weeks) after the final application. This would allow observations of and monitoring similarity in conditions between septic tanks. As with all microbial populations, impacts can occur through significant changes in temperature and pH, likewise chemical conditions through detergent applications, and hence EM populations are also affected (Newton, G. 2002 *pers. comm*., 15 Feb). This may have had an influence upon the results obtained and is recommended that in future studies significant flows to the septic tanks (e.g. showers, washing periods etc) be monitored to determine the associated impact upon the EM and hence sludge volumes.

## 5 Conclusions

This experiment was undertaken to determine if the application of Effective Microorganisms (EM) would decrease the volumes of sewage sludge produced in on-site wastewater treatment systems (septic tanks). There was no appreciable reduction in the suspended solids content of the septic tanks, with minimal influences on pH, alkalinity and electrical conductivity during the application of EM. It was observed following final application of EM that a decreasing trend in pH, EC, alkalinity, TS and TDS began. It was also observed that a phenomenon of common conditions was created following a two-week period with no application of EM. This was attributed to the creation of optimal conditions for EM survival and hence may result in further decreases of suspended solids content.

Based on the results obtained from this experiment, it was concluded that the use of EM has minimal affect on the solids content within a wastewater treatment plant. However, results suggest that the EM does have some affect upon certain parameters within on-site wastewater treatment systems (septic tanks) including the creation of optimum conditions within septic tanks, reflecting the conditions for EM. This tends to suggest that EM does have an affect on septic tanks, nonetheless results do not suggest realistic decreases in solids over the eight week sampling period. Further research is required before recommendations can be made towards recognising EM as an additive to be used to reduce the solids content of wastewater. Many previous studies have suggested that the use of EM has resulted in a significant reduction in solids handling. The results obtained from this study do not agree with this indicating that there is still a notable amount of solids present, hence requiring significant handling.

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