International Journal of Sciences: Basic and Applied Research (IJSBAR)

ISSN 2307-4531
(Print & Online)

http://gssrr.org/index.php?journal=JournalOfBasicAndApplied

The Effectiveness of EM_4 Addition into Anaerob-Aerob Biofilter in the Processing of Wastewater at Hasanuddin University Hospital, Makassar Indonesia

Pitriani[a*], Muh. Fajaruddin Natsir[b], Anwar Daud[c]

[a]*Public Health Department, Medical and Health Science Faculty Tadulako University*
[b,c]*Enviromental Health Department, Public Health Faculty, Hasanuddin University*

Abstract

Hospital waste water is a potential environmental pollutant because it contains high organic compounds, and other chemical compounds and pathogenic microorganisms, and if released to the environment without prior treatment will affect the quality of the environment. This Study aims to find out the effectiveness of EM_4 addition on biofilter anaerob-aerob to reduce BOD, COD, TSS, PO_4, NH_3 and MPN Coliform levels from wastewater at Hasanuddin University Hospital. The research was a pra-experimental study with pretest-posttest design. It was conducted in some steps including literature review, preliminary study, and main study (creating the biofilter anaerob-aerob reaktor). The basic principle of biofilter is to use of microorganism with a mobile process in certain mediun to produce biofilm. In normal condition, it needs one month (30 days) for the biofilm to degrade oranic compounds and pollutants in wastewater. The results reveal that after 18 days, there was a change in the pollutant levels. The decrease of BOD level reached 91,22% (322,65 mg/l to 28,30 mg/l) and decrease of TSS levels reached 90.05% (48.82 mg/l to 4.86 mg/l), which fulfilled the allowed maximum level as the Regulation of the South Sulawesi Governor No. 69/ 2010. Furthermore, while the reduction percentages were relatively high, the level of COD, PO_4, NH_3 and MPN Coli form in the wastewater had not fulfilled the quality standard. It concluded that the addition of EM_4 was able to generate the formation of biofilm so that the efficiency of biofilters can increase in terms of time needed.

Keywords: Biofilter, EM_4; Anaerob-Aerob; Hospital Liquid Waste.

---

* Corresponding author.

1. Introduction

Wastewater which is generated of the hospital activities is one of the sources potential of water pollution because it contains high organic compounds, other chemical compounds and pathogenic microorganisms. Reference [1] proposed the production standard of liquid waste is 650 liters /bed/day. Hasanuddin University is a B type of hospital with218bedsrecently, the average daily production of wastewater can be estimated there is approximately ± 141.7 m^3 per day. Based on the description can be imagined how huge the potential of wastewater to pollute the environment. The value of early investigation of the waste water describes that BOD, COD, TSS, PO_4, NH_3, and MPN Coliform parameters is commonly remained above the threshold value, this is indicates that activated sludge wastewater treatment system applied is not running optimally.

An anaerobic-aerobic biofilter treatment system applied with utilizes natural microorganisms in wastewater with amobile on certain media in order to form biofilms [2]. The reactor use honeycomb media models based PVC 2 cm. Related research, found anaerobic-aerobic biofilter system have been carried out and proven anaerobic-aerobic biofilter system is capable to reduce BOD 84.93%, COD 72.22% and TSS 76.71% with a resting time of 16 hours after 1 month treatment in the Christian Tayu hospital [3]. Another study in the Elizabeth Situbondo hospital found anaerobic-aerobic biofilter system is able to reduce BOD of 100 mg/l to 12 mg/l and COD of 170 mg/l to 30 mg/l, TSS 150 mg/l to 2 mg/l and ammoniac (NH_3) 0,46 mg/l to 0,00003 mg/l after it operates a 2 months all the parameters is down to fulfill the quality standards that have been set [4]. Combination of anaerobic-aerobic biofilter systemic efficient on processing wastewater hospital, but it takes a long time to form biofilms. In the ideal conditions microorganisms take ± 1 month that process of biofilms was optimal, so it is necessary to accelerate this process.

Utilization of EM_4 in improving the biofilter efficiency in tofu wastewater treatment is proven effectively in reducing the organic pollutants. BOD and COD provision reach 98.65% and 89.95% on the thirtieth day [5]. A similar study showed significant reduction of organic pollutants which is accompanied by a decrease in the value of MPN Coliform. Utilizationof EM_4 in hospital wastewater treatment based on the fact that 70% component of it is a domestic wastewater with a high content of organic pollutants [6]. EM_4 is a constituents several types of microorganisms that live in artificially symbiosis with each other [7]. EM_4consists of a vary microorganisms, each of it has a specific function and cooperate synergy to decompose organic pollutants and capture the odor gases (H_2S, NH_3, etc.) as a source of energy to perform its activities, in addition to the *lactic acid bacteria* and *Actinobacteria* in EM_4 suppressed the pathogenic bacteria significantly [8].

The addition of EM $_4$ (5%) is expected to accelerate the formation and maturation of biofilms, therefore is increase gradually of the biofilter efficiency. The usage of 5% dose is based on the previous studies. This study aims to determine the effectiveness of EM_4addition (5%) in the anaerobic-aerobic biofilter in reducing BOD, COD, TSS, PO_4, NH_3 and Coliform MPN of wastewater in Hasanuddin University Hospital.

2. Material and Methods

2.1 Research Design

This research was a pra experimental study with pretest-posttest design [9]. It was conducted in some steps including literature review, preliminary study, and main study (creating the biofilter anaerobic-aerobic reactor). The study was conducted in April-August, 2014.

2.2 Data Collection

Examination of BOD, COD, TSS, PO_4, NH_3 and MPN Coliform carried out at the Laboratory of Makassar Health Polytechnic based on *the American Standard Method*. pH and temperature measurements performed in the location of study using the pH meter and thermometer.

2.3 Data Analysis

Data analysis was analyzed presenting descriptively by using SPSS 20. The data analysis results were presented in data tables, graphs and narrative.

2.4 Sampling

Sampling was done by *grab sampling* at 9:00 to 10:00 pm. Sampling was carried out at the time based on the average daily fluctuations of the highest wastewater hospital between 09:00 to 10:00 pm [10]. Sampling was carried out at the inlet to *the pretest*, done while at the outlet *to the posttest* after the bio-filter operation for 24 hours. Sampling was carried out respectively 6 times, from the first day until the eighteenth.

2.5 Experimental Procedure

Wastewater treatment is done by operating the anaerobic-aerobic bio-filter reactor consisting of tanks, initial sedimentation tanks, first anaerobic tanks, aerobic tanks and second anaerobic tanks, and last sedimentation tanks.

2.6 The Microorganisms breeding process (Seeding)

Before putting into the reactor, firstly, activate EM $_4$ by mixing 1 liter of EM_4 with 20 liters of water and 5 table spoons of brown sugar liquid, then fermented in a sealed condition 2-4 days. Furthermore, seeding process in honeycomb bio-filter media is conducted naturally by flowing waste continuously into the reactor in 24 hours resting time with debit of 5 ml/ sec. At the same time, add the activated EM_4 into bio-filter with debit of 0.25 ml/sec, additions were made with infusion system in the initial sedimentation tank in 5%.Bio-filter volume was 437 l/day.

2.7 Core Experiment

In this experiment the reactor is operated continuously. During the operation carried out pH and temperature measurements as environmental factors that can affect the reproduction of microorganisms. pH and temperature measurements are conducted every day (9:00 to 10:00) while observe the formation of biofilm on media. At this core experiment was also conducted to measure the parameters of BOD, COD, TSS, PO_4, NH_3 and MPN Coli

form to see the magnitude of removal efficiency of organic pollutants and pathogens wastewater.

3. Results

3.1 Characteristics of Wastewater

Waste water being sampled in this study is the wastewater of Hasanuddin University Hospital. Based on laboratory analysis, the quality of waste water before it is processed at the initial examination shows that almost all the parameters tested has exceeded the threshold value as specified in the South Sulawesi Governmental Law No.69 on 2010 (Table 1).

Table 1: Main Characteristic of Hasanuddin University Hospital Wastewater

Parameter	unit	Magnitude	Standard
Physic			
Temperature	ºC	29	30
Chemist			
pH		*6,8*	6,0-9,0
TSS	Mg/L	42,07	30
BOD	Mg/L	*446,81*	30
COD	Mg/L	*892,47*	70
NH_3	Mg/L	*2,39*	0,1
BIOLOGIS			
MPN Coliform	Per 100 ml	*240.000*	10.000

3.2 Environmental Conditions and Biofilm Formation

The pH and temperature results of the wastewater are a major environmental factor in the proliferation of microorganisms. During the 18 day measurement, the pH is within the range of optimum value for the proliferation of microorganisms, is 6.4 - 7.4.Likewise, the temperature value is still in the optimum range, it is 26-29 ° C.

Observations on the proliferation of microorganisms, which are demonstrated by the formation of biofilms is done directly. The addition of EM_4 (5%) is proven to accelerate the formation of biofilms which become visible during the fifth day and more clearly on the eighth day, looks increasingly thick biofilm on the next days. More detail on table2.

3.3 Allowance efficiency of BOD, COD, TSS, PO_4, NH_3 and MPN Coliform

Decreasing levels of waste water parameters before and after treatment are shown in Table3. Based on the value

of each parameter reduction, determine the efficiency of bio-filter descriptively. Determination of bio-filter efficiency in designated waste water parameters can be calculated based on the formula that has been determined by calculating between difference the influent parameter value minus effluent concentration divided further influent parameter values multiplied 100%. Parameters removal efficiency of BOD, COD TSS, PO4, NH3 and Coliform MPN of the whole time is varied (Figure 1).

Table 2: Observation Data of Environmental Condition and Bacterial Growth in anaerobic-aerobic Bio-filter Hasanuddin University Hospital.

Day	Date	pH	Temperature (°C)	Biofilm
1	23 Mei 2014	6,6-6,8	29	-
2	24 Mei 2014	6,6-6,8	28	
3	25 Mei 2014	6,6-6,8	26	-
4	26 Mei 2014	6,8-7,0	29	
5	27 Mei 2014	6,6-6,8	27	-
6	28 Mei 2014	6,4-6,6	29	
7	29 Mei 2014	6,4-6,6	29	-
8	30 Mei 2014	6,6-6,8	29	
9	31 Mei 2014	6,6-6,8	29	Thin membrane getting visible
10	1 June 2014	6,6-6,8	27	
11	2 June 2014	6,8-7,0	27	
12	3 June 2014	7,2-7,4	29	
13	4 June 2014	6,6-6,8	29	Membrane more clear
14	5 June 2014	6,8-7,0	29	
15	6 June 2014	6,8-7,0	27	
16	7 June 2014	7,2-7,4	27	
17	8 June 2014	6,8-7,0	29	
18	9 June 2014	6,8-7,0	29	Membrane getting thicker
				Biofilm formed perfectly

4. Discussion

This study describe that the addition of EM4 (5%) in anaerobic-aerobic bio-filter which supports ideal environment capable of facilitating the formation and maturation of biofilm, from one month to 18days. The range pH value of the wastewater throughout the operation of reactor account for 6.4-7.4, at this range, the bacteria are more dominant than other microorganisms [8]. The optimum pH on the environment greatly affects the biological wastewater treatment process, generally microorganisms requires of pH between 6.5–9.0 [11].

Too high pH (>9) will inhibit the activity of microorganisms, while below pH 6.5will result in the growth of fungi and bacteria in competition with the metabolism of organic matter [12].

The temperature in wastewater throughout the operation of reactor account for 26-29°C, it shows the microorganisms were properly breeding. The ideal temperatureis25-30°C, too high temperature will damage the process by preventing the enzyme activity in cell. Increases1°C of temperature from the ideal range may cause a decrease in the efficiency of treatment [13].

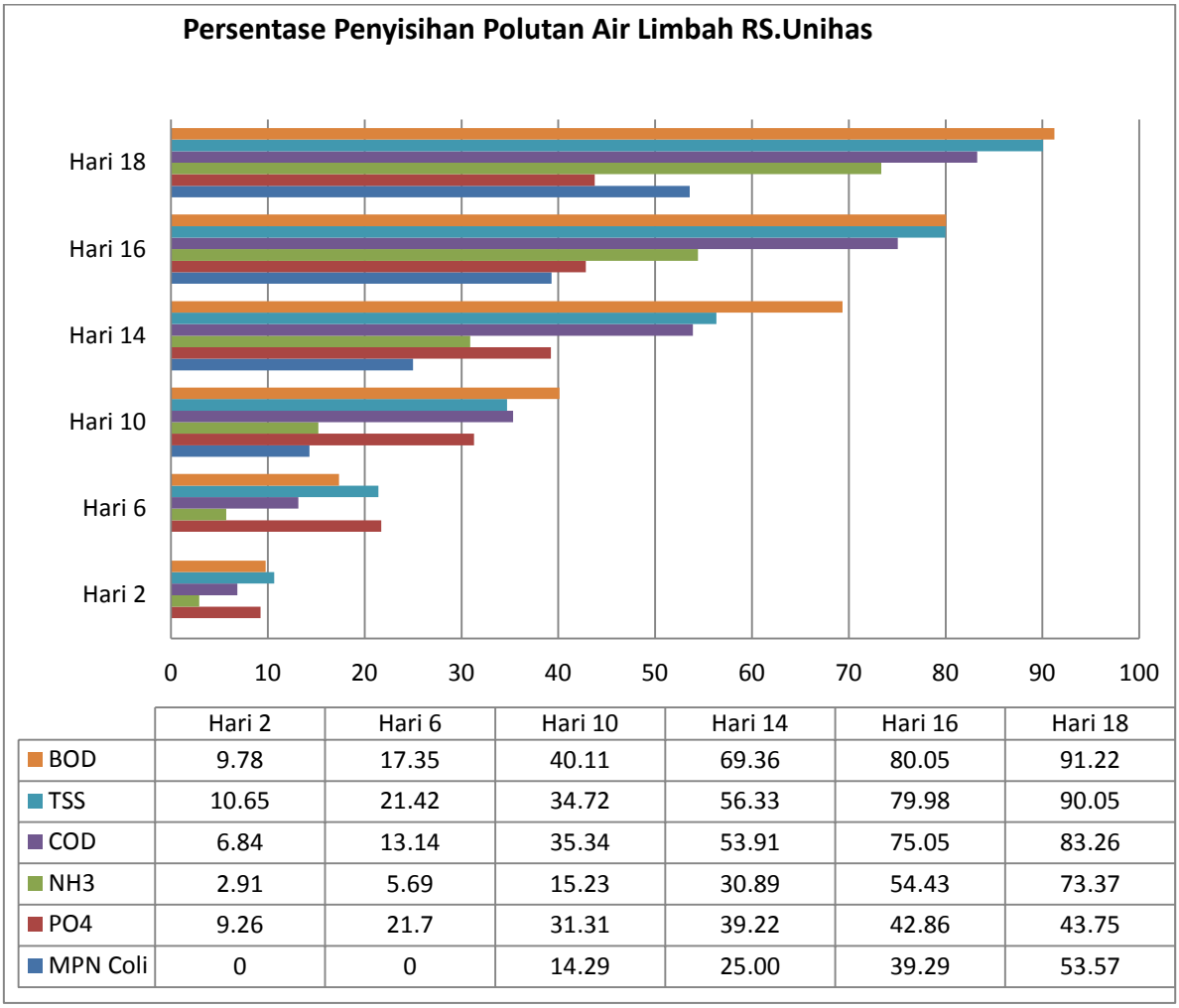
Table 3: The Value of Wastewater Parameter before and After Processing of Anaerobic-Aerobicbio-filter System with addition of EM_4 (5%)

Sample	BOD (Mg/L)		COD (Mg/L)		TSS (Mg/L)		PO_4 (Mg/L)		NH_3 (Mg/L)		MPN (Per 100 ml)	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
I	424,10	407,25	703,80	655,67	46,19	41,27	10,8	9,8	4,12	4,0	240×10^3	240×10^3
II	396,42	327,62	688,12	597,70	41,74	32,80	10,6	8,3	4,22	3,98	240×10^3	240×10^3
III	408,68	244,75	621,46	401,82	37,50	24,48	9,9	6,8	4,07	3,45	280×10^3	240×10^3
IV	348,50	106,78	652,75	288,40	40,14	17,53	10,2	6,2	3,82	2,64	240×10^3	180×10^3
V	441,84	88,15	706,45	176,24	43,55	8,72	9,8	5,6	3,84	1,75	280×10^3	170×10^3
VI	322,65	28,30	586,32	98,12	48,82	4,86	9,6	5,4	3,68	0,98	280×10^3	130×10^3
Std	**30**		**70**		**30**		**2**		**0,1**		**10×10^3**	

Observations on the breeding of microorganisms, which are demonstrated by the formation of biofilms is done directly. In contrast to Khaer research [14] with the same methods and bio-filter, the process of biofilm formation is slower, where a biofilmis visible after the eleventh day. Addition of EM4 which is a collection of various kinds of bacteria is proven to accelerate the seeding of microorganisms, biofilms form thin membranes become visible during the fifth day and with the passage of time the operation of the reactor, the biofilm is getting thicker. Decrease concentration of organic pollutants increase since the measurements of samples I to samples VI also show the microorganisms seeding in reactor are getting better.

Laboratory analysis result in Table 3 shows that the concentration of organic pollutants is illustrated through BOD and COD levels decrease after treatment. The decrease is because the degradation process of microorganisms is going better if contact between the waste water and microorganisms in biofilm layer are

longer [4]. BOD and COD are declined since the first day, though not significant. The removal process of BOD has been started at the beginning of the settling basin due to the deposition of particles suspended organic matter [15]. The presence of organic matter deposition of particles is detected by the silt bottom equalization basin. Elimination process of BOD takes place in the next anaerobic basin, at the time of the waste water passes through this medium inorganic substances is retained by the filter and will be degraded by microbes that attach to the filter so that the amount of diminishing returns and the reduction of organic matter in the wastewater levels of BOD and COD is dropped [16].



	Hari 2	Hari 6	Hari 10	Hari 14	Hari 16	Hari 18
BOD	9.78	17.35	40.11	69.36	80.05	91.22
TSS	10.65	21.42	34.72	56.33	79.98	90.05
COD	6.84	13.14	35.34	53.91	75.05	83.26
NH3	2.91	5.69	15.23	30.89	54.43	73.37
PO4	9.26	21.7	31.31	39.22	42.86	43.75
MPN Coli	0	0	14.29	25.00	39.29	53.57

Picture 1: The graphic of Percentage of Allowance Parameters on the wastewater after Treatment

In anaerobic process of complex organic substances such as carbohydrates, fats and proteins decompose to produce methane and carbon dioxide, as follows:

Organic Compounds----------> CH4+CO2+H2+NH3+H2S

The reduction process of BOD is continued in the aerobic treatment, organic matter and nutrients residue on anaerobic process will decompose so the aerobic treatment process is usually placed after anaerobic process. In this tank also takes a nitrification process [3].

Organic compounds + O2 ----------> CO2 + H2O + Energy + New cells

After aerobic processing resumes with the anaerobic process, in this process, BOD reduction is little considering the availability of organic matter decreases. This process is more on denitrification efforts so the removal of nitrogen wastewater compounds does not only stop in nitrite or nitrate form [17]. The final part of bio-filter is final sedimentation, with a similar process at the initial deposition. Final sedimentation is needed to accommodate access sludge generated from the previous process where aerobic processes produce enough mud. The effectiveness of biological treatment in anaerobic-aerobic bio-filter system with the addition of EM4 (5%), generally afford to reduce BOD and COD levels with up 91.22% and 83.26% in 18 days. The amount of removal efficiency further confirms that the addition of EM4 (5%) were able to increase the efficiency of bio-filter by shortening the processing time, though the level of COD is still above the quality standards.

TSS Parameters after the processing day by day also decreases significantly, on the tenth day of TSS levels is 24.48mg/l so it fulfills the quality standard based on South Sulawesi governmental law number 69 in 2010 that is (30mg/l). On the eighteenth day, TSS levels after treatment each 4.86mg/l with removal efficiency reaches 90.05%. This study is also in line with Said and Ineza research [15], by using a submerged bio-filter honey comb media, wastewater of hospital treatment efficiencies of TSS are high enough that is 80.0 to 97.8%. Unfortunately, the addition of EM4 is not able to reduce PO4, NH3and Coliform MPN optimally.

The ammonia (NH3) measurement result on 18 day is going down from 5.4 mg/l to 0.89 mg/l after treatment with 73.37% removal efficiency. Although the removal percentage is huge enough, the levels of NH3 is still above the quality standard that is 0.1mg/l. Previous research by khaer [14] using the reactor and the same media model, but without the addition of EM4 removal efficiency reached only 49.57% on 18 day. The removal of nitrogen compounds in wastewater can be done in two sequential processes those are nitrification then dinitrification [17]. If we observe on the process, we still find a process which in principle does not pay attention to the function of parameter ammonia. High levels of ammonia in hospital wastewater can be caused in poor aeration or mud that never dumped out and not doing further sludge process [18]. This ineffectiveness bio-filter in reducing NH3 is also caused by the installation of bio-filter media vertically, so that the aeration process is not running optimally.

Phosphate (PO4) from the first day since the bio-filter operation has been able to be low. Day by day PO4 removal efficiency is increased. Great removal efficiency occurs on the 18^{th} day that reaches 43.75% (9.6 mg/l to 5.4mg/l). Phosphate removal that we obtain is not too much. The results that we obtain are still above in quality standards allowance that is 2mg/l. Phosphates which contain in hospital wastewater can be derived from food waste, kitchen, and waste from leaching due to excessive use of detergents. One factor that cause levels of PO4 are still above the quality standards after treatment is because the wastewater is not separated by its characteristics before processing in bio-filter. Processing methods that are applied is also not able to reduce MPN Coliform well. On 18 day, the efficiency is only reached 53.57% (280 x 10^3 to 130 x 10^3 per 100ml of sample), this value is higher than the quality standard that is 10x10^3per100ml sample. The high value of MPN Coliform is an indicator of a bad bacteriological water quality. The existence of coli bacteria is an indicator of human fecal contamination or other warm-blooded animals and is always accompanied by the presence of other

pathogenic bacteria, especially Vibrio cholera and Salmonella typhi [19]. Besides, the virus species Rotavirus that causes diarrhea in children and Entamoeba protozoa species histolitica cause dysentery often found in wastewater hospital [12].

5. Conclusions and Suggestions

The addition of *Effective Microorganism* 4 (EM_4) is able to accelerate the formation of biofilms thus improving the bio-filter efficiency in terms of time. With the addition of EM_4 (5%) the requiring time to reduce organic pollutants of wastewater is getting short. After 18 days treatment, BOD and TSS are down so it fulfills the quality standards that have been set. Despite the COD removal percentage is high, the value is still above the quality standards. While the removal of PO_4, NH_3 and MPN Coliform is not optimal, this is due to the initial value parameters are very high and still found some deficiency in its application methods. Water delivery system of hospital waste should be separated based on its waste characteristics, and each of it is equipped with a pretreatment before it is processed by using bio-filter, so the reduction process of wastewater pollutants parameters can run up.

References

[1] Metcalf and Eddy. (1979). Wastewater Engineering Treatment, Disposa, and Reuse (2 nd Edition).New York;McGraw-Hill Book Company, Inc.

[2] Prayitno. (2011).Hospital Wastewater Treatment Technology. J-PAL, Vol.1, No.2, February, 72-139.

[3] Nurdijanto, Stephanus A et al., (2011).Design and Engineering Wastewater Treatment Hospital.Indonesian Journal of Environmental Health 11 (8): 42-55.

[4] Said, Nusa Idaman et al., (2011). Technology Hospital Wastewater Treatment with Anaerobic-aerobic biofilter System Case Study: Hospital Elizabeth Situbondo.Jakarta: Directorate of Environmental Technology.

[5] Jasmiati et al., (2010).Bioremediation of tofu Industrial Liquid Waste Using Effective Mikroorganism ($EM_{4)}$.Journal of Enviromenral Science, 52, 2 (4).

[6] Amouei, A et al., (2012).Investigation of hospital wastewater treatment plant efficiency in north of Iran during 2010-2011. International Journal of Physical Sciences Vol.7 (31), pp.5213-5217.

[7] Feng, Lin et al., (2013).Quorum Sensing in Water and Wastewater Treatment biofilms. Journal of Environmental Biology, 34, 437-444.

[8] Muliawan, Sylvia Y. (2012). Textbook of Medicine: Bacterial Pathogens Spiral. Accessed: Makassar May 14, 2014. (http // // 2F.2Ftekpan.unimus.ac.id 3A)

[9] Notoatmoedjo, Soekidjo. (2010). Revised Edition: Health Research Methodology. Rineka Copyright: Jakarta.

[10] Sugiharto. (2011). Application of wastewater treatment plants biofilter to Reduce pollutant content of BOD, COD and TSS in the hospital the mother Surabaya (Thesis).Environmental Engineering Program PGRI Adi Buana University of Surabaya.

[11] Flathman, Paul E et al., (1994). Bioremediation Field Experience. Accessed: Makassar May 12, 2014. (http://books.co.id/Bioremediation//Exp.html)

[12] Waluyo, Lud. (2009). Environmental Microbiology. UMM Press: University of Muhammadiyah Malang.

[13] Saraswati, Rastiet et al., (2010). Microorganisms perombak Organic Materials.Participatory Technology Assessment Project. The research Center for Land.Research Center for Soil and Agro-climate. IAARD (Unpublished).

[14] Khaer, Ain. (2014). Effectiveness Analysis of Anaerobic-aerobic biofilter media in the Hornet's Nest Model Parameters Wastewater Reduce Hospital UNHAS (Thesis).Department of Environmental Health Graduate Program Hasanuddin University, Makassar.

[15] Ramadan, Ishaq. (2010). Submerged Biofilter Process Technology Guidelines (Submerged Biofilter).London: Faculty of Civil and Environmental Engineering, ITB.

[16] Satrawidana, DK et al., (2013) Testing Technology Consortium Bacterial Biofilms on anaerobic-aerobic reactor Semi for Wastewater Treatment Hospital of Small and Medium Scale. Journal of Science and Technology.Vol 2, April (ISSN 2303-3142).

[17] Nugroho, Rudi. (2009). Waste denitrification Nitrate at Different Levels of acidity by Utilizing Microbial autotrophs.JAI Vol.1 1.

[18] Munawaroh et al., (2013). Allowance parameter Environmental Pollutants in Wastewater Industry Know Using Effective Microorganisms 4 (EM $_{4)}$ And Utilization .Journal of National Institute of Technology (Itenas) No.2 Volume 1.

[19] Sumantri, Arief. (2013). Revised Edition: Environmental Health. PT.Dawn Interpratama Independent: Jakarta.