THE REMOVAL OF ORGANIC SUBSTANCE USING THE MODIFIED TRIPIKON S FOR THE USAGE IN COASTAL AND THE SWAMP AREAS

Dian Ardina Kusumaningayu[1], Dyah Wulandari Putri[2], and Prayatni Soewondo[3]
Master Programme of Environmental Engineering
Institut Teknologi Bandung
Ganesha Road No.10 Bandung 40132
Email : [1]dianardinak27@gmail.com , [2]dyah.wulan059@gmail.com, and [3]prayatnisoe@yahoo.com

Abstract: Sanitation facilities which can be used in reliable and sustainable ways for specific areas must be helpful to improve health condition and environmental quality. Tripikon-S is a vertical septic tank (cesspool) with three pipes used concentrically. However, this tank still has weaknesses. This current research, therefore, attempts to modify Tripikon-S by adding venturi pipes and some baffle pipes to facilitate the occurrence of anaerobic-aerobic processes in Tripikon-S. An experiment is conducted over the influence on COD of various influent concentrations of 1500 mg/L and 2000 mg/L and also that of various hydraulic retention times (HRT) of 24 hours, 36 hours and 48 hours. The measured parameters include pH, temperature, Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Volatile Suspended Solid (VSS), Nitrogen Total Kedjal (NTK), and Total Phosphate (TP). Result of experiment of continueefficiencyorganic substance for the highest reactor control is 63,04% achieved on influen variation concentrate 2000 mg/1 COD and HRT.Meanwhile,the highest elimination for venturi reactor is 67,39% achieved same variation with control reactor.
Keywords: black water waste, tripikon-S, batch system, continuous

INTRODUCTION

The presence of sanitation facilities to process waste liquid is a very important structure to separate human wastes from life environment in order to prevent disease (Setiawati et al., 2013). Environmental condition of each region throughout Indonesia is different to each other and therefore,this is cause not every area can built processing instalation domestic wastewater with on-site system.For example in a spesific area where have a geographic condition although the weather,so the services system its dificult to apply.Spesific area include coastal areas and estuaries along the river, swamp area, flood prone area, areas prone to water and lake (Djonoputro et al., 2010).Tripikon-S is a solution to develop sanitation for specific areas, especially coastal and swamp areas. Work principle of the modified Tripikon-S is still similar to conventional septic tank. The processing in Tripikon-S is typically facultative anaerobic processing(Sunjoto,2008).

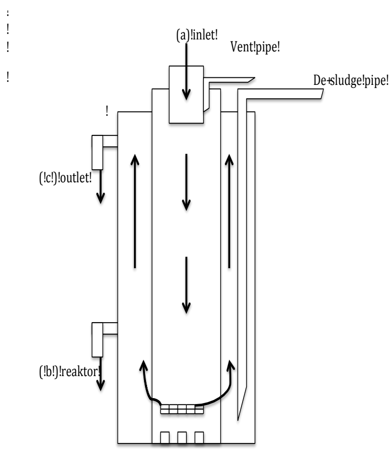
Marthee et al. (2010) said that anaerobic processing is a core technology to recover energy and nutrient from black water waste. Anaerobic processing has been widely emphasized by researchers of sanitation because it is more economic than conventional aerobic method (Khrisna et al., 2009). Anaerobic treatment is considered as the core technologi for energy and nutrient recovery from wastewater blackwater(Marthee et al., 2010). According to Khrisna et al., (2009) anaerobic digestion received widespread attention among researchers sanitation, especially on the economic side instead of the conventional aerobic.

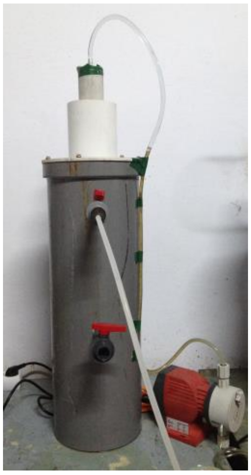
This research will be carried out modifications to Tripikon S by using additional pipe.The addition of the first pipe shaped like venturi aerator which has a hole in his throat so that the air can get into the flowing fluid(Pratama, 2010). It is intended to occur naturally aerated.Aeration is a natural or mechanical process by increasing the contact between water and air for the purpose of removaing entrained gases,adding oxygen,and improve the physical and chemical characteristics of the water (Ozkan et al.,2009). Higher dissolved oxygen means better quality of the system. Pursuant to F.A.Magnaye et al. (2009), aerobic process take more time for aeration and will generate a large amount of mud, but this process allows the nitrification process. The next pipe to be added is a pipe with some bulkhead or barrier with the aim to extend and cause a mud flow that is not joined to the outside through the channel.It is expected that anaerobic-aerobic process,it can provide better treatment result in Tripikon S.

Research attempts to review the processing (the removal of organic substance) with Tripikon-S,study the effect of modifications to the process Tripikon S elimination of organic substance,study the effect of residence time variation and the influent COD concentration on the process of eliminination of organic substance,reviewing preliminary kinetic parameters in the process of degradation of organic substance, a kinetic model used is Monod Model.

METHODOLOGY

Research method is a laboratory research using artificial waste which the characteristic is made similar to black water waste. Two reactors are used at laboratory scale. First reactor is Tripikon-S reactor (control reactor) made of PVC pipe at total height of 80 cm while the outmost pipe (overflow pipe) is at height of 19 cm. Second reactor is a modified Tripikon-S reactor with additional pipes of PVC and acrylic pipes at total height of 80 cm, while the diameter of outmost pipe (big pipe) is 31 cm. The following is the description of reactors used in research,





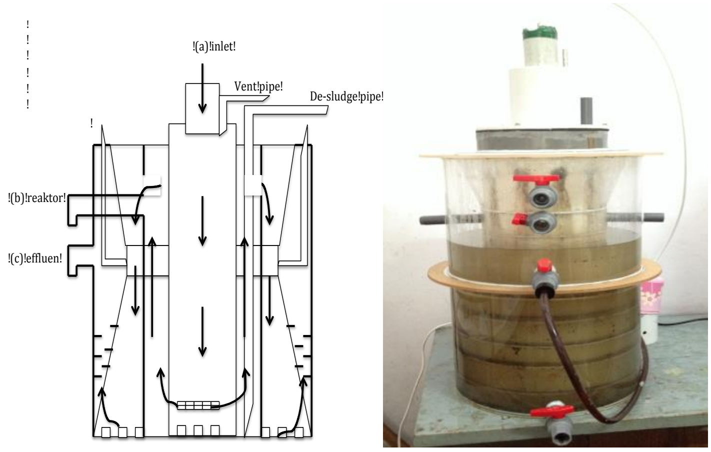


Figure 1. Scheme and photo tripikon-S reactor; (right) control reactor and (left) modified reactor.

The process begins with the preparation of wastewater artificial.Preparation of artificial wastewater using materials such as glucose as carbon user, $(NH_4)_2SO_4$ as nitrogen source, KH_2PO_4 as phosphate source and kaolin as total solid. The mixer water is tap water from Laboratory of Water Quality of Environment Engineering, Technology Institute of Bandung. This artificial waste is blended with anaerobic bacteria at VSS concentration of 2000 mg/L. Ratio of waste to bacteria is 80% waste and 20% anaerobic bacteria of total volume of reactor.

Research begins with batch system,where there is no flow in and out of the reactor in a batch system.Research conducted in the batch until it reaches a steady state is a characterized by the absence of significant changes in the parameters tested.Two variations of influent concentration are 1500 and 2000 mg/L. Recirculation pump is used in batch phase to mix the waste,with the purpose of waste can be mixed and measurements of pH,temperature,DO,COD,VSS every day so that a steady state is achieved.NTK and Total Phosphate are also measured in the beginning and the end of batch phase,it aims to determine the nutrient processing or not. After finalizing batch phase, continuous phase is then examined. This phase involves three variations of HRT, which are 48 hours, 36 hours, 24 hours.

Sampling method is grab sampling. This method, also called as momentary collection, means where sample is collected directly at certain moment in certain point, respectively at similar point and similar depth of batch reactor.In this study,samples were taken at three points as shown in **Figure 1.**reactor scheme (a,b and c). Parameters measured in the continuous phase are pH, temperature, DO, COD, VSS, NTK and Total Phosphate.

RESULTS AND DISCUSSION

Initial Characterization

This study used artificial blackwater that refers to Palmquist et al., (2005)with the composition listed in **Table 1**.

Table 1. The Composition of Black Water Waste (Palmquist et al.,2005)

Wastewater Parameter	Units	Average (standart deviation)	Range
Q	m^3/h	0,17 (0,01)	0,16-0,18
Total Phosphorous	mg/L	42,7 (19)	21-58
Total Nitrogen	mg/L	150 (26)	130-180
BOD	mg/L	1037 (545)	410-1400
COD	mg/L	2260 (1268)	806-3138
Total Solids	mg/L	3180 (2000)	920-4320
VS	mg/L	2560 (1900)	420-3660
pH	mg/L	8,94 (0,1)	8,87-9,08

Making waste artificially made by trial and error.Material used, include material such as glucose as a carbon source,$(NH_4)_2SO_4$ as a nitrogen source,KH_2PO_4 as a source of phosphate and kaolin as the total solid.While the use of mixing water is tap water that comes from the water wuality labolatory of Environmental Enginering ITB.After the making of blackwater waste is complete,then proceed with the initial characteristics of the waste.The results of the initial characterization of artificial blackwater waste contained in **Table 2.**

Table2. Initial Characterization of Waste

No	Parameters	Unit	Rates
1	pH	-	6,25
2	Temperature	^0C	24
3	Dissolved Oxygen	ppm	4,64
4	BOD	mg/L	2120
5	COD	mg/L	2470
6	VSS	mg/L	2533
7	NTK	mg/L	147
8	Total Phosphate	mg/L	39

Batch Experiment

This study begins with a batch system,where there is no flow in and out of the reactor.This batch stage is also the stage of acclimatization with the goal of microorganism can adapt to teh artificial wastewater.Batch system is run by two variation of the influent concentration of 1500mg/l COD and 2000 mg/l COD.This stage recirculation batch samples were taken at one point(b) for analysis of ph,T,DO,soluble COD,and VSS.Total Phosphate and NTK parameters analyzed at the begining and end of the running to see if there is processing nutrients or not.In this batch phase,the concentration of COD used as the main parameter.This is because the concentration of VSS fluctuating so it can not be used as the main parameter.In a batch system,any variation of the influent COD concentration is performed three times running batch system.

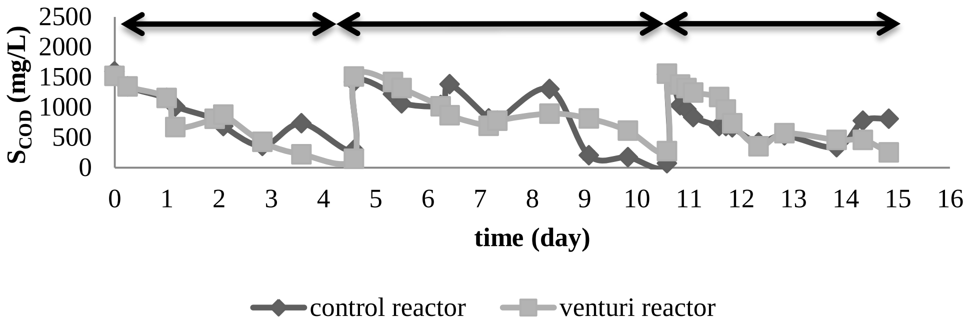


Figure 2. Decreasedconcentration of dissolved COD in the influent concentration variation 1500 mg/I of COD.

In **Figure 2.** it can be seen that the third running,steady state is achieved faster than running first and second, it occurs in both reactor.

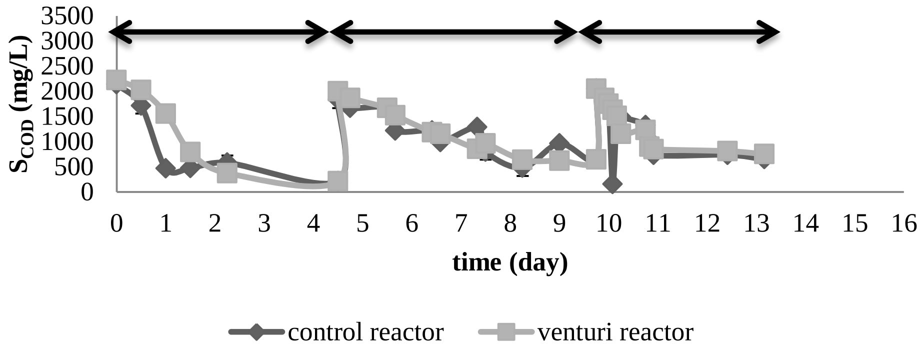


Figure 3. Decrease concentration of dissolved COD in the influent concentration variation 2000 mg/I of COD.

In **Figure 3.** looks the most rapidly achieved steady state at the third running within 2-3 days, this applies both to the reactor control and reactor venturi.From batch experiment, it is known that the COD reduction was obtained within 1-2 days,see the pattern of the time 24 hours,36 hours, 48 hours used as a variation for the continuous phase.While the S_{COD} , total phosphate and NTK removal efficiency for reactor control and reactor venturi at various influent COD concentration variation can be seen in **Figure 4.**

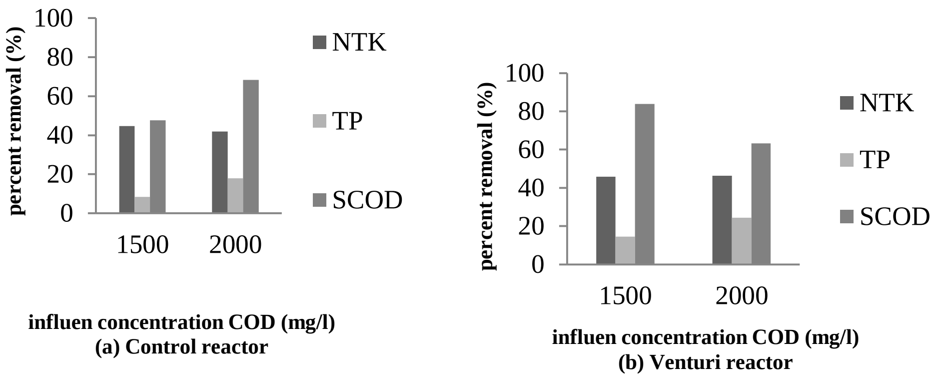


Figure 4. Removal efficiency of NTK, total phospate and $S_{COD.}$

Figure 5 and **figure 6** shown kinetics of maximum biomass growth.

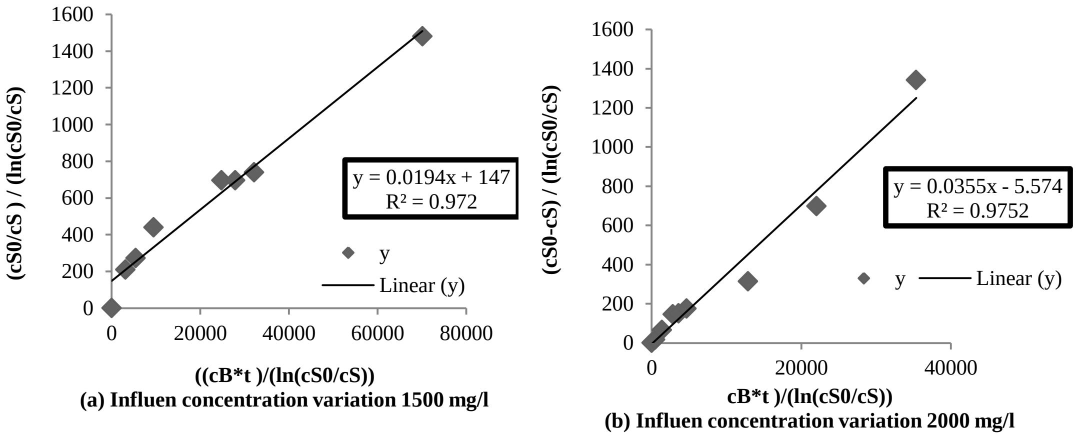


Figure 5. Kinetics of maximum biomass growth in the reactor control.

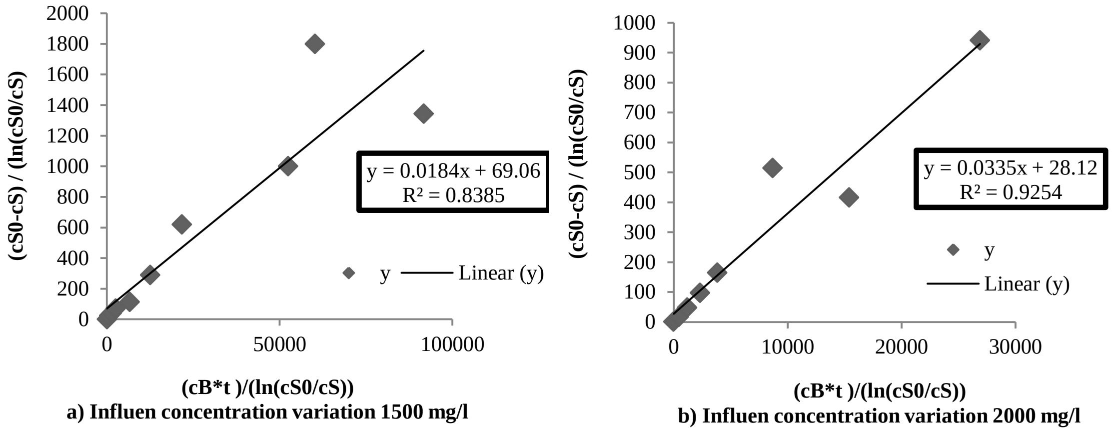


Figure 6. Kinetics of maximum biomass growth in the reactor venturi.

From **Figure 5.** shown at the control reactor with a variation of the concentration of 1500 mg/l was obtained r_{smax}0,0194 and Ks 147 and the variation of the concentration of 2000 mg/l was obtained r_{smax} 0,0355 and Ks 5,574. While in **Figure 6.** shown that the venturi reactor with a variation of the concentration of 1500 mg/l was obtained r_{smax} 0,0184and Ks 69,06 and the variation of concentration 2000 mg/l was obtained r_{smax} 0,0335 and Ks 28,12. And for the recapitulation of the kinetics calculations can be seen in **Table 3.**

Table 3. Recapitulation of kinetics calculation in a batch system

Reactor	r_{smax} (mg/l COD/hour)	K_s (mg/l COD)	$Y_{B/S}$ (mg/l VSS/ mg/l COD)	C_B (mg/l VSS)	μ_{max} (day^{-1})
control (Influen concentration variation 1500 mg/l COD)	0.0194	147	1.3411	1273.33	0.00049038
control (Influen concentration variation 2000 mg/l COD)	0.0355	5.574	0.6714	1235	0.000463184
ventury (Influen concentration variation 1500 mg/l COD)	0.0184	69.06	1.0126	961.17	0.000465229
ventury (Influen concentration variation 2000 mg/l COD)	0.0335	28.12	0.833	1261.67	0.000530831

Continues Experiment

After The reactor is operated with a batch system has reached steady state, then continued with the operation of the reactor with a continous system.Experiment with continous system aims to determine the performance of the reactor at several variation given.HRT variation to be used in the experiment was 48 hours, 36 hours and 24 hours.

pH is an important factor in the biological treatment. For microorganism, the pH became one of the conditions of growth.According to Benefield and Randal(1980),the optimum ph for bacterial growth is approching 7 ph conditions within the reactor were in the range of ph 5,4-6,2 and the venturi reaktor were in the range of Ph 5,4-6,4.This shows that both of the reactor and the reactor control venturi is in the range where the biodegradation process can take place in biology. For the effluent pH conditions, the pH range in control reactor is 5,5-6,25 and 5,96-6,47 in venturi reactor.

The level of overall efficiency of the biological processes affected by temperature(Metcalf and Eddy, 2003).Temperature is alos an important factor in a biological treatment process.This is due to the growth of microorganism that are strongly influenced by temperature.In the control reactor temperature range is 23-25,5°C and the reactor temperature range venturi is 23-26°C. Based on this range it can be seen that the range of temperature in the reactor either in reactor and reactor control venturi located in the mesophilic range.

The concentration of oxygen in the environment is a factor limiting the rate of growth of microorganism. In facultative anaerob,microorganism use oxygen as an electron acceptor. However if there is no oxygen, the microorganism will use molecules other thab oxygen as electron acceptor.In the venturi reactor, the addition of this pipeline will allow anaerobic-aerobic process, so DO parameters will be monitored to see venturi reactor performance.

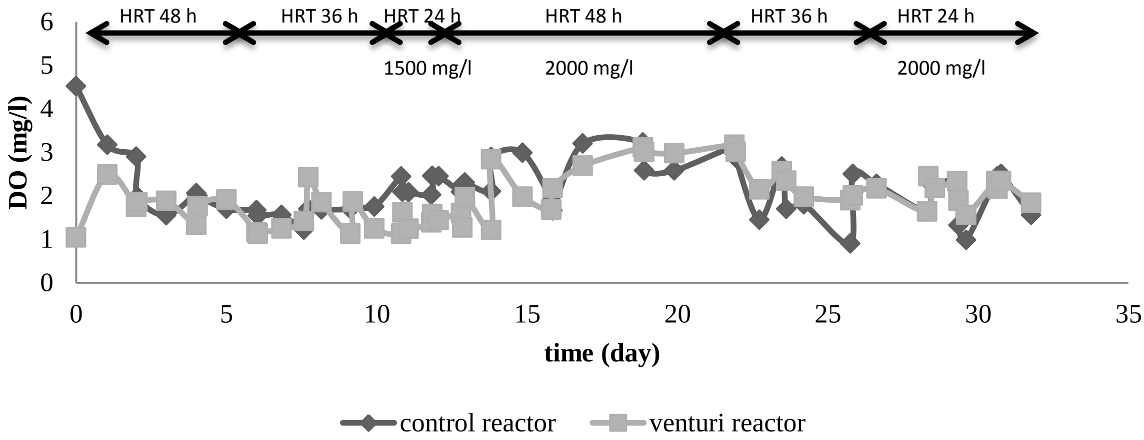


Figure 7. DO concentration in the reactor.

From **Figure 7.** it can be seen from the results of measurements of DO, DO measurement results between the control reactor with venturi reactor is not too much different. This indicates that the addition of a pipe with a venturi shape which allows the mechanical aeration does not occur significantly so that the desired aerobic process did not occur as desired. This may be due to the lack of significant reactor design so that the desired mechanical aeration process does not occur as desired. If the dissolved oxygen content is low, it will form an anaerobic environment. From the results obtained measurements conducted DO dissolved oxygen levels are so low that it can be concluded that the processes that occur in the same reactor with the reactor control venturi where the processes that occur in the form of facultative anaerobes.

In **Figure 8.** and **Figure 9.** we can seen various concentrations of COD and COD removal efficiency. For reactor control the highest removal efficiency is 63,04% achieved at the influent concentration variation to 2000 mg/l COD and HRT 48 hours. At the same variation in the reactor Venturi also obtained the highest COD removal efficiency is 67,39%.

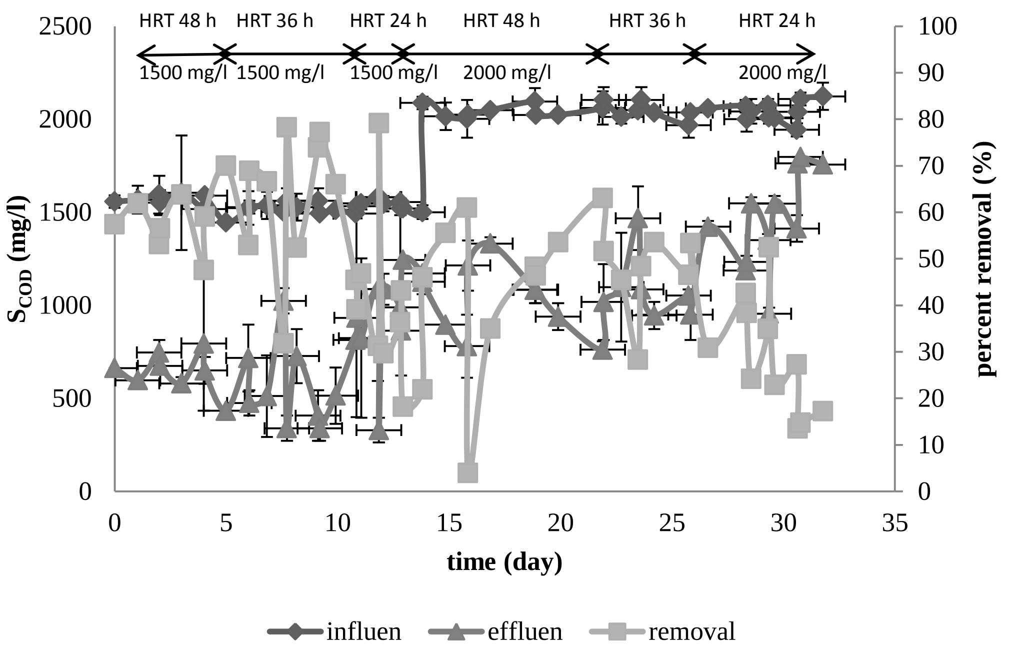


Figure 8. Influent, effluent concentrations of soluble COD and removal efficiency in the reactor control.

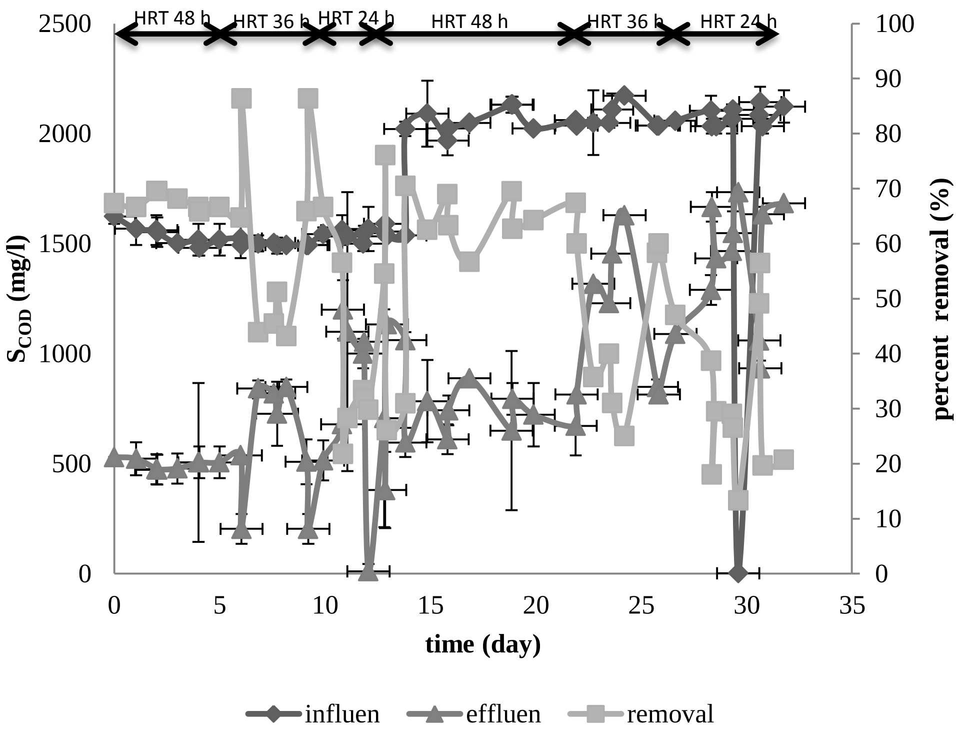


Figure 9. Influent, effluent concentrations of soluble COD and removal efficiency in the reactor venturi.

NTK influent concentration on variations both in the control reactor and the venturi reactor is in the range of 126-196 mg/l. While the total influent concentration of phosphates in a wide variety of both the control reactor and the venturi reactor is 40,25-57,35 mg/l**.** In **Figure 10**, it can be seen NTK, total phospate dan COD soluble removal efficiency in a wide variety both for reactor control and continuous reactor. We can seen that the highest NTK removal efficiency for reactor control is 24,39% achieved at the influent concentration variation 2000 mg/l COD and HRT 48 hours and with a similar variation in the venturi reactor obtained the highest removal efficiency of NTK 29,66%. While the highest removal efficiency of total phosphate (TP) in the control reactor at an influent concentration variation of 1500 mg/l COD and HRT 48 hours with 34,31% removal efficiency and the same variation in the venturi reactor obtained the highest removal efficiency of 35,16%.

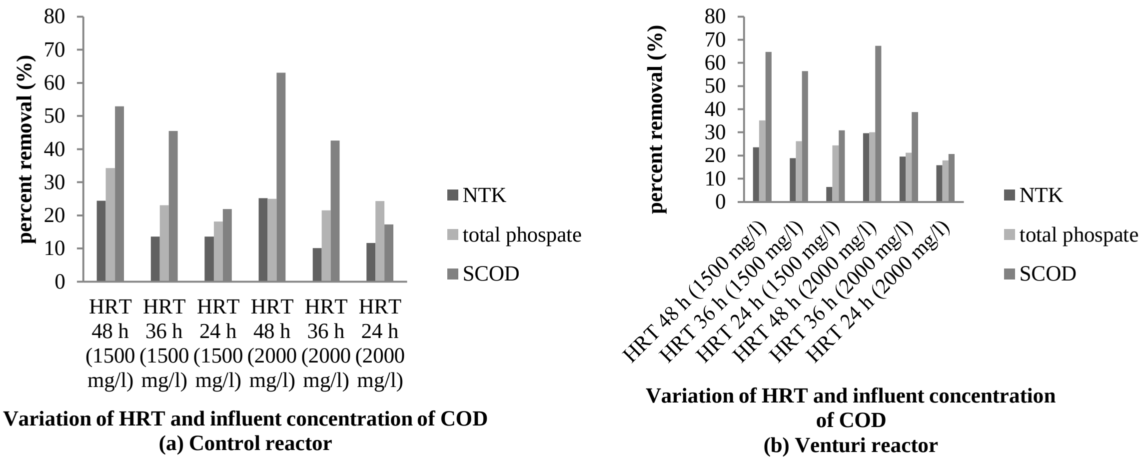


Figure 10. Percent removal in various variations.

And for the calculation of the rate of removal COD results in a continuous system can be seen in **Table 4.** for reactor control dan **Table 5.** for ventury reactor.

Table 4. Recapitulation of the rate of removal in control reactor

variation	t_d (hour)	C_{S0} (mg/l)	C_{si} (mg/l)	efficiency (%)	r_s (hour^{-1})
1500 mg/l	48	1523	717	52.94	16.80
1500 mg/l	36	1493	815	45.45	18.86
1500 mg/l	24	1501	1171	21.95	13.73
2000 mg/l	48	2061	762	63.04	27.07
2000 mg/l	36	2070	1188	42.62	24.51
2000 mg/l	24	2123	1757	17.24	15.25

Table 5. Recapitulation of the rate of removal in ventury reactor

variation	t_d (hour)	C_{S0} (mg/l)	C_{si} (mg/l)	efficiency (%)	r_s (hour^{-1})
1500 mg/l	48	1523	538	64.71	20.53
1500 mg/l	36	1561	679	56.52	24.51
1500 mg/l	24	1537	1061	30.95	19.83
2000 mg/l	48	2061	672	67.39	28.93
2000 mg/l	36	2104	1290	38.71	22.63
2000 mg/l	24	2123	1684	20.69	18.30

CONCLUSION

Based on the research results, obtained that the highest of removal efficiency of organic substance was reached 63,04% and 67,39% for ventury reactor in the variation of the influent concentration 2000 mg/l COD and HRT 48 hour. Optimum OLR on control reactor and ventury reactor was 1 kg COD/m^3/day. Removal efficiency of both reactor was not significant difference, this was because the desired aerobic process was not happen. That was seen fron the DO concentration in the control reactor which doesn't have significant difference between control reactor and ventury reactor.

ACKNOWLEDGEMENTS

Bill & Mellinda Gates Foundation in "Stimulating Local Innovation on Sanitation for Urban Poor in Sub-Saharan Africa and South East Asia" research project.

REFERENCES

Abdel-Kader, Amr M. (2013) : Studying the efficiency of greywater treatment by using rotating biological contactor system, *Journal of King Saud University - Engineering Sciences*, 25, 89–95.

Benefield, L.D. dan Randall, C.W. (1980) : *Biological Process Design for Wastewater Treatment*, Prentice Hall Inc., New York.

Chen, Hongbo, Dongbo Wang, Xiaoming Li, Qi Yang, Kun Luo, and Guanming Zeng. (2013) : Biological phosphorus removal from real wastewater in a sequencing batch reactor operated as aerobic/extended-idle regime, *Biochemical Engineering Journal*, 77, 147–153.

Chong, Siewhui, Tushar Kanti Sen, Ahmet Kayaalp, Ha Ming Ang. (2012) : The performance enhancements of upflow anaerobic sludge blanket (UASB) reactors for domestic sludge treatment e A State-of-the-art review, *Water Research*, 46 , 3434-3470.

Djonoputro, E.R., Blackett, I., Rosenboom, J.-. & Weitz, A. (2010) : Understanding sanitation options in challenging environments, Waterlines, vol. 29, no. 3, pp. 186-203

Grady, Jr. C. P. Leslie dan Lim, Henry C. (1990) : *Biological Wastewater Treatment*, New York, USA, Marcel Dekker inc.

Graff, marthe, et.al. (2010) : Anaerobic Treatment of Concentrated Black Water in UASB reactor at a Short HRT, Wetsus, Centre of Excellence for Sustainable Water Technology.

Hocaoglu, Selda Murat, Gu¨c¸lu¨Insel, Emine Ubay Cokgor, Ahmet Baban and Derin Orhon. (2010) : COD fractionation and biodegradation kinetics of segregated domestic wastewater: black and grey water fractions, Research Article, Interscience.wiley.com.

H. Palmquist, J. Hanaeus,. (2005) : Hazardous subtances in separately colected grey- and blackwater from ordinary Swedish households, *Science Total Environment*, 348, 151-163.

Krishna, G.V.T. Gopala, Pramod Kumar, Pradeep Kumar. (2009) : Treatment of low-strenght soluble wastewater using an aerobic baffled reactor (ABR), Journal of Environmental Management 90, 166-176

Magnaye, Florante A. , Pag-asa D. Gaspillo, Joseph L. Auresenia. (2009) : Biological Nitrogen and COD Removal of Nutrient-Rich Wastewater Using Aerobic and Anaerobic Reactors, *J. Water Resource and Protection*, **1**, 376-380

Ozkan. Fahri. Turgut Kaya and Ahmet Baylar (2009) : Study of the influence of venturi weir type on air buble entrainment. Scientific Research and Essay Vol.4 (11), pp. 1184-1193, November, 2009

Pratama, Prasdiatma. (2010) : Model Alat Pengolahan Fe Dan Mn Menggunakan Sistem *Venturi Aerator* Dengan Variabel Diameter Pipa Venturi Dan Kemiringan Irisan Pipa Venturi, Skripsi Program Studi Teknik Lingkungan, Institut Teknologi Sepuluh November.

Setiawati, Endang, Suprihanto Notodarmojo, Prayatni Soewondo, Agus Jatnika E., Bambang Widjarnako O. (2013) : Infrastructure Development Strategy For Sustainable Wastewater System By Using SEM Method (Case Study Setiabudi And Tebet Districts, South Jakarta), Procedia Enviromental Science Volume 17**,** Pages 685-692

Shafy, H.I. Abdel, M.A El-Khateeb, M. Regelsberger, R. El.-Sheikh, and M. Shehata. (2009) : Integrated system for the treatment of black water and grey water via UASB andconstructed wetland in Egypt, *Water Research & Pollution Control Department*, National Research Center, El-Behous Street, Dokki, Cairo, Egypt.

Torondel, Belen. (2010) : Sanitation Ventures Literature Review: On-site sanitation waste characteristics, London School of Hygene & Tropical Medicine.

Ningrum, Ardina Sita, Syarifuding dan Sudarno. (2012) : *Pengaruh Hydraulic Loading Rate (HLR) Dan Konsentrasi Influen Terhadap Penyisihan Parameter BOD, COD Dan Nitrat Pada Pengolahan Air Limbah Domestik Campuran (Grey Water Dan Black Water) Menggunakan Reaktor UASB*, Skripsi Program Studi Teknik Lingkungan, Universitas Dipenogoro.

Noor,Rijali . (2011) : T-Pikon-H sebagai teknologi alternative untuk perbaikan sanitasi didaerah spesifik rawa, Info Teknik, Volume 12 No. 2.

Manfaati, R. (2010) : Kinetika dan Variabel Optimum Fermentasi Asam Laktat dengan Media Campuran Tepung Tapioka dan Limbah Cair Tahu oleh Rhyzopus Orizae, Tesis Program Magister, Universitas