ROLE OF EFFECTIVE MICROORGANISMS ON THE REDUCTION OF COLIFORM IN THE UPFLOW ANAEROBIC SLUDGE BLANKET REACTOR TREATING DOMESTIC WASTEWATER UNDER TROPICAL CONDITIONS

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ABSTRACT

The present study examined the role of Effective Microorganisms (EM) on reduction of coliform bacteria in Upflow Anaerobic Sludge Blanket (UASB) reactor under tropical conditions. Two laboratory scale UASB reactors, each having 4 liters effective volume were operated at HRT of about 6h for consecutive thirty-five days with an average temperature of 25.7±2.6°C.

The reactor were seeded with about 1.5L of well adapted mesophilic granular sludge from existing and operating domestic scale UASB reactor to facilitate the start up processes. Activated EM was added at ratio 1:1000 every six hours in one reactor abbreviated as UASB-EM reactor while the other reactor was operated as control without addition of EM and abbreviated as UASB-Control.

The average percentage removal of total and feacal coliform in UASB –EM reactor were 93±6 and 96±4 respectively compared to control UASB of 83±6 and 85±5. Others parameters like COD and SS also showed higher percentage removal in UASB-EM reactor. EM revealed marvelous ability to enhance removal of coliform bacteria along with COD and SS and thus appears to be potential in improving performance of the UASB reactor during the treatment of domestic wastewaters.

Improvement of the UASB effluent quality is of great importance as it may cutoff the necessity of post treatment and thus minimizes costs and operation time. However further research is needed to understand the removal mechanisms and the behavior of the UASB-EM during hydraulic and organic shock loads which is natural phenomena in the fully scale applications.

KEYWORDS: UASB, Total Coliform, Feacal Coliform, Effective Microorganisms, EM.

1. INTRODUCTION

Upflow Anaerobic Sludge Blanket (UASB) reactors are used successfully for treating several types of wastewaters including domestic wastewaters. Due to its robustness in terms of initial and operation costs, simplicity in design and better performance, UASB reactors offer great promise in developing countries (Aiyuk et al., 2004, and Mgana, 2003). The reactor retains a high amount of biomass in the forms of dense granules or aggregates of microorganisms that play very important role on bio-conversion of organic material in the reactor under anaerobic conditions. Furthermore, good contact between biomass and wastewater is ensured due to mixing as result of recirculation and biogas production (Aiyuk, et al., 2004). This tendency extends the organic load of the reactor along with minimization of the hydraulic retention time thus minimize the need of large space for its construction. However, effluents from UASB reactor can rarely comply with stringent emission standards (Verstraete and Vandevivere, 1999) and hence generally requires post treatment to remove of residual COD, nutrients and pathogens (Uemura et al., 2000). Several options have been applied as post treatment of the UASB's effluent such as activated sludge system, constructed wetland systems, sand filters etc resulting into addition costs and sometimes they also fail to produce the final effluent that meet the disposal standards.

The recent technology of Effective Microorganisms (EM) discovered by Professor Higa from University of the Ryukyus based in Okinawa Japan in early 80's seems to provide significance contribution in wastewater treatment systems. EM technology was primarily focused on improving productivity in agriculture but then came to prove to have important role to play in wastewater treatment processes. EM itself is a consortia of microbes mainly photosynthetic bacteria (*Rhodopseudomonas spp.)*, lactic acid bacteria (*Lactobacillus spp.)* and yeast *(Saccharomyces spp.)* co-exist symbiotically with incredible ability to carry out several enzymatic and biochemical reaction which bring benefits to the ecosystem (Higa, 1995). There has been major success on application of EM in septic tank systems, lagoons, and activated sludge systems, reducing BOD, suspended solids (SS), sewage odor, coliform bacteria, and etc (Shanka, 2002).

Improving performance of the UASB reactor in terms of coliform and nutrients reduction by inoculating EM within the reactor is an inspiring endeavor to produce better quality effluent that can be directly disposed into receiving water bodies. When the effluent from the UASB reactor is improved to meet the disposal standards along with its endowed advantages of biogas production then it would appear superb anaerobic wastewater treatment system applicable both in developed and developing countries.

Therefore, laboratory scale UASB reactors have been used to ascertain the role of EM in reducing coliform bacteria during the treatment of domestic wastewaters under tropical conditions. EM was injected in the reactors intermittently at different dosage through different operational conditions followed by interval sampling and analysis of several parameters. Generally, the UASB reactor with EM elicited fabulous performance by manifesting relatively higher percentage removal of coliform bacteria probably due to competition exclusion mechanisms established by EM against coliform.

Nomenclature

AEM	activated EM
EM	effective microorganisms
COD	chemical oxygen demand, mg/L
FC	feacal coliform, cells/100mL
HRT	hydraulic retention time, h
SVI	sludge volume index, mL/g
TC	total coliform, cells/100mL
TDS	total dissolved solids, mg/L
TS	total solids, g/L
TSS	total suspended solids, mg/L

2. MATERIALS AND METHODS

2.1 Experimental set-up and experimentation planning

The study was carried out using two laboratory scale UASB reactors fed with partial pretreated domestic wastewater. The reactors were made using PVC pipe with working volume of 4L, a height of 1.0m and six lateral ports for sample collection. They had a modified gas-solid-liquid separator as shown in Fig. 2.1. Each reactor was seeded with well adapted mesophilic granular sludge from existing and operating domestic scale UASB reactor to facilitate the start up processes. Total of 16ml of Activated EM (AEM) was added in one reactor every after 24h, 4ml every 6h for consecutive 35 days making the ratio of AEM to wastewater to be 1:1000. The reactor added with EM was abbreviated as UASB-EM and the other reactor abbreviated as control. The sewage flowed from elevated 20L plastic bucket at the rate of about 0.67L per hour to maintain the retention time of 6h in the reactor.

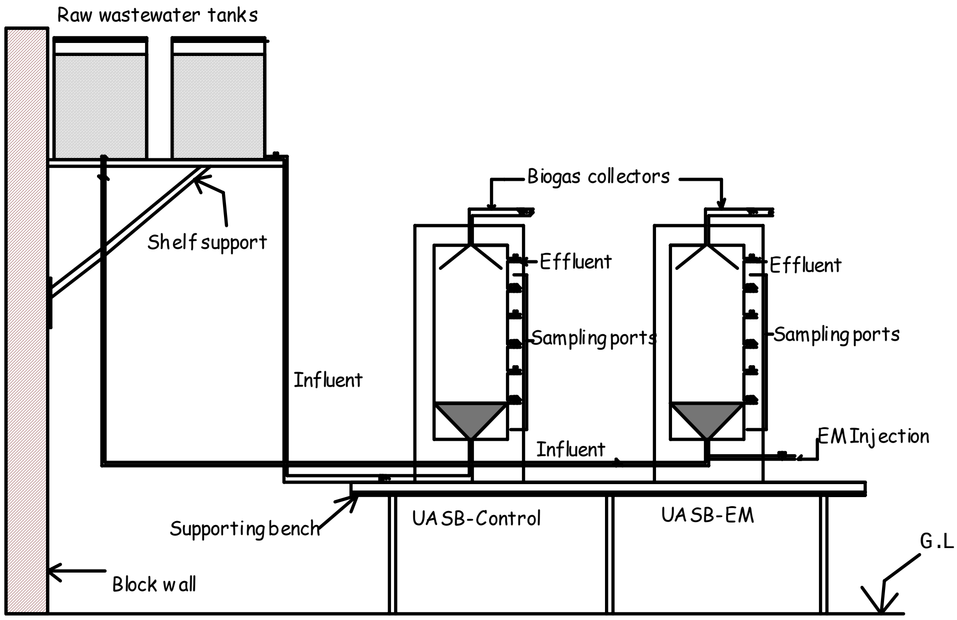

Figure 2.1. Schematic diagram of experimental set-up

2.2.2 Preparation, characterization and dosage of EM

The stock solution of EM was activated by ratio of 1:1:18 (EM: Molasses: Water) as to make 20 liters of activated EM after incubation of seven days as recommended by Higa, 1995. The incubation was kept using non-chlorinated water in a plastic container which was thereafter closed tightly to create complete anaerobic environment. After seven days the pH of the incubated EM (activated EM) was measured to ensure that it is below 4.0 to confirm its suitability. The EM characterization was done by measuring its pH, COD, TDS, TSS, TS, and Electrical conductivity. The dosing of EM in the reactor was done intermittently as stated above. The characteristics of both EM and activated EM is shown in Table 2.1

2.2.3 Seed sludge characterization

The seed sludge was obtained from existing domestic scale UASB reactor harboured in mesophilic conditions. 1.5L of granular seed sludge was poured in UASB-EM reactor and allowed to settle for some time before the wastewater was allowed to flow in it. The characteristic of the granular seed sludge is presented in Table 2.2.

Table 2.1. Characteristics of EM and AEM

Parameter	Units	EM	AEM
pH		3.8	3.75
TDS	g/l	3.83	3.72
Salinity	‰	3.8	4.1
Temperature	oC	27.6	27.9
TS	g/l	20.46	19.64
TSS	g/l	16.63	15.92
COD	mg/l	8710	8010
TC	cells/100mL	0	0
FC	cells/100mL	0	0

Table 2.2. Characteristics of mesophilic seed sludge from existing UASB reactor

Parameter	Unit	Value
pH		7.6
TDS	mg/l	1230
Salinity	‰	1.2
Temperature	°C	25.8
TS	mg/l	56606
TSS	mg/l	55302
SVI	ml/g	39.23

2.2.4 Laboratory analysis

Wastewater samples taken from UASB reactors were analyzed for TC and FC along with other physico-chemical parameters such pH, TDS, TS, and TSS. The same parameters were applied to measure the quality of EM and seed sludge along with SVI. Analyses were done as illustrated by “Standard Methods for the Examination of Water and Wastewater” (APHA, 1995) with minor modification. TC and FC were measured by Membrane Filtration method whereby 100mL samples were filtered using 0.45µm membrane filters. Each filtrate was cultured in petri-dish with M Endo broth and MFC broth culture media for TC and FC and then incubated at 37±0.5°C and 44±0.5°C for 24h respectively.

2.2.5 Calculation and statistics analysis

To evaluate performance of each reactor (UASB-control and UASB-EM), removal efficiencies were computed on the basis of the concentrations. The concentration-based efficiency, E_c, was computed according to Eq (1) below.

$$E_c = \frac{C_i - C_e}{C_i} \times 100\% \qquad (1)$$

Where C is concentration (cells/100mL), and subscripts i and e represent influent and effluent, respectively.

Statistical analysis of the data to evaluate performance differences among the two reactors was done using the two-sample *t*-test and analysis of variance (ANOVA). Performance differences were deemed to be significant if $p < 0.05$.

3. RESULTS

3.1 TC and FC

Both TC and FC were removed better in UASB-EM reactor as shown in Fig. 3.1 and Fig. 3.2. The average percentage removal in UASB-EM reactor was 93±6 and 96±4 for TC and FC respectively compared to 83±6 and 85±5 of the UASB control. The better performance of the UASB reactor inoculated with EM is evidence that EM played important role by suppressing coliform bacteria. One of the possible mechanism of which microbes in EM consortia can provide is competition exclusion in the reactor which limit availability of food for coliform and other non-beneficial microbes.

The action of EM to prevent coliform to multiply further was shown within 24h in the reactor though it was stabilized after about 5 days when the EM fully acclimatized the environment in the reactor. There is also a possibility that coliform bacteria are reduced through the general mechanism of EM to enhance the solid-liquid separation due to its power of antioxidation (Higa & Chinen, 1998). Okuda and Higa, 1999 reported significant reduction of COD and BOD from the Gushikawa Library wastewater when treated with EM. Likewise, the unpublished study conducted in Naha City, Okinawa Japan elucidated 85% removal of coliform after application of EM (1:1000) in the wastewater system.

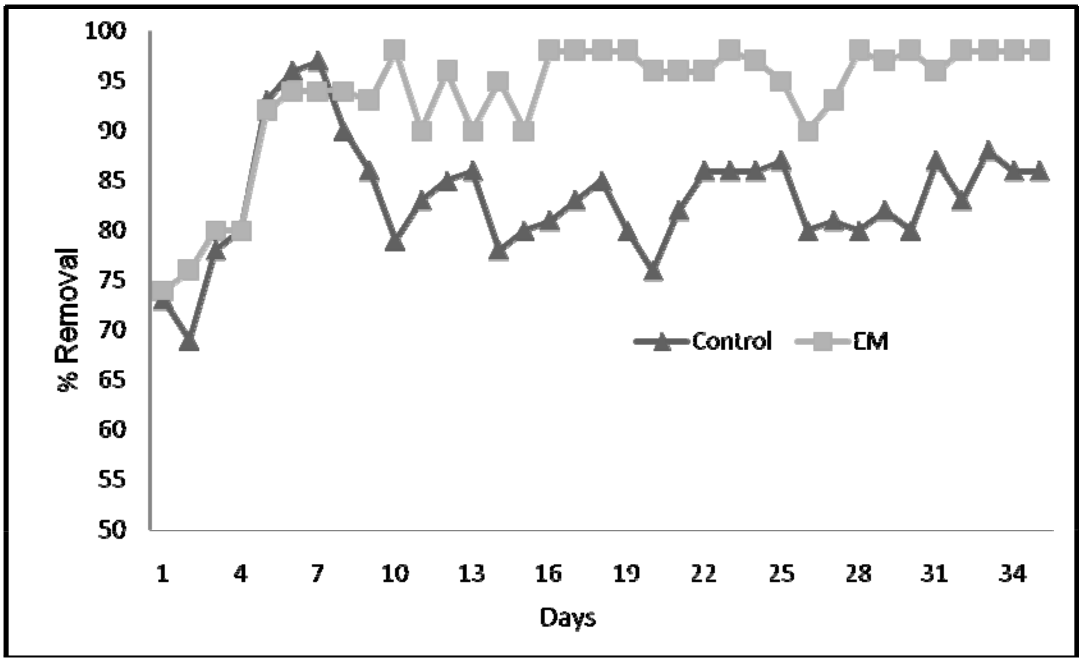

Figure 3.1. Percentage removal of Total Coliform bacteria in UASB-Control and UASB-EM reactor

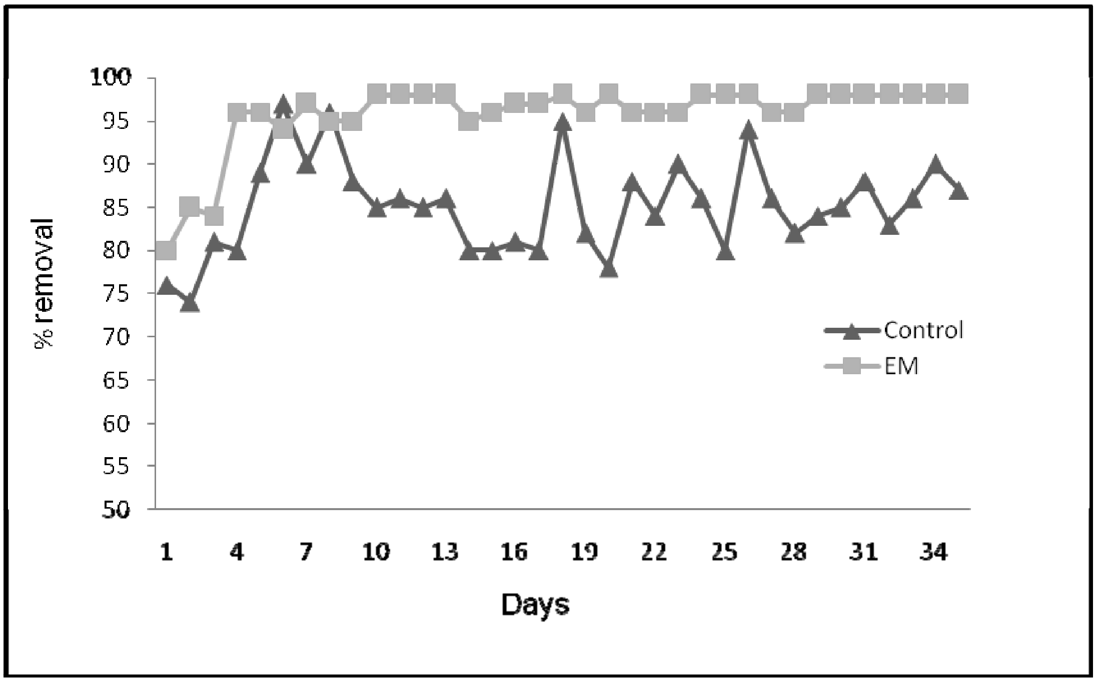

Figure 3.2. Percentage removal of Feacal Coliform bacteria in UASB control and EM reactor.

4. CONCLUSION

EM has shown a great power to reduce coliform in UASB reactor under tropical conditions. This is an indication that EM can be used to enhance performance of the UASB reactor in order to produce better quality effluent that can be discharged into receiving water bodies without tertiary treatment. Other unpublished studies have confirmed that EM when added in the UASB reactor can increase COD and TSS along with increasing biogas production. EM as probiotic tends to produce bioactive substance and secreting various enzymes that take part during hydrolysis of organic material and catalyzing subsequent anaerobic bioconversion which result into efficient removal of COD and increasing biogas production.

However, further studies are needed to understand better the mechanisms of EM in anaerobic wastewater treatment system. When adequate information is collected about the processes and mechanisms of EM in the UASB reactor, more efficient and optimum dosage of EM can be easily recommended.

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