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Decontaminating roles of Effective Microorganisms (EM) on Hospital Wastewater: A Case of Myung Sung Christian Medical Center and Bethel Teaching General Hospital, Addis Ababa, Ethiopia

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Abstract
The aim of this study was to evaluate the treatment performance of Effective Microorganisms (EM) for treatment of hospital wastewater in Bethel Teaching General Hospital (BTGH) and Myung Sung Christian Medical center (MCM). The EM solution was applied in Anaerobic Baffled Reactors (ABRs) and Anaerobic Digester (AD) based on the average quantity of raw wastewater influent. The result revealed that pollutants removal efficiencies of the two hospitals WWTP were in the same range for turbidity (23%-28%), TDS (23%-27%) and FC (41%-48%). The ABRs showed a higher achievement for COD (66.40%) and BOD5 (75.90%) while, AD showed higher TC removal (94%) with a lower COD (58.75%) and BOD5 (40%) removal efficiencies. After addition of EM in BTGH wastewater, the ABRs showed 3% boost in turbidity removal efficiency with no statistically significant difference (p = 0.246), the NH3-N removal efficiency of ABRs was 5% (without EM) and 1% (with EM) reveled to no significant difference removal (p>0.05). Application of EM in MCM anaerobic digester showed drop in turbidity from 26% to 7% with no statistically significant difference of (p=0.250) and a higher BOD5 treatment efficiency was observed after addition of EM (55%) than before addition of EM (40%) but the COD removal efficiency decreased from 59% to 45% after addition of EM in MCM wastewater. From eighteen physico-chemical and bacteriological parameters considered, addition of EM in the hospitals WWTP improved the pollutants removal performance of ABRs for only three parameters and for seven parameters in the case of AD removal performance. Therefore, it is concluded that the treatment performance of EM on the hospitals wastewater were not significant for removal pollutants. Hence, further studies should be carried out for better treatment efficiencies of EM by combining with supplementary treatment methods.

Key words: *Anaerobic Baffled Reactors, Anaerobic Digester, Effective Microorganisms, Hospital Wastewater.*

Introduction

The concept of EM was developed during the 1970's by Teruo Higa in Ruykyus University in Okinawa, Japan (Higa, 1991; Higa and Wididana, 1991). The technology was first introduced to the world through an international conference on Kyusei nature farming held in Thailand in 1989, where researches program to test its efficiency was undertaken by 13 countries in the Asia Pacific regions (Kyan *et al.*, 1999). The use of these aggregated microorganisms as inoculants was embraced in Ethiopia by Ministry of Agriculture and Rural Development (MoARD) in 2007 with the initiation made by Woljeejii Agricultural Industry a private limited company (Woljeejii, 2009).

EM is a mixture of microbial inoculants found in all ecosystems namely lactic acid bacteria, yeast and photosynthetic bacteria (Sangakkara, 2004). Many studies (Higa and Chinen, 1998; Higa and Parr, 1994; Higa, 1993; 1995; 1996, 1998) 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. In University of the Ryukyus, Okinawa, Japan a study showed that EM has a great potential in purifying wastewater, including that of a sewage system. Long term application of EM reduced the adverse characteristics of wastewater and increases the quality of the treated water, which also indicated its potential use for reuse without health hazards (Okuda and Higa, 1999).

The uniqueness of microorganisms and their often unpredictable nature and biosynthetic capabilities, given a specific set of environmental and cultural conditions, has made them likely candidates for solving particularly difficult problems in the life sciences and other fields as well (Higa and Parr, 1994). There are three types of microorganisms in the environment which are categorized into decomposing or degenerative, opportunistic or neutral and constructive or regenerative. EM belongs to the regenerative category whereby they can prevent decomposition in any type of substances and thus maintain the health of both living organisms and the environment (Higa, 1995). The first EM solution contained over 80 microbial species from 10 genera, isolated from environments in Japan, however with time; the technology was refined to include only lactic acid bacteria, phototrophic bacteria, and yeast (Sangakkara, 2000). The innoculum includes high populations of lactic acid bacteria (Lactobacillus and Pedicoccus) at 1×10^8 CFU/ml suspension, yeast (Saccharomyces) at 2×10^6 CFU/ml suspension and phototrophic bacteria 1×10^3 CFU/ml (Sangakkara, 2004).

Phillips and Philips (1996) states that EMs microbial inoculants are mixed culture of beneficial organisms with the following principle microorganisms being involved: photosynthetic bacteria, lactic acid bacteria, and yeast. The ability of photosynthetic bacteria to use hydrogen sulfide, which is toxic and convert it into nonpoisonous compounds is also very beneficial in the wastewater industry (Kobayashi and Kobayashi, 2002). Lactic acid bacteria (LAB) produce lactic acid from sugars and other carbohydrates produced by photosynthetic bacteria and yeast, the lactic acid bacteria enhance the breakdown of complex organic matter such as lignin and cellulose and ferment these materials without creating harmful substances caused by purifying of organic matter. Through the metabolism of LAB, CO2 (carbon dioxide) is formed. This is used by other species in the consortia as a source of energy to their own metabolic systems, (phototrophic bacteria) (Biocon, 2008).

Yeast has the ability to assimilate glucose as a substrate and produce pyruvic acid through metabolism of the saccharide decomposed system. Pyruvic acid can be used as a substrate of micro aerobic lactic acid bacteria. In this way, if the lactic acid bacteria using the metabolite of yeast multiply, the formed lactic acid becomes the substrate of photosynthetic bacteria and they can be multiplied. Then yeast uses the saccharides formed by these photosynthetic bacteria as a substrate and can multiply repeatedly. This implicates that the microbes continue to aid each other to keep alive and stay strong in the environment (Kyan *et al.,* 1999).

The development of EM Technology in the fields of agriculture and environmental protection, its impact on pests and diseases and its application in integrated aquaculture-agriculture food production systems, has received considerable attention since its inception in the early 1980's (Parr and Horvic, 1992; Sangakkara, 2004; Parr *et al.,* 1994; Higa, 1996). The value and beneficial application of EM Technology in agriculture, health and environmental sciences have been well documented in the literature (Higa, 1996; Joo and Lee, 1999).

The first concept of using EM in environmental management was in the process of composting. In Hanoi Vietnam (Quang, 2000), the city garbage is composted with EM and found to useful as solid fertilizers. In Khadim et al. (2007) study municipal solid waste was treated with Effective Microorganisms (EM) inoculums to convert it into Bio-fertilizer. Wastewater Treatment with Effective Microorganisms simply enhance the natural cleaning process (Higa and Chinen, 1998). Figure 1 shows the conceptual differences between the natural oxidation process and the EM treatment process. EM treatment helps to produce antioxidant substances such as low molecular polysaccharides, polyphenols and Chelates of minerals. These antioxidants substances, in turn allows the multiplication of beneficial microbes, while inhibiting the harmful species, which enhance solid-liquid separation (through depositing), the basis for cleaning the water.

The basis for using these EM species of microorganisms in wastewater treatment is that they contain various organic acids due to the presence of lactic acid bacteria, which secrete organic acids, enzymes and antioxidants. The addition of EM increases the reliability of „notoriously fragile‟ microbial ecosystems through competitive exclusion of pathogenic microorganisms; hence favoring the beneficial microorganisms present (Banerji *et al.,* 2008). It also helps to prevent the corrosion of inorganic materials, such as rusting, and help organic matter towards fermentation as opposed to putrefaction (Higa and Chinen, 1998).

Freitag (2000) suggests that introducing EM into the anaerobic treatment facilities help to reduce the unpleasant by-products of decomposition and also reduce 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. In Okinawa, Japan the home of EM, The city library of Gushikawa uses EM for treating sewage water, which is recycled for the garden and in toilets. The COD and BOD5 of the water are reduced significantly when treated with EM (Okuda and Higa, 1999) and this water is reused, thus saving costs and energy.

EL-Monayeri *et al.* (2007) studied the effect of using effective microorganisms on anaerobic sludge digestion and insure that effective microorganisms have unique ability to stabilize complex organic matter through a shift from anaerobic putrefaction cycles to a fermentative cycle. In study conducted in USA using EM technology to solve the odor and pollution problem of Jefferson City Wastewater Treatment Facility (JCWTF). The study concluded that EM is successfully helping to reduce foul odors, decrease sludge and improve effluent water quality at the Jefferson City project (Wood *et al.,* 2001). A study conducted by Raja et al. (2011) to evaluate EM on pollutant reduction in domestic wastewater. The wastewater alkalinity, TDS, BOD5, and COD of domestic sewage showed distinct reduction. 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 EM has the potential to improve the effectiveness of treatment of domestic wastewater.

Environmental management, wastes recycling, treatment and disposal, pollution control and prevention and wastewater reuse became the most important issues, on top of the global agenda (Azab, 2008). Although there are many wastewater treatment methods used, there are numerous concerns raised regarding the presence of constituents including heavy metals, pathogens and other toxic substances. This requires considering new technologies like EM which is being produced to assist in the treatment and disposal system. EM consists of a wide variety of effective, beneficial and nonpathogenic microorganisms of both aerobic and anaerobic types coexisting (Higa, 1993).

In Min *et al.* (2005) study to improve the stability and efficiency of activated sludge membrane bioreactor (MBR), with addition of EM in activated sludge membrane bioreactor, the average values of effluent quality were: COD average efficiency of removal 90.0% and NH4+-N average efficiency of removal 99.4%. For the activated sludge membrane bioreactor, the COD removal rate was 91.7%, and the NH4+-N removal (94.8%) was less than that of the EM (MBR). The study conclude that compared with the activated sludge MBR, the EM MBR not only produced an excellent and stable quality of effluent but also resulted in a shorter time to start-up and significantly improved the efficiency of NH4+-N removal. In Tanzania a study was conducted to determine the role of EM on reduction of coliform bacteria in up flow Anaerobic Sludge Blanket (USAB) reactors. The average percentage removal of TC and FC in USAB with addition of EM was 93±6 and 96±4, respectively compared to the control UASB, 83±6 of TC removal and 85±5 of FC removal. Other parameter like COD and SS also showed higher percentage removal in USAB with addition of EM thus, EM appears to be potent in improving performance of the USAB reactor during the treatment of domestic wastewater (Maalim *et al.,* 2009). In Brazil, The duckweed growth and EM applications were tested for dairy wastewater treatment. Combined application of EM and duckweed growth significantly reduced the ammonium nitrogen, TP, TSS and BOD5 compared to control treatment after three months and EM considered as a very efficient way of dairy wastewater treatment (Rashid and West, 2007). The main objective of this research is to assess the effect of EM in treating hospitals wastewater (pathogen, nutrient and organic matter) removal.

Methods and materials

Description of the study area

This study was conducted in Bethel Teaching General Hospital and Myang Sung Christian Medical Center (MCM), Addis Ababa, Ethiopia. Bethel Teaching General Hospital was commissioned in 2000 at Kolfe Keranyo Sub City. Myung Sung Christian Medical Center is found in Gerji area, Bole Sub City (BTGH, 2011; and MCM, 2011).

Study Design

A descriptive study design was employed during October 2010 – September 2011 to gather data by laboratory analysis. A preliminary survey was carried out to be familiar with different aspects of the study area and major data acquisition by laboratory analysis of the selected hospital wastewater samples for determination of the various physico-chemical and bacteriological parameters.

Sampling Sites

The main source of the sample is wastewater from Bethel Teaching General Hospital (BTGH) and Myang Sung Christian Medical Center (MCM) wastewater, samples were collected from influent and effluent of the hospitals WWTP for physico-chemical and biological parameters analysis based on standard methods for the examination of water and wastewater (APHA, 1998). Samples were also taken from septic tanks influent and effluent to evaluate the pollutant removal efficiency of septic tanks and to determine the effect of EM in domestic wastewater treatment.

Sampling Equipment and Interval

All samples for physicochemical were collected using a sterilized sampling plastic bottle and for bacteriological analysis sample were collected by sterilized glass bottle. Filtering Apparatus and all laboratory equipments for bacteriological analysis were first autoclaved, at 121 ^{0}C for 15 minutes including the sampling bottles (APHA, 1998). From each sampling site triplicate samples were collected, raw influent sample was collected at the point before it enters to the treatment plants and raw effluent of wastewater were collected at the point before discharge to municipal drainage system. EM solution was directly poured as indicated in instruction, 1 liter of EM in 1000 liter of wastewater in to inlet point of the hospitals WWTP. Two samples were collected from the wastewater after addition of EM solution from inlet and outlet points based on the interval of the hospitals wastewater HRTs. Samples were collected for three rounds from each hospital. Therefore, a total of 18 samples from both hospitals and MCM guest house wastewater were collected and analyzed. With consideration of Quang (2000b) study, EM was added each day at the dilution rate of 1:1000 in the studied hospitals WWTP for five days.

Sampling Volume and Techniques

From each sampling point for bacteriological analysis, a composite sample of 300mL water samples were taken in sterile glass bottles and transported to the laboratory with ice box. For the physicochemical analysis composite water samples of 500mL were collected in plastic bottles, labeled and transported to the AAU Environmental Science Research Laboratory with ice box. Before sample collection the bottles was washed with distilled water and repeatedly rinsed with the wastewater at each sample site. Moreover, for prevention of cross contamination and infection from the hospital wastewater all the necessary personal protective equipments: gloves, mask, gown and goggle were worn during sample collection and analysis as necessary.

Laboratory Analysis

The influent and effluent of the hospital wastewater sample collected for determination of physico-chemical and bacteriological parameters were analyzed in AAU; Environmental Science, Mycology and Microbiology laboratories. Samples were characterized in terms of its physical, chemical and biological composition. The laboratory analysis was done by HACH (2004) procedures, Standard Methods for the Examination of Water and Wastewater (APHA, 1975; 1998) and USEPA (1983) accepted procedures for reporting wastewater analyses.

Result and discussion

The effects of effective micro-organisms (EM) treatment on BTGH Hospital wastewater had been assessed (Table 1).

Table 1: Physicochemical and bacteriological characteristics of BTGH wastewater with addition of EM (Mean ± SD)

Parameter Analyzed	Influent	Effluent
Temperature (^{0}C)	19.67±0.55	20.36±1.5
PH	6.9±0.2	6.88±0.69
EC	1138±20.78	1128±59.6
Turbidity, JTU	183.6±3.5	243±28
TSS	97.3±4.6	81±9.84
TDS	796.6±14.5	789±41.7
S^{2-}	483±32	276.6±14.7
SO_4^{2-}	101.3±28	77±14.6
NH_3-N	13.2±2.3	13.1±3.1
NO_3- N	29.3±9.19	14.3±4.1
NO_2- N	70±10	61.6±13
TN	47.3±14	43.3±13.7
TP	8.83±1.01	8±6.8
PO_4^{3-}	8.3±3.2	8.2±1.13
COD	310±92	174.6±98
TC (cfu/100)	$1.54x10^7±0.55x10^7$	$3.97x10^6±6.13x10^5$
FC (cfu/100)	$2.93x10^5±1.5x10^5$	$1.5x10^5±2.5x10^4$
BOD_5	94±5.67	42.7±1.52

All units are mg/L unless otherwise mentioned.

Table 2: Physico-chemical characteristics of BTGH wastewater with addition of EM for five days

Parameters	Influent Before Addition of EM	Effluent After Addition EM*				
		1^{st} day	2^{nd} day	3^{rd} day	4^{th} day	5^{th} day
Temperature (^{0}C)	20.1	19.3	18.05	17.8	20.4	19.5
PH	6.88	6.90	6.16	6.72	6.78	6.92
EC	1091	1110	1123	1160	1122	1150
Turbidity, JTU	290	268	236	220	200	180
TSS	100	84	60	110	180	150
TDS	763.7	777	786.1	812	785.4	805
S^{2-},	390	810	290	560	1840	330
SO_4^{2-}	60	62	70	50	90	80
NH_3-N	16.1	15.6	14	12.8	14.5	15.5
NO_3- N	90	63	14	9	34	13
NO_2- N	0.1	85	70	40	80	80
TN	60	47	9	4	37	35
TP	17	10	0.8	0.6	0.10	12.9
PO_4^{3-}	6.3	6.5	6.3	6.3	10	8.7
COD	608	632	640	722	534	1014
BOD_5	82.8	69.7	66.6	58.8	47	26

**All units are mg/L unless otherwise mentioned.*

Temperature and pH

The temperature of the ABR‟s was fluctuating throughout the five days experiment and pH of BTGH wastewater rose sharply soon after dosing with EM (Table 3 and Table 4), however there was no statistically significant difference (p= 0.961) in pH value. The gradual increase in pH may have been caused by the EM bacteria mixture with optimizing conditions of the new environment for survival. Horikoshi (1999) found that alkaliphilic (alkali-loving) and neutrophilic (neutral pH range) bacteria could alter their environment by increasing the pH to conditions suitable for their growth.

Turbidity

The average turbidity removal efficiency of BTGH treatment plant before addition of EM was 23% and after addition of EM was 25%, the EM solution showed a 3% boost in the removal efficiency of turbidity in the ABR's (Figure 2). The ANOVA result showed no statistically significant difference between the wastewater without addition EM and with addition EM (p = 0.246) in Turbidity. Similar, result observed in Bach Mai hospital wastewater in Vietnam before addition of EM in the activated sludge removal performance of turbidity was 54% and after addition of EM it enhance the performance in to 59% (Quang, 2000a).

EC

The EC of the hospital wastewater was rose from a value of 1091(before addition of EM) to a value of (after addition of EM) as shown in Table 4.4 and the result did not confirm any significant difference between the effluent before addition of EM and after addition of EM (p= 0.905) while, the removal competency of the ABRs has been reduced in 2% (Figure 2). A similar result was obtained by Phyllis (2010) in Johannesburg on application of EM to Goud koppies municipal wastewater within an anoxic environment the conductivity rose up and report the highest value by the end of the experiment compared with the beginning.

TSS and TDS

As explained in Table 4 the value of TSS increased from 100 mg/L to 150 mg/L after addition of EM with no statistical significant difference (P=0.834) between the groups and a higher removal competency of ABRs with addition of EM (17%) than without addition of EM (14%). Nevertheless, the TDS removal competency of the reactors has been reduced drastically after addition of EM (1%) than before addition of EM (27%) as shown in Figure 2. A higher TSS removal efficiency can be seen in study carried out by Quang (2000b) on Hanoi city wastewater treated by means of activated sludge the addition of EM in the treatment plant has increased the TSS removal performance in 36%.

TC and FC

Even if there is not that much study available on application of EM on hospital wastewater, a study on application of EM in dairy wastewater revealed that 63% TC reduction (Rashid and West, 2007), comparable reduction percentage has been observed after addition of EM on BTGH wastewater which was 75% for TC and 46% for FC. Higher TC removal might caused by the lactic acid bacteria presented in EM solution, during biodegradation of organic particles in wastewater they produces lactic acid and antimicrobial products having antibacterial properties which will inhibited the growth of TC (Barrett *et al.,* 2005).

TN and TP

Relatively high TN and TP removal efficiencies were observed in the ABR without EM (22% and 50%) than with EM (8% and 9%) a contradictory result showed in Okuda and Higa (1999) study on a City library wastewater the reductions of nitrogen and phosphorus after application of EM were 55% and 82% in the treated ponds in comparison to that of untreated water. This result showed there was not that much microbial utilization of these nutrients in the ABRs for attribute of the wastewater.

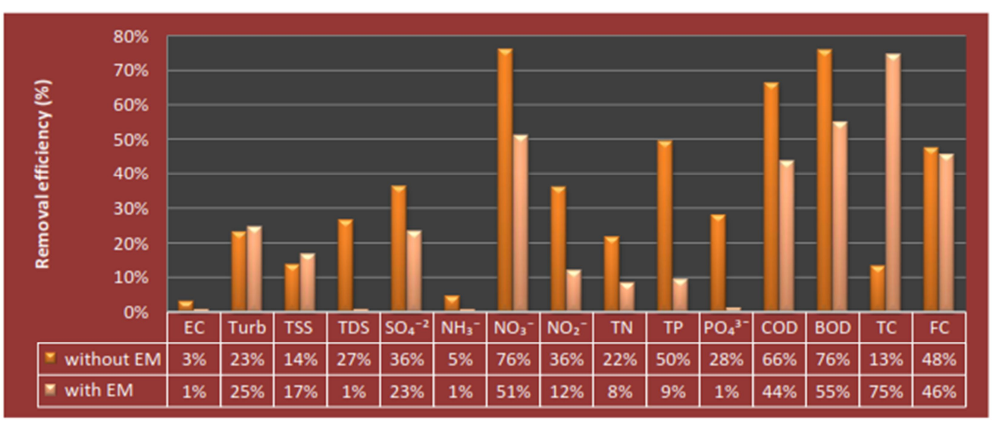

Fig 1: Treatment performance of BTGH (ABRs) without and with addition of EM.

BOD5 and COD

In BTGH hospital wastewater application of EM has increased the value of COD from 608 mg/L in the influent to 1014 mg/L of COD in the effluent (Table 1) with no statistical significant difference of (p = 0.259) between groups and COD removal competency of ABRs declined in 22%. In contrast the value of BOD5 reduced from 82.8 to 26 mg/L by addition of EM with no statistical significant difference (p=0.299) and 21% decrease in BOD5 removal efficiency (Figure 2).

Nutrients

There was a decrease in ammonia from 16.1 mg/L before dosing with EM to 15.5 mg/L after addition of EM but the NH_3-N removal performance of ABRs decreased from (5%) without EM to (1%) with EM and no statistical significant difference (p = 0.388) between the groups. NH3-N conversion may have been carried out by denitrifying bacteria that were present in the wastewater. The denitrification cycle provides a competitive advantage to these bacteria in oxygen-limiting environments (Leta *et al.,* 2004).

The $PO_4$3- has increased from 6.3 mg/L to 8.3 mg/L after addition of EM (Table 1), which reduced the PO43- removal competency of the reactor from 28% (without EM) to 1% (with EM). The NO3-N concentrations reduced from 90 mg/L to 13mg/L after addition of EM but the ABRs NO3-N removal efficiency has been decreased from 76% (without EM) to (51% with EM). In addition the value of NO2-N rise up after addition of EM from 0.1 mg/L to 80 mg/L as the removal efficiency decreased in 24%. In Quang (2000a) study on Bach Mai hospital the value of PO43- without application of EM was 5.45 mg/l and increased to 5.5 mg/L with addition of EM in the effluent, as for NO2-N in the effluent without EM (0.177 mg/L) and with EM (0.225 mg/L).

Effects of EM treatment on MCM hospital wastewater

Table 3: Physico-chemical and bacteriological characteristics of MCM wastewater with addition of EM. (Mean value ± SD)

Parameters	Hospital effluent	Residential influent	Residential Effluent	Hospital influent
Temp ^oC	21.5±3.28	22.8±2.8	19.9±1.03	20.45±1.34
PH	6.5±0.43	6.36±0.2	6.94±0.44	6.64±0.57
EC	429±39.3	251±21.9	469±95.3	409±26.76
Turb, JTU	168±17.6	123.6±16	167±15.7	154±12.9
TSS	286±82.2	206±64	131±26.16	113±45.47
TDS	271±25.7	195±14.13	316.5±76.6	286±18.7
S^{2-}	295±21	174±49.2	270±22.7	206±50.1
SO_4^{2-}	36.6±9.07	17.3±3.05	25±7	13±2.64
NH_3-N	23±6.9	18.2±10.8	6.67±2.24	5.48±2.19
NO_3- N	12±2.9	11.8±4.8	25.3±9.03	14.33±1.26
NO_2- N	45±7.8	20±4	50±3.6	24.6±13.6
TN	66±14	54.3±23	9.33±3.05	4.92±0.86
TP	18.7±7.8	12.8±4.2	4.8±0.8	4.32±0.62
PO_4^{3-}	7.2±5.5	7.1±0.63	8.2±1.9	4.06±1.3
COD	468±31.5	386.6±22	815±51	447±28
TC, cfu/100	$18.7x10^7±2.7x10^7$	$1.77x10^7±2.72x10^6$	$1.6x10^6±1.94x10^5$	$8.9x10^5±1x10^4$
FC, cfu/100	$8.3x10^6±14.4x10^6$	$3.5x10^6±1.07x10^5$	-	$3.6x10^5±5.3x10^4$
BOD_5	155±12.4	143±11.4	462±38	210.5±21

All units are mg/L unless otherwise mentioned.

Temperature and pH

According to Table 4, the temperature value in the AD was the same in the five days experiment, except in day four and five there is a slight increase (Figure 2) but the ANOVA results indicated no significant differences in temperature between groups (p= 0.147). There was a continual drop in pH for 5 days after addition of EM, even if there was a drastic rise in pH in the 3rd day and went down to 6.53 the day after.

EC and Turbidity

The wastewater EC rose slightly during the course of the study, there was a slight drop during the 3rd day but the value was highest by the end of the experiment compared with the beginning (Table 4) even no statistically significant difference (p = 0.366) encountered between groups.

EC removal competency of AD before application of EM was 19% and the competence reduced to 13% after application of EM in the wastewater. A different result encountered in Chamberlain *et al.* (1997) study on Dairy shed wastewater, the wastewater EC seems to be unaffected by EM treatments. As indicated in Table 4.6 there was a significant drop in turbidity but at the end of 5th day it showed a higher value than the beginning, which minimizes the removal efficiency of the AD from 26% to 7% with no statically significant difference on removal of the turbidity between the groups.

TSS and TDS

The value of TSS was erratic throughout the days and there were no significant differences in mean TSS value as the ANOVA depicted p= 0.345. The TSS and TDS in the hospital wastewater has been reduced in 55% and 23% in the AD but after application of EM in the plant the TSS and TDS removal efficiency has been reduced in 14% and 9% respectively (Figure 3), similar result obtained in New Zealand dairy wastewater with EM the TSS gradually increase and finally the TSS value was generally greater in EM treatments than in the nil-control (Chamberlain *et al.,* 1997).

BOD_5 and COD

A higher BOD5 (55%) treatment efficiency was observed with addition of EM than without EM (40%) and the COD removal efficiency has been decreased after addition of EM (14%) as shown in Figure 4.6. In Gushikawa City library in Japan application of EM to the pond reduced the BOD5 and COD values of wastewater by 93% and 20% respectively (Okuda and Higa, 1999). Quang (2000a) study has showed 9% improvement in BOD5 removal efficiency of Bach Mai hospital wastewater after addition of EM and Hanoi city wastewater activated sludge shows 5% higher BOD_5 removal performance after addition of EM (Quang, 2000b).

Table 4: Physico-chemical characteristics of MCM wastewater with addition of EM for five days

Parameters	Influent before adding EM	Effluent after adding EM				
		1st day	2nd day	3rd day	4th day	5th day
Temperature ^{0}C	19.3	19.0	18.5	19.5	21.8	20.2
PH	7.38	6.70	6.53	6.70	6.53	6.75
Conductivity, $\mu s/cm$	370	400	480	420	420	434
Turbidity, JTU	170	160	100	142	100	180
TSS	90	65	50	70	80	110
TDS	259	280	336	294	294	303.8
S^{2-}, $\mu g/l$	160	360	500	70	510	230
SO_4^{2-}	20	32	60	0	30	100
NH_3-N	5.5	8.6	12.6	3.3	5.4	7.2
NO_3- N	60	45	18	11	18	23
NO_2- N	29	52	80	60	100	40
TN	46	0.64	1	7	26	10
TP	13.5	3.5	0.2	0.5	2.2	4
PO_4^{3-}	3.4	5.4	6.5	6.4	8.1	9.6
COD	666	674	760	702	447	1228
BOD_5	103.8	46.6	12.2	86	52	13

All units are mg/L unless otherwise mentioned

FC and TC

Before addition of EM in the hospital influent FC and TC removal efficiencies in the AD was 41% and 94% after 4 days of application of EM in the wastewater, the removal performance for FC increased to 61%, while the TC removal efficiency decreased to 49%. Higher removal efficiency can be observed in Bach Mai hospital wastewater FC removal in activated sludge was 98.35% and with addition of EM it became 99.3% (Quang 2000).

Effects of EM treatment on MCM guest house wastewater

TSS and TDS

The studied guest house septic tank TSS removal efficiency was 33% (without EM) and 28% (after addition of EM) in the case of TDS 42% has been removed without addition of EM in the septic tank but with addition of EM only 28% of the influent TDS has been removed, which lowered the septic tank performance rate 5% for TSS and 14% for TDS (Figure 4). In the study carried out by Szymanski and Patterson (2004) in the Armidale-Dumaresq region of Australia, the results indicated no obvious decrease in the solids content of the septic tanks but addition of EM resulted in an increase in TSS within the water fraction of the septic tank and decrease in the level of TDS.

pH and EC

The pH of the residential wastewater has been increased after application of EM with outcome of negative result on pH removal efficiency of the septic tank. The septic tank EC removal competency was 14% without EM and after addition of EM the removal was enhanced to 42% (Figure 4), in contrast Szymanski and Patterson (2004) study of Shanahan and O'Connell septic tanks did not show any removal change in EC after applications of EM.

Nutrients

Before addition of EM the NH3-N value was 5.5 mg/L and after addition of EM the it increased to 7.2 mg/L (Table 4.6) with ANOVA result showing no statistically significant differences in NH3-N (p=0.906). The influent value of PO43- was 3.6 mg/L and it increased slightly to 9.6 mg/l (Table 4), yet the AD removal competence of PO43- mount from 36% to 50% (Figure 3). TN removal efficiency has been increased in 5% after addition of EM in the reactor, which is similar with Quang (2000b) study in Hanoi city wastewater after addition of EM the removal performance boots up to 9%. Some nutrients removed better with addition of EM such as; NO2-N (51% with EM and 44% without EM), NH3-N (18% with EM &17% without EM), TN (47% with EM &42% without EM), SO42- (48% with EM and 46% without EM) and few nutrients increased pressure on the removal performance of the digester after addition of EM, for instance NO3-N (43% with EM and 52% without EM) and TP (10% with EM and 15% without EM).

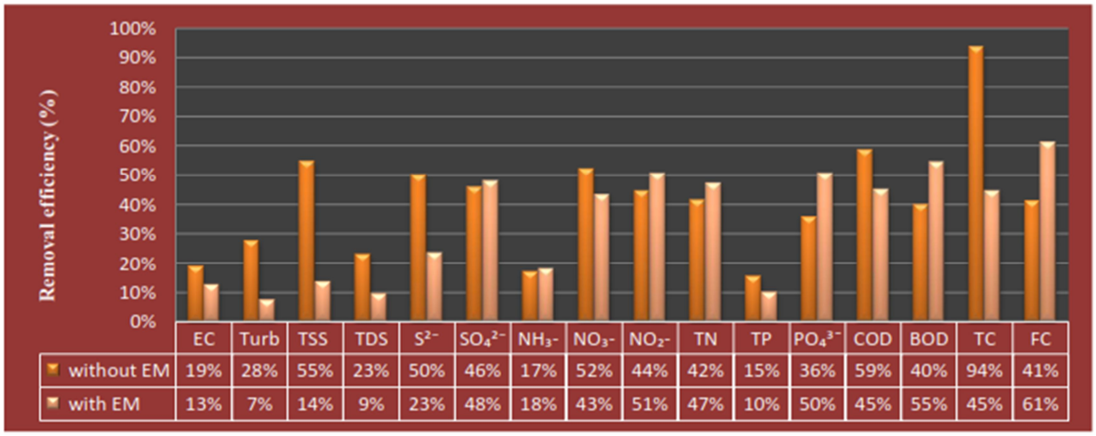

Fig 2: Treatment performance of MCM (AD) without and with addition of EM

S^{2-} and SO_4^{2-}

S^{2-} concentrations removal proficiency before addition of EM was 40% and after addition of EM increased in to 41%, because the odor of the wastewater gradually reduced the SO42- removal efficiency value sinks to the negative. Similarly the smell of dairy wastewater has been changed from the typical strong-pungent dairy effluent smell (nil control) to a rather sweet composting/mushroom smell after application of EM (Chamberlain *et al.,* 1997).

COD and BOD5

Higa and Kanal (1998) conclude from their study COD and BOD5 value of domestic wastewater was significantly reduced when treated with EM. However, in the guest house wastewater not that much significant difference was observed COD removal in the septic tank was 20% and with EM only 17%, in fact the BOD5 removal performance of the septic tank has been reduced 26% after addition of EM (Figure 4). ANOVA results showed that there was no significant difference (P<0.05) between the effluent without EM and effluent with EM for BOD5 and COD removal, this shows that EM did not show any enhancement in organic matter removal of the residential wastewater.

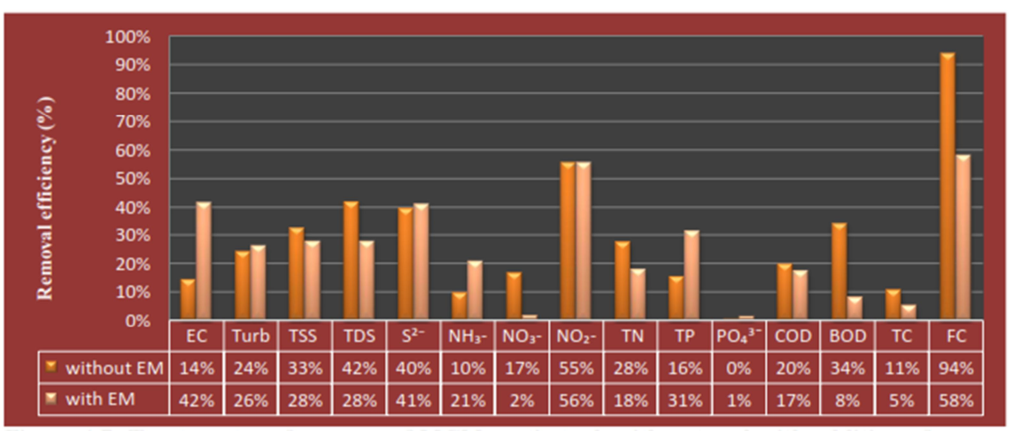

Fig 3: Treatment performance of MCM septic tank with out and with addition of EM.

Nutrients

Higher removal efficiency of NH3-N (21%) and PO43-(1%) has been achieved in septic tank after addition of EM than without addition of EM 10% and 0% respectively. A better removal of TP recorded after addition of EM in the guest house septic tank 31%

than before addition of EM (16%), which increases the removal performance of the septic tank in 15%. In Rashid and West (2007) study the dairy wastewater showed a 23% rise in the removal of TP after addition of EM in the treatment system while, in Vietnam the city wastewater showed 36% higher TP removal in the activated sludge after addition of EM (Quang, 2000b). An average pollutant removal performance of the septic tank has been decreased after addition of EM for NO3-N (17% without EM and 2% with EM), TN (28% without EM and 18% with EM). A similar pollutant removal performance reduction in activated sludge after addition of EM has been record in Bach Mai hospital in terms of NH3-N (12.6% without EM) and (29.12% with addition of EM) (Quang, 2000a).

TC and FC

Application of EM on the MCM septic tank evidently lowered down the removal efficiency from 11% to 5% for TC and from 94% to 58% for FC (Figure 4.6). In Maalim *et al.* (2009) study to examined EM on the reduction of coliform bacteria in Upflow Anaerobic Sludge Blanket (USAB) of domestic wastewater, the average percentage removal of TC and FC in USAB with EM were 93±6 and 96±4 respectively, when compared to control UASB of 83±6 (TC) and 85±5 (FC).

Conclusion

From this study it is concluded that the decreased in removal efficiency of the hospitals WWTPs after addition of EM might caused by insufficient performance of the hospital WWTP units, inappropriate organic loading to system, organic shock by the raw wastewater and negative effect on performance of the EM, microorganism's death because of drugs and antibiotics in raw wastewater. Therefore from the overall result it is concluded that the levels of treatment achieved by EM on hospitals wastewater were considered to be not significant for pollutants removal.

Recommendations

Based on the findings of this study the following points were recommended for concerned bodies. Since the levels of treatment achieved by application of EM on the hospital wastewater are considered insignificant. It is anticipated that better treatment efficiencies may be realized by combining EM with supplementary treatment methods. In both of the hospital wastewater a better TC and FC removal was observed after application of EM in the wastewater. Therefore, further studies should be carried out on application of EM for treating wastewater with high loading rate of TC and FC bacteria. Raising awareness, followed by government subsidy in the area of research could be a great help to the overall control in the pollution problems caused by hospital wastewater. Strict monitoring of these healthcare facilities by regulatory agency should be implemented as well as environmental agencies visit to the particular treatment plants can be made more mandatory. As a body to safeguard the public's health, hospitals need to take an active role in recognizing the impact and hazards posed by their wastewater discharged towards the aquatic and terrestrial ecosystems and, most importantly, carry out proper and effective measures. In order to achieve effective wastewater control from hospitals, collaboration among healthcare professionals, management personnel and the environmental protection agencies are necessary.

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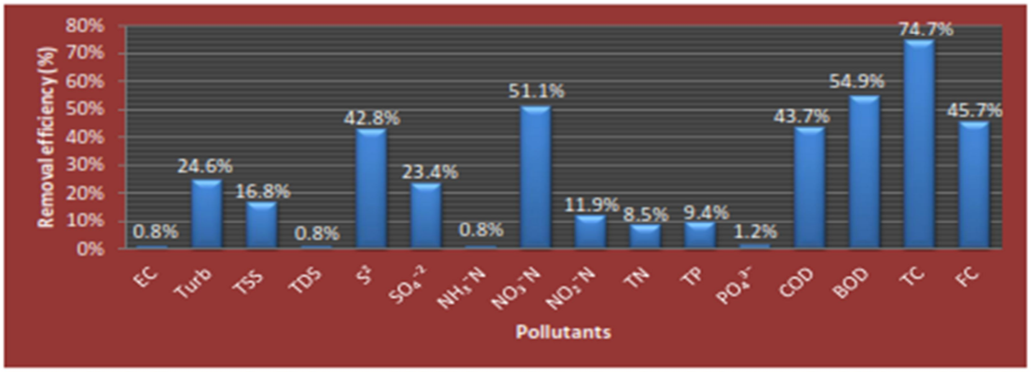
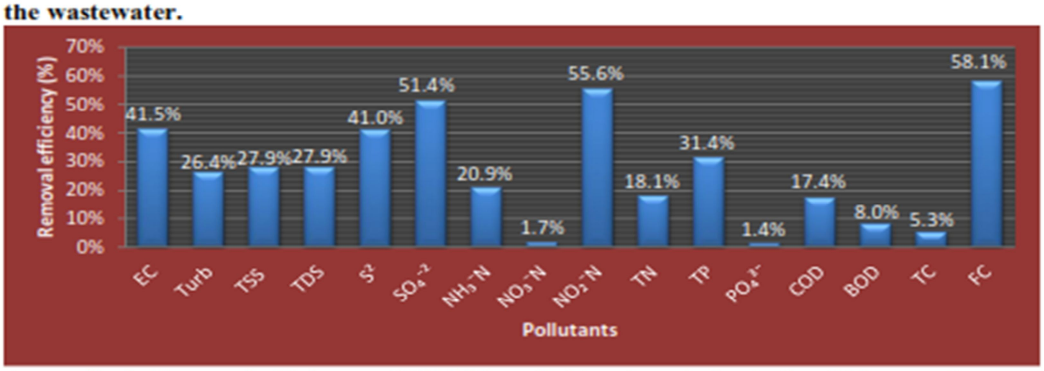
Appendix : Removal performance of hospital wastewater treatment plants after 24 hr of addition of EM.

Appendix 1: Removal efficiency of BTGH treatment plant after 24 hours of addition of EM in the wastewater.



Appendix 2: Removal efficiency of MCM septic tanks after 24 hours of addition of EM in the wastewater.



Appendix 3: Removal efficiency of MCM hospital treatment plant after 24 hours of addition of EM in the wastewater.