STUDY OF THE USE OF *BIOFILTER* REACTOR FOR GREYWATER PROCESSING IN THE AREA OF FLOATING SETTLEMENT KELURAHAN MARGASARI KOTA BALIKPAPAN TOWARD THE CONCEPT OF *ZERO WASTE*

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Abstract

The floating settlement in Margasari is one of the settlements in Kota Balikpapan which is known as a Beach City. PDAM (State Water Company) as the main resource of clean water fulfillment in Balikpapans, needs to needs to be used efficiently. One of the ways is by processing the *Greywater* which can be reused for *toilet flushing* in order to support the concept of *Zero Waste*.

The purpose of this research is to obtain the composition and the potential data of *Greywater* which is appeared from the data and reusable for the citizens, to find out the effectiveness of the use of *Biofilter* Reactor as an alternative processing unit of *Greywater* towards the parameters of pH, BOD, COD, TSS, and NH_3-N, and also to identify the citizens' role potential in processing the *Greywater* towards the concept of *Zero Waste* in terms of processing domestic liquid waste.

The *Greywater* level in Margasari Floating Settlement of Balikpapan with the parameters of BOD of 520,1–840,1 mg/l, COD of 1.562,5–2.450,0 mg/l, TSS of 297,0–1.047,0 mg/l, and NH_3-N of 0,0002-16,257 mg/l is still very high. Margasari Floating Settlement of Balikpapan consists of 6.546 people and 1.198 buldings with an average of *Greywater* potential of each house of 393,42 l/day or 14.139.360 l/month for the whole area, while the average need for toilet flushing in each house is about 264,03 l/day atau sebesar 9.489.081,60 l/month for the whole area. The *Biofilter* Reactor can be used to process the *Greywater* for the whole area. The *Biofilter* Reactor which has an effective volume of 247 liter, has a diameter of the gravel media of 2,5–4 cm with an optimum effectiveness towards the BOD parameter of 86,54%, COD of 82,27%, TSS of 84,60%, and NH_3-N of 19,99%. It can be used to process the *greywater* from a house consisted of 5 people with a *Greywater* debt of 0,36 m^3/day, average BOD debt of 686,77 mg/l and average TSS of on Margasari Floating Settlement.

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1. Introduction

In a city, a trend of increasing population following the city activity which tends to more develop caused a trend of increasing/varied wastes (Syafrudin, 2006). Similarly, the need of water will increase as well as the domestic liquid wastes.

Balikpapan has a total area of 504,32 km^2 with the sea processing area of 287,41 km^2 which makes it has many settlements developed / built in the coastal or even floating areas. One of them is Margasari Floating Settlement. This kind of settlement has successfully changed the condition of the environment which was dirty to be clean, green, and comfortable for the residents.

Margasari Floating Settlement is located on kelurahan Margasari, kecamatan Balikpapan Barat. Kecamatan Balikpapan Barat has an area of 179,95 km^2 with a population of 93.134 on 2014 and has 27.145 householders. Kelurahan Margasari is located on Kecamatan Balikpapan Barat which is an area of Balikpapan City, East Kalimantan. Kelurahan Margasari has an area of 58.90 Ha. It can be seen on the Figure 1 as follow:

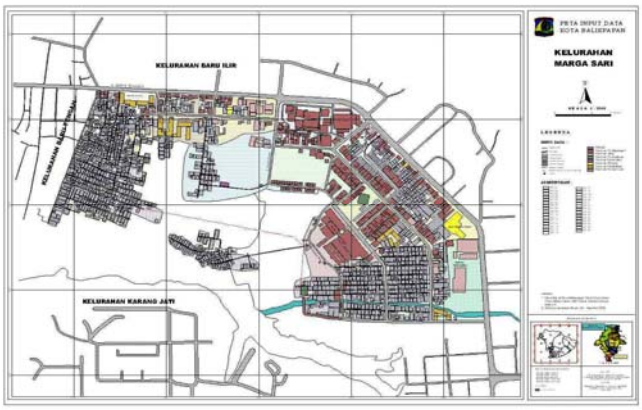

Figure 1. Map of Kelurahan Margasari (Regional Planning and Developing Institution of Balikpapan City, 2011)

There is a need to save the water consumption and to preserve the clean water because the there is a prediction that the clean water will be more difficult to get in the future. The use of water in a large building is should be considered related to the stock of the clean water starting form consumption savings, equipments choosing in the activity of reusing the *greywater* for toilet flushing.

Greywater is a part of domestic liquid wastes which is not flowed through the toilet such as, bathing, washing, and dishwashing wastes. About 60 – 85% of the total volume of the need of clean water will be domestic liquid wastes (Metcalf, 1991). The part of *greywater* is about 75% of the total volume of domestic liquid wastes (Hansen & Kjellerup, 1984 cited from Erikson et al., 2001). According to Jefferson (2004), *greywater* is often called as low organic load waste although it is difficult to classify the waste type of *greywater* based on the wastes classification of Metcalf & Eddy (2004). It is caused by the organic matters inside the liquid waste are highly varied from the effluent quality matter from the tertiary treatment at the lowest up to the IPAL quality influent at the highest (Betharia, 2010).

Now, one of the wastes processing ways used mostly is the biological process with an adhere breading. According to Saravanan dan Sreekrishnan (2006), a *biofilter* reactor is a bioreactor with a biocatalyst which is in an adhere position (fixed), both in the fixed media and adhered to each other. The most often used process is the *biofilter* process either anaerobic or aerobic process. *Biofilter* process is a biological reactor with a fixed bed film where the micro-organisms grown and developed adhered to the surface of the rigid media such as plastic or stone. The influent of liquid wastes is inserted to the reactor which is filled by the buffer media (*biofilter* media) where the micro-organisms will be adhered each other to the surface of the media. Thus, the organic pollutant consisted in the liquid wastes will be scattered into some respiration products, i.e., CO_2 and H_2O.

In its application, the effectiveness of *biofilter* process is highly affected by the types and forms of the media used. It is very important to know that the *biofilter* media has a function to provide the surface area where the bacteria or micro-organisms colonize. In this case, the bacteria play an important role in the *biofilter* system. In order to work effectively, the designs of the *biofilter* and the buffer media has not only to distribute the nutrient and oxygen but also to remove the output production both dissolved and suspended. In general, *biofilter* uses aerobic bacteria but can be designed and operated for the anaerobic ones. The important part of this *biofilter* is the media used as the surface area provider. The media type selection is highly affected by the price and also the cost of *biofilter* operation.

The buffer media is the most important part of *biofilter.* Therefore, according to Said dan Ruliasih (2005), the media selection has to be conducted carefully suited with the process condition and also the type of liquid wastes wanted to be processed.

The gravels and rocks had been used in *biofilter* since the 19th century for many purposes. It would be better for the use into submerged *biofilter* or trickling filter. It is still be used for many nedds such as, aquarium, aquaculture and household wastes processing. There are so many things made from clay, which are easy to get, cheap and relative to have a high specific surface. Rocks and gravels are inert and not broken in a good mechanical strength, and also have a good wet property.

According to Santoso (2009), Zero Waste concept is an approach and application of urban waste treatment systems and technologies in an integrated regional scale with the objective to conduct a regional-scale urban waste management to reduce the volume of wastes as little as possible, and that a small industry of recycling processes managed by the residents or local government.

According to Bebassari (2003) in Kristiyanto (2007), the definition of the concept of Zero Waste is a concept of integrated waste management, including the process of reducing the volume of waste and the waste from its source to the approach through technological, environmental, economical aspects, and the active role of the community.

According to E.HSU,Cm. Kuo (2004), *Zerowaste society* is a waste management starting from production until the end which can avoid or minimize the production of waste based on the needs and demands of society which are planned, executed, controlled and evaluated with the residents in order to find out the potential of the concept of 3R (*Reuse, Reduce, Recycle*).

2. Methodology

In conducting the research, the researcher uses the analysis of the findings about the greywater condition in the floating settlement in Margasari, Balikpapan by directly observing and interviewing the related parties who understand about the greywater problems. Besides doing the analysis to find the suitable alternative greywater processing which is applied in Margasari floating settlement in Balikpapan to support the concept of zero waste and also to conduct a direct test to the tools which will be used.

Tools and materials which are used in collecting the data are as follows:

1. The alternative tool in processing the *greywater* is the *Biofilter* Reactor using a *biofilter* media in the form of stones and gravels in 2 kinds of dimension variations.
2. Photos about the objects which will be observed based on the observation objects about the problems seen.
3. Questionnaire as the materials to collect the subjective information from the parties related to the wastes problems in Margasari Floating Settlement of Balikpapan City.

The flows of the research process can be seen on Figure 2 (The flow Diagram of of the research process) and on Figure 3 The Flow Diagram of Alternative Test of The Processing Tools.

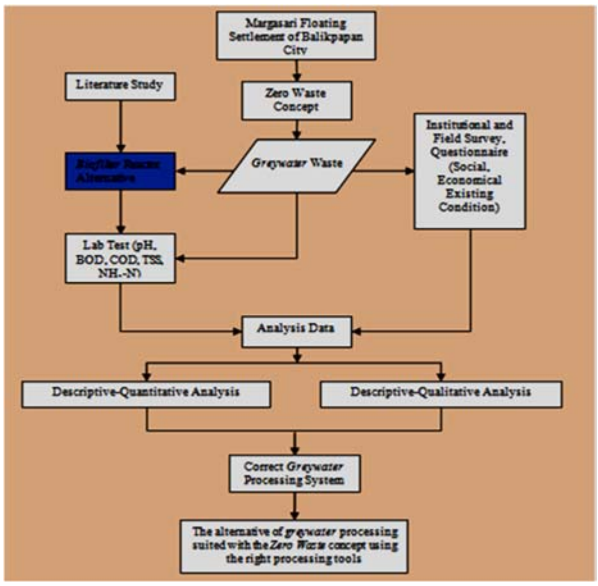

Figure 2. The Flow Diagram of The Research Process

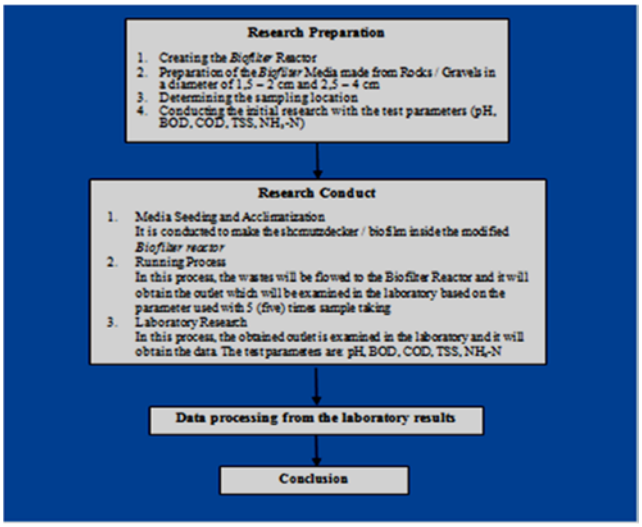

Figure 3. The Flow Diagram of *Biofilter* Reactor Test

In designing a biofilter reactor, it used drums in a diameter of 50 cm and height of 70 cm, and the middle of the pipe with a diameter of 6 inches and also a small pipe with a diameter of ½ inches.

Figure 4. Unfilled *Biofilter* Reactor

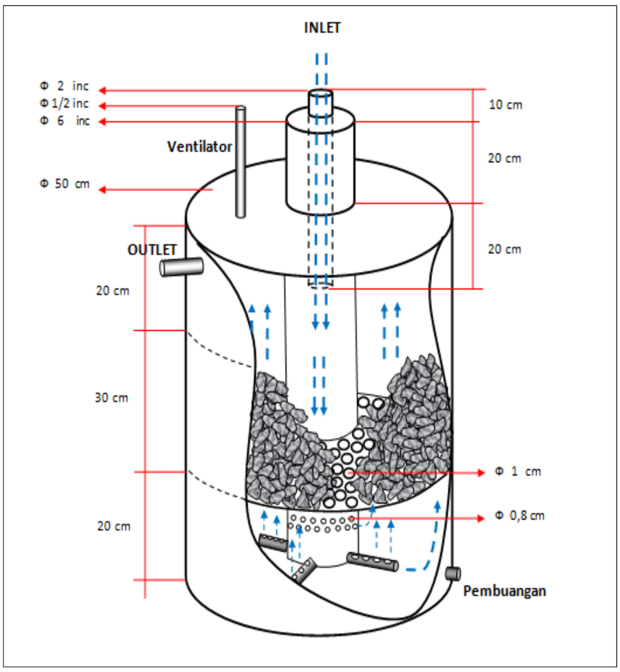

Figure 5. *Biofilter* Reactor Design

Table 1. The Calculation of the Reactor Volume

No	Section	Diameter		High	Volume	
		mm	m	m	m³	l
1	Total Drum	500	0,500	0,650	0,128	127,563
2	Drum Middle Section	500	0,500	0,300	0,059	58,875
3	Pipe Inside Φ 6 inc	152,4	0,152	0,650	0,012	11,851
4	Pipe section in the middle Φ 6 inc	152,4	0,152	0,300	0,005	2,735

Thus, the total volume of the wastes which can be processed in a period of fulfillment is:

= V Drum Total – (V Drum Middle – V Pipe Middle-Inside)

= 127,563 – (58,875 – 2,735)

= 71,422 liter

3. Results and Discussion

In order to find out the characteristics of greywater on Margasari Floating Settlement as a tested sampling was taken from three different sources of some of the houses in the floating settlement area which is expected to represent the characteristics of greywater in Margasari Floating Settlement Area.

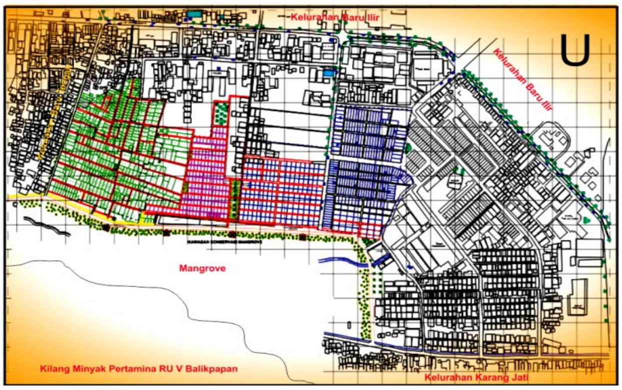

Figure 6. Maps of Margasari Floating Settlement Area (Regional Planning and Developing Institution of Balikpapan City, 2011)

The purpose of this characteristics test is to find out the composition of the *greywater* which eases the utilization and management such as plants or toilet flushing or other things. Sampling was conducted from 6 different sources with two types of wastes samples, i.e., liquid wastes from the kitchen and laundry. The taken samples were then taken to the laboratory to find out the characteristics of the waste with the results shown in Table 2 below.

Table 2. The Characteristics of *Greywater* From the Sampling in Margasari Floating Settlement

Parameter	Laundry Waste			Kitchen Waste			Unit
	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	
pH	9,6	9,7	9,3	6,6	6,6	6,6	mg/l
BOD	600,1	720,1	520,1	780,1	660,1	840,1	mg/l
COD	1.775,0	2.050,0	1.562,5	1.962,5	1.750,0	2.450,0	mg/l
TSS	796,0	1.047,0	544,0	325,0	297,0	372,0	mg/l
NH3-N	10,0912	16,2574	9,0830	<0,0002	<0,0002	<0,0002	mg/l

Seeing that the parameters of the characteristics test results of the sample taken from Margasari Floating Settlement are still higher than the value of the parameters allowed to use *greywater* in agriculture and Domestic Waste Quality Standards, then, the reuse of the *greywater* still needs some beforehand processing.

a. *Greywater* Potential

For the calculation of the water use in Margasari Floating Settlement was calculated from the PDAM bills data of the residents in the last 3 months, i.e., April, May, and June of 2014 which can be seen on Table 3.

Table 3. The Calculation of The Total Consumption

Average (m^3)			Average	Number of Houses	Total Water Consumtion Area
April	May	June	(m^3)		(m^3)
17,30	20,15	19,97	19,14	1.198	22.929,29

Thus, for the area, the result of the calculation is as follows:

The Area Water Needs = Baseline Standard x People
= 120 liter/day x 6.546 people
= 785.520 liter/day

The total wastes is about 80% of the total consumption of clean water, so it is assumed that *greywater* is coming from 75% of the total liquid wastes of Margasari Floating Settlement. About 60 – 85% of the total volume of clean water needs will be domestic liquid wastes (Metcalf & Eddy, 1991).

Table 4. *Greywater* Potential

Total Kebutuhan Air		Total Limbah (80%)		Volume Greywater (75%)	
l/hari	l/bulan	l/hari	l/bulan	l/hari	l/bulan
785.520	23.565.600	628.416	18.852.480	471.312	14.139.360

Based on the field research of the questionnaire data, it was found the percentages of the toilet type used by the residents as shown in Figure 7.

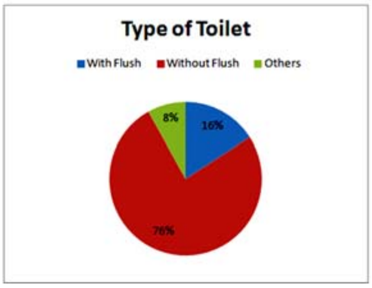

Figure 7. The Toilet Types Used by the Residents

From the chart above can be explained that the residents in the Floating Settlement using a squat toilet without a flush for 76%, with a flush toilet seat for 16% and the 8% for the rest which means that some residents still use the latrines directly connected to the sea. It will be used as the scenario in the calculation of the use of *greywater* for toilet flushing in Table 5.

Table 5. The Use of *Greywater* For Toilet Flushing

BAB (l/hari)	BAK (l/hari)	Total (l/hari)	Total (l/bulan)	*Greywater* (l/bulan)	% Reduction (l/bulan)
39.537,84	276.764,88	316.302,72	9.489.081,60	14.139.360,00	41,38

So that it is obtained that the reduce of clean water of 41,38%.

b. *Biofilter* Reactor Efficiency

Acidity parameter (pH) is a measure of the quality of water and liquid wastes. The good levels of concentration which still allows the biological life in the water running well, normal water is not acidic or alkaline with pH = 7 or neutral pH. The concentration of water which did not have a pH in the neutral position will complicate the biological processes, which is disrupting the purifying process.

Table 6. The pH changes of the Kitchen Wastes

Time (day)	Inlet	Outlet A	Outlet B
1	5,6	5,3	5,4
2	4,9	5,3	5,3
3	4,7	5,3	5,4
4	5,3	5,5	5,5
5	5,2	5,2	5,2

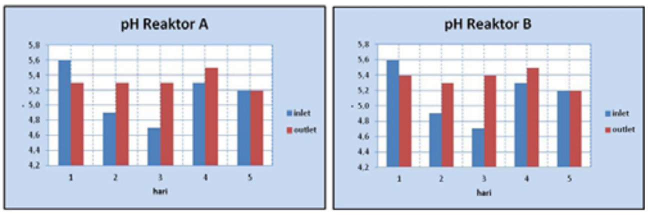

Figure 8. The changes of kitchen wastes after the process

Tabel 7. The pH changes of Laundry Wastes

Time (day)	Inlet	Outlet A	Outlet B
1	5,6	5,3	5,4
2	4,9	5,3	5,3
3	4,7	5,3	5,4
4	5,3	5,5	5,5
5	5,2	5,2	5,2

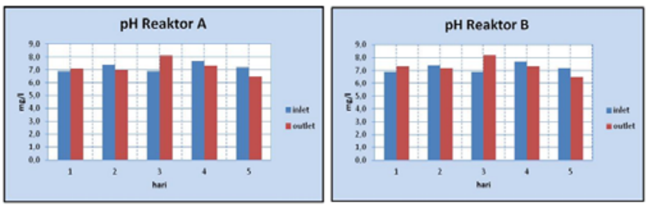

Figure 9. The changes of Laundry Wastes after the Process

The pH value is highly related to the respiration process of the organisms resulted CO_2, so that the pH is increased or in contrast that the use of CO_2 that increases the pH. It can be seen on the following equilibrium:

$$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^- \quad (1)$$

The more CO2 that is used for respiration reaction is moving right and the release H^+ ion so that the pH of the water tends to fall (inclined acid) is happening on kitchen wastes because of many organic materials contained. Thus, many microorganisms require CO2 to the process of respiration so that the pH of kitchen wastes tends to be low and decreased after the treatment with *biofilter* reactor.

Domestic liquid wastes not only contained the organic material but also the other microorganisms, and of course still have the dissolved oxygen content. This organic material serves as food for the bacteria and dissolved oxygen to fulfill the needs of its respiration. Over the time, the content of organic material and dissolved oxygen will be decreased while the bacterial population increased. So the higher the organic matter contained in the liquid wastes, the more dissolved oxygen required to decompose. This situation is expressed in mg / l of required dissolved oxygen or in terms of BOD. The calculation of the effectiveness of BOD reduction of the kitchen wastes can be seen in Table 8.

Table 8. The effectiveness of BOD reduction of the kitchen wastes

Time (day)	Inlet (mg/l)	Outlet A (mg/l)	Outlet B (mg/l)	Effectiveness (%)	
				Reactor A	Reactor B
1	1800,1	850,1	400,1	52,77	77,77
2	1500,1	700,1	640,1	53,33	57,33
3	900,1	405,1	380,1	54,99	57,77
4	620,1	1250,1	480,1	-101,60	22,58
5	640,1	660,1	520,1	-3,12	18,75
			Average	11,28	46,84

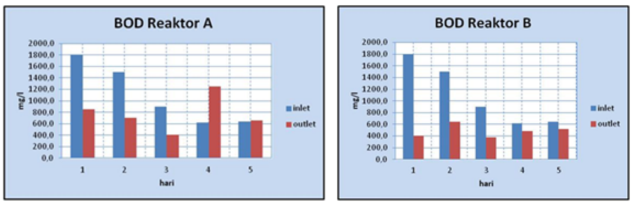

Figure 10. The changes of Kitchen wastes BOD after the process

Table 9. The effectiveness of BOD reduction of the Laundry wastes

Time (day)	Inlet (mg/l)	Outlet A (mg/l)	Outlet B (mg/l)	Effectiveness (%)	
				Reactor A	Reactor B
1	350,1	170,1	47,13	51,41	86,54
2	195,1	150,1	15,38	23,07	92,12
3	270,1	130,1	48,13	51,83	82,18
4	250,1	130,1	41,98	47,98	83,21
5	510,1	110,1	68,61	78,42	86,55
			Average	50,54	86,12

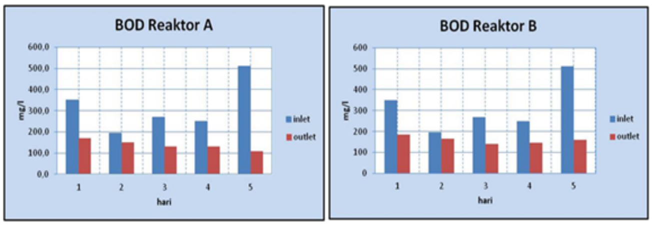

Figure 11. The changes of Laundry wastes BOD after the process

In this research, BOD of the kitchen wastes is higher than of the laundry wastes. It is caused by the kitchen wastes contains organic materials in a very high level which came from the leftovers such as Carbohydrate, oil / fat, and protein. The organic materials will be oxidized by microorganisms (bacteria) to be CO_2, NH_3, H_2O and the new cells of microorganisms will also be grown. *Chemical Oxygen Demand* (COD) is one of the indicators which states the water pollution either organically or inorganically. A high COD indicates that the liquid wastes can pollute the water environment. This condition has to be reduced firstly through the process. COD is the amount of oxygen in a ppm unit or milligram per liter which is needed to oxidize the organic materials chemically both *biodegradable* and *non biodegradable* to be CO_2 and H_2O. The calculation result of the effectiveness of the kitchen wastes COD can be seen in Table 10.

Table 10. The effectiveness of COD reduction of the kitchen wastes

Time (day)	Inlet (mg/l)	Outlet A (mg/l)	Outlet B (mg/l)	Effectiveness (%)	
				Reactor A	Reactor B
1	4850,0	2425,0	860,0	50,00	82,27
2	4300,0	1512,5	1262,5	64,83	70,64
3	2062,5	1030,0	965,0	50,06	53,21
4	1562,5	3600,0	1380,0	-130,40	11,68
5	1800,0	1250,0	1125,0	30,56	37,50
			Average	13,01	51,06

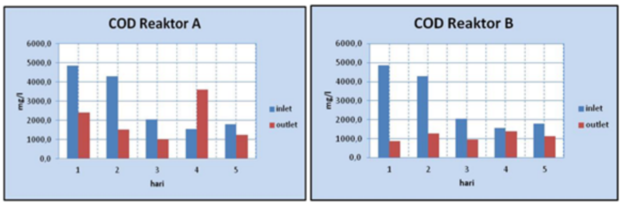

Figure 12. The changes of kitchen wastes COD after the process

Table 11. The effectiveness of COD reduction of the Laundry wastes

Time (day)	Inlet (mg/l)	Outlet A (mg/l)	Outlet B (mg/l)	Effectiveness (%)	
				Reactor A	Reactor B
1	710,0	455,0	492,5	35,92	30,63
2	502,5	375,0	407,5	25,37	18,91
3	667,5	331,2	377,5	50,38	43,45
4	610,0	312,5	347,5	48,77	43,03
5	1237,5	260,0	340,0	78,99	72,53
			Average	47,89	41,71

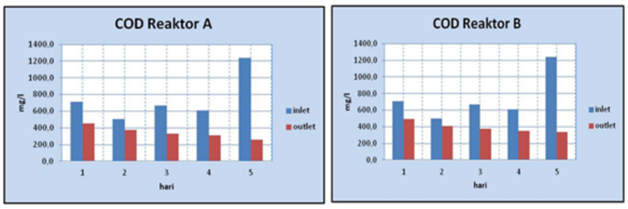

Figure 13. The Changes of Kitchen wastes COD after the process

Both COD values are always bigger than the BOD because COD not only illustrates the *biodegradable* organic materials but also the *non-biodegradable* ones. Thus, the comparison of BOD and COD in domestic liquid wastes befor the process is 0,40 – 0,60 and 0,20 after the process (Alaerts dan Santika, 1987).

Water processing using *biofilter* reactor in the process is conducted more by the microorganisms adhered to the buffer media. The process will reduce BOD and also the COD as well because the organic materials had been biodegraded by the microorganisms inside the *biofilm* layer.

In contrast, the increasing BOD of the kitchen wastes in Reactor A with a live period for 4 (days) as explained above. Gravels, as the place for bacteria adhered, show its weakness when the bacteria become thicker, which makes the inside layer becomes an anaerobic ones. If it is happened, the layer will lose its adhesion potency towards the substrate and then will be escaped. If the bacteria which is inside the small aperture and the *biofilter* will increase the BOD inside the *biofilter,* it will also increase the COD of the kitchen wastes in reactor A with a live period of 4 days, from the initial inlet of 1562,5 mg/l to be 3600,0 mg/l.

Solids inside the water were classified into dissolved, suspended, and deposited solids. Total Suspended Solid (TSS) states the amount of solids inside the water which can be in the form of floating organic and inorganic compound which is not dissolved and deposited directly. This kind of solid is highly affected the muddiness of the water. The calculation result of TSS reduction of the kitchen wastes can be seen in

Table 12. The effectiveness of TSS reduction of the kitchen wastes

Time (day)	Inlet (mg/l)	Outlet A (mg/l)	Outlet B (mg/l)	Effectiveness (%)	
				Reactor A	Reactor B
1	1065,0	183,0	164,0	82,82	84,60
2	692,0	148,0	195,0	78,61	71,82
3	618,0	118,0	87,0	80,91	85,92
4	325,0	129,0	137,0	60,31	57,85
5	371,0	97,0	75,0	73,85	79,78
			Average	75,30	75,99

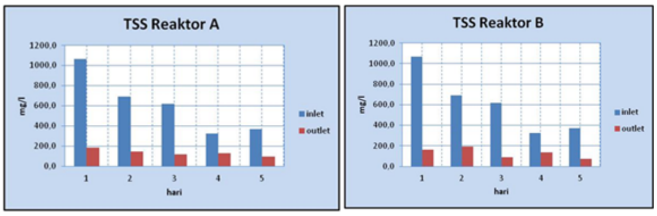

Figure 14. The changes of kitchen wastes TSS after the process

Table 13. The effectiveness of TSS reduction of the kitchen wastes

Time (day)	Inlet (mg/l)	Outlet A (mg/l)	Outlet B (mg/l)	Effectiveness (%)	
				Reactor A	Reactor B
1	244,0	134,0	113,0	45,08	53,69
2	188,0	138,0	121,0	26,60	35,64
3	265,0	85,0	90,0	67,92	66,04
4	219,0	48,0	123,0	78,08	43,84
5	520,0	110,0	150,0	78,85	71,15
			Average	59,31	54,07

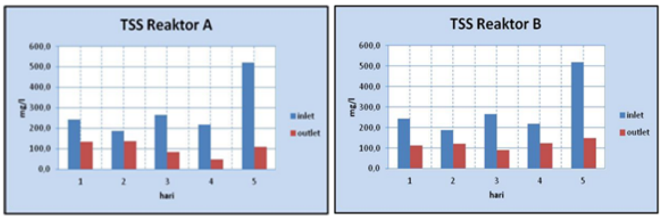

Figure 15. The changes of Laundry wastes TSS after the process

The organic materials contained in the wastes are parts of the Total Suspended Solid (TSS). The high BOD value in the kitchen waste indicates a high content of organic material that can be decomposed by microorganisms or bacteria in the *biofilter*. Thus, the more effective the *biofilter* in reducing BOD, the lower in reducing the TSS. *Biofilter* is a process of adhered fertile which is very good in reducing the value of BOD. So it is also very effective in reducing the TSS in the kitchen wastes which is full of organic materials.

In contrast, the effectiveness of the *biofilter* reactor is lower in reducing the TSS in Laundry wastes that in the kitchen wastes because the laundry wastes contain less organic materials than the kitchen wastes which is indicated by the BOD of the laundry wastes. *Biofilter* relies on microorganisms (bacteria) in decomposing the organic materials.

Nitrogen Ammonia (NH_3-N) in the water is in the form of ammonia ion (NH_3) and ammonium (NH_4^+). The source of ammonia in the water is the result of inorganic nitrogen breaking (protein and urea). The inorganic nitrogen in the soil and water also came from the decomposition of the organic materials (dead plants or aquatic biota) conducted by microbe and fungi which is known as ammonification (effendi, 2003).

$$N_{organic} + O_2 \rightarrow NH_3\text{-}N + O_2 \rightarrow NO_2\text{-}N + O_2 \rightarrow NO_3\text{-}N \qquad (2)$$

Table 14. The effectiveness of reduction NH_3-N of Kitchen wastes

Time (day)	Inlet (mg/l)	Outlet A (mg/l)	Outlet B (mg/l)	Effectiveness (%)	
				Reactor A	Reactor B
1	0,0002	0,0002	0,0002	0,00	0,00
2	0,0002	0,0002	0,0002	0,00	0,00
3	0,0002	0,0002	0,0002	0,00	0,00
4	0,0002	0,0002	0,0002	0,00	0,00
5	0,0002	0,0002	0,0002	0,00	0,00
			Average	0,00	0,00

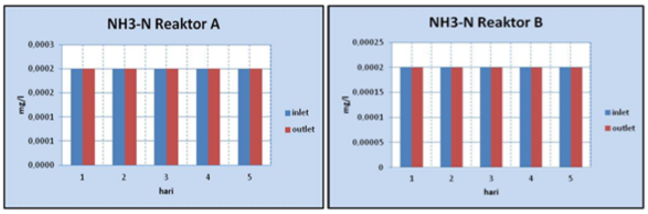

Figure 16. The changes of kitchen wastes NH_3-N after the process

Table 15. The effectiveness of NH_3-N reduction of the laundry wastes

Time (day)	Inlet (mg/l)	Outlet A (mg/l)	Outlet B (mg/l)	Effectiveness (%)	
				Reactor A	Reactor B
1	0,3361	0,1683	0,4574	49,93	-36,09
2	0,4430	0,1906	0,3343	56,98	24,54
3	0,2375	1,0896	1,4791	-358,78	-522,78
4	0,5086	0,4096	0,4480	19,47	11,92
5	0,4151	0,0002	0,0002	99,95	99,95
			Average	-26,49	-84,49

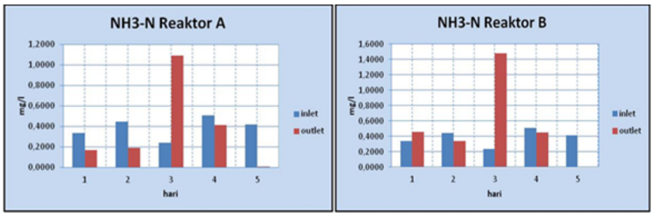

Figure 17. The changes of laundry wastes TSS after the process.

Nitrogen Ammonia (NH_3-N) in the water is in the form of ammonia ion (NH_3) dan ammonium (NH_4^+). The relationship between both of them is in an equilibrium system, as follows :

$$NH_3 + H_2O \leftrightarrow NH_4^+ + OH^- \quad (3)$$

Ammonia can form its complexity with some metal ion, which is absorbed into the suspended materials or colloid, so that it will be deposited on the ground water or even the ammonia can be lost through volatilization process due to the partial pressure. Ammonia will be increased as well as the pH.

In the bigger than 7 reactions pH, it will move to the left side of the reactions (ammonium is not ionized) so that the ammonia increased. In contrast, in the lower than 7 reactions pH, it will move to the right side of the reactions (most of ammonium is ionized).

It was happened on the laundry wastes with a live period of 3 days where in the reactor A there is an increased pH from 6,9 to 8,1 so that the NH_3 increased from 0,2375 mg/l to 1,0896 mg/l. As well as in reactor B, pH is increased from 6,9 to 8,2 so that the NH_3 increased from 0,2375 mg/l to 1,4791 mg/l. The high pH >7 caused most of un-ionized ammonium (NH_4^+) caused the increase of ammonium (NH_3) in the laundry wastes with a live period of 3 days.

c. The *Biofilter* Reactor Analysis

Based on the research results towards the *Bofilter* reactor can be concluded that the design has fulfilled or suited with the *Biofilter* design criteria which can be seen on Table 15.

Table 16. The Analysis of *Biofilter* Design Criteria

No.	Design Criteria	Target	Caption
1.	Processing efficiency can reach the standard of Environmental Quality Standards.	appropriate	Able to reduce the parameter sd environmental quality standards for domestic waste.
2.	Management (operation and maintenance) should be easy.	appropriate	It is easy to maintain.
3.	Land required is not great.	appropriate	Appropriate land use drum diameter.
4.	Low energy consumption wherever possible.	appropriate	Energy consumption 0 (zero).
5.	Sludge generated whenever possible small	appropriate	Very small.
7.	Resistant to fluctuations in the concentration of waste water so it can be used for wastewater with BOD load large enough	appropriate	Resistant to organic load fluctuations and fluctuations in hydraulic load.
8.	Can remove suspended solids (TSS) with either.	appropriate	Optimum efficiency of 84.60%

In this *greywater* treatment, the want to be processed wastes are from the kitchen, laundry, and bathing wastes. The *greywater* debt was calculated based on its potential calculated in the condition of a house inhabited by 5 people which results on an average data of the people lived in the floating settlement of 6546 people divided by the buildings available which is 1198 buildings. The result is 5,464 which is then integrated into 5 of people inhabit a house. With a water need of people/day = 120 l/day (*standard baseline*). Thus, results on the *greywater* debt for each house of 0,36 m^3/day. This debt will be use for the calculation base of the *biofilter* reactor design on the field. The existing *greywater* sample which had been tested in the laboratory has an average BOD of 686,767 mg/l, with a process through the *biofilter* reactor using the gravels media with a diameter of 2,5–4cm is more effective in reducing BOD concentrate for 86,54% which is resulted by the effectiveness of the BOD reduction optimum of the *biofilter* reactor.

Then, there was a calculation of *biofilter* reactor design which is according to Hadiwidodo et al. (2012), as follows:

- BOD in the *biofilter* = 686,767 mg/l (average of the measurement over Margasari floating settlement)
- The efficiency of BOD reduction = 86,54% (Results of *bofilter* reactor test)

- BOD out = 686,767 mg/l – (686,767 mg/l x 0,8654)
  = 95,323 mg/l
- Wastes Debt (Q_{waste}) = (5 x 120 l/hari) x 80%
  = 480 l/hari
- *Greywater* Debt ($Q_{greywater}$) = 480 l/hari x 75%
  = 360 l/hari
  = 0,36 m^3/hari
- BOD debt in the wastes = $Q_{greywater}$ x BOD_{in}
  = 0,36 m^3/day x 686,767 mg/l
  = 247,236 g/day
  = 0,247 kg/day

- Volume of the necessary media
  = BOD Debt in the wastes / Standard BOD debt
  = 0,247 kg/day /2 kg BOD/^{m3}.day
  = 0,124 m^3
  For water processing with a standard *biofilter* process, the BOD debt per media volume is 0,4 – 4,7 kg BOD/m^3.day (Ebie Kunio, 1995). It is fixed that the BOD debt used = 2 kg BOD/m^3.day
- The percentage of the media volume inside the reactor : 50% of the reactor total volume
- Thus, the necessary reactor volume on the field
  = 100/50 x 0,124 m3
  = 0,247 m^3 = 247 liter
- Live period in the reactor:
  = $V_{reactor}/Q_{greywater}$
  = (0,247 m^3 x 24 hours/day) / 0,360 m^3/day
  = 16,4824 hours

From the calculation, the *biofilter* reactor used on the Floating Settlement of Margasari should be bigger than 0,247 m^3 (247 liter), can use the drum with a volume of 250 liters which is generally available in the market.

Margasari Floating Settlement is located on an intertidal area (tides transition) so that the shape of the houses on the stilts eases the installation of *biofilter* reactor. The *biofilter* reactor unit can be located on the spacy location among the buildings with the small needs of field suited with the diameter of the used drum. By utilizing the difference of the floor height outside with the inside one, and trying to locate it as near as possible to the toilet to ease the access of water taking of the *greywater* processing for toilet flushing. Remember that the installation did not use the pump so that it was conducted manually. Prior to be filled to the *biofilter,* the *greywater* is firstly filled to the tank. The tank is utilized as the debt buffer and to deposit the solid in the *greywater*. In the tank, we have to put a filter to filter the leftovers or other solid particles cannot go inside the tank. From the tank, the *greywater* can go inside the processing unit in the form of *Biofilter Reactor* to reduce the pollutant debt inside the *greywater*. For the details, it can be seen on the Figure 18, as follows:

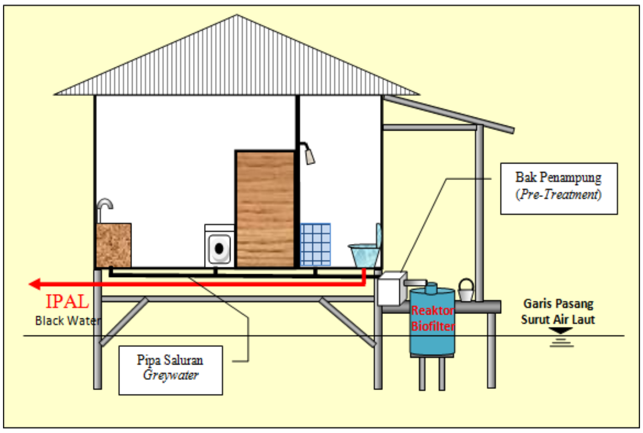

Figure 18. The sketch of *Biofilter Reactor* placing

4. Conclusion

Based on the purpose and the result of the research, it can be concluded that:

1. The level of *greywater* on Margasari Floating Settlement of Balikpapan City with BOD Parameter of 520,1–840,1 mg/l, COD of 1.562,5–2.450,0 mg/l, TSS of 297,0–1.047,0 mg/l, dan NH_3-N of 0,0002-16,257 mg/l is still very high.
2. Margasari Floating Settlement of Balikpapan City which consists of 6546 people and 1198 buildings, there is an average *greywater* potential of each house is 393,42 l/day or 14.139.360 l/month for the whole area, while the average need for toilet flushing of each house is 264,03 l/day or 9.489.081,60 l/month for the whole area.
3. The *Biofilter* Reactor with an effective volume of 247 liter using the gravels media with a diameter of 2,5 – 4 cm with an optimum effectiveness towards the BOD parameter of 86,54%, COD of 82,27%, TSS of 84,60%, and NH_3-N of 19,99%, can be used for processing the *greywater* from a house inhabited by 5 people with a *greywater* debt of 0,36 m^3/day with an average BOD debt of 686,77 mg/l and average TSS of 583,50 mg/l on Margasari Floating Settlement.
4. The residents of Margasari Floating Settlement is very supportive to the *greywater* processing where the 87% of the residents agree with the *greywater* processing and utilizing which is suitable with the *Zero waste* concept. However, there is still a problems faced on the field that is the low knowledge level of the residents about the utilizing and processing the *greywater*.

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