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A Study on Sewage Treatment Using Effective Microorganisms (EM) Technology

SmithaMathews*, & Denna Mary Tom,**

****Assistant Professor in Microbiology, Department of Zoology, Assumption college, Chanaganacherry, Kottayam, Kerala.***
*****Department of Zoology, Assumption college, Chanaganacherry, Kottayam, Kerala.***

ABSTRACT

The use of effective microorganisms (EM) for reducing volumes of sewage sludge has often suggested as feasible in wastewater treatment. The organisms such as lactic acid bacteria, photosynthetic bacteria, fermenting fungi, yeast and actinomycetes present in EM is supposed to eliminate the volumes of sludge produced, with consequently lower cost and decreased impact upon the environment.. Five samples were taken for experiment, were one as control. EM activated in jaggery and rice water and expired EM activated in jaggery and rice water were taken for the experiment. Results from experiment showed that there is a reduction in pH levels with improved settlement of sludge, and a significant decrease in BOD. There is an increase in the dissolved oxygen content also an increase in the conductivity of the water samples. However, there was no reduction in the total dissolved solids content in the effluent. Thus Effective Microorganism (EM) is effective for the treatment of wastewater.

KEY WORDS: *Effective microorganisms (EM), lactic acid bacteria, photosynthetic bacteria, activated in jaggery and rice water, BOD, wastewater.*

INTRODUCTION

A major problem 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. 1998; 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 applications.

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 Micro organisms (EM).The technology of Effective Micro organisms was developed during 1970's at the University of Ryukyus, Okinawa, Japan. Studies have shown that EM may have a number of applications, including agriculture, livestock, gardening and landscaping, composting, bioremediation, cleaning septic tanks, algal control and household uses. The application of EM will improve soil and irrigation water. It can be used in seed treatment. It can be used to make organic sprays for the enhancement of photosynthesis and control of insects, pests and diseases. 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 tank and industrial effluents.

The main species involved in EM include:Lactic acid bacteria- *Lactobacillusplantarum*. These bacteria are differentiated by their powerful sterilizing properties. They suppress harmful microorganisms and encourage quick breakdown of organic substances. In addition, they suppress the reproduction of Fusarium, a harmful fungus. Photosynthetic bacteria- *Rhodobacterspaeroides*.These bacteria play the leading role in the activity of EM. They synthesize useful substances from the secretions of roots, organic matterand /or harmful gases (e.g. hydrogen sulphide) by using sunlight and the heat of soil as source of energy. They contribute to a better photosynthesis. The metabolites developed by these microorganisms are directly absorbed into plants. In addition, these bacteria increase the number of other bacteria and act as nitrogen binders. Yeasts- *Saccharomycescerevisiae*.Thesemanufacture antimicrobial and useful substances for plant growth. Their metabolites are food for other bacteria such as the lactic acid and actinomycetesgroups.Actinomycetes- *Streptomyces albus*.These bacteria suppress harmful fungi and bacteria and can live together with photosynthetic bacteria.Fermenting fungi- *Aspergillusoryzae*.Fungi that bring about fermentation, they break down the organic substances quickly. This suppresses smell and prevents damage that could be caused by harmful insects.

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 . 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).

EM is eco-friendly safe and organic. 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 sewage water. The main hypothesis of this project is that the application of EM will result in the reduction in the level of dissolved particles and to improve the quality of the water.

MATERIALS AND METHODS

1. Effective Microorganisms

Effective microorganism (EM) used in this study was supplied by Consolidated Agri Tech CO. (Calicut) as Maple EM 1 (Environment – Solid waste Management which contains both Expired & Non Expired bottles) contained a mixture of lactic acid bacteria *Lactobacillus caesei* (1.0 X10^5 <) yeast with (1.0X10^3 <)CFU/ml *Saccharomyces cerevisiae*, actinomycetes *Streptomyces albus* (3.0X10^3 CFU/ml), fermenting fungi *Aspergillus oryzae* (1.1X10^5CFU/ml),Photosynthetic bacteria *Rhodopseudomonaspalustris* (1.0 X 10^2)CFU/ml .EM solution is a brownish liquid with a pleasant odour and sweet sour taste with a pH of 3 and stored in cool place without refrigeration before activation.

2. Activating the Effective Microorganisms

EM is available in a dormant state and requires activation before application. Activation involves either the use of jaggery or rice water. Here, both jaggery and rice water is being used to activate expired and non-expired EM in order to take a comparison among them.

Activation involves the mixing and subsequent dissolving of 100gm jaggery in 1900ml chlorine free distilled water without any visible suspended particles at the bottom by thorough heating and mixing contents uniformly. Activation involves the mixing and subsequent dissolving of 40gm sugar in 1900ml chlorine free distilled water without any visible suspended particles at the bottom by thorough mixing of contents uniformly. Both mixture is then transferred to a plastic container with 2L capacity to which 60ml of Maple EM-1 Solid waste management (non-expired) is added and mixed well to get uniform distribution with no air left in the container. The same procedure is repeated to activate Maple EM-1 Solid waste management (expired) in another plastic container with 2L capacity.

The containers were stored away from direct sunlight at ambient temperatures for 5 to 7 days. The gas was released from each container during every 24 hours until fermentation is completed. During the period of activation, a white layer of actinomycetes formed on the top of the solution accompanied by a pleasant smell and acidic pH within the range of 3-3.5.The Activated EM (AEM) must be used within 30 days of activation.

3. Treatment of waste water

The laboratory experiment was conducted to evaluate the effect of EM on sewage waste water treatment with 4 samples of EM and 1 untreated control..50 ml of activated EM is added to tank marked as rice water expired, jaggery expired, rice water compost and finally to jaggery compost. The effect of EM was assessed by changes in the pH, Dissolved oxygen(DO), Biological Oxygen Demand(BOD), Total Dissolved Solids(TDS),Salinity after incubation period in the EM treated sewage sample (APHA, 1989).The five water samples are placed in a safe place without the exposure of sunlight. Physical, chemical and microbial parameters is were checked every 5 days interval.

a. Measurement of Physical parameters

Smell: Smell occurring during fermentation were differentiated by two categories such as non-offensive smells (esters alcohol etc.) and offensive smells (ammonia, hydrogen sulfide, etc.) and measured based on sensual method.

Colour change and Appearance: Detected through visual observation.

b. Measurement of Chemical parameters

Temperature, pH, Salinity, Dissolved oxygen (DO),BOD. Conductivity and TDS (Total Dissolved Solids) is measured by using Systronics Water Analyzer 371.

c. Measurement of Biological parameters

Detection of coliforms and *E.coli:* It is analyzed using Multiple Tube Fermentation

Technique known as MPN.

RESULTS

Physical Parameters: The physical parameters of the five samples were shown in table 1.

Table 1: ***Results*** **of** ***physical parameters***

Sample	Zero Day	After 5 Days	After 10 Days	After 15 Days	After 20 Days
Control	Water with dissolved particles. Little brown colour. Unpleasant smell	No particular change in smell or colour.	Sediments starts to settle down Reduction in the smell	Colour is reducing Full settlement of sediments.	Water becomes clear No smell Sediments at the bottom.
Jaggery Compost	Yellow colour A sweet smell of jiggery is observed.	A white sheath like substance present on the surface. No particular change in smell and colour.	Becomes more turbid with the sediments settling down.	A punching, gas forming smell was observed. Sediments confined to bottom of the flask.	Lower sediments compared to others. The colour and smell remains same.
Jaggery Expired	Yellow colour A sweet smell of jaggery is observed.	A white sheath like substance present on the surface. No particular changes.	Less turbid with a gas forming smell.	Sediments start to settle at the bottom.	A fade in colour was observed Complete settlement of sediments.
Ricewater Compost	Light brown colour was obtained A pleasant smell.	No visible changes.	Sediments is relatively high The water sample light black colour.	Smell becomes punching and colour becomes light black.	Sediments are fully settled.
Ricewater Expired	Light brown colour was obtained a pleasant smell.	No particular changes.	Sediments start to settle at the bottom	Sediments is relatively high and turns The water sample light black colour.	Sediments are fully settled.

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Chemical Parameters

Effect of EM on pH and Dissolved oxygen content of Sewage water

Fig.1: ***Effect*** **of EM on pH and Dissolved oxygen content of Sewage water**

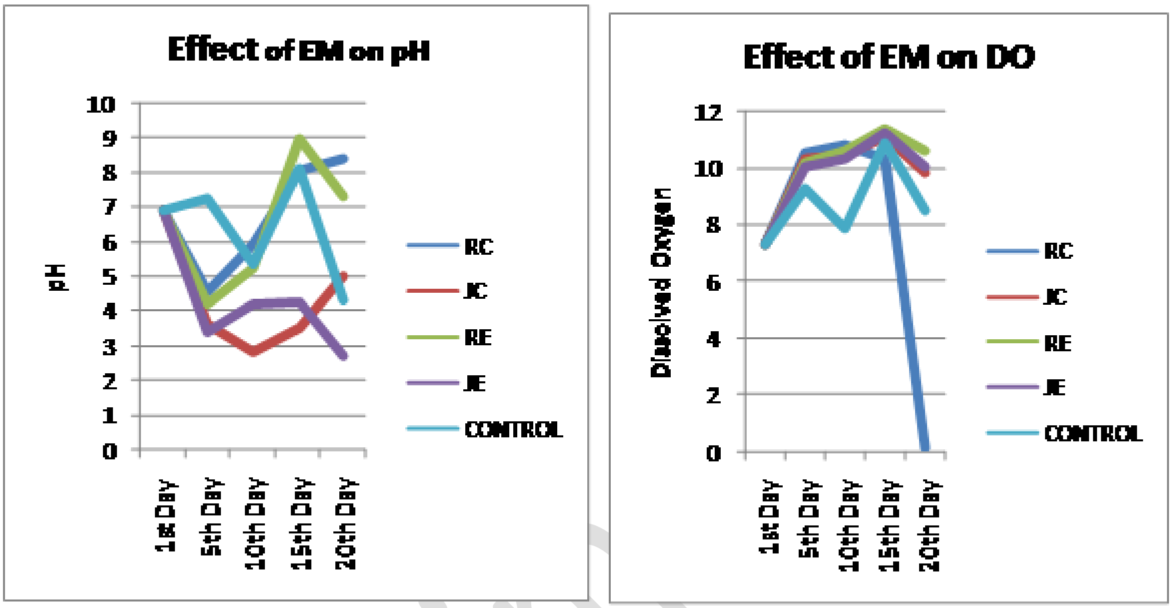
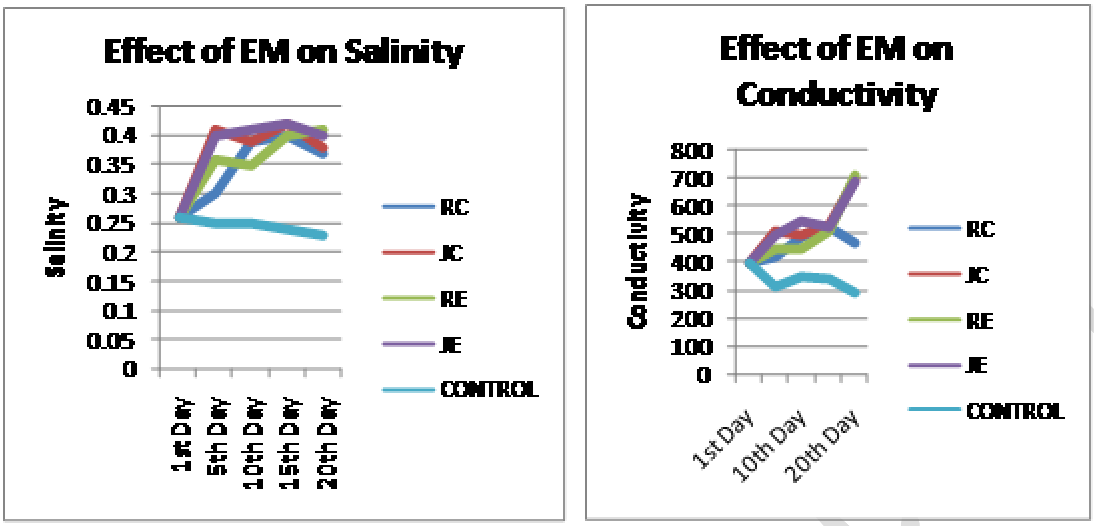


Figure 1 shows the comparison between the **pH** levels of the five water samples. pH levels were lowered on the 5th &10th day of EM activation. Following the 15th&20th day there was a slow rise in the pH. But coming to the 20th day the pH of the control becomes lowered compared to initial pH. From both the samples Jaggery Compost showed greater reduction in the pH compared to other 4 samples. Both Rice water Compost & Rice water Expired shows an increased pH values.

There is a rise in the **Dissolved Oxygen content** on 5,10&15th day of study.Natural levels of oxygen in aquatic systems are always somewhat depleted by normal levels of aerobic bacterial activity. In most cases, if dissolved oxygen concentrations drop below 5 parts per million (ppm), fish will be unable to live for very long. All clean water species such as trout or salmon will die well above this level and even low oxygen fish such as catfish and carp will be at risk below 5 ppm. (www.freshwater.com). All samples except Rice water activated compost showed an increase in DO (above 5 ppm).So Rice water compost is not good for treating sewage water and Jaggary is the best activator for sewage treatment.

Effect Of EM On Salinity And Conductivity Of Sewage Water

Fig.2:Effect Of EM On *Salinity* And Conductivity Of Sewage Water

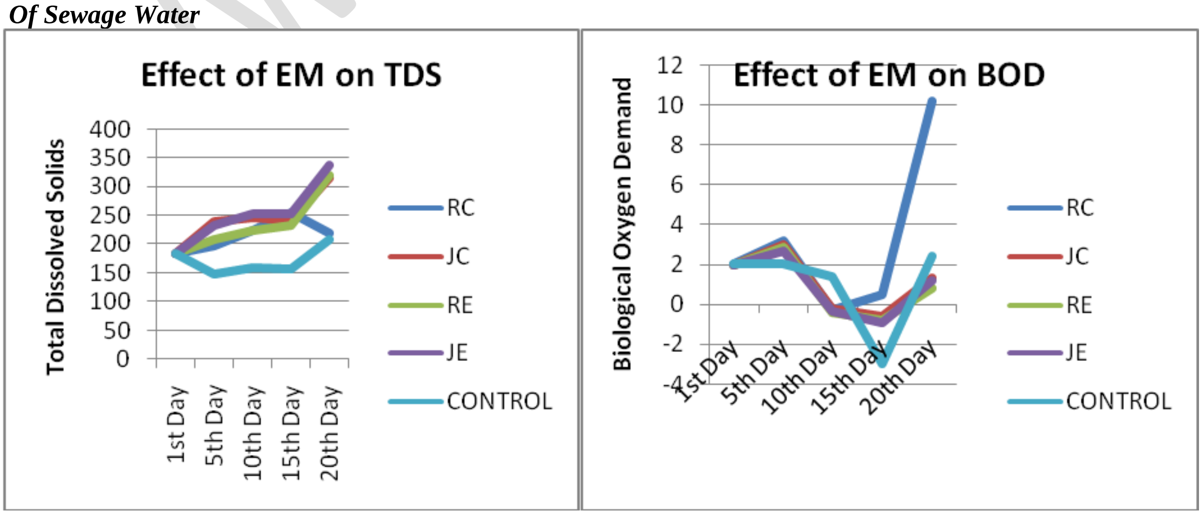


Similar to the previous parameter, there was an increase in the **salinity** of water sample on 5, 10&15th day of experimentation. An increase of salinity was shown in Jaggery Compost and Jaggery Expired compared to Rice water Compost and Rice water Expired. But the salinity of the control was decreased. All plants can best grow at salinity below 5ppt.So the treated water can be used for irrigation purposes.

Analysis of **conductivity** shows a gradual rise in all four water samples expect in control. Conductivity of control sample get reduced but there was a steady rise in the conductivity all other samples towards the final day of study. The most effective increase in the conductivity was shown by Jaggery Compost and Jaggery Expired. This may be due to reduction in total organic content (sludge) in the sewage water.

Effect of EM On Total Dissolved Solids (TDS) And Biological Oxygen Demand (BOD) Of Sewage Water

Fig.3: Effect Of EM On Total Dissolved Solids (TDS) And Biological Oxygen Demand (BOD) Of Sewage Water



There was a steep improvement in the values of Total dissolved Solids on the four experiment samples. All the four samples showed an increase in the TDS compared to control may be because of the rapid multiplication of EM in sewage water.

There was an increase in the Biological Oxygen Demand (BOD) on the 5th day of study in all samples except control.On15th day BOD of all samples except Rice water activated decreased below 1 mg/L. Most pristine rivers will have a 5-day carbonaceous BOD below 1 mg/L. Moderately polluted rivers may have a BOD value in the range of 2 to 8 mg/L. Municipal sewage that is efficiently treated by a three-stage process would have a value of about 20 mg/L or less (Clair N. Sawyer, Perry L. McCarty, Gene F. Parkin (2003).BOD of control sample was equal to moderately polluted river water.

Effect of EM on Number of coliforms Of Sewage Water.

Most Probable Number or MPN was analysed. From the table 2 it is very clear that Number of coliforms in control(sewage) was high (2.4x10^{6}cells/100ml)but with EM treatment there was significant reduction in coliforms on20th day of incubation for Jaggery activated EM(3x10^{2}cells/100ml).Rice water activated EM treated sewage and control(3x10^{4} cells/100ml) have the same number of coliform till 20thday.So Rice water is not a good activator of EM.

Table 2 :MPN/100ML of sewage water

Sample	5th Day	10th Day	15th Day	20th Day
Control	2.4x10^{6}cells/100ml	2.3x10^{6} cells/100ml	9x10^{4} cells/100ml	3x10^{4}cells/100ml
Jaggery Compost	9 x10^{4}cells/100ml	3x10^{2}cells/100ml	3x10^{2} cells/100ml	3x10^{2} cells/100ml
Jaggery Expired	4.3x10^{8}cells/100ml	3x10^{2} cells/100ml	3x10^{2} cells/100ml	3x10^{2}cells/100ml
Ricewater Compost	1.5x10^{10}cells/100ml	1.4x10^{10} cells/100ml	11x10^{6} cells/100ml	3x10^{4}cells/100ml
Ricewater Expired	4.3x10^{8}cells/100ml	2.1x10^{6} cells/100ml	9x10^{2}cells/100ml	3x10^{4} cells/100ml

DISCUSSION

The effects of EM on the pH and biological parameters are presented in Figure 1.Application of EM reduced the pH to near normal conditions from 6.91. Low pH explains that *Lactobacillus*, *Actinomycetes* etc., produce acid which make the sample acidic. BOD values of sewage water get reduced on treatment with EM shows the benefits of treating waste water with EM. But the Total Dissolved Solid content was increasing steadily in all four water samples. Szymanski, N and Patterson, R.A.(2003) supports a similar notion with respect to solids. Initial increase may have resulted from break down of organic matter within the septic tank, leading to an increase in entrained solids. Dissolved Oxygen concentration in the above study shows increases in all water samples thus confirming that EM can improve wastewater DO. In case of conductivity here, there is an increase in all samples except in control. When conductivity increases in water, turbidity decreases thus improving the water quality. Conductivity does not affect much on crops and soil microbial process. Salinity of water increases and when treated water is used in soil it can negatively affect plant growth and crop yield.

Namsivayam (2011) reported that there was a reduction of Alkalinity, Total dissolved solids Biological oxygen demand and chemical oxygen demand of domestic sewage under standard condition. But total hetrototropic bacterial and yeast population was increased. No change in fungal and actinomycetes population was recorded. The result of the experiment shows that the EM has the potential to improve the effectiveness of treatment of domestic wastes. There was 99.98 % reduction in the number of coliforms(Control-$2.4x10^6$cells/100ml to Jaggery Compost-$3x10^2$ cells/100ml)in treated waste water.

EM activated with Jaggery produces a pleasant smell during the time of treatment. There was no foul smell during the period of treatment. Bassam .H. Mashat in his work on Municipal Solid Waste (MSW) of Makah city discovered that by using effective microorganisms (EM), which results in a higher decomposition of organic matter and no odour during process. Therefore from initial findings, utilization of EM technology is highly recommended to solve same environmental pollution which facing Makah City such as municipal solid waste, odour emissions from garbage trucks and trash compressions.

CONCLUSION

This experiment was undertaken to determine the application of Effective Microorganisms (EM) would decrease the volumes of sewage sludge produced and the analysis of physical, chemical and biological parameters. There was no appreciable reduction in the suspended solid content of the water samples. It was observed that the following application of EM, there was a decreasing trend in pH with an increase in Dissolved Oxygen and Conductivity. But there was a considerable increase in the Salinity, and Total Dissolved Solids. EM has the potential to improve the effectiveness of treatment of domestic wastes. There was 99.98 % reduction in the number of coliforms(Control-$2.4x10^6$cells/100ml to Jaggery Compost-$3x10^2$ cells/100ml)in treated waste water.

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