Title: The Use Of Effective Microorganism Technology™ (EM) in the Waste Water Treatment Ponds of the Belize Sugar Industries Ltd

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Abstract:

The use of EM Technology™ within the management of the Belize Sugar Industry (BSI) waste water treatment pond system is proving to be a very effect cost saving mechanism for the factory. Within 4.5 months of management with the EM™ system cost savings have been in the range of 37%. Equally important is the reduction of Chemical Oxygen Demand (COD) levels from an average influent level at 13,579 ppm (mg/l) to an average effluent level of 2,036 ppm (mg/l); that is, Pond 1 to Pond 4 respectively within a the same period. This reduction represents an 85% purification level compare to previous years purification levels of an average 75% using an oxygen injected system. Complete odor control, significant housefly population reduction and noteworthy increase in avian population on site were other major positive influences in the use of EM Technology™ at BSI's wastewater treatment facility.

Key words: Effective Microorganisms, EM, EEM, Belize Sugar Industries Ltd (BSI), Wastewater treatment, COD, BOD

Introduction:

Belize Agro-Enterprise Ltd (BAEL) is the official representative of the Effective Microorganism Research Organization (EMRO) in Belize. EMRO is a Japanese company which specializes in cutting–edge microorganism research and technology for sustainable agricultural production and waste management. BAEL was contracted by the Belize Sugar Industry (BSI) to use Effective Microorganism (EM) within its wastewater treatment facilities because minimal physiochemical characteristic of processed sugar waste water effluent load demanded by the Belize Department of Environment to enter natural water ways after leaving sugar processing treatment systems was not being achieved under the process of oxygen injection within the pond system.

Expected effluent outflow of Biological Oxygen Demand (BOD) to natural water bodies, after passing through the water treatment system, according to the Environmental Protection Act (EPA) is 50 mg/l or less; currently and according to the calculated data as provided by BSI, such is not being achieved within the BSI treatment system. Chemical Oxygen Demand (COD) level at 200 mg /L or less is currently not being achieved.

The BOD data was calculated using a conversion factor of 1.83 upon the COD data presented by BSI. The conversion factor was attained through the history of past biochemical data available at BSI. There were no actual BOD data evaluated in the 2007-2008 processing year. The COD data however suggests that chemical activity is consuming much of the oxygen needed to allow for optimal biological activity, BOD/COD ratio of 0.5 - 0.6, within the treatment ponds.

The calculated retention time, taking into consideration the characteristic of the current influent flow and total pond volume at 10% sediment load within total pond volume, shows the treatment ponds should be characterized by a retention time of approximately 117 days as calculated. Such should allow for optimal biological activity using effective microorganisms thereby reducing the BOD level in the effluent to the desired level required by the EPA. This however is not the reality as observation from BSI characterized

the retention time from the start of the processing to the time the total pond volume attain its maximum capacity, to be approximately 30 days during the 2007-2008 processing season. Taken this observation into consideration with the calculated estimated retention time of approximately 117, there is a very high possibility that within 30 days almost 74.4% of the total pond volume became silted with organic & inorganic matter; a most probable reason for the high COD and calculated BOD levels observed.

Phosphate, nitrate, sulphate and pH levels are not known for the 2007-2008 processing season. These levels however, with the exception of pH, are very much suspected to be above the required maximum limit before the treatment effluents are disposed of in the natural water ways; a factor that also needs to be addressed in order to comply with the EPA effluent regulation.

Effluent movement from the sugar processing plant at BSI moves as follows:

Processing plant➔Buffer Pond➔Treatment Ponds (Pond 1→Pond 2→Pond 3→Pond 4)➔Cooling Pond➔Natural Creek

The objective for the use of EM in the waste water treatment system at BSI was for the following:

1. **To Reduce the electric cost** being employed in operating the Surface Aerators used to control the emission of noxious odors from within the waste water treatment ponds;
2. **To Maintain odor control** caused by hydrogen sulphide and ammonia gases within the waste water treatment ponds;
3. **To Reduce, in time, the COD, BOD, sludge and other physical and chemical parameter** in BSI's waste water effluent, as it leaves the waste water treatment system, thereby increasing the quality of effluent outflow to surrounding natural waters, and
4. **To Provide a cost saving mechanism** for waste effluent treatment in time for BSI.

Materials and Methods:

The application of Effective Microorganisms™ to BSI's waste water systems was done using Extended EM (EEM). This was done the activation of EM.1 to form Activated EM (AEM). Seven days later the AEM was further activated or extended for another seven days to form EEM that was applied as follows:

TABLE 1

EM application rates during the treatment period December 2008 – April 2009

Application Periods	Proposed EEM application	Actual EEM application
A) Inoculation	14,000 L	11,000 L
B) 1st twelve (12) weeks	151,460 L (12,640 L/Wk)	155,500 L (12,959L/Wk)
C) Month 4-9	12,640 L/Wk	12,640 L/Wk
Total per Year	**468,820 L**	**469,860 L**

Results and Discussions:

Table 2 shows the average Chemical Oxygen Demand (COD) that entered and left the waste water treatment system at BSI. Maximum entrance of COD entering pond 1 of the system during the execution period was 62,170 ppm while the maximum leaving pond 4 was 4,500ppm. This would be the same as the previous year's average COD level leaving pond 4 during the 2007-2008 period. On average, during the current period, the COD level was 50% less as can be appreciated in table 2. The minimum COD leaving pond 4 on a weekly basis was 355 ppm.

TABLE 2

Average COD (ppm) input and output at BSI Wastewater Treatment Ponds during EM™ Application period of December 2008 – April 2009

COD Levels	Inlet Pond 1	Outlet Pond 4
Minimum	1500	355
Average	13579	2036
Maximum	62170	4500
Std Dev	10261	1394
No. Samples	44	63

Table 3 shows the average COD changes per month during the current processing period with EM application. It can be appreciated that as the time passes from initial application of EM there was an upward increase in COD levels entering the treatment pond system. The levels of COD leaving pond 4 however was on average 85% less than what was entering. Initially there were decrease purification levels but as of March 2009 the purification levels remains constantly above 80%; a desired output by BSI.

TABLE 3

Monthly Average COD (ppm) changes at BSI Wastewater Treatment Ponds during EM™ Application of December 2008 – April 2009

Time➔	Dec 08	Jan 09	Feb 09	Mar 09	Apr (22/4/09)	Average
Pond 1 Inlet	6,105	11,575	14,350	19,001	14,490	13,579
Pond 4 Outlet	581	2430	3076	3070	2561	2,036
Purification (%)	90.48	79.01	78.56	83.84	82.33	85.01

Table 4 compares the COD levels entering and leaving BSI's wastewater treatment system and the respective purification levels during four successive years using previously used oxygen injected management system. This was compared to the current EM management system in place. It can be appreciated that in just five months, the EM Technology™ is much more efficient in its purification ability of COD leaving the wastewater treatment system at BSI (85% EM Technology™ vs. 75% Oxygen injected system).

TABLE 4

Annual COD purification within BSI wastewater treatment ponds during EM™ Application of December 2008 – April 2009

Time➔	2005	2006	2007	2008	2009 (Apr)
Pond 1 Inlet	15,669	19,946	28,800	26,826	13,579
Pond 4 Outlet	3,841	4,837	7,135	6,877	2,036
Purification (%)	75.49	75.75	75.23	74.36	85.01

Conclusions:

Table 5 shows the projected savings using EM Technology™ at BSI's waste water treatment system. A comparison of the previous processing year's cost with that of the EM Technology™ system reveals a 37% cost savings.

TABLE 5

BSI Projected Savings using EM Technology™

Components	**Crop Season Expenditures at Treatment Ponds**		**Projected Savings**
	2008	2009	2009
	Bze $		
Aerator maintenance	36,685.00	0	100%
Labour	30,142.00	0	100%
Energy use	72,273.12	0	100%
Other	7,900.00	20,504.58	+12,604.58
EM	0	67,115.00	+67,115.00
Total Cost///Project Savings	**139,100.12**	**87,619.58**	**37%**

Note: Bze$ 2 : US$ 1

Other major achievements with the use of EM Technology™ at BSI's waste water treatment system are as follows:

- Complete odor control
- Marked reduction in housefly population
- Complete elimination of air pumps and hence
  - ✓ Elimination of maintenance cost
  - ✓ Elimination of energy cost
- Significant reduction in labour cost associated with current EM ™ Pond management system
- COD level to natural water ways was noted at 40ppm after passing through waste water cooling ponds.
- Increase avian population around treatment pond area.

Bibliography:

Kojima. K. Undated. Technical Guide: El Uso de la Tecnologia EM (Microorganismos Eficaces). Unpublished document.

Usher, W. 2007. Final Technical Report: Management of Citrus Product of Belize Limited Wastewater Ponds using Effective Microorganism™ Technology. Belize Agro-enterprise Ltd (BAEL).

Annex

TABLE 1

Summary of Actual Condition of Sugar Processing at BSI Factory Waste Water Treatment System (2007-2008)

Location	BSI Waste Water Treatment Ponds	EPA Sugar Processing Standard
Total volume of treatment lagoon:	48,262 m^3 or 48,261,971 L	
*BOD entering per month:	10,929 mg/L	
*BOD leaving per month:	4,584.7 mg/L	< 50mg/L
COD entering per month:	20,000 mg/L	
COD leaving per month:	6,877 mg/L	< 200mg/L
Ph entering	4.09 (n) - 4.36 (s)	
Ph leaving	N/A	6 - 9
Phosphates entering	N/A	
Phosphates leaving	N/A	< 5mg/L
Nitrate entering	N/A	
Nitrate leaving	N/A	<10mg/L
Sulphate entering	N/A	
Sulphate leaving	N/A	<200mg/L
Daily waste water influent to treatment ponds:	98,097 gl/day or 371,297.1 L/day	
Retention time (Estimated by BSI – 2007-2008 Season):	30 days	
**Retention time (Calculated):	117 days	
Calculated Siltation Estimate (of total pond volume within 30 days)	74.4%	

Note: *-BOD was calculated using a conversion factor of 1.83 in reference COD : BOD historical data as no information exist in the processing year 2007-2008.

**-Calculated retention time is based on the influent flow and total pond volume taking into consideration 10% sediment load within total pond volume.