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Assessing the pollution reduction potential of organically formulated Effective Microorganisms (EM) in sewage water

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ABSTRACT

The biological treatment process has always been a significant part in wastewater treatment. The biological treatment utilizes the metabolic activity of the microorganisms in reducing the pollution load in the wastewater. In this context the effective microbial (EM) formulation gaining momentum nowadays because it is an eco-friendly sustainable technology. In this study, the EM formulation has been formulated totally using organic materials for the onsite wastewater treatment like sewers and septic tanks in a cost-effective manner. A lab scale experiment was also done to prove the effectiveness of the traditionally prepared EM applied to sewage water in different dosage (1 to 3%) and at different time intervals of 2, 4 and 6 days. The results showed that a significant decrease in the various parameters *viz.*, pH, EC, TDS, TSS, BOD and COD. The maximum reduction of BOD (82%) and COD (81%) was obtained in the sewage water inoculated with 3% dosage of EM for a incubation period of 6 days. The functional groups in EM which responsible for pollution reduction were also characterised using FTIR analysis.

Key words : *Effective Microorganisms, Sewage water, Pollution reduction, Functional groups*

Introduction

With unpredicted and rapid urbanisation in India increased the generation of sewage water tremendously. The maintenance and monitoring of sewage water treatment plants (STPs) becomes harder in the present scenario because of various reasons like energy consumption, technical competence, operational cost and unavailability of workforce. In a recent report of central pollution control board (CPCB) the total wastewater generation per annum in Class I cities and Class II towns in India is about 35,558 and 2,696 MLD respectively. Also, the existing sewage treatment capacity corresponding to the wastewater generation is only 11,553 and 233 MLD, resulting in a sewage treatment capacity deficit of 26,468 MLD (Kaur, 2012). One of the most significant issues with sewage water treatment systems is that none of the existing solutions provide a direct economic benefit. The urban local bodies are also not giving significant importance in sewage water treatment due to the lack of financial support. According to a performance review of STPs conducted by the CPCB in selected cities, out of 92 STPs evaluated 26 STPs failed to meet required BOD limits, rendering these waters unfit for further usage (Trivedy and Nakate, 2001).

The adoption of new technologies in treating the sewage water is the only hope to mitigate the lacunas in sewage treatment units on economic basis. The biological mode of sewage water treatment is considered to be the promising and profitable over the other treatment methods. Biological treatment of sewage water plays the vital role to attain the low energy level of input to output ratio by gaining the nutrient rich sludge with complete reduction of organic matter. So, there is a mandatory need in the improvisation of secondary stage of sewage water treatment units with advanced biological process to meet up the narrowed effluent discharge standards. This makes the whole system exceptionally complex and costly with enlarged footprint which is the challenging criteria in treating sewage water (Zhang *et al.,* 2019).

One such biological method is using the Effective Microorganisms (EM) for treating the sewage water in an efficient way to meet permissible limits in a cost-effective manner. EM is the microbial decoction of collective beneficial microorganisms with compatible nature synthesised naturally. The secretion of productive compounds in EM during the period of fermentation encourages the positive interaction in a synergistic pattern on its application to the environment. The existence of facultative anaerobes in an increasing rate throughout the fermentation process of EM formulation assist in the complete destruction of organic matter leaving very little residual sludge (Freitag and Meihoefer, 2000). Developing effective microbial formulation technology helps to recover, reinforce and sustain our ecosystem. This technology promotes the rehabilitation of polluted water bodies by restoring the quality of the water. Besides, treating the sewage water EM has the potential in promoting the plant growth and solid waste management in an eco-friendly manner. The prime objective of this study is to formulate the organic EM decoction traditionally using fruit wastes and organic materials with motive of onsite sewage water treatment in a cost-effective manner.

Materials and Methods

Formulation of EM

The fully ripened banana, pumpkin and papaya of 4 kg each were taken along with the organic materials like two numbers of tender coconut, 4 L of fermented rice water, 4 L curd, 4 kg of jaggery, handful of fertile garden soil and cow dung were taken as inputs for preparing the EM decoction. The fruits were finely chopped and were blended together with the other inputs mentioned to formulate the EM. The mixture was added with 10 L of non-chlorinated water, kept in air tight container and allowed for fermentation. The EM was aerated twice in a day by mixing it in clockwise and anticlockwise pattern. After the fifteen days of fermentation the microbial growth was observed by production of fruity odour and formation of a microbial mat (Plate 1). Further the EM formulation was filtered and stored in the refrigerated condition at -4^{0}C to maintain the microbes in dormant state for the future use.

Plate 1. Fermented EM

Activation of EM Formulation

The EM was activated by the addition of 30% autoclaved jaggery solution prepared using non-chlorinated water as a carbon source. The activated EM was again incubated at room temperature for seven days to increase the microbial population

Characterisation of EM Formulation

The Fourier-Transform Infrared Spectroscopy is used to identify the functional groups in the formulated EM. The peaks formed for the EM formulation were observed in the range from 600 cm^{-1} to 3600 cm^{-1} of wavenumbers against the % transmittance. The peak ranges for different functional groups in EM were examined and compared from the library in KnowItAll informatics system 2021, spectroscopy edition software USA.

Collection and analysis of Sewage water

The sewage water was collected from sewage Treatment Plant of Tamil Nadu Agricultural University for conducting the lab scale experiment. The sewage water was characterised for the following parameters *viz.*, pH, Electronic conductivity (EC), Total dissolved solids (TDS), Total suspended solids (TSS), Biological oxygen demand (BOD) and Chemical Oxygen demand (COD) with standard protocol of APHA (1985) within two hours of collection.

Lab scale experiment on sewage water treatment using EM

To assess the pollution reduction potential of the formulated EM a lab experiment was conducted with different concentration of EM formulation applied to the sewage water. The characteristics of sewage water was analysed at periodical interval of 0th, 2nd, 4th and 6th day.

Treatment details

T1 - Control (Sewage water); T2 - Sewage water + 1 % EM; T3 - Sewage water + 1.5 % EM; T4 - Sewage water + 2 % EM; T5 - Sewage water + 2.5 % EM; T6 - Sewage water + 3 % EM

Statistical Analysis

The data obtained for pH, EC, TDS, TSS, BOD and COD during the investigation were statistically analysed by the method given by Gomez and Gomez (1985). The laboratory study was analysed using Completely Randomized Design and the critical difference was worked out at 5 per cent (0.05) probability levels.

Results and Discussion

Characterization of sewage water

The initial parameters of the sewage water sample was analysed and the results were presented in the Table 1.

Parameters	Values
pH	7.84
EC (dsm^{-1})	1.18
TSS mgL^{-1}	542.7
TDS mgL^{-1}	2142
BOD mgL^{-1}	389.2
COD mgL^{-1}	650.5

Effect of EM on pH and EC

The results from the lab scale experiment revealed that the reduction in the pH was observed from 7.80 to 7.02 was presented in the Fig. 1a. The application of different concentration of EM significantly reduced the pH of the sewage water in all the treatments. The maximum reduction of 7.02 was observed in the treatment when sewage water applied with 3 % EM on 6th day of incubation than the control (7.78). This result was in line with the Lananan *et al.*, (2014) the reduction of pH in wastewater was guar anteed when treated biologically since the growth of microorganisms favour neutral condition. Similar results were shown by Okuda and Higa (1999) that the switching of balanced pH was observed in wastewater when treated with EM formulation.

Similarly, the reduction in salt content was proved with the drop in electrical conductivity in EM treated sewage water (Fig 1b) with 57% reduction over the control 8.5%. There was a significant reduction in the EC was observed on the application of EM. The highest reduction of EC (0.49 dS m^{-1}) was recorded in the treatment (T6) at the interval of sixth day applied with 3 % EM than control (1.08 dS m^{-1}). This study corroborates with results of Lavanya and

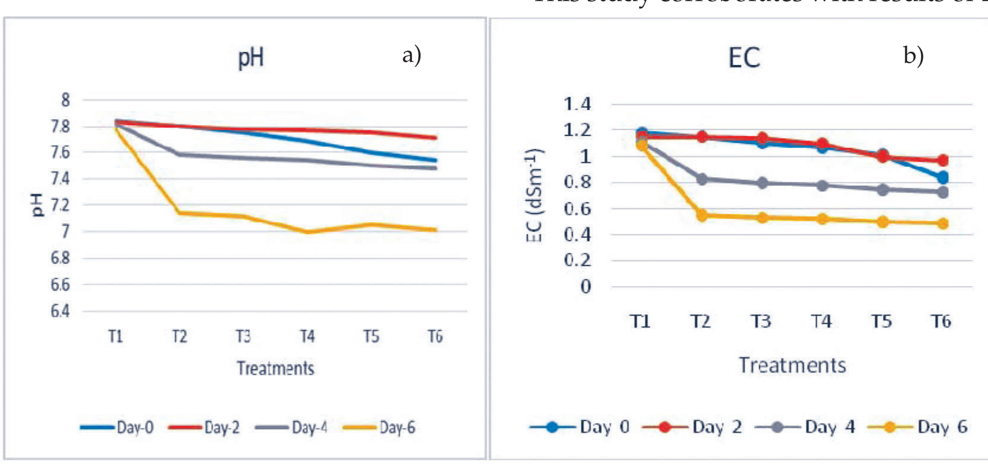


Fig. 1. Effect of EM formulation on a) pH and b) EC in sewage water

Kannan (2019), there is a positive correlation of EC and TDS towards the reduction of soluble salts after treating with EM. The level of reduction in pH and EC clearly shows that the suitability of the sewage water for inland surface irrigation when treated with the developed EM formulation.

Effect of EM on TDS and TSS

The TDS and TSS in the sewage water ranges from 2142 mg l^{-1} to 1902 mg l^{-1} and from 542.7 mg l^{-1} to 421.2 mg l^{-1} respectively. There was a constructive decrease of TDS (Fig. 2a) and TSS (Fig. 2b) were recorded in the EM applied sewage water samples than T1 (2142 mg l^{-1} to 1998 mg l^{-1} and 542.7 mg l^{-1} to 495.3 mg l^{-1}) on the sixth day. The reduction in TDS and TSS depicts the removal of solids in sewage water. The EM formulation in sewage water treatment corresponds to paired benefit of depletion in TDS and TSS along with the reduction of sludge (Plate 2) observed at higer concentration of 3% (1902 mg l^{-1} and 421.2 mg l^{-1}). The reduction in the sludge on the 6th day of treatment with EM than 2nd day proves the breakdown of the organic matter in the sewage water may be due to the metabolic activity of microbial population in the developed EM formulation. The same results had been obtained by Lananan *et al*. (2014) that the removal of sludge in EM treated wastewater that found suitable in onsite wastewater treatment like septic tanks. The lower level of TDS after EM treatment in wastewater was may be due to the oxidation of organic matter (Kannan and Kumar, 2012). The TDS and TSS were the important parameters that prevents inland surface irrigation of sewage water which leads to destruction of aquatic habitats so ruling over the reduction of these two parameters were significant to depict the effectiveness of formulated EM in wastewater treatment.

Plate 2. EM Treated Sewage at consecutive intervals

Effect of EM on BOD and COD

There was significant decrease in BOD and COD were achieved (Fig. 3) on application of develpoed EM formulation. The highest reduction in BOD (389.2 mg l^{-1} to 59.7 mg l^{-1}) and COD (650.5 mg l^{-1} to 170.1 mg l^{-1}) was observed in sewage water applied with 3 % EM on 6th day of treatment.

The lowest reduction of BOD (389.2 mg l^{-1} to 340.2 mg l^{-1}) and COD (650.5 mg l^{-1} to 570.2 mg l^{-1}) was observed in T1. The BOD and COD reduction of 82% and 81% in EM treated sewage water at 3% dose was seen respectively at the 6th day of treatment when compared to the control. This results proved that sewage water treated with developed EM when discharged in the aquatic ecosystem will have no negative impact. The fermentation process results in the evolution of bacterial succession that promotes the breakdown of complex organic matter to simpler one (Kantachote *et al*., 2009), this may favour the reduction of BOD and COD by using the developed

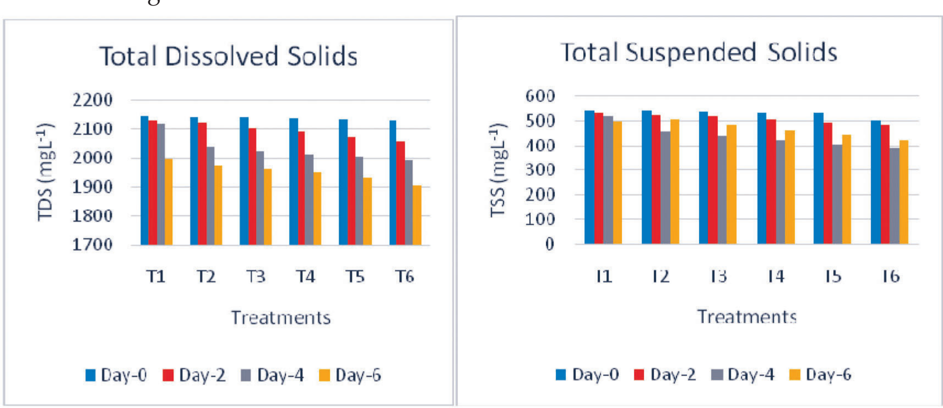
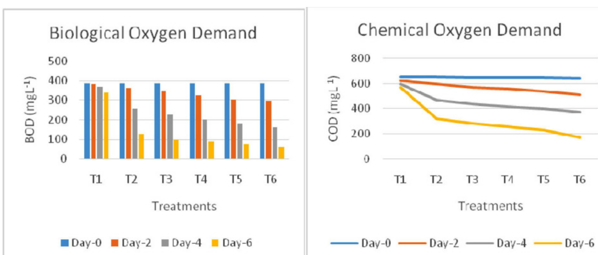


Fig. 2. Effect of EM formulation on a) TDS and b) TSS in wastewater

Table 2. Report of Infrared Spectral Characterization on EM Formulation

Classification	Group	Bond	Range	Intensity	Mode	Notes
Ketones	C-(C=O)-C=C-OH	C=O	1640-1540	Strong	Stretching	Beta diketones (enolic)
Ketones	C-(C=O)-Ph-βOH	C=O	1655-1635	Strong	Stretching	Beta-hydroxy aryl ketone
Ketones	R-(C=O)-C=C-NH_2	C=O	1640-1540	Strong	Stretching	a b unsaturated beta amino
Ketones	C-(C=O)-Ph-βNH_2	C=O	1655-1635	Strong	Stretching	Beta-amino aryl ketone
Ketones	Naphthoquinones	C=O	1655-1635	Strong	Stretching	Fused ring
Amides	R-CO-NR_2	C=O	1670-1630	Strong	Stretching	Tertiary amide
Guanidines	RNH-(C=NH)-NHR	C=N	1680-1550	Strong	Stretching	Structureshows one possible resonance form
Nitriles	C-N=C	C=N	1650-1550	Strong	Stretching	Isonitriles
Azines	RCH=N-N=CHR	C=N	1680-1600	Medium-strong	Stretching	C=N
Hydrazones	CH=N-NH_2	C=N	1680-1580	Medium-stron	Stretching	C=N



a) b)

Fig. 3. Effect of EM formulation on a) BOD and b) COD in sewage water

EM in sewage treatment. *E.coli* which is the common indicator to evaluate the water quality found to be suppressed after the treatment with EM formulation adding to that its application notably reduced BOD, TDS, acidity, alkalinity and total hardness by 40% over the inflow effluent (Kannan and Kumar, 2012). There was sturdy reducing trend in BOD and COD with formulated EM application to wastewater at 3% dose on 3^{rd} day after treatment (Monica *et al.*, 2011).

Identification of functional Groups in the developed EM Formulation

The FTIR spectra of EM formulation were given in Fig. 4. The presence of naphthoquinone group with C=O bond at the wavelength range of 1655-1635 cm^{-1} known to has its role as scavenger of superoxide radicals (Patel *et al.*, 2007) which may benefit in the oxidation and breakdown of organic matter in wastewater treatment. The antibacterial activity was noticed with lapachol which is a natural naphthoquinone indicating the removal of pathogens in wastewater treatment (Fernandes *et al.*, 2017). Qian *et al.*, (2011) reported that presence of guanidine activates the antibacterial activity against the *E. coli*. The presence of hydrazones also aids in the antibacterial activity ultimately it shows the presence of beneficial organisms eliminating the pathogens Table 2. (Noshiranzadeh *et al.*, 2017).

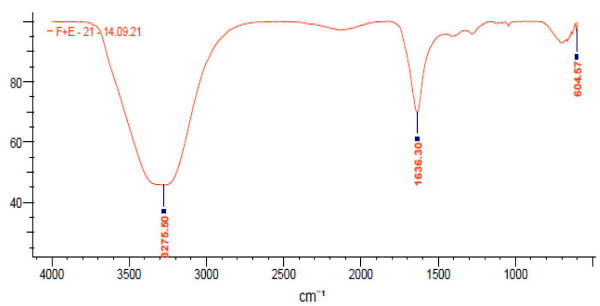


Fig. 4. Fourier transform infrared spectra absorbance of EM formulation

Conclusion

The application of EM developed using fruit waste and other organic materials in sewage water treatment proves to be effective in significant reduction of the pollution load and also meeting the desired standards of sewage water in an economical way for in land irrigation. It minimalizes the need for more complexed structure of sewage water treatment unit. The EM treated sewage water can be utilised effectively after the tertiary treatment of chlorination to meet out the water scarcity in agriculture. Hence usage of EM in sewage water treatment paves a way for sustainable management of sewage water treatment plants.

EM Effective Microorganisms
BOD Biological Oxygen Demand
COD Chemical Oxygen Demand
TSS Total Suspended Solids
EC Electrical Conductivity
TDS Total Dissolved Solids
FTIR Fourier-Transform Infrared Spectroscopy
CPCB Centre Pollution Control Board
STP Sewage Treatment Plant

References

APHA, 1985. *Standard Methods for the Examination of Water and Wastewater,* 16th edition. American Public Health Association, Washington, D.C. Chatterjee, P., Ghangrekar, M.M. and Rao, S., 2016. Low efficiency of sewage treatment plants due to unskilled operations in India. *Environmental Chemistry Letters*. 14(3) : 407-416.

Fernandes, A.W.C., dos Anjos Santos, V.L., Araujo, C.R.M., da Cruz Araujo, E.C., de Oliveira, H.P. and da Costa, M.M. 2017. Antimicrobial activity and FTIR characterization of lapachol derivatives against *Staphylococcus aureus*. *African Journal of Microbiology Research*. 11(22) : 915-919.

Freitag, D.G. and Meihoefer, H. 2000. The use of Effective Microorganisms (EM) in organic waste management. *Sustainable Community Development, L.L.C.,* 811 Cherry St, Ste 302 Columbia, MO 65201 573/441-0151

Kannan, D. and Kumar, S.V. 2012. Effective microorganisms used in domestic effluent treatment system. *Proceeding of the BALWOIS*. 28.

Kantachote, D., Kowpong, K., Charernjiratrakul, W. and Pengnoo, A. 2009. Microbial succession in a fermenting of wild forest noni (Morinda coreia Ham) fruit plus molasses and its role in producing a liquid fertilizer. *Electronic Journal of Biotechnology*. 12(3) : 9-10.

Kaur, R., Wani, S.P., Singh, A.K. and Lal, K., 2012, May. Wastewater production, treatment and use in India. In; *National Report presented at the 2nd regional workshop on Safe Use of Wastewater in Agriculture* (pp. 1-13).

Lananan, F., Hamid, S.H.A., Din, W.N.S., Khatoon, H., Jusoh, A. and Endut, A. 2014. Symbiotic bioremediation of aquaculture wastewater in reducing ammonia and phosphorus utilizing Effective Microorganism (EM-1) and microalgae (*Chlorella* sp.). *International Biodeterioration& Biodegradation*. 95: 127-134.

Lavanya, V. and Kannan, D.P. 2019. Research Article Grey Water Treatment Using Effective Micro-organisms and its Impact on Water Qualities. *Journal of Applied Sciences.* 19 : 188-198.

Monica, S., Karthik, L., Mythili, S. and Sathiavelu, A. 2011. Formulation of effective microbial consortia and its application for sewage treatment. *J Microbial Biochem Technol*. 3 : 051-055. nature farming and effective microorganisms for agricultural and environmental sustainability.

Patel, K.C., Patel, M.A., Chauhan, K., Anto, H. and Trivedi, U. 2007. Production of an antioxidant naphthoquinone pigment by Comamon as testosteroni during growth on naphthalene.

Qian, L., Xiao, H., Zhao, G. and He, B. 2011. Synthesis of modified guanidine-based polymers and their antimicrobial activities revealed by AFM and CLSM. *ACS Applied Materials & Interfaces*. 3(6): 1895-1901.

Trivedy, R.K. and Nakate, S.S. 2001. Treatment of hospital waste and sewage in hyacinth ponds. *Low Cost Wastewater Treatment Technologies. ABD, Jaipur, India*. 132-163.

Zakaria, Z., Gairola, S. and Shariff, N. M. 2010. Effective microorganisms (EM) technology for water quality restoration and potential for sustainable water resources and management. *International Conference on Environment Modelling and Software*: 142.

Zhang, X., Zhang, M., Liu, H., Gu, J. and Liu, Y. 2019. Environmental sustainability: a pressing challenge to biological sewage treatment processes. *Current Opinion in Environmental Science & Health*. 12 : 1-5.