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Nutrient Removal from Wastewater through Bio augmentation

M. M. Manyuchi[1,2]*
[1] BioEnergy and Environmental Technology Centre, Department of Operations and Quality Management, Faculty of Engineering and the Built Environment, University of Johannesburg, South Africa
[2] Department of Chemical and Processing Engineering, Faculty of Engineering, Manicaland State University of Applied Sciences, Zimbabwe
mercy.manyuchi@gmail.com; mmanyuchi@uj.ac.za

C. Mbohwa[1]
[1] BioEnergy and Environmental Technology Centre, Department of Operations and Quality Management, Faculty of Engineering and the Built Environment, University of Johannesburg, South Africa
cmbohwa@uj.ac.za

E. Muzenda[1,3]
[1] BioEnergy and Environmental Technology Centre, Faculty of Engineering and the Built Environment, University of Johannesburg, South Africa
[3]Department of Chemical, Materials and Metallurgical Engineering, Faculty of Engineering and Technology, Botswana International University of Science and Technology, P Bag 16, Palapye, Botswana
emuzenda@uj.ac.za; muzendae@biust.ac.bw

Abstract

Due to waster scarcity, several cheap and user friendly technologies are being adopted to improve the efficiency in operation of wastewater treatment plants. In this study, Hycura, an engineered biocatalyst is proposed for use as a bio nutrient removal catalyst in municipal wastewater in a bid to enhance the treatment methods and improve the quality of effluent being disposed. The effectiveness of bio nutrient removal was measured through the biological oxygen demand (BOD), the chemical oxygen demand (COD), the total Kjeldahl nitrogen (TKN) and the total phosphates (TP) ratios. The COD/BOD ratios were >1.25, whilst the BOD/TKN ratios were >4.2, the COD/TKN ratios were >8.0 and the COD/TP ratios were >15. The ratios indicated a high bio degradability of bio nutrients from the municipal wastewater enhancing bio contaminants removal upon addition of Hycura to the system.

Keywords: Bio augmentation, bio contaminants, nutrient removal, wastewater

1. Introduction

Water is a scarce commodity and various strategies are being implemented for managing wastewater treatment systems with regards to removal of biological nutrients like total Kjeldahl nitrogen (TKN) and total phosphates (TP). Surplus TKN and TP exist as bio-nutrients in municipal wastewater and can result in eutrophication if disposed direct to water

bodies, Bio nutrients ratios, biological treatment, municipal wastewater treatment systems therefore leading to a significant destruction of water bodies (Muserere et al., 2013). Thus, there is need to monitor these bio nutrients in municipal wastewater using Hycura, an engineered enzyme biocatalyst which has been found to be useful in wastewater treatment technology as a biological organism (Tshuma, 2010; Dzvene, 2013). Municipal wastewater is generated daily from domestic usage contains biological components as contaminants which result in deteriorated water quality if left untreated (Lai et al., 2011). The rate at which biological contaminants are removed in municipal wastewater can be measured by its biodegradability and de-nitrification which focuses on organic matter removed per sample of municipal wastewater (Lee and Hamid, 2010; Tas et al., 2010). The rate of bio nutrient removal is measured through the bio nutrient removal ratios which include: the chemical oxygen demand to biological oxygen demand ratio (COD/BOD), biological oxygen demand to total Kjeldahl nitrogen ratio (BOD/TKN), chemical oxygen demand to total Kjeldahl nitrogen ratio (COD/TKN) and chemical oxygen demand to total phosphates ratio (COD/TP) are used as good indicators in bio nutrient removal through biodegradability and de-nitrification (Tas et al., 2010). Recently, Hycura has become an interesting engineered bio catalyst for application in municipal wastewater treatment but there is need to understand its effect on bio nutrient removal in a wastewater treatment system (Khambete and Christian, 2014).

In this study, the impact of Hycura on bio nutrient removal in wastewater systems was studied. This was used through the measurement of biodegradability and de-nitrification of the organic pollutants through the wastewater parameter ratios.

2. Materials and methods

Municipal wastewater was obtained from a local wastewater treatment plant and tested for pH, the total phosphates (TP), the total Kjeldahl nitrogen (TKN), the biological oxygen demand (BOD), the chemical oxygen demand (COD), the total suspended solids (TSS) and the total dissolved solids (TDS) (Singh and Singh, 2010; Popa et al., 2012). The municipal wastewater was then treated with Hycura loading of 0.050 g/L for treatment times between 0-40 days, temperature was maintained at 37 ° C (Powel and Lundy, 2007). Standard methods were used for the measurement of the TKN, TP, BOD, and COD concentrations (APHA, 2005). The TSS and TDS were determined through filtration (APHA, 2005).

3. Results and discussion

3.1 Municipal wastewater characteristics

The raw municipal wastewater had BOD, TKN, COD and TP of 587 mg/L, 295 mg/L, 748 mg/L and 52.3 mg/L respectively as shown in Table 1. These bio nutrient parameters significantly reduced by more than 75% after using Hycura as the bio catalyst in municipal wastewater treatment (Table 1).

Table 1. Characteristics of the municipal wastewater

Parameter	Raw municipal wastewater	Effluent after treatment with Hycura
TKN (mg/L)	295±6	10±0.4
BOD @20°C (mg/L)	587±15	43±2
TSS (mg/L)	638±16	39±1
TDS (mg/L)	555±13	57±0.6
pH @25°C	9±0.2	7±0.2

TP (mg/L)	52±4	2±0.3
COD (mg/L)	748±13	79±2

3.2 Wastewater treatment systems optimization through bio nutrient removal

Municipal wastewater treatment with Hycura resulted in significant bio nutrients removal. Significant reduction in TKN, BOD, TP and COD was attributed to the bio catalytic capability of Hycura in reducing organic pollutants which is becomes more effective with increase in treatment time during treatment.

3.2.1 Effect on COD/BOD ratio

The COD/BOD ratios were all greater than 1.25 which indicated a high rate of biodegradability in municipal wastewater, hence high bio nutrient removal especially at higher treatment times and systems loaded with Hycura (Figure. 1). Previous studies indicated that COD/BOD ratios of greater than 0.5 are an indication of high degradability of the municipal wastewater (Muserere et al., 2013). The COD/BOD ratios were greatest at increased treatment time possibly because Hycura had enough time to acclimatize in the municipal wastewater and perform its bio catalytic role.

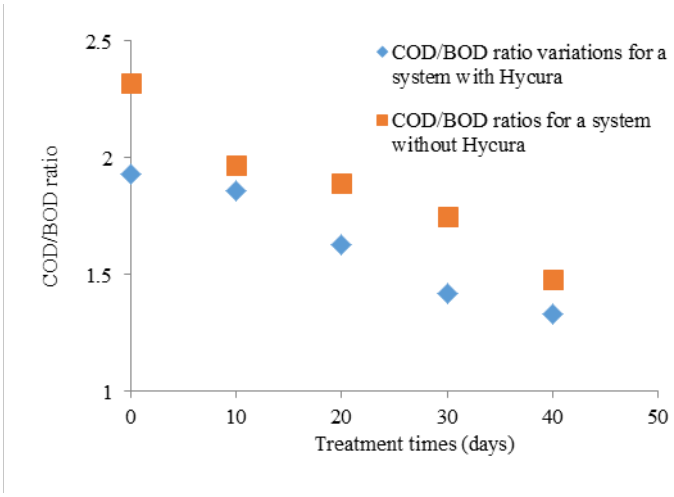

Figure 1. Effect of Hycura on COD/BOD ratio in a biological wastewater treatment system

3.2.2 Effect on BOD/TKN ratio

The BOD/TKN ratios were all greater than 4 for all the treatment combinations with Hycura at varying treatment times, with the highest ratios of around 12 being observed for a system with 0.05g/L of Hycura (Figure 2). Previous studies indicated that all the BOD/TKN values which are greater than 3.0 are an indication of low biological de-nitrification in the municipal wastewater at the same time achieving clear effluent at the end (Lai et al., 2011). However, favorable BOD/TKN ratios were achieved at 40 days treatment time (Figure 2), indicating that Hycura promotes de-nitrification in municipal wastewater.

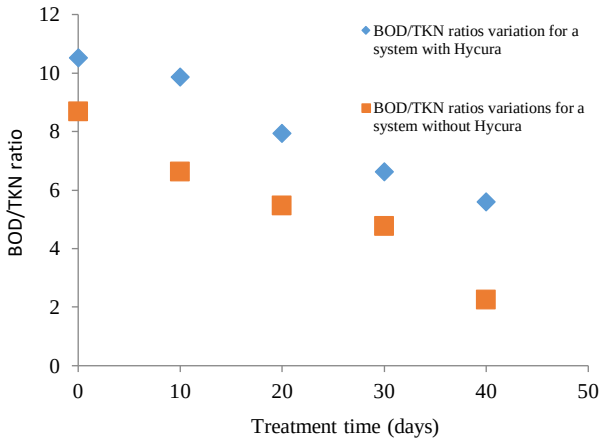

Figure 2. Effect of Hycura on BOD/TKN ratio in a biological wastewater treatment system

3.3.3 Effect on COD/TKN ratio

In this study, the COD/TKN ratios were greater than 8 especially for a system with Hycura and high treatment time (Fig 3). This showed Hycura has a potential for de-nitrification of nitrogen contaminants in municipal wastewater. Higher values of the COD/TKN ratio showed a moderate rate of de-nitrification in municipal wastewater system (Shin et al., 2005). High de-nitrification was achieved at the 40 day treatment period promoting biodegradability, higher treatment times are encouraged as this result in lowered COD/TKN ratios hence improved de-nitrification in wastewater treatment systems (Figure 3).

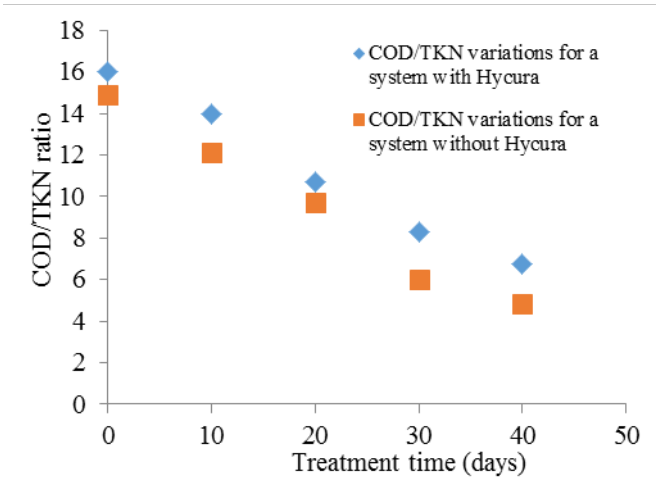

Figure 3. Effect of Hycura loading on COD/TKN ratio in a biological wastewater treatment system

3.3.4 Effect on COD/TP ratio

Lastly, the COD/TP ratios were greater than 15 for the various treatment times in a wastewater treatment system loaded with Hycura (Figure 4). In previous studies, COD/TP values of 20-60 were also reported for Harare City wastewater in Zimbabwe by Muserere *et al*. (2013) and they indicated that values within this range show that the wastewater has

increased biodegradability efficiency. Total phosphate and nitrogen removal in municipal wastewater is essential in avoiding eutrophication in water bodies such as rivers and lakes where it is disposed in.

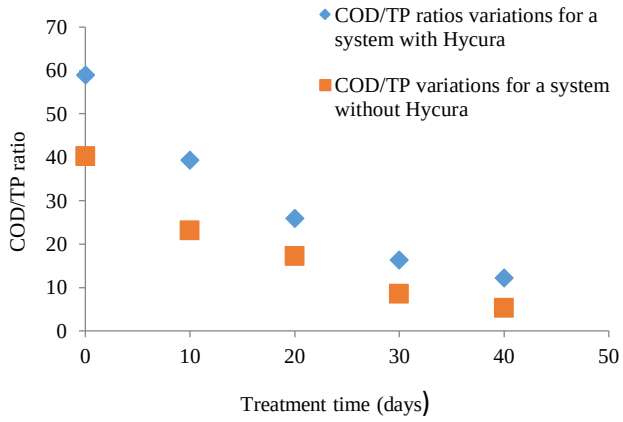

Figure 3. Effect of Hycura on COD/TP ratio in a biological wastewater treatment system

4. Conclusion

Nutrient removal is critical in wastewater to prevent environmental pollution. Use of engineered bio catalyst is essential for improving biological wastewater treatment systems hence improving their operational efficiency. Hycura addition during anaerobic treatment of municipal wastewater promotes bio nutrient removal through biodegradability and de-nitrification as indicated by the COD/BOD, BOD/TKN, COD/TKN and COD/TP ratios.

References

Abdalla, Z., and Hammam, G., Correlation between biochemical oxygen demand and chemical oxygen demand for various wastewater treatment plants in Egypt to obtain biodegradability indices, *International Journal of Applied Sciences: Basic and Applied Research*, 2014.

APHA, *Standard methods for the examination of water and wastewater*, 21st Edition, America Public Health Association, American Water Works, Association, Water Environment Federation, Washington, DC, USA, 2005.

Muserere, S. T., Hoko, Z., and Nhapi, I., Characterization of raw municipal wastewater and performance assessment of primary settling tanks at Firle Municipal wastewater Treatment Works, Harare, Zimbabwe, *Physics and Chemistry of the Earth*, vol. 67-69, pp. 226-235, 2013.

Tshuma, C., *Impact of Acti-zyme compound on water quality along Mid-Mupfuure Catchment-Chegutu*, BSc Honours Thesis, Geography and Environmental Studies, 2010.

Dzvene, K., *An investigation on the effectiveness of Acti-zyme bacteria to treat organic waste at Tripple C Pigs (Colcom)*', Bachelor of Science Honours Degree in Environmental Sciences and Technology, School of Agricultural Sciences and Technology, November 2013.

Gomes, A. C., Silva, L., Simoens, R., Canto, N., and Alburquerque, A., Toxicity reduction and biodegradability enhancement of cork processing wastewaters by ozonation, *Water Science and Technology*, vol. 68, no 10, pp. 2214-2219, 2013.

Khambete, K., and Christian, R. A., Statistical analysis to identify the main parameters to effecting WWQI of sewage treatment plant and predicting BOD, *International Journal of Research in Engineering and Technology*, vol. 3, no. 1, pp. 186-195, 2014.

Lai, T. M., Shin, J., and Hur, J., Estimating the biodegradability of treated sewage samples using synchronous Fluorescence Spectra'. *Sensors*, vol. 11, 7pp. 382-7394, 2011.

Lee, H., and Hamid, N., BOD_5: COD ratio as an indicator for pollutants leaching from landfill, *Journal of Clean Energy Technologies*, vol. 2, no. 3, pp. 263-266, 2014.

Popa, P., Timofti, M., Voiculesai, M., Dragan, S., Trif, C., and Georgescu, L. P., Study of physicochemical characteristics of wastewater in an urban agglomeration in Romania, *The Scientific World Journal*, Article ID 549028, 10 pages. http://dx.doi.org/10.1100/2012/549028, 2012.

Powell, B. and Lundy, J., *Acti-zyme agricultural and municipal wastewater treatment'*. Environment Depot Canada, pp. 1-23, 2007.

Singh, S., and Singh, K. N., Physicochemical analysis of municipal wastewater discharged into Varuna River at Varamasi', *Current World Environment*, vol. 5, no. 1, pp. 201-203, 2010.

Shin, J., Sang, L., Jung, J., Chung, Y. and Noh, S. (2005) Enhanced COD and Nitrogen Removals for the Treatment of Swine Wastewater by Combining Submerged Membrane Bioreactor (MBR) and Anaerobic Up flow Bed Filter (AUBF) Reactor. Process Biochemistry, 40, 3769-3776.

Tas, D. O., Karahan, O., Insel, G., Ovez, S., Orhon, D. and Spanjers, H. (2010). 'Biodegradability and denitrification potential of settleable chemical oxygen demand in domestic wastewater,'*Water Environment Research*, 81 (7), 715-727, 2010.